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OAE Mini-Review

Astronomy Education with Authentic Data

IAU OFFICE OF ASTRONOMY FOR EDUCATION

OAE

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The following is a collection of summaries originally published in the proceedings of the 3rd Shaw-IAU workshop on Astronomy for Education held 12 – 15 October, 2021 as a virtual event. The workshop was organised by the IAU Office of Astronomy for Education. More details can be found on: https://astro4edu.org/shaw-iau/3rd-shaw-iau-workshop/.

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The IAU Office of Astronomy for Education (OAE) is hosted at Haus der Astronomie (HdA), managed by the Max Planck Institute for Astronomy. The OAE's mission is to support and coordinate astronomy education by astronomy researchers and educators, aimed at primary or secondary schools worldwide. HdA's hosting the OAE was made possible through the support of the German foundations Klaus Tschira Stiftung and Carl-Zeiss-Stiftung. The Shaw-IAU Workshops on Astronomy for Education are funded by the Shaw Prize Foundation.

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Astronomy Education with Authentic Data

Session organiser: Niall Deacon, Office of Astronomy for Education/Max Planck Institute for Astronomy, Germany

Session overview

Over the past seventy years, astronomical surveys have accumulated huge amounts of data about the sky. This includes a wide range of wavelengths, time domain data allowing the study of motion & variability, and even non-electromagnetic signals such as gravitational waves or cosmic rays.

Now this wealth of authentic data is being used to introduce school students to the universe. This could include curated educational datasets from remote observatories, training teachers to use survey data in projects with their students or incorporating authentic data into planetarium shows for schools.

This session included speakers who have worked to incorporate survey data into resources for schools. They talked about their own projects, but more importantly shared the lessons they learned along the way, allowing you to learn from their experiences when building your own activities.

What You Need to Know about the NASA/IPAC Teacher Archive Research Program (NITARP)

Speaker: Luisa M. Rebull, Caltech-IPAC, USA

NITARP, the NASA/IPAC Teacher Archive Research Program gets teachers involved in authentic astronomical research using the same online astronomy data archives as professional astronomers. We partner small groups of educators with a professional astronomer mentor for a year-long original research project. The teams experience the entire research process, from writing a proposal, to doing the research, to presenting the results at an American Astronomical Society (AAS) meeting. This talk will provide an overview of the program, highlighting use of real data in astronomy educator professional development experiences.

Talk link: https://youtu.be/MLSFNozOZ_c

There are a lot of programs getting teachers in touch with real astronomy data. I find it useful to think of organizing all these programs as a funnel, where the most interested people move down the funnel (see Rebull 2018a for more discussion). The programs that reach the most people are at the broadest part of the funnel, and people just need a web browser and an internet connection to participate. The most interested people might be enticed to participate in working more directly with real data, or even contributing their own data. Very few people end up near the bottom of the funnel, doing original research.

"Everyone should know" that there are a lot of programs populating the funnel (listed here: https://nitarp.ipac.caltech.edu/page/other_epo_programs), and all levels of the funnel are important! Programs at each level have vastly different goals and audiences. NITARP (http://nitarp.ipac.caltech.edu), the NASA/IPAC Teacher Archive Research Program, lives near the bottom of the funnel.

In NITARP, teachers get an authentic research experience using real data and tools. We model the entire research process from proposal to results in a year. (See Rebull et al. 2018b for more information about NITARP.) We have been operating since 2005, so we have refined our procedures (and continue to do so). Participants must be US based. They get three trips out of the program: (1) an American Astronomical Society (AAS) meeting to get started on their project and see how the AAS works; (2) 3-4 days at Caltech/JPL to work on their project; (3) back to the AAS to present results. NITARP pays for up to 2 students per teacher for the second two trips. All NITARP teams must use data housed at IPAC, but fortunately there are quite a bit of ready-to-use data in the archives, with tools getting better all the time.**"Everyone should know"** that teachers and students get really excited about working with real data and tools.

"Everyone should know" that teachers do not have as much control over their computers as astronomers do, and moreover use Windows or Chromebooks. So, we use online tools like those at IRSA (`http://irsa.ipac.caltech.edu`) and Excel (because it is widely available). "Everyone should know" that few teachers pre-pandemic had experience working remotely, but our alumni did, and they felt like they had an advantage over other teachers!

