Activity Summary: The H-Files

Venue: Astro-WEST 2017

"The H-Files" was an activity taught to 21 undergraduates at the University of California, Santa Cruz (UCSC) as part of the Workshop for Engineering and Science Transfers (WEST). All the undergraduates were beginning their first year as transfer students at UCSC. In our activity, learners used the concept of simple electron transitions and the concept of Doppler shifting to explain features in a spectrum of an astronomical system where light is interacting with hydrogen. Spectroscopy is fundamental to many fields of research, and students rarely get a chance to interact with the concepts at a deep level before their upper division classes. Our activity focused on the astronomical application of spectroscopy, and hydrogen systems are ubiquitous in this context. The learners worked in groups to investigate an unlabeled, "mystery" spectrum. We kept the activity close to home by using spectra taken by UCSC astrophysicists.

Learners also engaged in the authentic STEM practice of developing and using models. Specifically, they were tasked with *developing* a model which could explain their mystery spectrum. Part way through the activity, they were required to *use* their colleagues models by swapping them between groups with different spectra. Learners were tasked with sketching out their colleagues' spectrum based on the model. This also served as a formative way for us to assess their engagement with the model development. Modeling is core to scientific research, and we chose it specifically so students could gain experience with it before engaging with UCSC faculty in a research setting. To support development of students' STEM identities, we provided multiple ways to demonstrate competency and drew explicit connections between our activity and authentic research environments they would encounter at UCSC.

To raise questions, we developed a set of python-based Jupyter notebooks which simulated astronomical spectra. We left carefully chosen parameters (or "knobs") free in these simulations so that learners could raise investigable questions about each knob's impact on the resultant spectra. We also had a "zoo" of spectra for learners to sort through, and we prompted them to categorize the data and look for patterns. Ultimately, learners were able to choose which content area to focus on based on the question that was most interesting to them. This guided their participation during the investigations of their mystery spectrum.

In the group portion of our culminating assessment task, learners gave a short oral presentation describing their model and presenting an annotated spectrum where features in their data were labeled. They were guided with the following prompt:

“Prepare an annotated spectrum and presentation to describe an astrophysical system or scenario that could be the source of this hydrogen spectrum. Use the physics of atomic energy levels (e.g., the Rydberg formula), and the Doppler effect, to justify your explanation.

With the provided paper, sketch your spectrum and illustrate the geometry of the components within the system. Label where the observer/telescope is situated within that geometry, as well as the components and their characteristics (e.g., which components create which lines).”

Additionally, we had learners complete worksheets with open ended questions crafted to elicit their understanding of the content on an individual level. The majority of the learners scored 2 out of 3 points on both the content and practice rubrics which we designed for our activity. We did not quantitatively assess any attitudinal outcomes, such as developing a growth mindset or STEM identity, but we did see anecdotal evidence that this was successful for a fraction of our learners. Several students reflected to us at the end of the activity that they were excited by the seemingly authentic format of the activity and had learned more about doing research than they ever had in a traditional lab setting. Two of the PDP participants that designed and facilitated this activity (a physics graduate student and an astrophysics graduate student) saw several of the WEST undergraduates attending colloquia and seminars during the 2017-2018 school year. A few of the undergraduates have also participated and took on leadership positions in physics and astrophysics student organizations.