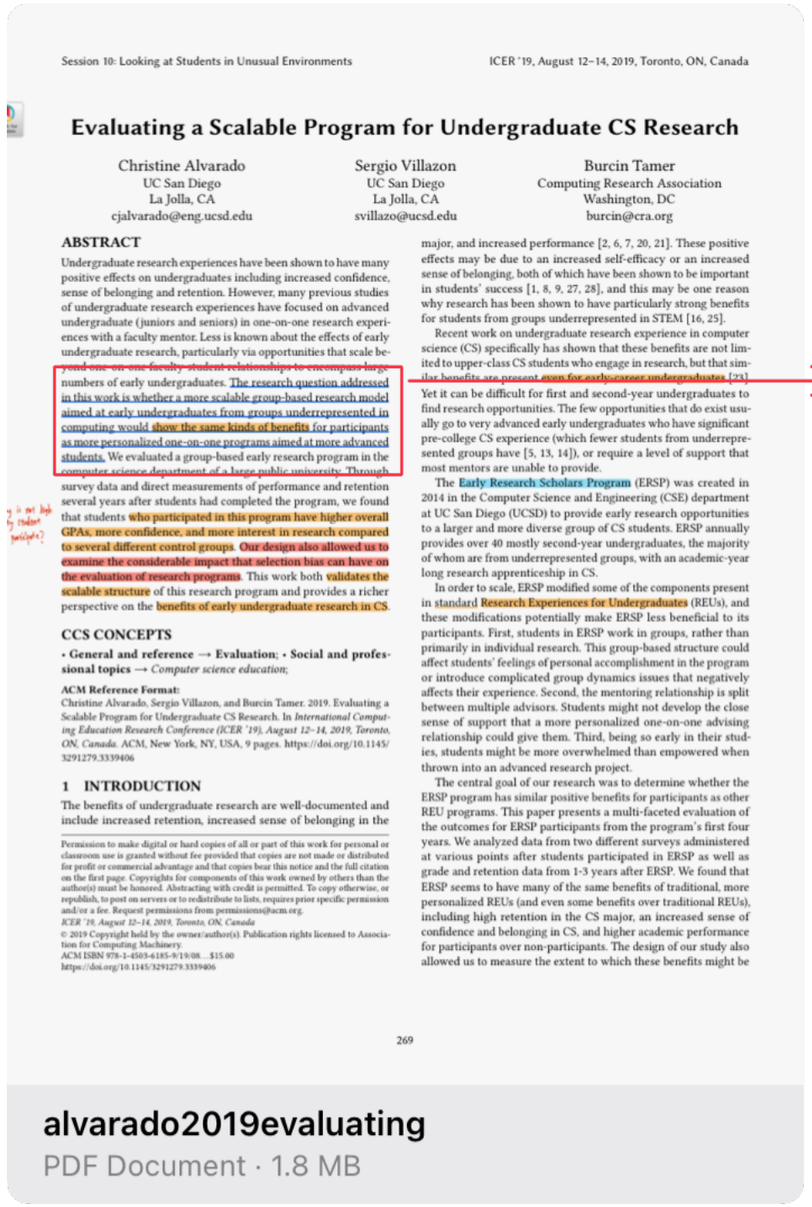
Evaluating a Scalable Program for Undergraduate CS Research



Evaluating a Scalable Program for Undergraduate CS Research

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ABSTRACT

Undergraduate research experiences have been shown to have many positive effects on undergraduates including increased confidence, sense of belonging and retention. However, many previous studies of undergraduate research experiences have focused on advanced undergraduate (juniors and seniors) in one-on-one research experiences with a faculty mentor. Less is known about the effects of early undergraduate research, particularly via opportunities that scale beyond one-on-one faculty-student relationships to encompass large numbers of early undergraduates. The research question addressed in this work is whether a more scalable group-based research model aimed at early undergraduates from groups underrepresented in computing would show the same kinds of benefits for participants as more personalized one-on-one programs aimed at more advanced students. We evaluated a group-based early research program in the computer science department of a large public university. Through survey data and direct measurements of performance and retention several years after students had completed the program, we found that students who participated in this program have higher overall GPAs, more confidence, and more interest in research compared to several different control groups. Our design also allowed us to examine the considerable impact that selection bias can have on the evaluation of research programs. This work both validates the scalable structure of this research program and provides a richer perspective on the benefits of early undergraduate research in CS.

