Research Supporting Multisensory Engagement by Blind, Visually Impaired, and Sighted Students to Advance Integrated Learning of Astronomy and Computer Science

aka – Innovators Developing Accessible Tools for Astronomy (IDATA)

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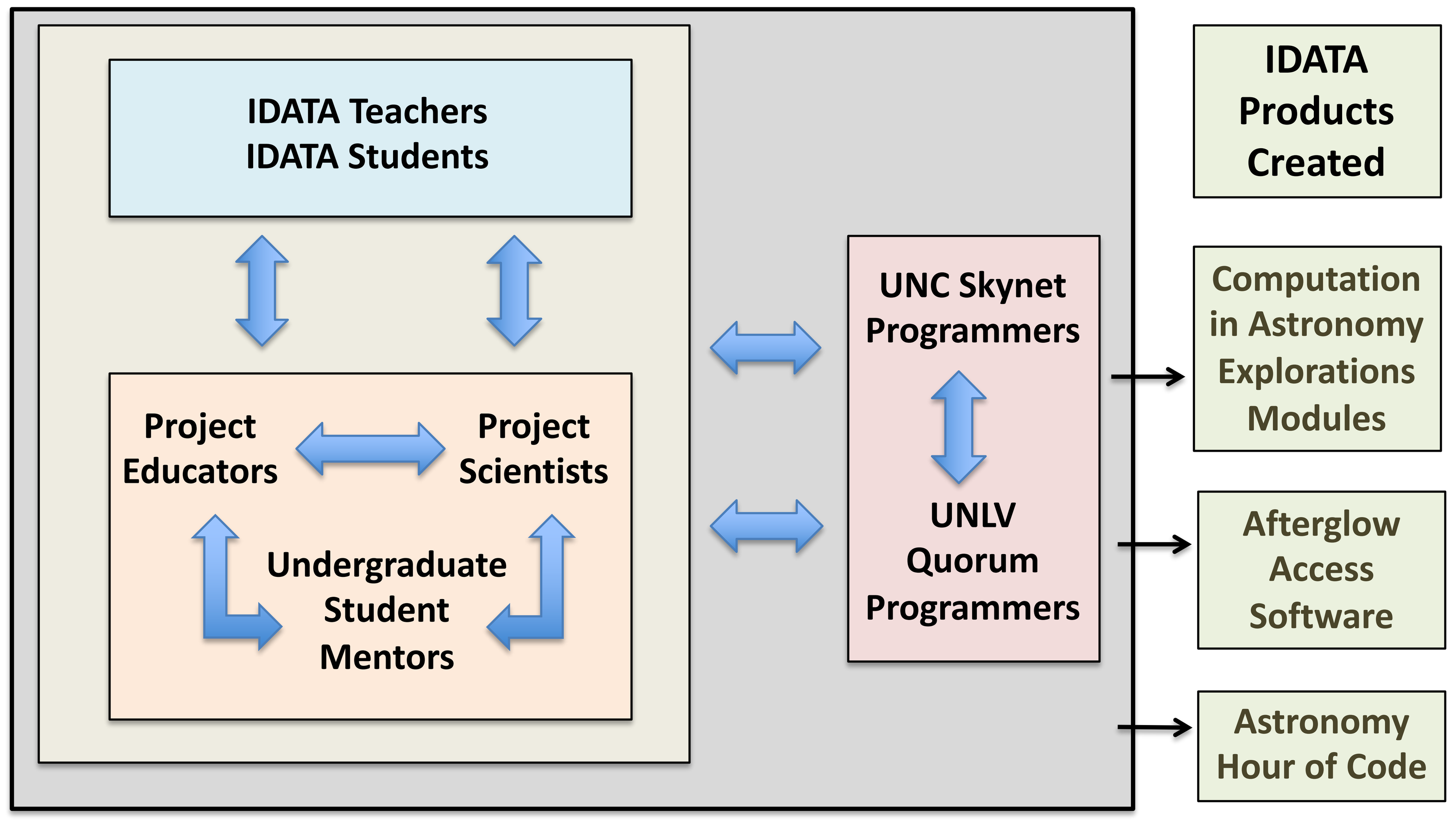
About IDATA - NSF STEM+C Project

Major Goals of IDATA

- **Exploring computational thinking and learning in astronomy**
- **Engaging students in authentic software design/ development and understanding its impact**
- **Designing and developing astronomical image/ data analysis software that is accessible to people who are blind and visually impaired (BVI)**
- **Developing curricular resources to support computation in astronomy and software use**