"Everyone should know" that partnerships only work if both partners get something out of it. (See, e.g., "The Power of Partnerships: A Guide from the NSF Graduate STEM Fellows in K-12 Education Program".) In NITARP, scientists learn better how to teach, and teachers learn how research works and how to get data. **"Everyone should know"** that working with teachers substantially leverages your influence, because if you change the way that teachers think, you change everyone they teach thereafter, from students in their own classes, to after-school clubs, to peer teachers in the break room.

"Everyone should know" that teachers rarely get to collaborate with other teachers, much less people in other states. Teachers often work in isolation. Astronomers collaborate easily and often. Teamwork and sharing skills are an important 'product' that NITARP gives these teachers (see Rebull et al. 2018c). **"Everyone should know"** that teachers have not been on "research trips" like astronomers. The summer trip is based on that, and it is a new, very intense experience for participants. "Everyone should know" that teachers are being asked by the Next Generation Science Standards to teach in ways that they themselves were not taught. They crave training on how to do this and how to use real data. (See, e.g., Rebull et al. 2018d.) NITARP meets that need. As a result, NITARP has 5x oversubscription, which is rare in education.

"Everyone should know" that we really do publish, in major journals, results of NITARP teams' work. To date, we have 70 science posters, 74 education posters, 8 refereed astronomy journal articles, & 6 refereed education journal articles. All are on the NITARP website.

"Everyone should know" that teachers are used to literally being the smartest person in the room when it comes to their subject matter. Astronomers, indeed all scientists, feel stupid all the time. (We share Schwarz 2008, which is entitled, "The Importance of Stupidity in Scientific Research.") Teachers are also not used to learning at this level, rapidly, much less in tandem with their students. NITARP teachers learn how to learn in a new way. (See Rebull et al. 2018c.)

"Everyone should know" that teachers tell us their experience in NITARP is "life changing" (see Rebull et al. 2018c), so we must be doing something right!

There are a lot of programs getting authentic astronomy data into the hands of teachers and students, but few that do research with the data. Teachers and students are more than capable of using research-grade data and tools to conduct authentic research with a mentor; they will rise to high expectations. They get really excited about doing real research! And, despite the learning curve, they love using research-grade software & data. This requires a long-term ($\approx$year at least) commitment to the program; it is a large investment of time per participant, but it can change teachers' lives. Educators continue after NITARP to incorporate authentic data and experiences into their classroom using skills they learned from us.

References:

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Rubin Observatory's User-Friendly Approach to Working with Authentic Data

Speaker: Ardis Herrold, Education Specialist for Vera C. Rubin Observatory, USA

Working with authentic data can be an engaging experience. Historically, the challenges with accessing, querying, and analyzing datasets can cause significant time and technology issues. Additionally, novice learners often struggle to develop quality research questions and the skills to explore data. These constraints often limit the types of students or classes that can successfully work with authentic data. Rubin Observatory's desire is to make data accessible to all students and teachers in a way that honors the time and technology constraints of the classroom, and is designed to match the appropriate reasoning level and common learning challenges of students who are novice learners. We introduce interactive online investigations designed to increase accessibility.

Talk link: https://youtu.be/-7ewXhW9gQk

Rubin Observatory will begin a sky survey in early 2024, covering the entire visible sky every three to four nights with wide field, high resolution images. Over the first ten years of the survey, co-added images will reveal billions of previously undetected faint objects. For this reason, the survey is sometimes described as "wide, fast, and deep".

The Education and Public Outreach team at Rubin Observatory has been working to design ways to allow non-scientists to explore data. One aspect of this has been developing and testing classroom investigations that will utilize Rubin data once it becomes available. We aim to apply the "wide, fast, deep" method to our education audience: Provide access to a wide diversity of learners, by designing means to quickly access and analyze data, and create experiences that lead students to a deep understanding.

Working with authentic datasets comes with its own set of challenges, which historically has discouraged teachers and students from using them. Our goal is to make data access and analysis so user-friendly that it is accessible to most students and teachers, instead of only those in advanced classes, or in classes with no curricular or time constraints.

To make data user-friendly, we identified and addressed the issues facing teachers and students in a typical classroom. We chose to focus on topics that are typically covered in an introductory astronomy course or unit, and designed the investigations to support novice learners.

