

# Examining Students' Perceptions of Innovation and Entrepreneurship in Physics

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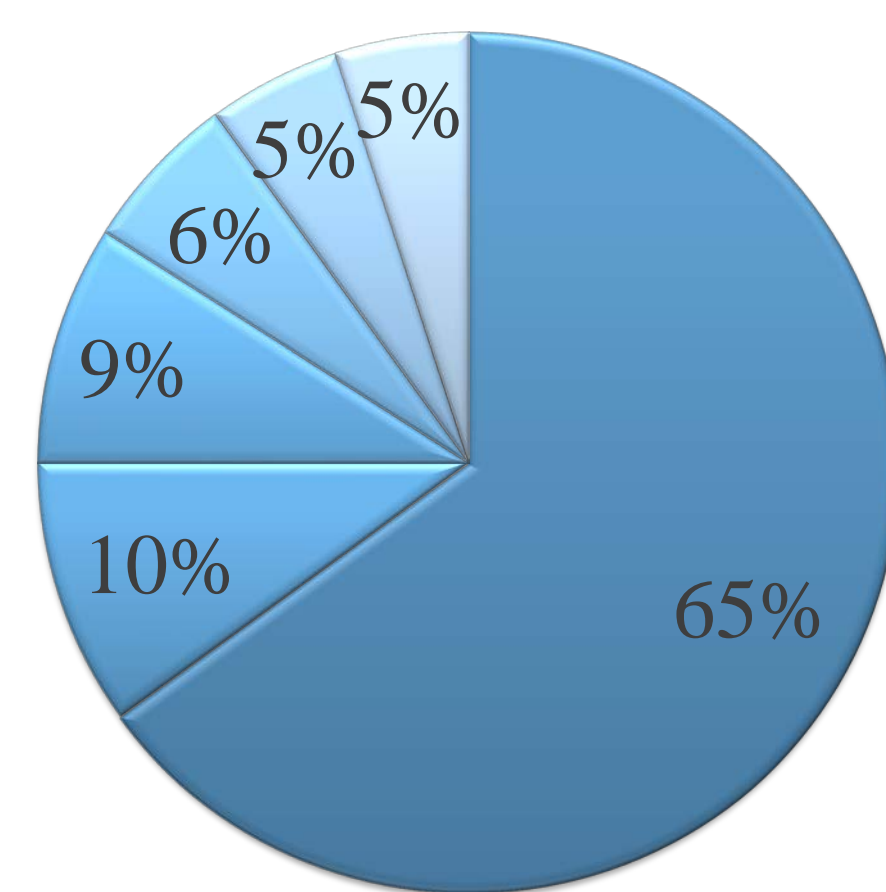
## Abstract

The joint AAPT and APS PHYS21 report emphasizes preparing students for diverse career paths, including the need for more opportunities to learn innovation and entrepreneurship in physics. To support these changes, research is needed on students' interest and perceptions of innovation and entrepreneurship, and suggestions for integration into the undergraduate physics experience. We conducted semi-structured focus groups with 20 physics majors around several concepts related to innovation and entrepreneurship (I&E): technology, creativity, design, business, communication, and leadership. Emergent and thematic coding was used to analyze students' responses. Students have a complex view of innovation and entrepreneurship in physics perceiving creativity as closely related to physics, especially in undergraduate research, while business and leadership skills were distinct from physics and closer to engineering. These findings have implications for understanding students' perceptions of physics as a disciplinary community and field of study, and can assist departments seeking to better support students' careers.

## Introduction

### Physics Students' Retention and Career Paths

- There are difficulties retaining students in physics yet departments with strong a strong career focus have better retention. [1]
- Physics students go on to pursue multiple different career paths including a sizable number in the private sector. [2]
- Physics bachelors recipients who worked in the private sector reflected that learning more innovation and entrepreneurship skills in physics would benefit future students to enter and succeed in these careers.



■ Private Sector  
■ High School  
■ Civilian Government  
■ College and University  
■ Active Military  
■ Other

\*Adapted from Mulvey and Pold (2015)

### What are the I&E Values

- From the PHYS21 report, Epicenter research and the NSF funded PIPELINE network, students need to better connect their technical, conceptual and laboratory skills in physics that highlight career related innovation and entrepreneurship (I&E) values. [3,4]
- I&E includes: Creativity, Communication, Technology, Leadership, Design, Business.

