

# Undergraduate Research Experiences as a Critical Thinking and Educational Tool

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## Abstract

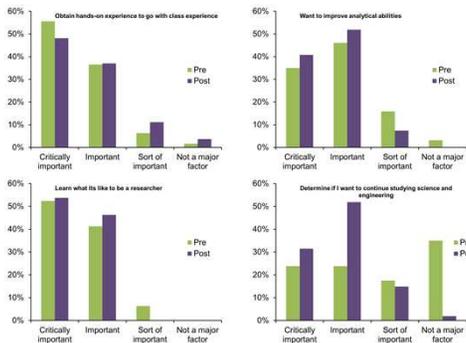
The objective of the proposed engineering education innovation is to develop methods to enhance learning of fundamental STEM concepts relevant to undergraduate researchers' fields of study and increase critical thinking capabilities through undergraduate research experiences. Two activities will be introduced into a 10 week summer research program. The students will make an Interactive Mid-Summer Concept Presentation to teach the other participants about fundamental, undergraduate level concepts in their research. They will also participate in sessions, organized using a critical thinking rubric, throughout the summer to help them synthesize background, results, and literature review for their final poster presentations.



## Introduction

Undergraduate research is used as a tool by both undergraduates and faculty members in STEM disciplines to:

- Enhance undergraduate learning outside of the classroom
- Recruit students for graduate school
- Promote continued interest in STEM disciplines
- Inform undergraduates' decisions about whether to pursue a career in research
- Increase research productivity



Results from pre-survey about undergraduate researchers' motivation to participate in research program and post-survey about students' rating of outcomes of research programs at Colorado School of Mines, Clemson, and Washington State University.

## Objectives

The assessment and optimization of the first aim, undergraduate learning through research experiences, should be addressed more rigorously and formally. Thus, the objectives of the proposed work are to:

- Improve students' learning of fundamental concepts related to their engineering fields through self-identification of concepts embedded in their research projects
- Enhance students' critical thinking abilities through organized activities designed to improve specific elements of critical thinking

## Undergraduate Research Program Overview

- NSF Research Experience for Undergraduates Program
- 10-12 students each with independent research project
- Each student works with a faculty advisor/research group
- 10 week summer research experience
- Poster session at culmination of summer
- Other activities: metallurgy workshops, local tours, weekly lunches

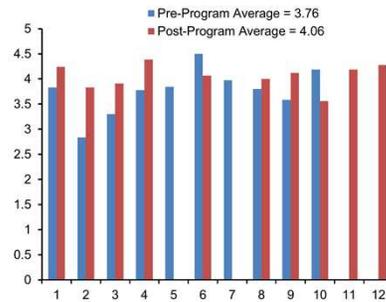


## Developmental History

A critical thinking rubric was developed specifically for undergraduate research experiences. The rubric contains descriptions for beginning, developing, and mastering of skills in the following areas:

- Identifying a research problem or question
- Identifying the research impact and purpose on a broader level
- Developing a research hypothesis that is informed by literature review
- Designing research activities to effectively conduct experiments and collect and document data
- Analyzing, synthesizing, and interpreting research data and literature
- Identifying conclusions and implications of the research

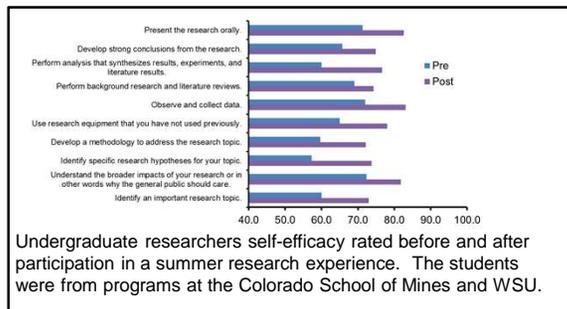
Undergraduate students' self-efficacy before and after participating in the program has also been assessed.



Critical thinking scores, based on the critical thinking rubric, for undergraduate researchers at WSU.

**Pre-program assessment:** Students critically analyzed a technical paper by other undergraduate researchers. The paper contained experimental and technical concepts the students could understand.

**Post-program assessment:** Students were evaluated on posters they presented at the end of the summer research experience.



Undergraduate researchers self-efficacy rated before and after participation in a summer research experience. The students were from programs at the Colorado School of Mines and WSU.

## Proposed Learning Activities

### Interactive Mid-Summer Concept Presentations

"One of the best ways to learn something is to teach it to somebody else"  
**Objective:** Help the students identify and learn about areas of their research that overlap with concepts they have been or will be exposed to in their science or engineering curriculum

- 1) Students will identify a fundamental engineering concept related to their project.
- 2) Students will develop a short, interactive presentation to educate the other REU participants using their research as an example.

### End of Summer Poster Session

Poster sessions are a good venue for undergraduate researchers to present their work, because they provide a mechanism for the students to synthesize the results and analysis of their project. However, the posters are often not organized until the very end of the research experience, minimizing the important synthesis and analysis time.

**Objective:** Improve the use of the poster presentation to promote critical thinking in a more formal manner throughout the whole summer research experience (using REU lunches)

**Lunch 2:** Prepare an informal summary of research hypothesis and broader impacts of research

**Lunch 4:** Prepare an informal summary of research procedures and assumptions

**Lunch 8:** Give examples of the connection between research results and literature data

## Major Issues to Resolve

- What is the most effective method to assess the proposed learning activities?
  - Interactive Mid-Summer Concept Presentation: Interviews immediately after program and after students have taken classes relevant to their concept?
  - End of Summer Poster Session: Use of critical thinking rubric with a relatively objective and easy to implement assessment?

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