CCS CONCEPTS

• **General and reference** → **Evaluation**; • **Social and professional topics** → *Computer science education*;

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1 INTRODUCTION

The benefits of undergraduate research are well-documented and include increased retention, increased sense of belonging in the major, and increased performance [2, 6, 7, 20, 21]. These positive effects may be due to an increased self-efficacy or an increased sense of belonging, both of which have been shown to be important in students' success [1, 8, 9, 27, 28], and this may be one reason why research has been shown to have particularly strong benefits for students from groups underrepresented in STEM [16, 25].

Recent work on undergraduate research experience in computer science (CS) specifically has shown that these benefits are not limited to upper-class CS students who engage in research, but that similar benefits are present even for early-career undergraduates [23]. Yet it can be difficult for first and second-year undergraduates to find research opportunities. The few opportunities that do exist usually go to very advanced early undergraduates who have significant pre-college CS experience (which fewer students from underrepresented groups have [5, 13, 14]), or require a level of support that most mentors are unable to provide.

The Early Research Scholars Program (ERSP) was created in 2014 in the Computer Science and Engineering (CSE) department at UC San Diego (UCSD) to provide early research opportunities to a larger and more diverse group of CS students. ERSP annually provides over 40 mostly second-year undergraduates, the majority of whom are from underrepresented groups, with an academic-year long research apprenticeship in CS.

In order to scale, ERSP modified some of the components present in standard Research Experiences for Undergraduates (REUs), and these modifications potentially make ERSP less beneficial to its participants. First, students in ERSP work in groups, rather than primarily in individual research. This group-based structure could affect students' feelings of personal accomplishment in the program or introduce complicated group dynamics issues that negatively affects their experience. Second, the mentoring relationship is split between multiple advisors. Students might not develop the close sense of support that a more personalized one-on-one advising relationship could give them. Third, being so early in their studies, students might be more overwhelmed than empowered when thrown into an advanced research project.

The central goal of our research was to determine whether the ERSP program has similar positive benefits for participants as other REU programs. This paper presents a multi-faceted evaluation of the outcomes for ERSP participants from the program's first four years. We analyzed data from two different surveys administered at various points after students participated in ERSP as well as grade and retention data from 1-3 years after ERSP. We found that ERSP seems to have many of the same benefits of traditional, more personalized REUs (and even some benefits over traditional REUs), including high retention in the CS major, an increased sense of confidence and belonging in CS, and higher academic performance for participants over non-participants. The design of our study also allowed us to measure the extent to which these benefits might be

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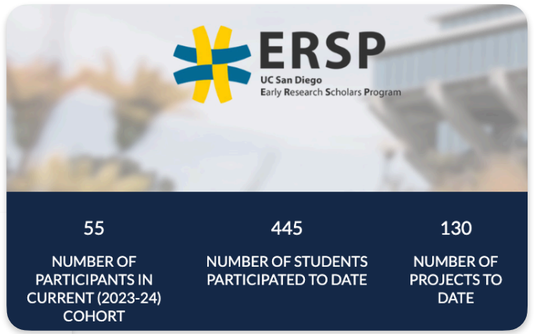

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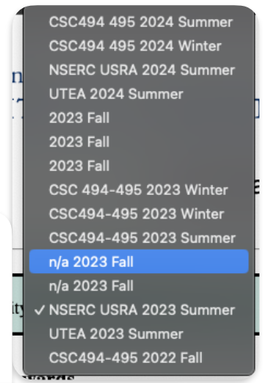


CSCD92H3: Readings in Computer Science

Students will examine an area of interest through reading papers and texts. This course is offered by arrangement with a computer science faculty member. It may be taken in any session, and must be completed by the last day of classes in the session in which it is taken.

