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# Growing Entrepreneurially Minded Undergraduate Researchers with New Product Development in Applied Energy

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Dr. Jose M. Garcia-Bravo graduated from Los Andes University in Bogota, Colombia with a B.Sc. in Mechanical Engineering in 2002. He moved to the United States in 2003 and completed his M.Sc.E in 2006 and Ph.D in 2011 from Purdue University. He worked as a Research Assistant Professor at IIT in Chicago from 2011-2012. In 2012 he returned to Purdue to serve as an Assistant Professor at the Purdue Polytechnic Kokomo. Dr. Garcia-Bravo, joined the School of Engineering Technology at Purdue main campus in 2015, he is currently an Associate Professor for the Mechanical Engineering Technology program where he has a special focus on fluid power (hydraulic systems) research and instruction. Dr. Garcia-Bravo investigates how hydraulic systems can improve the performance and efficiency of heavy duty vehicles. He also researches techniques for the creation of flexible components with embedded sensors using additive manufacturing for robotics, rehabilitation and industrial applications. During his time at Purdue, he has been awarded several grants to develop technology for the improvement of fluid power systems. As the director of his research group at Purdue, he received funding for the development of contamination resistant valves for the throttle control of fighter jet engines. The resulting design of this project generated a modified poppet valve that improved its response time from 40ms to 10ms. He has developed with his students an IoT irrigation system for water deprived areas in Arequipa, Peru. He has also conducted research in novel methods for the hybridization of electrically powered drive trains using hydraulic accumulators. Most recently he is developing an autonomous micro-drilling robot for underground applications. More recently, he has been studying the principles for the creation of startup companies and have been personally interacting with industry professionals in the truck, automotive and off-road sectors.

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## 1. Introduction

Undergraduate research programs benefit students, faculty, and universities (Bauer & Bennett, 2003; Cox & Andriot, 2009; Lopatto, 2007; Seymour, Hunter, Laursen, & DeAntoni, 2004). Due to the benefits of undergraduate research, the National Science Foundation (NSF) has funded Research Experiences for Undergraduates (REU) in science, engineering, or mathematics programs, allowing students to participate in research programs at Universities across the United States during the summer (NSF, 2019a, 2019b). One of the main benefits of REU programs is the impact on students' decision to pursue a graduate degree and pursue a career in academia or scientific research. Additionally, REU programs have benefits related to retention, research skills, teamwork, and oral and written communication skills (Zhan, 2014), all of which will benefit students even if they decided to go to industry instead of pursuing grad school.

In industry, new product development, marketing research, and project management tend to work differently than in academia. CEOs, project managers, and design leads are less concerned with how new theories or data analysis techniques can be applied and where good ideas come from, and instead are more concerned with their effective implementation. This means that the successful discovery, evaluation, and exploitation of opportunities in industrial settings require a more collaborative and convergent approach to research and development than in academia. This includes input from people with various engineering, marketing, and information technology backgrounds. As such, the academic approach to research (where faculty drive the research efforts in an attempt to optimize individual value) is different from the industry approach to research (where the research efforts are done in an attempt to optimize a company's value). The problem is that STEM students have limited exposure to the convergent-like research that is often required of employees working in the industry. Given the ever-present disproportional participation of women and minoritized populations in STEM, this problem only exacerbates and further excludes broader participation to a diverse audience of students.

This poster will showcase the findings from a virtual REU program which provides students with a research experience that combines the best aspects of academic applied research (including theoretical basis and rigorous scholarship) with essential business practices (including real-world customer discovery and the generation of sound business models). The guiding research question is as follows: *What benefits does a virtual REU program have on student career goals, academic research skill development, and entrepreneurial competencies?*

## 2. REU Intervention

The one-year virtual REU intervention offered during Spring and Fall semesters was a 400-hour long program (includes both intensive on-site and virtual learning experience) as shown in Figure 1. The program began with a forty-hour intensive week of orientation and onboarding activities in August, followed by a sixteen week, ten-hour per week REU virtual experience offered during the Fall and Spring semesters where students conducted research both from an academic and industry perspective.

- August Intensive Virtual (40 hrs, 1 week): The focus was on team building, introducing students to research projects, and gaining comfort with online and independent learning.
- Fall Virtual (10hrs/week, 16 weeks): The focus was on academic research skill development (e.g., data collection, data analysis, literature reviews, report writing, etc…).
- January Intensive Virtual (40 hrs, 1 week): The focus was on introducing students to business development tools (e.g., value proposition canvas, business model canvas, pitch development, and writing an executive summary).
- Spring Virtual (10hrs/week, 16 weeks): The focus was on customer discover (e.g., interviewing potential customers to gain feedback) and market analysis.