We recognize three common challenges for teachers:
- A limited amount of time to prepare and teach lessons
- School technology and infrastructure issues
- Feeling under-prepared to work with authentic data

Students introduce additional considerations:
- A wide spectrum in background knowledge and skills (math, reading, writing, data literacy) exist within the same classroom
- Some students lack confidence in their ability to be successful in math and science

Traditional access to data often requires substantial time and training. There may be firewalls to pass through, or constraints on the size of a data download. Selecting datasets may involve learning a query language, and/or teaching it to students. The school technology infrastructure may not support downloading data, or installing specialized software for analysis on a series of computers.

We have designed a way to process data in the cloud by using online tools that are embedded within each investigation. All that is needed is access to the internet through any modern browser.

Real data are messy, and often need to be processed in order for a general trend to become obvious. We have done necessary reductions in the data and curated data sets where necessary in order for novice learners to be able to effectively analyze them. Where possible, we have designed guided practice with feedback before students begin to analyze their own data.

To assist students with diverse needs, we present data using clearly-designed plots, data visualizations, and tools that span multiple types of representations: images, interactive histograms, 3D spatial analysis tools and mathematical relationships. Embedded calculators do the arithmetic, so that students have more time to focus on computational relationships and quantitative reasoning. Narratives are concise and avoid the use of unnecessary jargon.

Teachers are likewise supported with an extensive teacher guide, assessments and additional instructional materials, so that they feel sufficiently prepared to deal with the nuances of working with authentic data.

Finally, we have given much thought to the instructional design that empowers students to unpack and make sense of new complex ideas. Some interactive tools are designed to help students confront and explore learning confusions or misconceptions. We suggest questions that lead students through a sequenced reasoning process.

The takeaway message is that making data access and analysis easy does not mean it lowers the degree of intellectual engagement or rigor. Rather, by removing distractions and unnecessary data processing and analysis tasks, students have more time and confidence to actively engage in learning, to explore their unique data set, converse and collaborate with peers, and develop robust conceptual models that lead to deep learning and an enthusiasm for exploring the cosmos.

Using Radio Astronomy Data to Engage and Challenge Students

Speaker: Robert Hollow, CSIRO, Space and Astronomy, Australia

Collaborators: G. Hobbs (CSIRO), L. Toomey (CSIRO), S. Dai (School of Science, Western Sydney University)

Using authentic data, especially that obtained directly by students is an effective way to engage their interest and develop questioning and analytical skills. Whilst there are many excellent examples of programs using optical data, astronomy is a multi-wavelength discipline. Using radio astronomy as the context we explore a variety of ways in which students can obtain, be presented with and use data. Flexibility in program design allows students to be engaged in a one off experiential engagement or use in short-term or more open-ended student investigations. Examples of these are presented and advantages and pitfalls discussed. With the massive increase in data rates with new facilities there are exciting opportunities in coming years for astronomy education projects across wavelengths.

Talk link: https://youtu.be/u7AuXulOn2U

Whilst there are many excellent examples of educational programs using optical data, astronomy is a multiwavelength discipline. Using radio astronomy as the context, we explore a variety of ways in which students can obtain, be presented with, and use data. Activities can range from simple pen and paper exercises, building simple radio telescopes, or using major facilities remotely and online tools to view and analyse data. With the massive increase in data rates with new facilities there are exciting opportunities in coming years for astronomy education projects across wavelengths.

Radio astronomy has the benefit of large (massive) data sets, many of which are freely available online. As radio telescopes can operate day and night, they are ideal for school use whenever suits the school. Recent developments allow simple radio telescopes to be built at low cost within schools. Challenges exist in that radio data is generally less"obvious" than optical data. It may have file formats that require professional research level software, UNIX-based, that are difficult for school students to engage with. File sizes may also be massive.

Simple activities:

1. Use a transistor radio, tuned between AM stations. To detect Radio Frequency Interference (RFI) from sources such as laptop screens, phones, power points. Can map out sources of RFI in the environment. Discuss how a transistor radio is basically a radio telescope – antenna, amplifier, output source (speaker).

2. Colouring in image maps – simple paper examples (https://edu.inaf.it/astrodidattica/immagine-radio-primarie/) or use coding with colour palettes (https://play.inaf.it/la-galassia-m77/) to illustrate images of, e.g., radio galaxies.