Prerequisite: Students must obtain consent from the Supervisor of Studies before registering for this course.
Breadth Requirements: Quantitative Reasoning
Link to UTSC Timetable

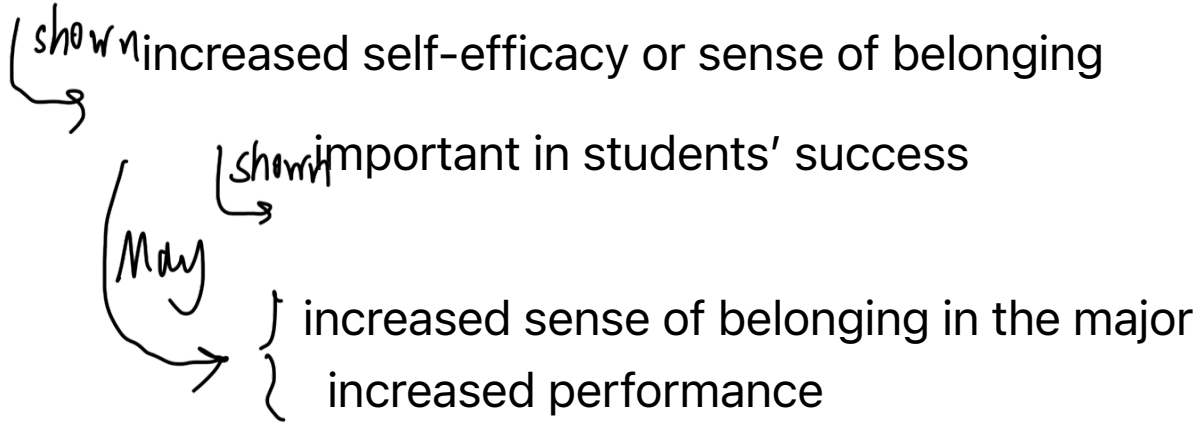
CSCD94H3: Computer Science Project

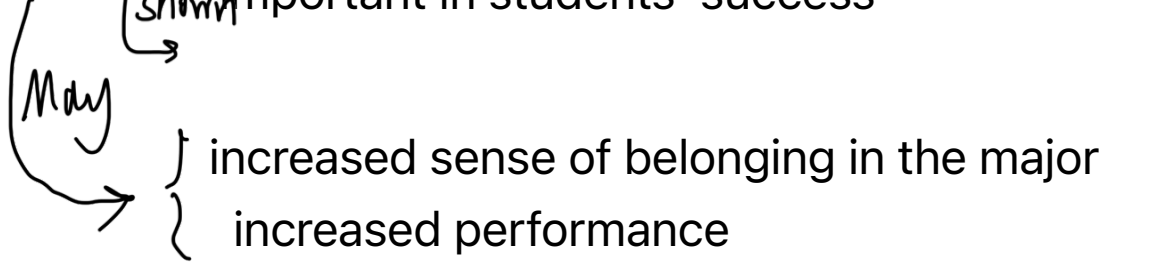
A significant project in any area of computer science. The project may be undertaken individually or in small groups. This course is offered by arrangement with a computer science faculty member, at U of T Scarborough or the St. George campus. This course may be taken in any session and the project must be completed by the last day of classes in the session in which it is taken. Students must obtain consent from the Supervisor of Studies before registering for this course.

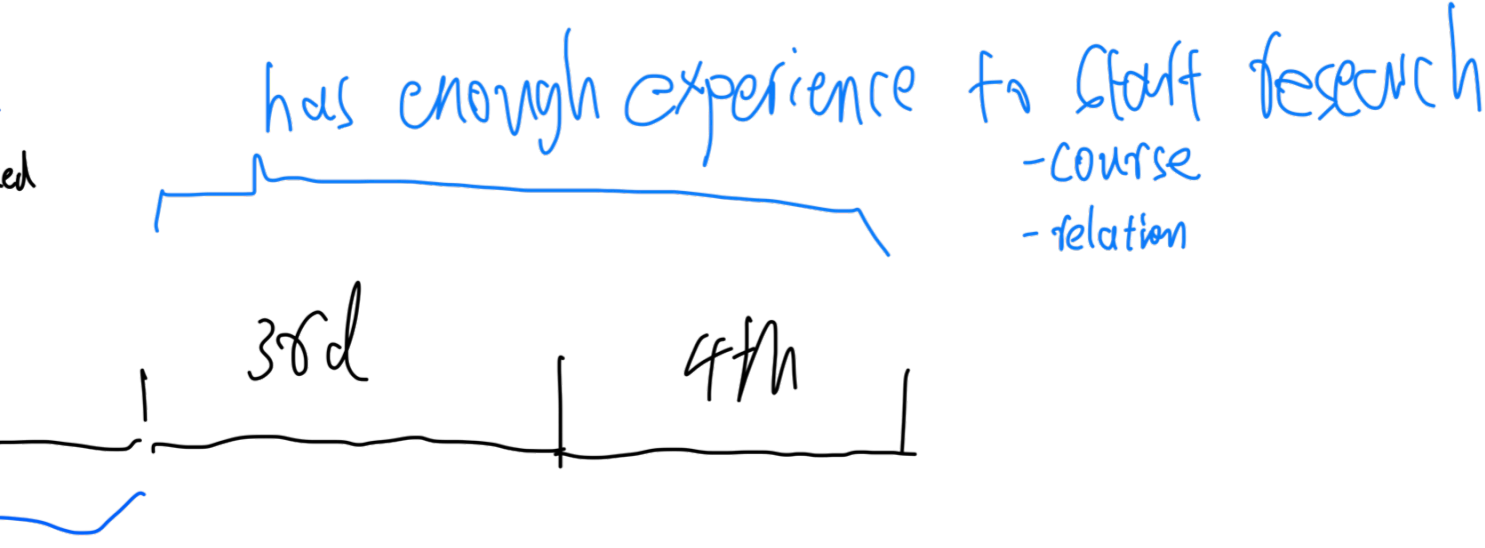
Prerequisite:
[Three C-level CSC courses] and [permission of the Supervisor of Studies] and [CGPA 3.0 or enrolment in a CSC Subject POSt] Enrolment procedures: Project supervisor's note of agreement must be presented to the Supervisor of Studies, who must issue permission for registration.
Exclusion: CSC494H
Link to UTSC Timetable

