ULAB: A Peer-Led Framework for Facilitating Undergraduate Research Experiences in Physics and Astronomy

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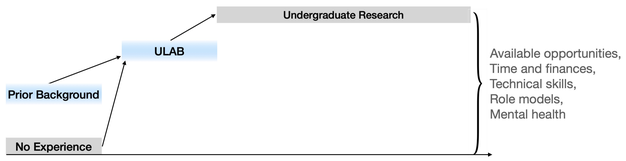
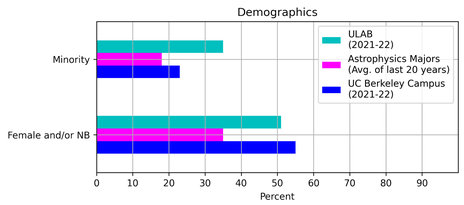
The Undergraduate Lab at Berkeley



Undergraduate research favors students with prior knowledge and experience. ULAB is a novel framework for a Course-Based Undergraduate Research Experience (CURE) [1].

ULAB is an **undergraduate run**, 2 semester, 2 unit (6 hr/wk), P/NP, course at UC Berkeley with the goal of bridging this gap. The program has been operating for 5 years and conducted 38 projects.

- **Mentorship:** In groups of 5-6 students work with guidance from an **undergraduate mentor** to conduct an original research project throughout a year; e.g. *Measuring Cosmic Distance using Gravitational Waves*, *Simulating Partial Quantum Search*, and *Environmental Dependence of Cosmic Ray Muons*.



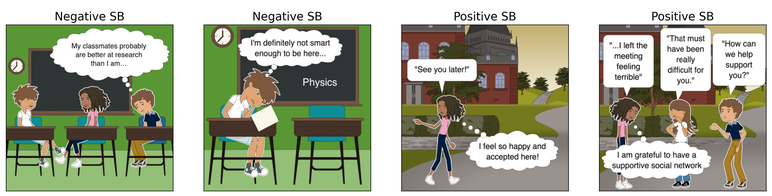
- **Hands-on experience:** First semester, students attain background for their sub-field, design a project, and present a proposal. Second semester students conduct their project and synthesize results in a poster presentation.
- **Technical skills:** Students attend lectures on Python, statistics, LaTeX, etc and complete associated homework assignments.
- **Community:** Mental wellness workshops, social events, facilitating interactions with graduate students, postdocs, and faculty.
- Skills and experience, not publications.
- Learning experience for mentors + stipend.

A Pilot Study

In FY 2020, the NSF alone allocated $943 million (11%) to education and human resources [2]. Despite this significant commitment of resources, there lacks well-established tools to evaluate the effectiveness of such programs. In conducting a pilot survey, we hope to:

1. Determine the effectiveness of ULAB in improving (1) confidence in research skills, (2) understanding of research and long-term plans, and (3) sense of belonging within the research and broader community.
2. Understand modes in which ULAB can be improved
3. Develop a set of evaluation tools applicable to CUREs.

The survey probes the three areas described above. For confidence in research skills (conf), and long-term plans (LT) students were ask to rate their confidence and understanding on a Likert-like scale (e.g. from "extremely uncomfortable" to "extremely comfortable"). For sense of belonging (SB), students were shown cartoons displaying scenarios with positive and negative SB and asked to rate the degree they relate [3].

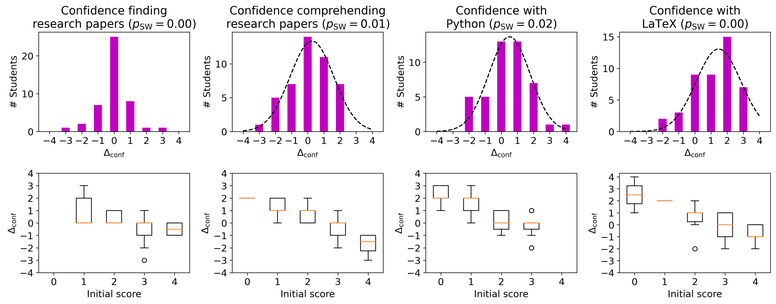


Responses for conf and SB are mapped to a 0–4 scale. Students responses between the initial (fall) and post (spring) survey are matched and the differences $\Delta \in \{-4, -3, \ldots, 4\}$ are calculated. -4 is the largest leftward change and $+4$ is the largest rightward shift. We recorded ∼60 responses per semester, but dropped students who did not respond to both surveys: $n = 45$ mentees.

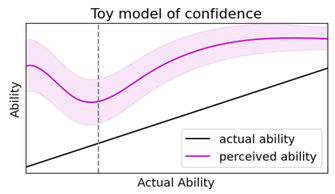
In our analysis, we report p-values for the Shapiro–Wilk (SW) test of normality and the non-parametric Kolmogorov–Smirnov (KS) test of equality of distributions.