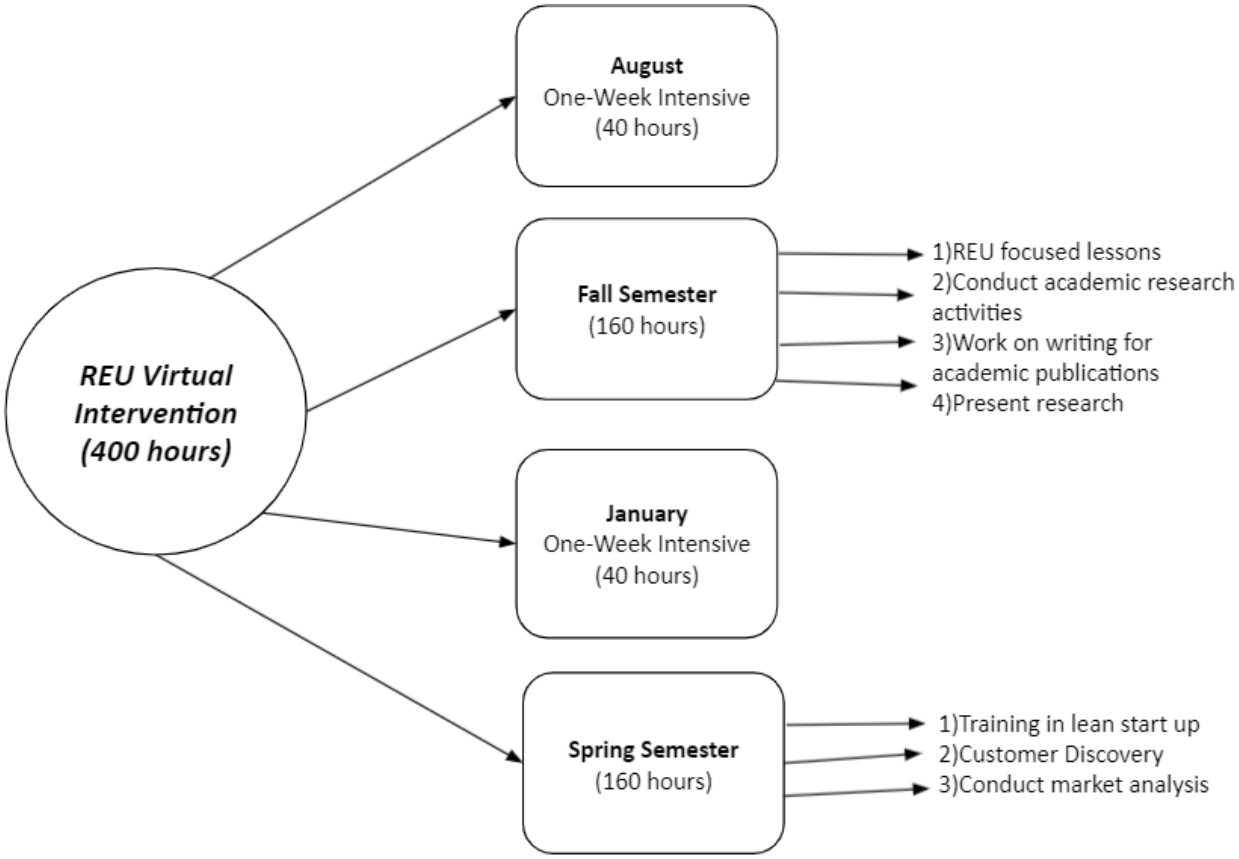


Figure 1. REU Virtual Intervention (400 hours)

## 3. Preliminary Findings

The preliminary findings of the virtual REU program highlight the benefits provided by the program on student career goals, academic research skill development and entrepreneurial competencies. The triangle of learner motivation as shown in Figure 2 encompasses three categories of motivation:

1) Value recognition includes attributes of program context (enrollment in the program based on interest in the engineering-related disciplines), program incentive (recognizing the opportunities and incentives the program provides), and professional development (professional skills development such as networking, research experience, and higher education credentials such as certifications and degrees).