IDATA Project Structure and Products

IDATA Goals and Objectives

IDATA aims to build an inclusive community of practice centered on the common goal of design and production of accessible astronomical software, along with the necessary supports for an impactful educational experience for diverse learners. Through authentic student engagement in the software design and development process, the project explores an innovative approach to improving knowledge, skills, self-efficacy and interest (including career interest) in astronomy, computing science, and the creation of tools that use the user-centered design/ universal design (UCD/UD) processes to increase accessibility for all. The IDATA curricular materials and community-building activities will pay particular attention to girls and traditionally underrepresented groups, in particular blind and visually impaired (BVI) students, helping them come to see themselves as doers of STEM+C. IDATA will highlight computing in astronomy, engaging a community of diverse students in astronomical explorations and improve access to Astronomy+C for all.

Key components of the education intervention include (a) inquiry-based curricular modules and facilitated activities that teach computing in the context of astronomy; (b) a scaffolded process of user-centered design/ universal design that underscores computational thinking practices in the context of optimizing astronomy tools to be fully-accessible to all users; (c) student-driven, authentic astronomy research; and (d) BVI and sighted astronomers and computer scientists as mentors and role models to the community of learners. The project currently engages 16 teachers and 160 students from mainstream and specialized schools for the blind over three years. IDATA will advance core knowledge in the learning sciences and educational research communities by studying questions related to the development of Astronomy+C knowledge as well as changes in STEM+C interests and identities.

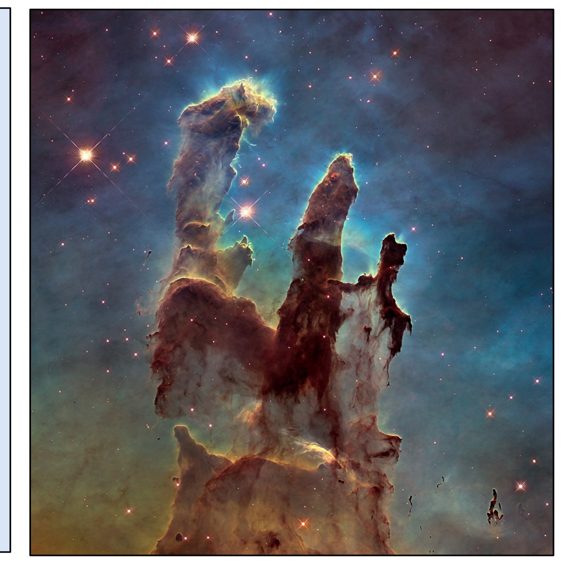
Broader Impacts

IDATA will produce online imaging software accessible to a community of users previously excluded from astronomy research, create a curricular resource that demonstrates how computational thinking and tools are used to solve problems in astronomical research, and serve as a model for user-centered, accessibility-aware development for continued refinement of scientific, educational, and engineering software. Because astronomy has evolved into a data-driven science rather than one based primarily upon visual inspection of images, IDATA expects community-wide benefits from a UCD/UD process inclusive of persons who require non-visual analysis pathways. Based on adoption patterns of other universal design technologies, we expect the accessible interface and command-line entry point to be adopted by a broad range of both sighted and BVI users far beyond the initial target audience. The functionality that allows astronomical data to be analyzed is transferable to other file formats and disciplines, opening the door for accessible analysis, for example, of satellite, geophysical, and medical images. Finally, the cost-free, secure, online image processing software developed in IDATA will benefit schools and individuals lacking adequate computing resources or where there are severe restrictions on what can be installed on computing devices.

The project team and advisory board members will disseminate findings to their respective professional associations and networks, including the American Astronomical Society and the American Geophysical Union, and through traditional means, such as papers in peer-reviewed journals and conference presentations. The accessible tools and educational resources produced in this study will be freely available to K-12 teachers nationwide and could be widely adopted by BVI and sighted individuals in astronomy and other visually-intensive domains.

How Can We Experience Data?

