# The Effectiveness and Benefits of an Undergraduate Research Experience: A Review of Literature

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## Introduction

It has been conventional wisdom for many years that research opportunities for undergraduate students are important to the academic and professional growth of young scientists. With increases in funding for Undergraduate Research Experiences (URE) comes demand for quantitative and qualitative assessments of URE effectiveness. This literature review makes the current research on the effect of UREs on participants available to researchers interested in expanding on the known body of knowledge. Several aspects were considered in this review: benefits for student researchers, benefits for mentors, the effectiveness of UREs in preparing students for graduate school, and deficiencies in the current body of knowledge.

## Methodology

Scholarly articles relevant to the evaluation of UREs were analyzed for their methodology and findings.

## Results

The literature indicated that URE's provide a number of benefits for undergraduate researchers and their mentors.

- Graduate and postdoctoral mentors benefit from improved career preparation, cognitive growth and improved communication and teaching skills (Dolan and Johnson 2009).
- Undergraduate researchers benefit from
  - clarification or confirmation of career goals,
  - increased independence,
  - and increases in self-efficacy, the belief that one can produce a certain action successfully (Lopatto 2007, Russell, Hancock et al. 2007, Seymour, Hunter et al. 2007)
- A positive correlation between duration of the research experience with magnitude of perceived personal gains (Russell, Hancock et al. 2007, Zydney, Bennett et al. 2002).

## Seven Categories of Student Gains:

- Personal and professional gains
- "Thinking and working like a scientist"
- Skill gains
- Clarification and confirmation of future plans
- Enhanced career or graduate school preparation
- Changes in attitudes toward working as a researcher
- Other benefits

(Seymour, Hunter et al. 2007)

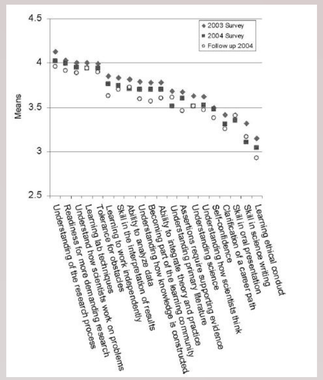


Figure 1. Perceived gains are consistent over different groups and over time. Participants indicated their degree of gain on a 1–5 Likert scale(Lopatto 2007).

| List of Learning Outcomes | Pre | Post | % Diff |
|---|---|---|---|
| Improve organizational skills | 30% | 74% | 43% ** |
| Improve work ethic | 32% | 74% | 43% ** |
| Use feedback from an experiment to improve solutions to an engineering problem | 42% | 84% | 41% ** |
| Effectively manage conflicts that arise when working on teams | 90% | 51% | -40% ** |
| Understand the ethical responsibility associated with the engineering profession and also your research project | 86% | 49% | -37% ** |
| Apply interpersonal skills in managing people | 85% | 53% | -32% ** |
| Apply technical codes and standards | 79% | 47% | -32% ** |
| Identify potential ethical issues and dilemmas in your design project | 71% | 43% | -29% ** |
| Analyze and interpret data | 58% | 86% | 28% ** |
| Gain strong leadership skills | 84% | 56% | -27% ** |
| Generate multiple design concept alternatives | 86% | 63% | -24% ** |
| Recognize knowledge transfer between research project and engineering courses (classroom) | 53% | 73% | 20% ** |
| Recognize the need for life-long learning | 67% | 86% | 19% ** |
| Gain leadership skills in managing team members and project tasks | 68% | 50% | -18% ** |
| Understand assumptions needed to be made to solve engineering problems | 69% | 87% | 18% ** |
| Know what you need to do to attain the goals you have for after graduation | 69% | 86% | 17% ** |
| Convey ideas verbally and in formal presentations | 78% | 93% | 15% ** |
| Engage in critical, reliable, and valid self-assessment | 58% | 73% | 15% ** |

Figure 2. Skill Gains for REU participants from 22 different sites (Pierrakos, Borrego et al. 2008).
Pre-REU values based on how well previous coursework has prepared them, post-REU values are based on how the REU effected the skills. Percentages are based on ratings of 4 or 5 on a 5-point Likert scale of learning outcomes.

