Exploring High Interest in Theoretical and Computational Physics Among Undergraduates Through Social Cognitive Career Theory

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Introduction

Data from the American Institute of Physics [1, 2] highlight distinct career trajectories for physics majors. About half of bachelor's graduates entering the private sector work in computing or engineering. For those attending graduate school, research specializations are divided among experimental methods (50%), theory (37%), and observational methods (10%).

Despite these clear trends, the underlying factors that influence these choices remain poorly understood, particularly what draws students to computational, theoretical, or experimental work. This study focuses on the preferences between computational and theoretical physics, setting aside experimental physics for reasons of brevity and the limited variation observed across 18 initial interviews. Future research will specifically investigate the factors influencing interest in experimental methods.

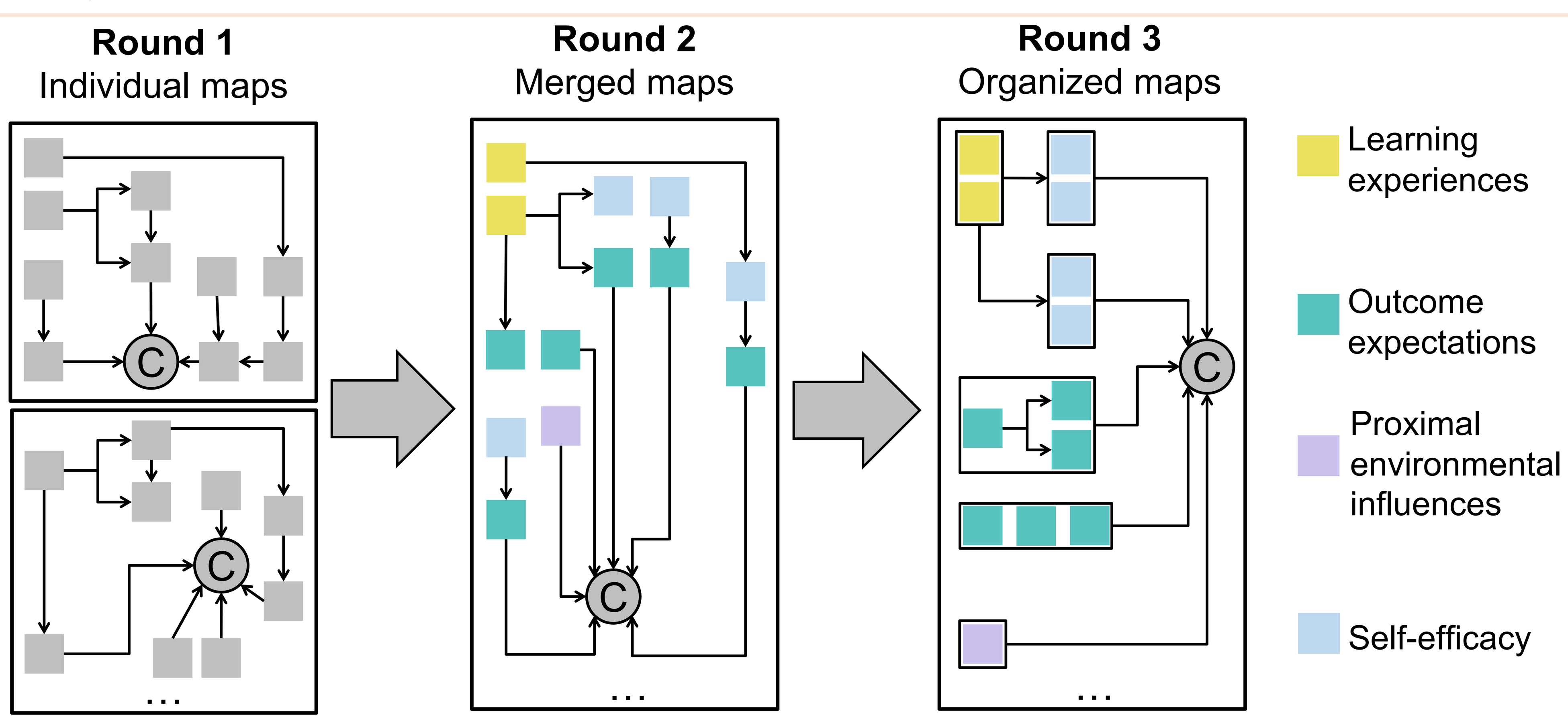
Research Question

What factors and experiences contribute to physics majors developing a high interest in two particular method specializations (theory and computation) in physics?

Qualitative Methods

- 18 interviews were conducted with undergraduate physics students in Summer and Fall 2022.
- 10 interviews were selected for analysis, chosen for the highest student interest ratings in: Theory (n=6) and Computation (n=4)
- The subset of 10 analyzed interviews included 4 men, 4 women, and 2 non-binary individuals; 7 identified as White, 2 as Asian, and 2 declined to disclose.

Data analysis steps [3]



Identified statements involving descriptions of their interest or factors that influenced their interest and created an individual diagram by using Lucidchart [4].