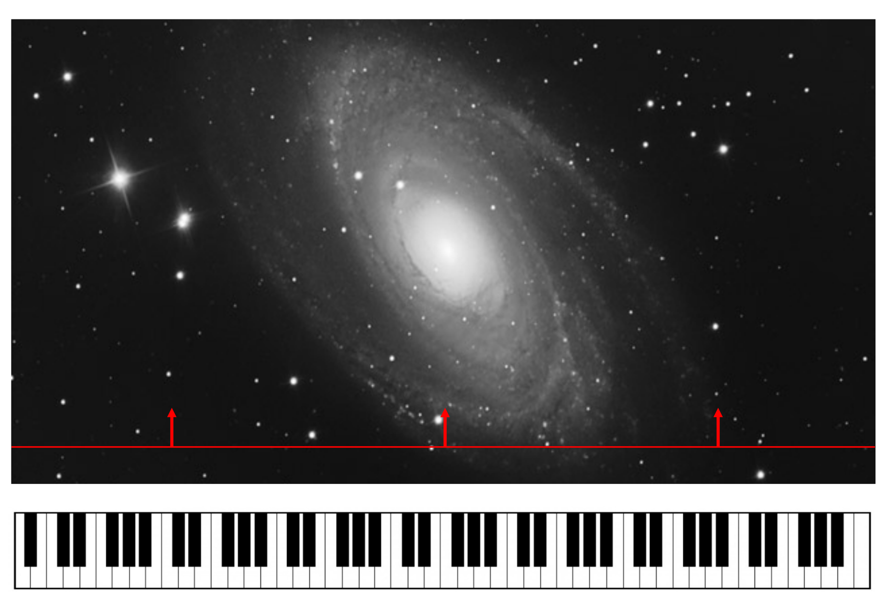
Astronomical Data – Perhaps you've seen those spectacular images from the Hubble Space Telescope: pillars of greenish gas and dust giving birth to new stars and planets, incredibly detailed spiral arms in galaxies millions of light-years away. But **you can't look through a telescope and see these amazing wonders of nature**. Light from these distant objects is converted into numerical data, and computers use that data to generate the images we see. **In reality, we are all "blind" to this data.** We simply choose to convert these numbers into visual images. But there are other ways, beyond our eyes, to analyze these data.



Exploring Astronomical Data Through Touch – Thanks to 3-D printers and other tools and techniques, today, blind planetarium show-goers can "see" the night sky with their fingers (below-right, Image Credit: IYA Valencia). In addition, images taken with a telescope can be explored by your fingertips (below-left: Image Credit: Tactile Universe).

Exploring a Data Array (image) Through Sound with IDATA

Data can also be transformed systematically into sounds that enable users to identify and explore astronomical objects and their characteristics aurally. We are working with students – both BVI and sighted – to identify which sonification methods work best.