Survey Results

Δ_{conf} are broadly distributed

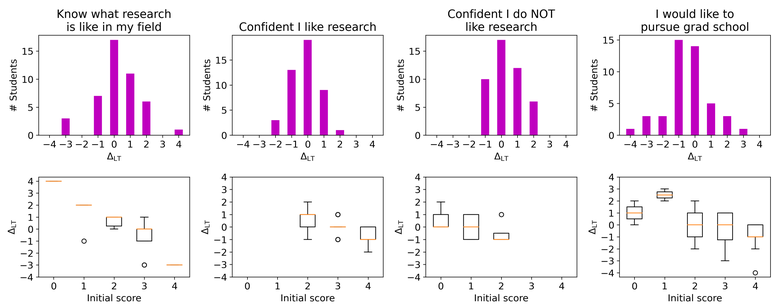


- No clear positive or negative trend in Δ_{conf}
- Mellowing of opinions: low initial values have positive Δ_{conf} and vice versa.
- Dunning-Kruger effect: students with low performance overestimate their ability and have a noisier representation of ability. [4].
- Student response: *I've had more trouble than I thought I would with the [Python] assignments.*



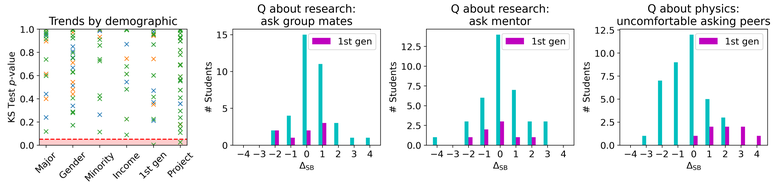
- Student response: *It's difficult to say I am comfortable in any one thing, there is always people performing better than where you're at, and its impossible not to compare.*
- Positive trends in LaTeX can be observed in comparison to Python.

Greater clarity in research preferences



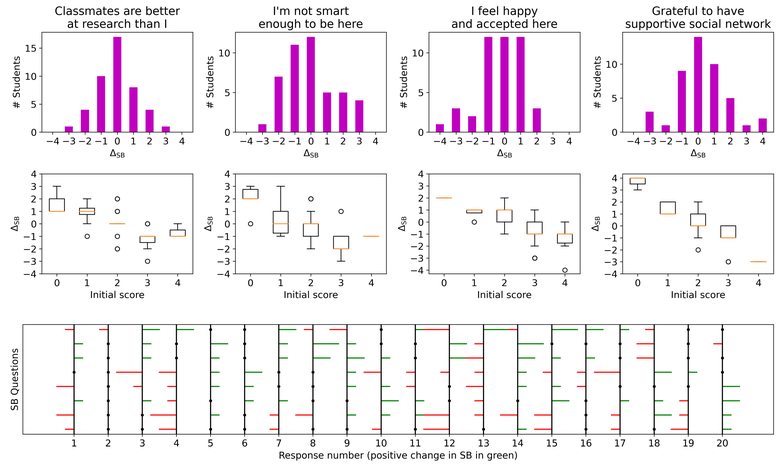
- Students realized they do not like research.
- Desire to pursue grad school tended towards a neutral position.

Trends by demographic



- There are no distinct trends by demographics—with 2 exceptions.
- First generation students tended towards less comfortable asking questions to peers compared to non-first generation. No such trend by first-generation is observed within ULAB.
- Groups displayed statistically-significant deviations in confidence in Python. Depending on the project, groups utilize Python to varying degrees.

From cartoons Δ_{SB} is inconclusive



- No strong conclusions can be made about the change in SB.
- SB depends on many variables that are difficult to convey through a cartoon (e.g. particular classes/experiences). The images alone overlook such dynamics.
- Written responses in reaction to cartoons are extremely valuable because because they reveal reasoning for changes in SB.
- No absolute sense of belonging—there are independence categories of belonging; e.g. student response: "I feel very comfortable with my peers, mentors, and GSIs (graduate student instructors) at Berkeley, however, I still suffer very much from imposter syndrome and feeling inadequate among my peers."

Trends in written responses

- Students felt comfortable interacting and working with peers but still compared themselves with peers.
- Students reported feeling unsure of whether they can genuinely contribute to a research group rather than expressing concern about securing a research position.

Conclusions and Future Work

Conclusions

- We identified two important areas of improvement for ULAB: (1) placing a greater emphasis on helping students apply to research positions in the second semester and (2) facilitation closer interactions with the department's research community.
- In the results of the pilot survey results, we are successful in highlighting indications of ULAB's effectiveness in achieving its goals. However, the data collected was not sufficient to show a strong and consistent trend on efficacy.
- There remains much additional work on refining the survey; presently there lacks an effective tool for evaluating CUREs such as ULAB.

Future work

- In future surveys: (1) develop methods to account for the transfer function between actual and reported confidence and SB, (2) refine survey questions from observed shortcomings.
- Expand the scope of the survey to include students taking physics & astronomy classes. This will allow for tracking of additional variables such a retention of intended physics & astronomy students.

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