3. Worksheets with data and explanations, can target different levels, e.g., Weighing a Galaxy Activity at https://www.icrar.org/outreach-education/resources/

Online Observatory and Virtual Sky Tours:

1. ALMA Walk-throughs with Google Street View: https://kids.alma.cl/walk-through-alma-with-google-street-view/

2. Murchison Radio-astronomy Observatory Virtual Tour: https://virtualtours-external.csiro.au/MRO/

3. Gleamoscope (uses GLEAM low frequency survey from Murchison Widefield Array, MWA): https://gleamoscope.icrar.org/

4. ASKAP RACS Virtual Sky Tour: https://www.atnf.csiro.au/research/RACS/RACStour/index.html

5. EMU Pilot Survey: http://emu-survey.org/pilot/

Citizen Science:
Examples using radio data in Zooniverse (https://www.zooniverse.org/projects):

1. Radio Galaxy Zoo LOFAR: uses LOFAR data to search for supermassive black holes (https://www.zooniverse.org/projects/chrismrp/radio-galaxy-zoo-lofar)

2. Bursts from Space uses data from CHIME telescope to search for Fast Radio Bursts (FRBS) (https://www.zooniverse.org/projects/mikewalmsley/bursts-from-space)

Small Radio Telescopes:

- Dipoles antenna, e.g., Radio Jove (https://radiojove.gsfc.nasa.gov/)
- Satellite dish, e.g., Itty Bitty Telescope (https://www.gb.nrao.edu/epo/ibt.shtml)

Software Defined Radios (SDRs):

Cheap Software Defined Radios (SDRs) replace purpose-built radio receivers and allow users to connect an antenna to a computer to detect and view radio waves from a variety of sources. They are excellent for viewing Radio Frequency Interference (RFI). Connect to a feedhorn-waveguide-low noise amplifier (LNA) and a software backend, radio signals from space can be detected, giving a radio telescope for less than $200. Students can experiment with feedhorn and waveguide designs, time of day, cooling the LNA or removing it. Software is free.

Examples of Programs Using Professional or Remote Facilities:

1. Pulsar Search Collaboratory: http://pulsarsearchcollaboratory.com/
2. Goldstone Apple Valley Radio Telescope (GAVRT): http://gavrt.lewiscenter.org/
3. INAF FRB Hunting: https://www.youtube.com/watch?v=4yghT3ZMzbU
4. VSSEC Radio Astronomy - The Invisible Universe: https://www.vssec.vic.edu.au/radio-astronomy-the-invisible-universe/
5. CSIRO's PULSE@Parkes: https://research.csiro.au/pulseatparkes/

There are multiple ways to engage students with radio astronomy from simple activities to using major research facilities. Opportunities for browser-based, archived, hands-on telescope construction, real-time observing.More user-friendly tools would be helpful. Massive data sets coming, e.g., ASKAP, SKA. Have an idea? Let's talk!

Using Real Data to Teach Astronomy

Speaker: Fraser Lewis, Faulkes Telescope Project and National Schools' Observatory, UK

I will present examples of IBSE (Inquiry-Based Science Education) activities, designed to be "teacher-free", and used as extended projects for students of astronomy and space science. Each project uses data and resources from the Faulkes Telescope Project and the National Schools' Observatory. Both projects provide free access via the internet to 2-metre robotic telescopes. These resources are based on open clusters and exoplanets and also include a Citizen Science type project using data from Type Ia supernovae, all of which provide an insight into the scientific process. Here, users perform browser-based photometry (using JS9) on images to add additional data-points to the Hubble Plot, enabling them to measure the expansion rate and age of the Universe.

Talk link: https://youtu.be/QuzvCVxY65w

Based in South Wales, the Faulkes Telescope Project (FTP, http://www.faulkes-telescope.com/) provides free access, via both queue-scheduled and real-time observations, to a global network of 2-metre, 1-metre and 0.4-metre robotic telescopes. FTP was originally conceived by Dr Martin 'Dill' Faulkes to promote the teaching of STEM through the medium of astronomy in schools in the UK and in Ireland.