Piano Scale

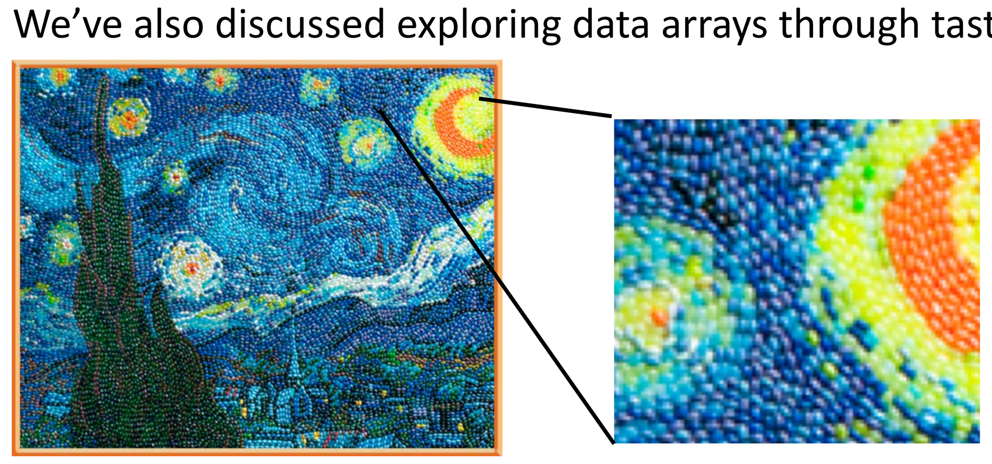
Mapping Data to Sound: One Idea

Brightness = Volume

Horizontal position = Pitch

Vertical position = Time in scan from bottom to top

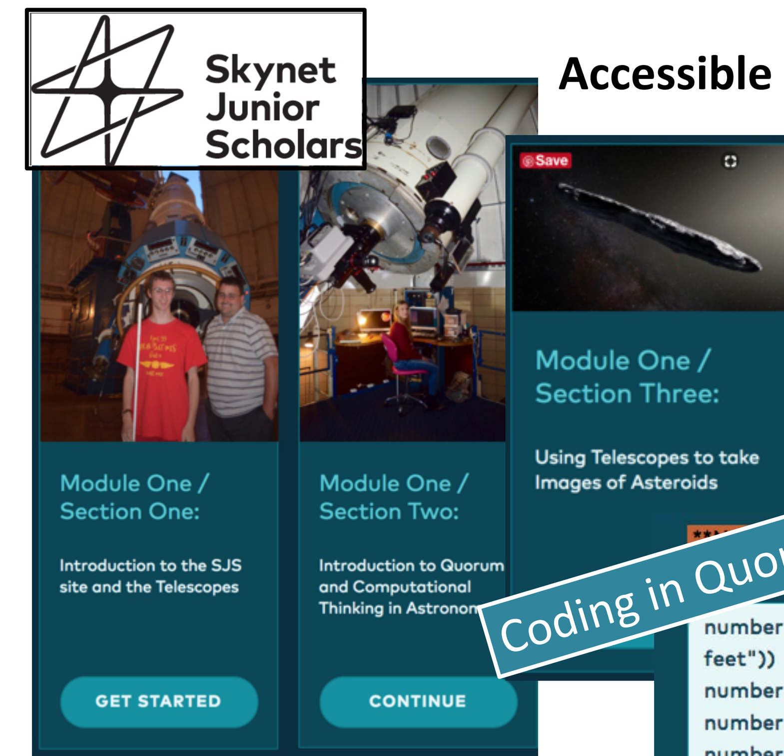
We've also discussed exploring data arrays through taste and smell...



Exploring a Data Array (image) Through Taste – This data array is made of jelly beans. By eating the jelly beans, could you experience patterns in the data?

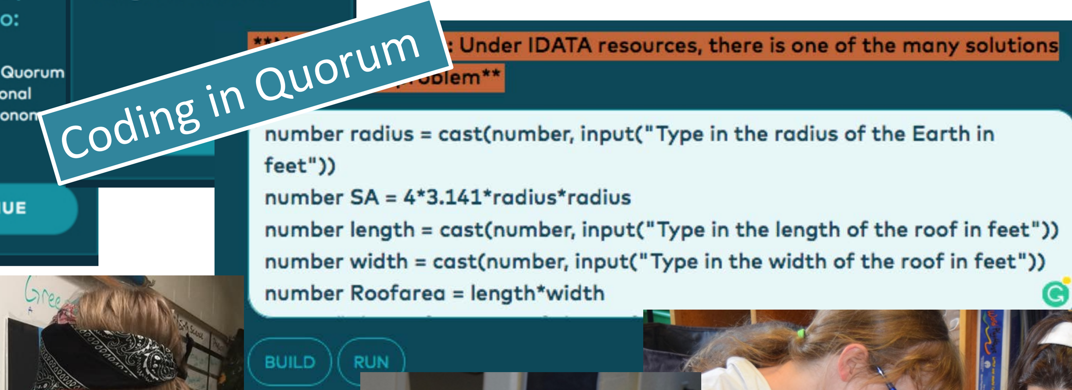
Exploring a Data Array (image) Through Smell – What if instead of jelly beans, the above image was composed of scented candles? Could a person use their nose to smell their way through the data array?

