Attending to Scientific Practices within Undergraduate Research Experiences

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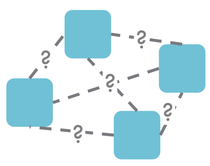
What does it look like for newcomers in physics research to engage peripherally in authentic practices?

Learning is becoming part of a Community of Practice. (Lave & Wenger, 1991)

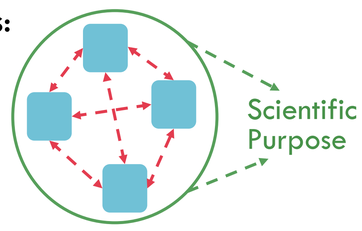
Novices develop expertise through engaging legitimate peripheral participation.

We use Ford's (2015) framework to model legitimate peripheral participation in undergraduate research

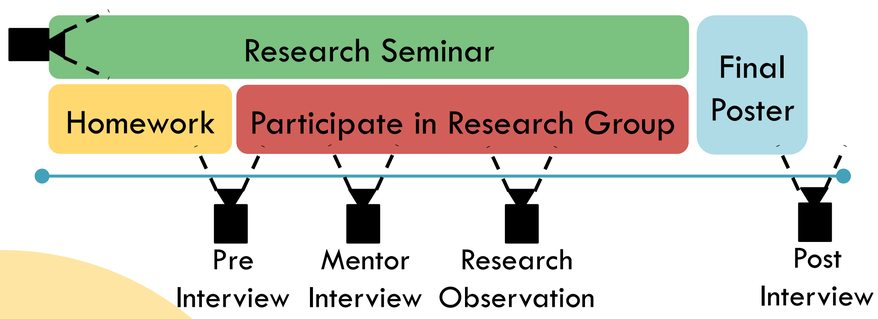


Prior work on undergraduate research has typically focused on independent outcomes.

Ford's more holistic *practices* approach has two key features:
1) Connectedness- Practices make sense in terms of one another.
2) Purposefulness- Practices make sense in terms of their ability to explain nature.



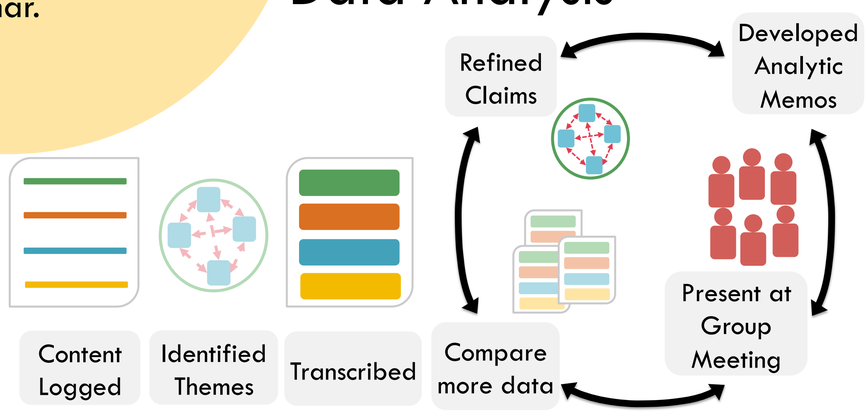
Course Outline & Data Collection



Course Context

- Pairs of students worked with research mentor.
- Authentic physics research questions.
- All students participated in weekly seminar.

Data Analysis



Physics Community

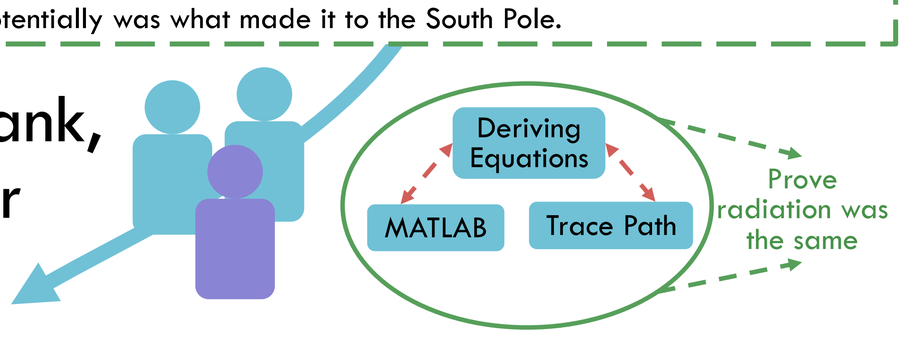
Frank describes several activities as substantively contributing to one another. (Connected)