## Confirmation/Enhancement of Future Plans

- While some surveys of alumni and former undergraduate researchers show that many URE participants feel their research experiences helped form their plans to attend graduate school (Bauer and Bennett 2003, Zydney, Bennett et al. 2002), data from surveys conducted during or immediately after UREs indicate that most URE participants intend to go to graduate school prior to URE involvement (Lopatto 2007, Pierrakos, Borrego et al. 2008, Russell, Hancock et al. 2007, Seymour, Hunter et al. 2007).
- Studies employing pre- and post-URE surveys show that, for the vast majority of participants, URE's sustain or confirm prior plans to attend or not attend Graduate School (Hirsch, Carpinelli et al. 2009, Pierrakos, Borrego et al. 2008).
- Interestingly, there is some evidence that URE's may increase the number of students interested in attaining PhD's (Russell, Hancock et al. 2007).

| What are your plans after graduation? | NESLOS Pre (N=275) | NESLOS Post (N=235) |
|---|---|---|
| Industry - In an engineering/scientific occupation | 10% | 9% |
| Industry - Outside an engineering/scientific occupation | 1% | 0% |
| Graduate School - In an engineering/scientific discipline | 76% | 76% |
| Graduate School - Outside an engineering/scientific discipline | 3% | 4% |
| Other | 10% | 11% |
| TOTAL | 100% | 100% |

Figure 3. REU participants at 22 different sites saw minimal changes in future plans over the course of the program. This leads to the finding that students selected to participate in REU experiences are students that already have plans to attend graduate school. REU experience served to validate their future plans and career path. (Pierrakos, Borrego et al. 2008)

| Response | Percentage of respondents | Percentage of follow-up sample |
|---|---|---|
| Had a plan for postgraduate education that has not changed | 62.2 | 57.3 |
| Confirmation of postgraduate education consideration | 27.1 | 28.4 |
| Research has changed prior plan; student initiates plan for postgraduate science education | 3.7 | 2.7 |
| Research has changed prior plan; student discontinues plan for postgraduate science education | 4.2 | 6.2 |
| Still no plans for postgraduate education | 3.1 | 2.9 |

Figure 4. In a survey of 3,156 students from 66 institutions over a 2 years period, research is seen to have very little influence on future plans beyond confirming previous decisions. A follow-up survey 9 months later saw little change in opinions. (Lopatto 2007)

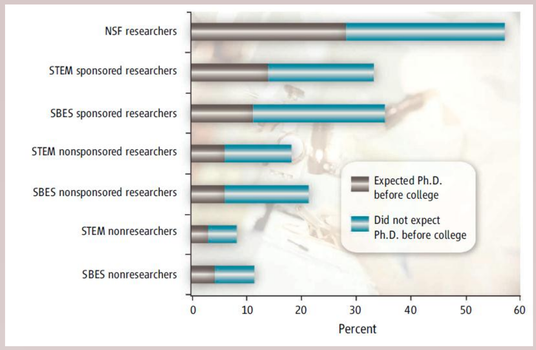


Figure 5. A surveys of 15,000 undergraduate students, faculty and individuals who had received bachelor degrees showed participation in UREs increased the number of students expecting to obtain a Ph.D. (Russell, Hancock et al. 2007)

## Acknowledgement

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## Other Findings:

- Increased Interest in careers in Science, Technology, Engineering and Mathematics (Russell, Hancock et al. 2007)
- A positive correlation between magnitude of benefits experienced with duration of URE (Bauer and Bennett 2003, Russell, Hancock et al. 2007, Zydney, Bennett et al. 2002).

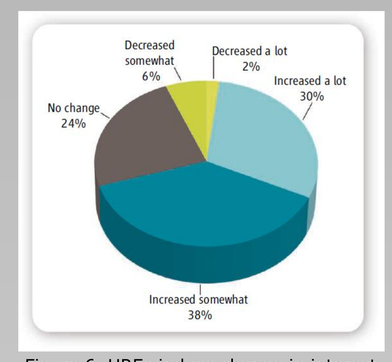


Figure 6. UREs induce change in interest levels for STEM Careers.
(Russell, Hancock et al. 2007)

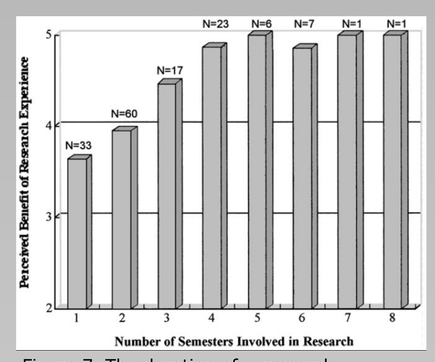


Figure 7. The duration of a research experience effects the perceived benefits of participation. (Pierrakos, Borrego et al. 2008)

## Problems with Data Collection

- The Self-Reported nature of much of the data doesn't necessarily indicate the factual change in skill levels.
- Qualitative methods of examining skill gains are difficult and costly to develop, implement and analyze.
- Selection Bias leads to uncertainty in the relationship between URE participation and graduate school attendance.
- Lack of control groups in many of the studies.

## WSU Data Collection

The Laboratory for Atmospheric Research (LAR) at Washington State University is in the process of collecting pre- and post-REU data on future plans and perceived skill gains from participants . Data collection has been ongoing since 2009 and will continue in future years to add to the REU effectiveness knowledge base.

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