Previous Studies

Undergraduate CS Research




May
increased sense of belonging in the major
increased performance


has enough experience to start research
-course
-relation
3rd
4th

d second-

shown → increased self-efficacy or sense of belonging

shown → important in students' success

May → increased sense of belonging in the major
May → increased performance

have significant pre-college experience

↑ small size → less so underrepresented

has enough experience to start research
- course
- relation

ERSP

difficult for first and second-year undergraduates (especially underrepresented group) to find research opportunities

year undergraduates (especially underrepresented group) to find research opportunities

Early Research Scholars Program (ERSP)

- Academic-year long research apprenticeship in CS.
- Larger & diverse group (annually > 40 students)

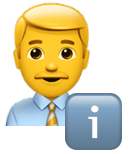
- Candidate should possess only the “typical” amount of computing knowledge
  - second year at UCSD in a CS or CS-related major
  - must not have completed any upper division coursework
- Acceptance rates of around 30%
- Selection criteria focus on the applicant's motivation and their contributions to diversity as reflected in their application essays.

Table 1: Demographics for ERSP participants in our analysis.

Cohort (N)	Female / Male	Minority / Majority
2014-15 (16)	69% / 31%	50% / 50%
2015-16 (28)	75% / 25%	39% / 61%
2014-15 (34)	65% / 35%	26% / 74%
2015-16 (36)	56% / 44%	31% / 69%
Total (114)	65% / 35%	34% / 66%

2015-16 (36)	56% / 44%	31% / 69%
Total (114)	65% / 35%	34% / 66%

Students will be split into teams of 2~5 members each team matched with



- a central ERSP mentor

- a graduate student assistant

They provides general mentoring support, such as goal setting and communication skill development, to help the students navigate the research process.

- a research group in the CS department.
  - a technical advisor

They provide specific guidance and expertise related to the research project.

Difference from standard **Research Experiences for Undergraduates (REUs)**

1. Students in ERSP work in groups, rather than primarily in individual research.
2. The mentoring relationship is split between multiple advisors.
3. Being so early in their studies, students might be more overwhelmed than empowered when thrown into an advanced research project.

Research Questions

whether the ERSP program has similar positive benefits for participants as other REU programs

- RQ1: Does participation in ERSP correlate with higher student retention and/or performance?
- RQ2: Do students who participate in ERSP feel more confident and included in the CS community?
- RQ3: Does ERSP influence students' desire to continue with research and/or attend graduate school?

Result

RQ1: RETENTION AND PERFORMANCE

Does participation in ERSP correlate with higher student retention and/or performance?

Summary: We compared the overall GPA and the retention in a CS major to two different matched control groups.

Group	init. N	Retention	z-score	p-values
ERSP	56	98%	N/A	N/A
Finalist	21	95%	0.73	0.46
Comparison	615	84%	2.90	0.004*

Group (N)	Mean GPA	p-values	Cohen's d
ERSP (114)	3.54	N/A	N/A
Finalist (38)	3.40	0.04*	0.41
Comparison (784)	3.26	< 0.001**	0.918

RQ 2: SELF-EFFICACY AND BELONGING

Do students who participate in ERSP feel more confident and included in the CS community?

