Dashboarding Research Experiences for Undergraduates

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Abstract

Research Experiences for Undergraduates (REU) programs at universities, and industry mentoring programs, often have difficulties evaluating and assuring quality student experiences. Results from evaluations for two universities conducted in 2021 indicate that weekly reflection surveys and dashboards can raise the visibility of issues, and have the potential to improve mentoring and outcomes. This strategy has provided insights for instruction and program evaluation, suggesting both can benefit from collecting ongoing feedback on program challenges, accomplishments and interactions.

Program Overview

The Center for Discrete Mathematics & Theoretical Computer Science (DIMACS) was founded as a National Science Foundation Science and Technology Center. It has a long-running Research Experiences for Undergraduates (REU) program, attracting and nurturing strong students with bright futures in graduate school, research careers, and CS and math-related fields. Topics of investigation include research in algorithms, foundations and applications of theoretical computer science. University of Minnesota REU program is more recent, and has an innovative focus on computing for social good. Due to safety concerns related to COVID-19 the programs ran online in 2021. Goals are to nurture interests in research and programming careers.

Evaluation Overview

This paper focuses on how evaluation monitoring of student experiences can improve learning outcomes. The evaluation work began at Rutgers in 2020 and continued in 2021, while University of Minnesota evaluation began in 2021. While providing evidence of outcomes, these evaluations also explored ways to improve students' experiences. Weekly reflections, shared via an interactive R-Shiny dashboard, generated insights for both Research Experiences for Undergraduates (REU) programs during Summer 2021. Because the programs ran online-only, the evaluation prioritized the need for tools to increase visibility and communication.

Data collection coincided with official program launch and conclusion events, coordinated with the program to get near 100% participation. Pre- and post-surveys, asked about student objectives and prior experience, and attitudes at the conclusion of the program, among other topics. These pre-post findings framed analyses of the weekly reflections with the goal of understanding their relevance to eventual outcomes. The number of participants were as follows

- Rutgers DIMACS
    - 12 pre (100%)
    - 11 post (92%)
    - 13 reflections from 3 participants (25% participation)
        - Max N = 8; mean N = 4.3, median N = 3
- Rutgers Other
    - 19 pre (100%)
    - 17 post (89%)
    - 15 reflections from 6 participants (31% participation)
        - Max N = 6, mean N = 2.5, median N = 2
- Minnesota
    - 11 pre (100%)
    - 10 post (91%)
    - 53 reflections from 11 participants (100% participation)
        - Max N = 6, mean N = 4.8, median N = 5

Our analysis focuses on qualitative "case studies" using the weekly reflections, framed by the pre-post surveys to help us gain insights into each participant's experience.

Analysis of Weekly Reflections

Each week, students had the opportunity to reflect on challenges and accomplishments, and rate these from 1 to 10. They also rated interactions with mentors and peers, and whether the work was fun, interesting, successful, looked promising going forward, and was encouraged by someone. These weekly reflections were used by several participants at Rutgers, including additional voluntary use outside the originally-funded REU, and in Minnesota by all participants. Analyses raised questions and stimulated ideas for improving the programs – related to peer and mentor interactions, sense of accomplishment, and project completion.

Key theoretical questions concern finding the balance of self-reported learner challenges and accomplishments (the third scatterplot above (student challenges vs. accomplishments), as "flow theory" from Csikszentmihalyi (1990) suggests learning occurs when there is an appropriate balance. Another issue these data allow us to explore is the importance of a sense of competition ("finishing" their work), compared to promoting a "growth-mindset" (Yeager & Dweck, 2020). Many students had positive experiences without necessarily a sense of completion, while not all who were able to finish reported positive results.

The role of social encouragement **(**Wang, Hong, Ravitz & Ivory, 2016) is also highlighted. Findings confirm the importance of consistent supportive relationships in REUs (Fang, Lawanto, Goodridge & Villanueva, 2016) and of"strong relationships with their faculty mentor and graduate student mentors through consistent and professional interactions."

Dashboard View

The figure below shows the availability of data filters and the ability to "brush" on the experience of individuals or ranges of students (in the top chart) to explore the outcomes shown on the right. The data include scatterplots showing the evolution and rating of challenges and accomplishments over time, with qualitative explanations, and how they relate to each other.

Our evaluations found that positive learning experiences, as reflected in both qualitative and quantitative responses in the weekly reflections and the pre-post surveys, generally included experiences with these qualities:

- Consistent communications with mentors and peers
- A strong sense of project direction
- Trust and encouragement from mentors to take project ownership
- High quality social interactions with peers
- Feelings of accomplishment

These findings were consistent with program thinking over the years, but the availability of data provided added urgency to making sure all students have these opportunities to learn and grow, with these kinds of conditions being considered even more important and worth tracking as they move through their summer research experiences.

Discussion

Given the importance of social encouragement, it is not surprising that the few students with less positive outcomes often reported less contact with their mentor or not feeling supported. This was sometimes in reference to logistics issues at project launch, but consistent communication seemed to be essential throughout the experience. Weekly reflections might improve student learning experiences if mentors, coordinators (or peers) can identify when they are facing significant challenges or need more or different interactions with peers or mentors.

Challenges did seem to be related to outcomes, as theory might suggest. The only DIMACS student who admitted being less interested at the end was the same one who reported a lower sense of accomplishment than challenge. In Minnesota, a few students reported high levels of accomplishment throughout the project, but leading up to and through the final presentation some of them began to feel less accomplished than they did before, suggesting challenges with the final product and completion may have cut into their sense of accomplishment overall.

A recommendation is to try to make sure accomplishments are seen along the way, building toward overall success, without losing sight of and balancing the challenges of what is expected in the end. One DIMACS student may have exemplified what might be an ideal trajectory: Their project seems to have ramped up in intensity with low ratings of challenge and accomplishment initially, followed by a period of greater challenge and less accomplishment, but ending with more accomplishment than challenge. When they had the highest challenge they disagreed the work was successful, while their period of low challenge was associated with only neutral success. This seems to be consistent with a theory of productive struggle which suggests that accomplishment should follow significant challenge and support (Warshauer, 2015).

A final consideration is to consider what success looks like for each program and, perhaps, for each student. Several learners reported having successful experiences without, in the end, feeling they had completed their work. So, this raises the question of how important is the final product compared to having a positive experience and developing a growth mindset as a researcher? The answer may depend on what the objective is, unpacking what it means to be interested in a "career as a researcher" as an outcome, and what success requires.

Conclusion

The programs were largely successful in increasing student research interests and providing a positive learning experience, despite running online-only during the summer of 2021. There were a few cases where weekly reflections suggest students wanted additional attention or support, and experienced less than ideal levels of challenges/accomplishment or clarity about their roles. Especially during the online-only runs for these REUs using these reflections provided an important opportunity to assist mentors.

In conclusion, the learner reflections, made available via the weekly dashboard, were useful for identifying students' challenges or accomplishments at different moments, and overall experiences with their research project throughout the summer. Future use of dashboards can explore making these reflections more transparent for use among students and mentors, and may reveal how reflecting on their own experiences could help students become better advocates for themselves as learners and future researchers. There is much evidence that REUs can provide a

valuable learning experience for undergraduates, including clarifying their interests and encouraging continued pursuits in research fields. This paper has identified issues and opportunities that emerged when a tool was added for monitoring weekly reflections and used in coordination with other evaluation and program efforts.

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