### Supporting Physics Department Change

- To be successful, PER department change efforts to integrate I&E values should be: [5]
  - Coordinated across multiple levels of university.
  - Grounded in multiple research-supported change perspectives.
- Efforts tend to focus on faculty, rather than students; yet, students become members of the department culture. [6]

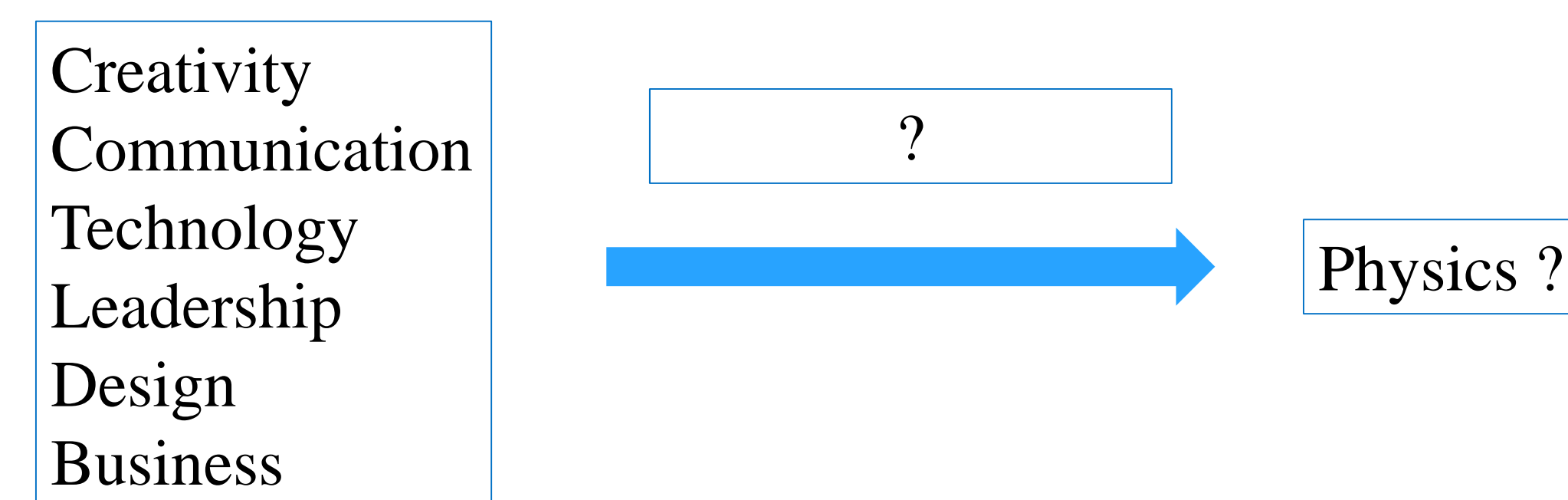
## Findings

I&E Aspect	Relation to Physics
Creativity	Is beneficial to physics students Is present in physics coursework and problem solving Is present in physics labs and research
Communication	Is important for interdisciplinary work and working with other physicists Is important for presentations and writing papers in physics Is important to physics but learned elsewhere
Technology	Is important to physics students when focused on computers and software Should be available to physics students, but optional Is more of an engineering aspect than physics
Leadership	Is important for group work in physics Is important to learn for any career path for physics students and others Is not important to physics
Design	Is more of an engineering aspect than physics Should be available to physics students, but optional Is important to lab work and some physics careers
Business	Is important to grant funding in physics Should be available to physics students, but optional Is not important to physics

- “Yeah. I know creativity is needed for research. And if you're working with professors on research, you're building up all these new ways to attack an actual unknown problem...”
- “You've got to be able to share your findings with people. And you have to be able to share your findings accurately too. You've got to be able to write it.”
- “I think that's just a big part of any job or anything. You're probably going to have to give a presentation at some point.”
- “[Technology] should be an option [but I'm] probably never ever going to be a part of some hands-on... technical aspect of physics.”
- “Knowing how to lead a group, [and] knowing how to respond to a leader in a group is what you would do in your job no matter what you're going to go into.”
- “It's like if an instrument breaks...you can call up an engineer. It's their job to fix these kind of things.”
- “[I] think it would be helpful knowing... how to deal with writing a grant proposal...”
- “I feel there are ways you can apply business, but I don't think it's really core physics.”

## Study Design and Analysis

- Six semi-structured focus groups with 20 students were held at a university in Western New York.
- The discussion was centered around the six aspects of I&E.
- We applied ethnographic domain analysis based on the work of Spradley to explore the relationships physics students perceived between the I&E aspects and physics. [7]