Summary: We used data from a national survey of undergraduates to compare ERSP participants' self-reported confidence and belonging to that of students from other REU programs and students who had not participated in an REU.

CERP: Data Buddies Project

Org: Computing Research Association - CERP

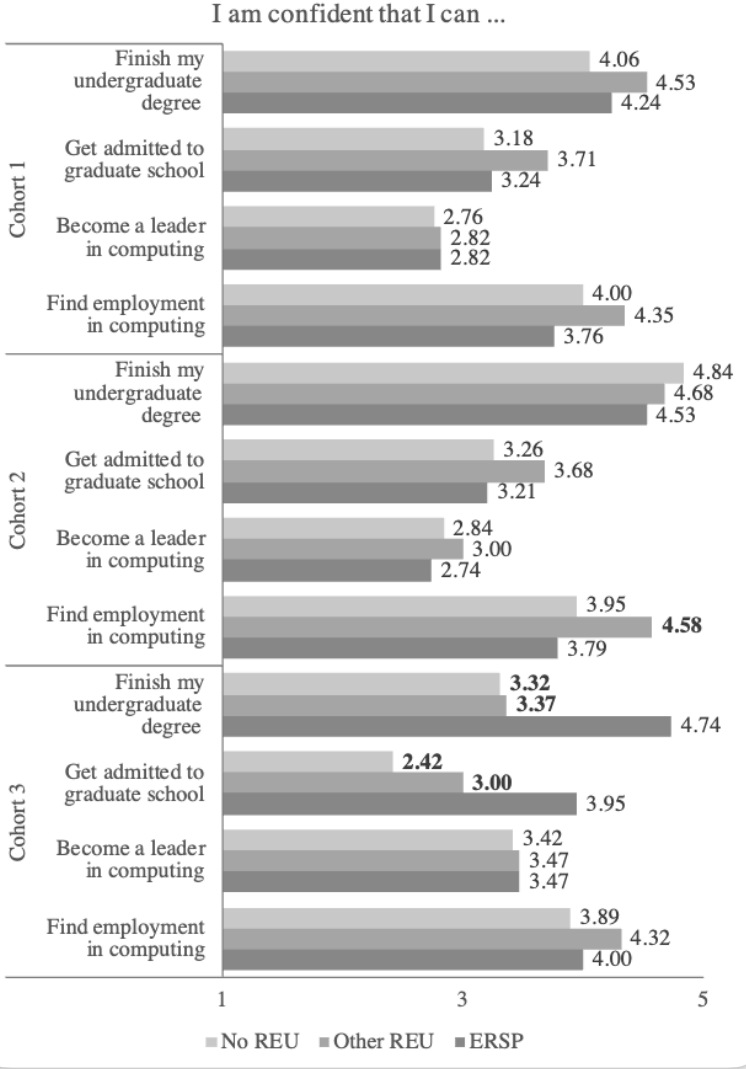
Url: http://www.cra.org/cerp

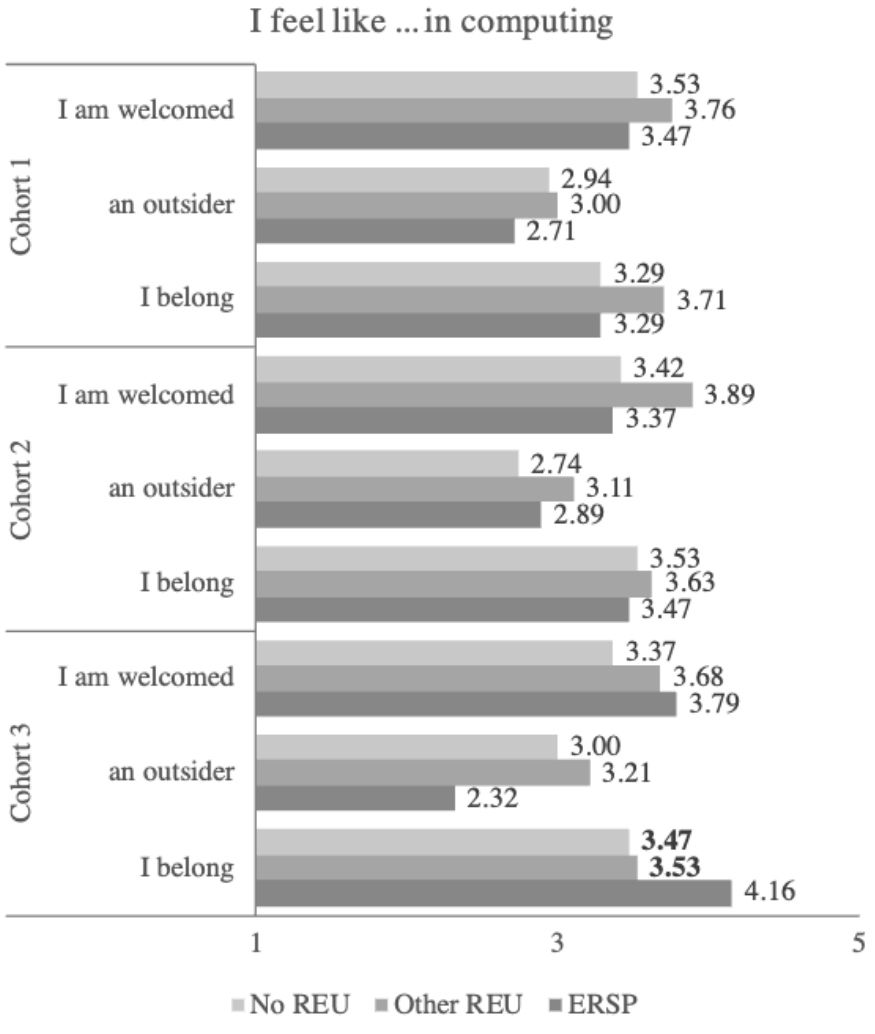
Sense of belonging

(1) I feel like I belong in computing
(2) I feel like an outsider in the computing community
(3) I feel welcomed in the computing community

Self-efficacy: I am confident that I can ...

(1) find employment in my area of computing interest
(2) become a leader in the field of computing
(3) get admitted to a graduate computing program
(4) complete my undergraduate degree in computing





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RQ3: CONTINUED RESEARCH

Does ERSP influence students' desire to continue with research and/or attend graduate school?

Summary: We surveyed ERSP participants 1-3 years after their participation to gauge the influence of ERSP on their post-RP research and career choices.

(1) In what cohort did you participate in ERSP?
(2) Have you graduated or will you graduate from UCSD by the end of summer 2018?
(3) After finishing your degree at RU, what did you do, or what do you plan to do?
(4) After ERSP, did you do any additional undergraduate research outside of a formal course?
(5) Have you ever applied for a graduate program (in any field)? If so, which one(s)?
(6) If you have never applied to a graduate program, are you thinking about applying to any graduate program in the next 5-7 years?
(7) Have you ever been enrolled (or will you be enrolled in the the next 6 months) in any graduate program (in any field)? If so, which one(s)?