Frank: Jack would explain to us what the objective was for the day. Whether it was basic coding towards the beginning of the sessions or theory of the plasma frequency and the index of refraction. He lays down the groundwork, and then we go in. We start coding exactly what we think should happen... from what we know, and then submit that to Jack, he would look it over, and then we confer... Or it would be Jack gives us a code and tells us to play around with it and see what we can do... Arthur and I then figure out whether our ideas are aligned, whether they're not aligned, what makes sense, what doesn't make sense. And so it would be a group project, where we go back and forth. We all have a third of the project to do. And, we confer and we make it a whole.

Arthur and Frank describe their activities in terms of prior research and a broader scientific purpose.

Arthur: So, we wanted to accomplish two objectives...our first objective was to prove that the radiation that was detected in the South Pole was the same radiation that was scattered off the plasma in our ionosphere. And our second objective was to find out the exact path the ray took in coming to the South Pole. To do that we had to first off learn about MATLAB... But the more intensive part was developing and deriving the ray tracing equations used to calculate the path the ray took.

Frank: Well basically we built a theoretical model of what was already done by researchers in the North Pole... nobody has ever actually traced the path or given a concrete, a concrete statement saying that "oh this is definitely possible"... We just made a model of what potentially was what made it to the South Pole.



Simon (mentor) described intentionally connecting practices

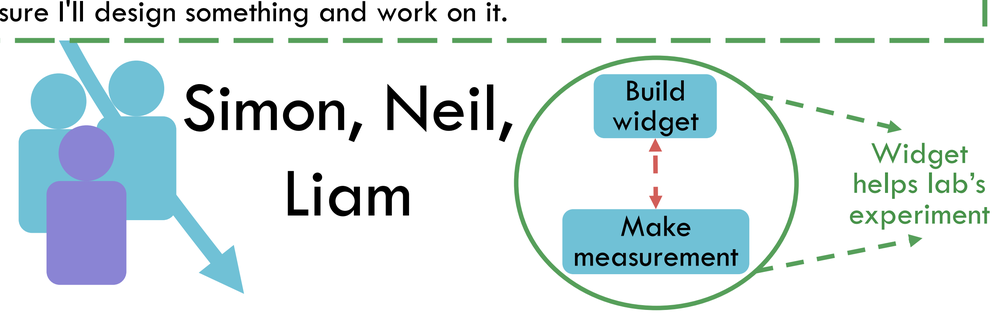
Simon: So the theme is, make some widget, use widget to measure something we didn't know... That whole combined package of that is really what I want out of these projects.

Neil attributed his limited understanding of purpose to lack of coursework.

Neil: We were working in a lab that dealt with Bose- Einstein Condensates...what they had saw was that there was fluctuations in the current and they weren't sure why. They thought it might have been temperature, and so me and my partner designed a circuit to measure temperature... then see if there's a correlation between the temperature and the changes in the current. And it turned out there seemed to be...
Interviewer: Alright, how much did you feel like you understood how your research fit into the broader goals of the lab?
Neil: I'd say not very well. I mean I understood that they're trying to clean up some data and remove some weird fluctuations but why they're measuring the uh the electric fields of the Bose-Einstein Condensates, that sort of stuff I didn't really understand.

Liam attributed his limited understanding of scientific purpose to the nature of experimental physics.

Liam: Theorists just give me things to work on. They say 'I have a problem here, can you test it?' Like, sure I'll design something and work on it.



Discussion

- Ford's framework gives a more holistic sense of students' research experiences than prior studies of undergraduate research and helps us characterize different forms of legitimate peripheral participation.
- This perspective allows us to not only see whether students see their experiences as *connected*, and *purposeful* but also allows us investigate the sensibility and plausibility of how well these accounts hang together.
- Our analysis supports research mentors in seeing connectedness and purposefulness in students' experiences and recognize opportunities for intervening.
- We think that mentors and research environments can influence the extent to which students see practices as connected and purposeful.
- Additional data suggests that students' experiences of connectedness and purposefulness in early research experiences may be consequential to their long-term engagement in physics research.

Ford, M. J. (2015). Educational implications of choosing "practice" to describe science in the Next Generation Science Standards. Science Education, 99(6), 1041-1048.
Lave, J., & Wenger, E. (1991). Situated learning: Legitimate peripheral participation. Cambridge university press.

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