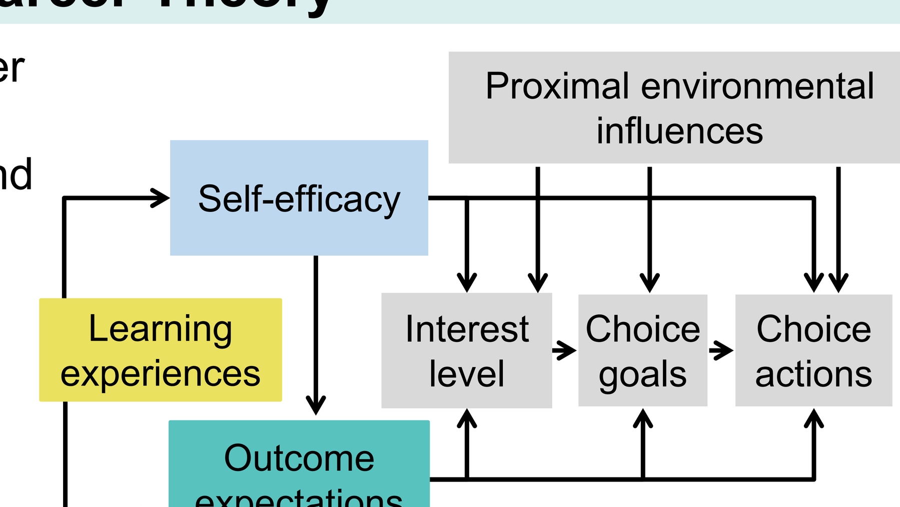
Coded each student's statements into SCCT categories and merged individual maps. Nodes representing a group of similar excerpts with SCCT codes applied.

Nodes were grouped into emergent subcategories within the SCCT constructs and sense of belonging factor.

(C) means a computation.

Theoretical Framework: Social Cognitive Career Theory

Social Cognitive Career Theory (SCCT) [5] seeks to answer several questions about academic and career decisions, including how interests develop, how choices are made, and how success is achieved. SCCT posits that interests are shaped by self-efficacy and outcome expectations that are influenced by learning experiences.



References

[1] AIP, 2020, [2] Mulvey, 2021, [3] Zohrabi et al., 2023, [4] Lucidchart, 2023, [5] Lent et al., 1994.

Results

	Theory	Computation
Learning experiences		
Self-directed learning	Highlighted the **role of online video platforms**, especially YouTube	**Learned computational programming**, such as MATLAB, through self-directed efforts.
High school and college coursework	Had positive experiences with **theory-related courses,** both before and during college, such as calculus and classical mechanics.	Had positive experiences with **programming courses and lab-based classes**, both before and during college.
High school teachers and mentorship	Positive experiences with **high school physics teachers and support from college professors**.	Guided by **an inspiring physics teacher**, a student successfully **merged their computational interests with physics, choosing it as their degree**.
Research and applications	Successfully conducted theoretical research, **focusing on mathematical derivations and constructing robust models**.	Contributed to computational research by **programming, recording data, and analyzing it using coding software,** with a strong emphasis on R.
Outcome expectations		
Disciplinary ideas	The **abstract nature** of theoretical work sometimes made it seem **less tangible**.	The **practical value and essential skills, such as programming** in computational physics, were emphasized.
Practices	The theory is **a math-intensive method.** Work in theory was perceived as merely **"thinking," drawing attention to its abstract, cognitive core.**	Enjoyment stemmed from **the processes of coding, problem-solving, and transforming data into visual insights.**
Professional and personal life	It was commonly **associated with academia,** perceived as abstract and solitary. The discussion revealed her preference **for work settings with fewer interpersonal interactions.**	**Avoid spending an entire workday exclusively at a computer**, like a software engineer might.
Self-efficacy		
Beliefs in mathematical ability	Linked success directly to their math skills.	
Beliefs in understanding, learning, and success	Reflected students' ability to **grasp complex physics concepts and solve problems.**	Highlighted students' **developed skills in programming and problem-solving.**
Motivation and happiness	A **profound curiosity** simply drove their commitment to their chosen physics specialization	Computational physics is **naturally aligned with personal interests.**

Conclusion

- **Theoretical Physics:** High interest stemmed from early exposure to engaging content, supportive mentors, inspiring teachers, and well-designed coursework that provided intellectual satisfaction and skill development.
- Success in understanding complex material and solving problems, particularly mathematical ones, built confidence and curiosity despite its perceived difficulty.
- **Computational Physics:** High interest was driven by practical importance, immediate results, and visualization capabilities. Low interest is related to perceptions of tediousness, excessive screen time, and lack of guidance.

Future work

The future aim is to develop an online survey that will explain student perceptions, experiences, and outcomes around two major decisions:

- To pursue a specific subfield (e.g., optics, astronomy, medical physics).
- To develop a specialization in particular methods (i.e., experimental, theoretical, computational).