The network contains two 2-metre f/10 Richey-Chretien telescopes, located on Haleakala on the island of Maui, Hawai'i (FT North; FTN) and at Siding Spring in New South Wales, Australia (FT South; FTS). In 2006, FTN and FTS were bought by Las Cumbres Observatory (LCO) and since then, FTP has been an educational partner of LCO.

The LCO network now has a further nine 1-metre telescopes along with ten 0.4-metre telescopes. FTP provides free access via LCO's queue-scheduler and exclusive real-time access to 2-metre and 0.4-metre telescopes in both Hawai'i and Australia. This access is for educational users, predominantly in the UK and Ireland, but also including educators and schools from other parts of the World.

FTP also provides resources (http://resources.faulkes-telescope.com/) with suggestions on suitable targets, when they are visible, how to analyse the data and access the data archive.

The National Schools' Observatory (NSO, http://www.schoolsobservatory.org.uk/), allows observing on the 2-metre Liverpool Telescope (LT). The LT is based at the Instituto de Astrofísica de Canarias (IAC) at Observatorio del Roque de los Muchachos on La Palma in the Canary Islands, Spain. The LT features a broader range of instrumentation than FTN/FTS and is run by the Astrophysics Research Institute (ARI) at Liverpool John Moores University.

Established in 2004, the NSO provides schools in the UK and Ireland with access to the Liverpool Telescope through a guided observing system, using 10% of the LT's time. Its website contains astronomy-related content, news and learning activities. With over 4,000 users, the NSO allows non-UK/Ireland based schools and teachers to register by granting free access to both the observing portal and resources.

The Activities

The first activity (http://www.schoolsobservatory.org.uk/discover/projects/clusters/main) was created in 2017. It allows students to learn about open clusters, the life cycle of stars and the Hertzsprung-Russell diagram as well as the technique of photometry. Including screenshots and screencasts, this activity teaches students how to analyse their data using Makali'i (https://makalii.mtk.nao.ac.jp/) and e.g., Microsoft Excel. They are then encouraged to upload their results in the form of a colour-magnitude diagram with the aim of encouraging them to discuss their findings with other students.

Students can choose between 28 datasets (Bessel- B and -V images from FTP) but it is also possible for students to perform their own observations of an open cluster of their choice with FTP or NSO. There is also the opportunity here to use the FLOYDS (FTN/FTS) or SPRAT (LT) spectrographs to follow-up any object of interest, such as outlier supergiant stars or those stars which appear to be very red or blue. A second activity (https://www.schoolsobservatory.org/discover/projects/exoplanets/main) focuses on population studies of exoplanets from the exoplanet.eu website. Students explore the properties of exoplanets (e.g. radius, mass, orbital period) and can search for any correlations between these properties. The activity includes information on selection effects, which in turn can lead to incorrect conclusions.

Finally, I present a third activity, which has been created as a crossover between IBSE and Citizen Science (https://www.schoolsobservatory.org/discover/projects/supernovae). It uses data collected by FTP from Type Ia supernovae as discovered by Gaia Alerts (http://gsaweb.ast.cam.ac.uk/alerts/alertsindex). Users are instructed on how to perform photometry using an online browser-based photometry tool called JS9. Using robotic telescopes, users can add additional data-points to the Hubble Plot, giving them ownership of their data and enabling them to measure the expansion rate and age of the Universe.

Advantages and Disadvantages of IBSE-type Activities

We believe students using these activities can gain an insight into the scientific process and the collaborative nature of science and in time, will go on to develop their own projects and make their own suggestions for extensions activities. We note that these projects require a level of background information and can present problems around software installation on different platforms and operating systems. Moreover, real data can introduce further obstacles over the sample datasets that we present in the activities.

We will create other IBSE-type resources and intend to base these resources on topics such as variable stars, black holes and spectroscopy. We hope we can encourage interested parties to contact us with feedback and suggestions on both current activities and future direction.

Co-creation 3.0: Taking the Development of Astronomy Education Resources to the Next Level in the Project Stargazing Live!

