NITARP Benefits for High School Level and Introductory College Level Astronomy Classes

Jeff Benter[1], Jack Benter[2], David Dahari[3], Gabriel Dahari[3], Tanner Hurliman[1], Joseph C. Perry[4], Richard J. Perry[4], Luisa Rebull[5], Jackson Ritchie[1], Madeleine Sullivan[4], Sahar Sultani[3], Bo Zeleznik[2],

[1]Tri-Valley High School, Downs, IL; [2]Le Roy High School, Le Roy, IL; [3]Berkshire School, Sheffield, MA; [5]Palmyra - Macedon CSD Palmyra, NY; [6]Caltech-IPAC/IRSA, Pasadena, CA

Next Generation Science Standards (NGSS)
Using NITARP and Young Stellar Objects (YSOs) to Understand Star Formation

The Problem:

With the implementation of the Next Generation Science Standards (NGSS), there has been significant growth in astronomy content for the Earth and Space Sciences classes across the nation. NITARP's program and content can not only address this need but also bring greater context and understanding to these standards.

Currently, when compared to the other core sciences of Biology, Chemistry, and Physics, Earth and Space Sciences has a much smaller breadth of resources and available content at both a national level and state level. In addition to this, Earth and Space Science teachers often have a greater depth of knowledge in geology or meteorology, whereas the astronomy teachers are often physics teachers. Many astronomy investigations are limited in scope in sequence with little use of actual or meaningful astronomical data.

> **HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation. (https://www.nextgenscience.org/pe/hs-ess1-1-earths-place-universe)**
> **HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements. (https://www.nextgenscience.org/pe/hs-ess1-3-earths-place-universe)**

A Solution

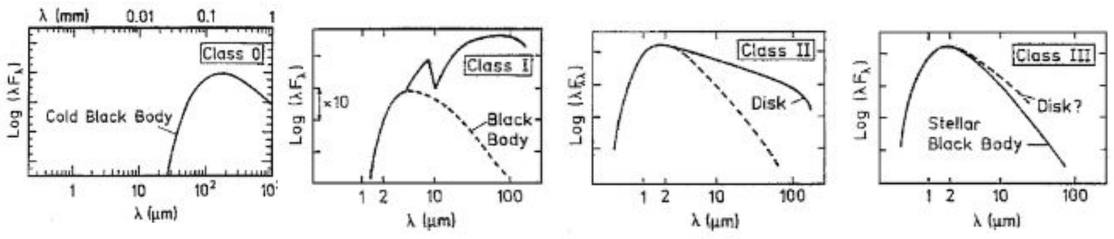
One program to help fill the void of astronomy content and activity is the NASA/IPAC Teacher Archive Research Program (NITARP). Each year, NITARP pairs a handful of predominantly high school science teachers from around the country to work with a Caltech astronomer to conduct an authentic astronomical research project using archived infrared data housed at the Infrared Processing and Analysis Center (IPAC), and supplemented as needed with other archived data, including some optical.

The content and data necessary to conduct an authentic astronomy research project not only meets the ESS standards identified above, but exceeds them and adds great context to them. Using NITARP data, students can understand the Disciplinary Core Ideas (DCIs), the Science and Engineering Practices (SEPs) and the Crosscutting Concepts (CC).

A Sample NITARP Research Project

One common type of NITARP research project involves identifying young stellar objects (YSOs) in a given region. Investigating Young Stellar Objects (YSOs) and how their spectral energy distribution (SED) changes as the YSO ages allow for the modeling of young star formation. Students using data from NITARP / IPAC construct graphs of SEDs for each YSO and then use them to classify the YSO according to its evolutionary progress to becoming a star. This classification of YSOs from their SEDs addresses the SEP of HS-ESS1-1 of the NGSS: "using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s)". Taking this data, creating SEDs allows for the classification within the models below addresses the SEP of HS-ESS1-1 of the NGSS.

SED Models



(Bachiller 1996).

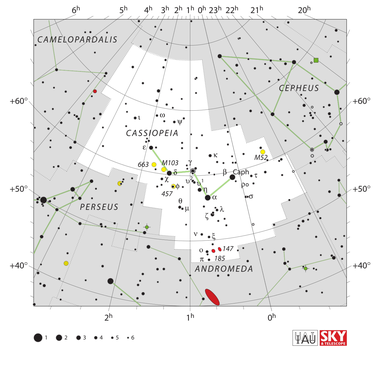
The data that NITARP uses also lends itself to a better understand the many different space telescopes studying the electromagnetic spectrum that study the universe and stars. The CC of standard HS ESS1-1 is about phenomena are dependant upon understanding scale, proportion and quanity. In the creation of SEDs, students learn about the scale of logarithms that are encountered when understanding the H-R diagram. Often logarithms are first encountered when using the H-R diagram. Those skills and CC can be reinforced within the same unit of content with the use of SED and YSO data.

Processing YSO Data with Excel (and Other Graphic Programs)

A major component in astronomy is data processing, formulas and spreadsheets. Many students who take Introduction to Astronomy courses often have high interest in the concepts and theory but don't want to get bogged down in extensive mathematical equations. Most high school students have limited knowledge of log formulas and compounding tables in order to process data in meaningful ways. Some of this can be addressed with spreadsheets. NITARP excels in the development of these types of activities for introductory-level astronomy classes and addresses many goals of the NGSS:

- The construction of SEDs (even using just Excel) brings a greater meaning to the concepts of magnitude, flux, luminosity and flux density. (HS-ESS1-2: DCI - ESS1.A)
- By selecting the appropriate datasets available on IPAC's web-based IRSA Viewer, students see the various sources and telescopes for the archival data they use. This creates a better understanding of the many different space telescopes that study the universe and stars using different parts of the electromagnetic spectrum. (HS-ESS1-2: SEP)
- Students, working with data on YSOs (or other stellar objects), learn the basic properties of formulas in spreadsheets.
- Students, through the tool of a spreadsheet program, get a taste of the extensive data computation required to make various models and charts.(HS-ESS1-3: SEP & DCI - ESS1.A)
- The CC of standard HS ESS1-1 is about phenomena that are dependant upon understanding scale, proportion and quantity. In the creation of SEDs, students learn about the scale of logarithms that are also encountered when using Hertzsprung-Russell (H-R) diagrams. Often logarithms are first encountered when using the H-R diagram. Those skills and CC can be reinforced within the same unit of content with the use of SED and YSO data.
- Using NITARP and IPAC data allows students to learn via the medium of spreadsheets to communicate scientific ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats, in this case numerically and graphically. Once the SEDs are completed, students can identify the class of YSO development graphically. (HS ESS1-3 SEP and DCI)
- By using YSOs' light spectra and energy distributions, students will understand how the light spectra and brightness can be used to identify their distances from Earth. Students creating these SEDs will then be able to match and categorize these YSOs against others, even match them to other YSOs in ISRA viewer. (HS-ESS1-2: DCI ESS1.A)

Investigations and activities such as this meaningfully address the NGSS and thus bring a greater science literacy to students that have an interest in science.



Future Investigations and Development

NITARP's program of continuing research and the resources offered lend to the creation of many other investigations in modeling through both computing and graphic investigations. The investigations into YSOs and other objects can be done through Color - Color diagrams and light curves. In addition to this, possible investigations using IRSA viewer to view stars and their properties are valuable tools for students to gather data for evidence to build greater scientific literacy.