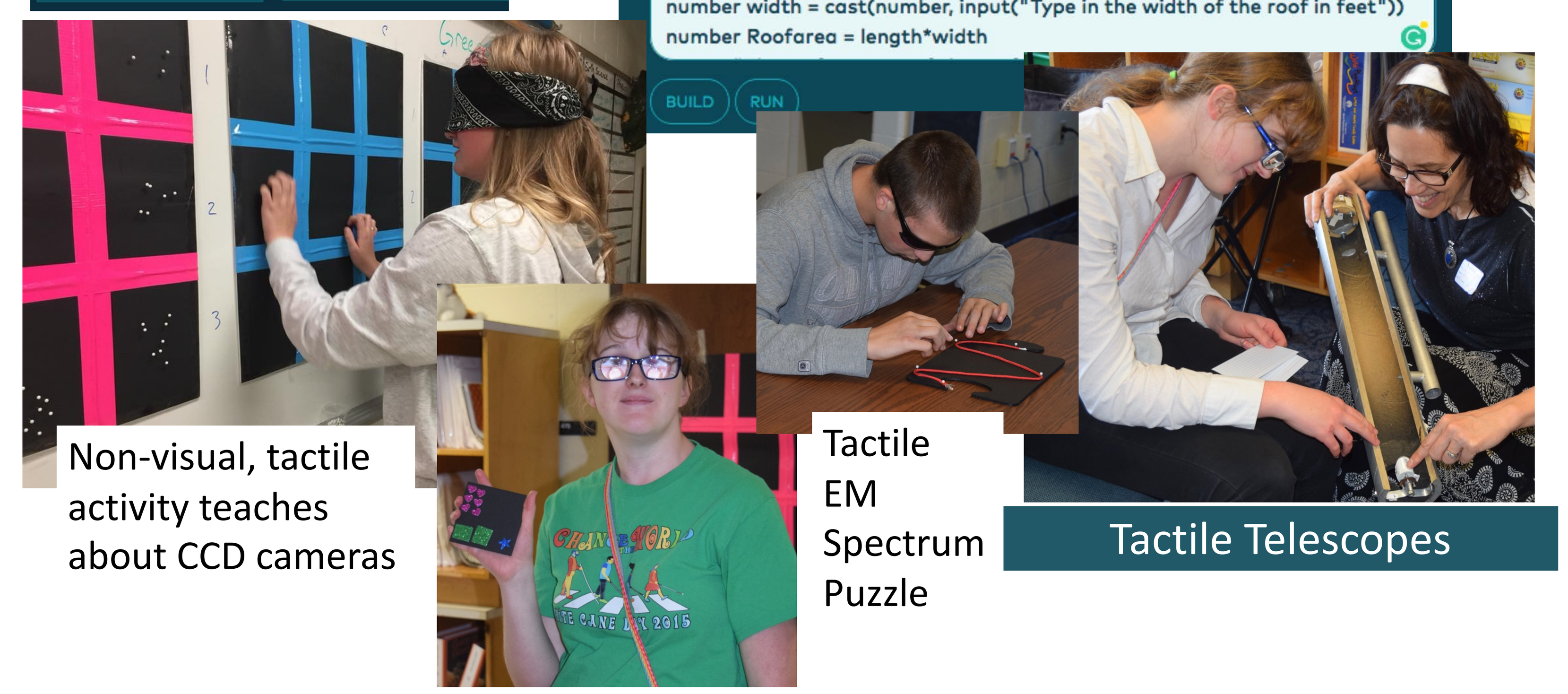
Progress To Date



Accessible Activities for Computation in Astronomy

- Hands on activities explain astronomy concepts
- Online modules teach the science of asteroid orbits and light curves
- Quorum, an accessible programming language, allows BVI students non-visual ways to explore data and control telescopes





Non-visual, tactile activity teaches about CCD cameras

Tactile EM Spectrum Puzzle

Tactile Telescopes

IDATA Research

1) Understanding of computational thinking. How does being involved in IDATA affect students' understanding of computational thinking? How does it affect their understanding of the process of software development and, in particular a user-centered design/ universal design process (UCD/ UD)?

2) Understanding and use of computing in astronomy. How do students' ideas about the relationship between astronomy and computation develop through involvement in IDATA?

3) Interest and identities. How does being involved in IDATA influence student interest in computing science and/or astronomy and in pursuing STEM+C careers? How does this differ by students' gender or level of visual ability? How does involvement in IDATA affect students' views of others' abilities in STEM+C fields?

In addition, we study how teachers participating in IDATA learn to support their students' engagement with computational thinking and astronomy, and how their views about who can do astronomy and computing change.

Sample: Teachers (N=16) and their ~160 students (grades 7-12) from both near the Yerkes Observatory (IL and WI locations within 70 miles of Williams Bay, WI) and further afield (CA, FL, MA, OR, TX, WI, WY) are participating in IDATA. Some integrate IDATA activities into regular classes, others create after school clubs. We also work with 6 undergraduate near-peer mentors, who engage with students to support their learning.

Data Sources: We have found or created BVI accessible measures of students' astronomy knowledge, knowledge of computational thinking, and of students' attitudes, beliefs and identity and have administered these as baseline assessments. Our measure of computational thinking focuses on computational problem-solving practices and data practices (Weintrop, et al., 2016). We are also logging and analyzing student activity through the CAEM modules and in AfterGlow Access; are asking teachers, UG mentors, and staff to log classroom activity; are observing in a sample of classes; and are interviewing teachers, UG mentors, and student leaders about their experiences.

Analyses: We will conduct quantitative analyses of changes in our measures of astronomy, computation, and Astronomy+C attitudes/ interest and identity. Qualitative analyses of student activity and experience will provide rich descriptions of how engagement with astronomy and computing with the goal of increasing accessibility affects students and their teachers.

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