2) Supportive learning ecosystem includes the attributes of instructional support (instructor guidance), transferrable skills (application of a newly learned skill in coursework and workplace), growth mindset (confidence in learning ability despite lacking experience in the subject), and collaborative workspace (enhanced learning experience stemmed from collaborating with people with diverse backgrounds).
3) Confidence in abilities highlights the beliefs that participants have about their own abilities and includes attributes of time management, stress management, and communication. Findings suggest that the virtual REU program can be successfully implemented to equip students with research and entrepreneurial skills while delivering accessible, equitable, and impactful education to underrepresented and minoritized students.

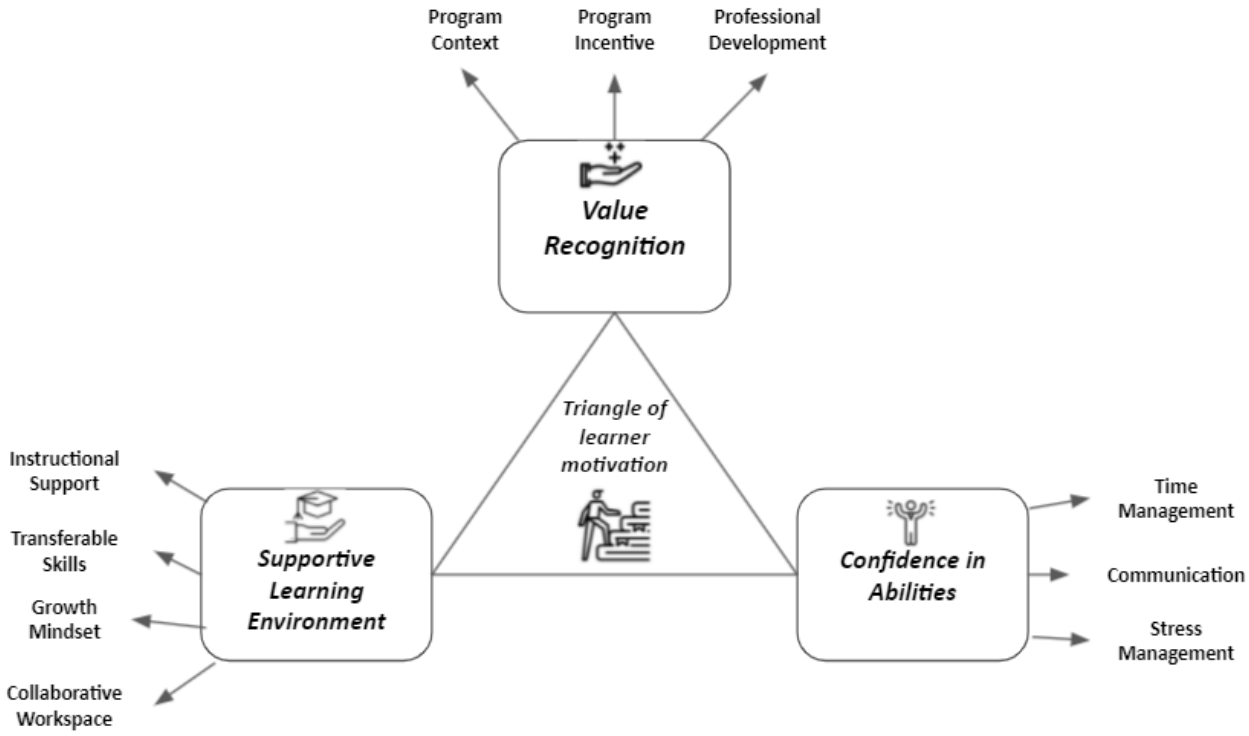


Figure 2. Summary of Preliminary Findings

## 4. Conclusion

Based on the preliminary results, the virtual REU program offers benefits such as professional development opportunities, academic and industrial research experience, collaborating with people with diverse backgrounds, real-world project experience, job skills development, and motivation, thus exposing STEM students to a convergent-like research workspace often required by employees working in the industry. The participants of the virtual REU program recognized the value that the program adds to their career goals, provides academic research experience and develops entrepreneurial competencies (as shown in Figure 2). REU programs can be implemented virtually, which not only reduce program costs but also have a greater national and international scope due to the flexibility of learning it offers and broadens participation amongst underrepresented engineering students by increasing access, equity, and impact. Future research should continue to investigate the benefits of virtual REU program in

other STEM related disciplines and measuring the impact of REU program considering in-person versus virtual delivery.

## 5. References


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