(8) If you attended or applied to attend a graduate program, when did you begin or when would you have begun your graduate studies?
(9) Reflecting on your ERSP experience, how, if at all, do you think your ERSP experience shaped your future career trajectory?
(10) Do you have any other thoughts about ERSP that you would like to share?

Cohort (N)	Addl. res.	GS interest	GS apply	GS attend
2014-15 (17)	76%	88%	29%	12%
2015-16 (22)	41%	73%	23%	5%
2016-17 (24)	58%	88%	30%	17%

Response rates
>100% (error)
79%
71%

No direct comparison group, but:

- 39% of CS majors reported doing undergrad research
- 85% reported having an industry internship.
- 24% reported plans to attend graduate school in a related field

Result

ERSP seems to have many of the same benefits of traditional, more personalized REUs (and even some benefits over traditional REUs)

- RQ1: Does participation in ERSP correlate with higher student retention and/or performance? YES
- RQ2: Do students who participate in ERSP feel more confident and included in the CS community? YES
- RQ3: Does ERSP influence students' desire to continue with research and/or attend graduate school? YES

Selection bias exists:

- *The design of our study also allowed us to measure the extent to which these benefits might be due to selection bias ... we found that selection bias does account for some of the differences between participants and non-participants ... analysis suggests there might be benefits of ERSP even when completely controlling for selection bias.*

- Detail of **propensity matching** for RQ1 and the **propensity score matching** for RQ2
- RQ2 also compare the UCSD student with other institute?