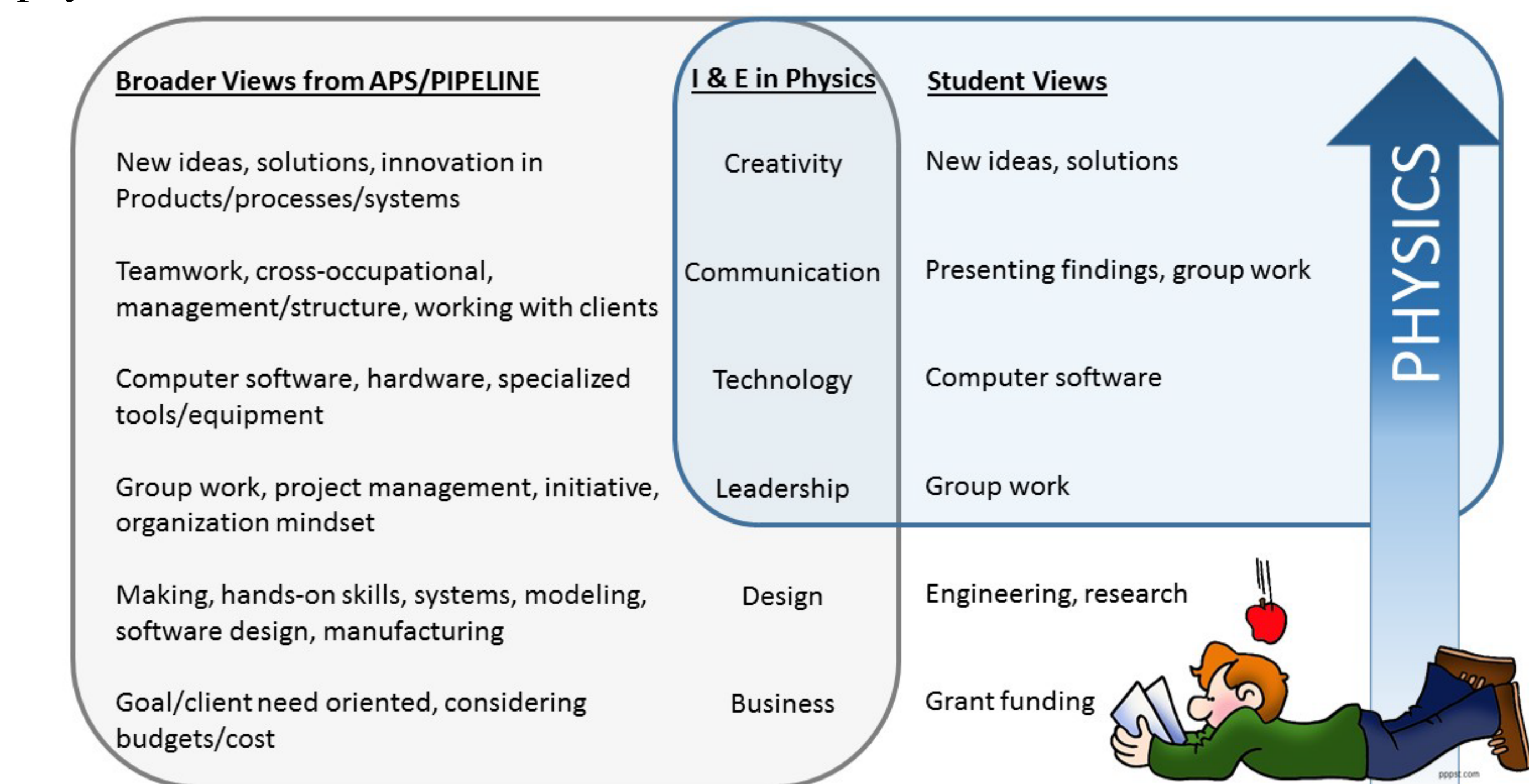
(Included Term) (Semantic Relationship) (Cover Term)  
\*Adapted from Spradley (1980)

## Research Questions

- 1) What aspects of innovation and entrepreneurship do physics students value as integral to the physics curriculum?
- 2) What expectations do physics students have for learning innovation and entrepreneurship?

## Selected References

[1] R. Hilborn, R. Howes, and K. Drane, "Strategic Programs for Innovations in Undergraduate Physics: Project Report," The American Association of Physics Teachers, College Park, MD, (January 2003).  
 [2] P. Mulvey and J. Pold, Physics Bachelor's Initial Employment, Tech. Rep. (American Institute of Physics, 2015).  
 [3] P. Heron and L. McNeil (Co-chairs), "Phys21: Preparing Physics Students for 21st-Century Careers," (American Physical Society, 2016).  
 [4] Engineering Majors Survey, Epicenter National Center for Engineering Pathways to Innovation, Accessed on July 1, 2017 at <http://epicenter.stanford.edu/page/engineering-majors-survey> (2015).



## Discussion

**Physics majors think about I&E differently from the broader physics community and engineering:** I&E to physics majors focuses on ideas, solutions and research, but leaves out design and customers that are important to I&E in engineering. [8]

**Department change initiatives should consider physics majors' perspectives:** A culture change framework suggests that attending to underlying culture at multiple institutional levels leads to successful transformation and students are a key part of department culture who have the power to shape their department culture.

[5] J. C. Corbo, D. L. Reinholz, M. H. Dancy, S. Deetz, and N. Finkelstein, Framework for transforming departmental culture to support educational innovation, Phys. Rev. Phys. Educ. Res., 12, 010113 (2016).  
 [6] E. C. Collins and J. L. Green, Learning in classroom settings: Making or breaking a culture, In K. T. Clift and C. M. Evertson (Eds.) Focal points: Qualitative  
 [7] J. P. Spradley, J. P. Participant Observation. San Francisco: Holt, Rinehart and Winston (1980).  
 [8] A. R. Peterfreund, E. Costache, H. L. Chen, S. K. Gilmartin, S. Sheppard, Infusing innovation and entrepreneurship into engineering education: Looking for change as seen by ASEE members, 2012 to 2015, ASEE's 123rd Annual Conference and Exposition (New Orleans, 2016).