Speaker: Joanna Holt, IAU-OAE NAEC, Netherlands Research School for Astronomy (NOVA), The Netherlands

Collaborators: Joris Hanse (NOVA), Marieke Baan (NOVA, IAU-OAE NOC), Paul Groot and Steven Bloemen (Radboud University, Nijmegen, The Netherlands)

Traditionally, the majority of astronomy outreach and educational work has been undertaken by scientists with an interest in science communication. However, recent research has shown the importance of actively including teachers in designing and testing new educational materials. In this talk we will present a new project which takes co-creation to a new level. Stargazing Live! is a collaboration between the NOVA education and outreach group and the MeerLICHT and BlackGEM telescopes. It combines the expertise of 1) astronomy outreach and education professionals, 2) physics teachers and 3) scientists to create an exciting and innovative education package bringing semi-live telescope data into the classroom.

Talk link: https://youtu.be/ZTTCk0xoIxA

Introduction to the project Stargazing Live!

The Stargazing Live! project will bring semi-live data (e.g. from the previous night) from the MeerLICHT (www.meerlicht.org) and BlackGEM (www.blackgem.org) telescopes into the classroom. These small optical telescopes are designed to observe transients in the night sky and in the case of BlackGEM, to search for the optical counterparts of gravitational wave detections. Each night, the data is uploaded to Nijmegen where it is processed automatically.

This project aims to create a suite of educational resources suitable for upper secondary school physics students (16-18 yrs; pre-university education). The main product is a new interactive planetarium show for the NOVA network of mobile planetariums, which visit schools across the Netherlands. In addition to covering advanced topics in astrophysics linked to the scientific goals of the telescopes, the show will include real data projected onto the dome. The project will also develop complementary classroom activities, again using real data as much as possible. There will be a short activity suitable for an individual lesson and a more in-depth activity suitable for student projects. In addition, the project output has the following educational goals: 1) to be inspirational; 2) to be scientifically accurate and show-case cutting-edge research; 3) to be linked to the curriculum (knowledge & science skills) and 4) to be rigorously tested.

Co-creation of astronomy education resources

Traditionally, many educational resources and activities have been developed by astronomers with an interest in outreach. The goal is to create something fun and inspiring, or to promote the scientist's research area to a wider audience. However, the creation was often the focus with little structural testing in schools or feedback from teachers. Didactical tips for teachers or a link to the curriculum were rarely included. More recently, there has been a shift towards 'co-creation' whereby teachers are more involved in the development process, although the level of involvement of teachers is variable. Platforms such as `astroedu.org` have actively encouraged the involvement of teachers - publication on `astroedu.org` requires an activity to be tested in at least one classroom and all activities are 'peer-reviewed' whereby the content is checked by a teacher and a scientist.

Co-creation 3.0 in Stargazing Live!

We have chosen to title this work co-creation 3.0, due to our requirement to involve *three* key areas of expertise at all stages of our project: astronomy, communication/outreach and education. Our core team already includes a broad set of these skills with team members who are professional astronomers, astronomy communication and outreach professionals, a planetarium specialist and a former astronomer with formal education experience.

We will boost this expertise with input from physics teachers at all stages of our project, from a wide-scale survey and focus groups during the *pre-development phase*, to testing and feedback from teachers (including during a teacher training event) during the *main development phase* to extensive feedback and testing during the *post-development phase*. The post-development testing will last a full year.

Initial Teacher Feedback

Astronomers and astronomy education and outreach professionals are often in contact with one or more highly-engaged teachers. These teachers typically have a strong personal interest in astronomy and are often avid amateur astronomers. As such, this group of teachers often play a large (or main) role in providing advice and feedback regarding resources.

In our survey and focus groups we talked to a broader range of teachers and the results were not always what we were expecting. Highly-engaged teachers are typically keen to gain access to new results and insights, have activities based on real data and see the role of projects like Stargazing Live! to inspire their students. However, the majority of responses suggested that a strong link to the curriculum is the key and the main driver for teachers in deciding which activities to give to their students. Below is the summary of a few key differences.

- Topics: cutting-edge astronomy
  Activity size/length:
  - final year project (>20 hrs)
  - in-depth research with real data
  Quote: 'Leave the teaching to us, you inspire them with cutting-edge astronomy'.

- Topics: gravity & electromagnetic spectrum
  Activity size/length:
  - short (<30 min)
  - support curriculum
  Quote: 'My program is too full for activities which are only nice or inspiring, but if I think they will help my students do better in the exam, there is always time'.

Astronomy education resources should be created by *astronomy education and outreach professionals*, with significant input from both *astronomers* and *teachers*. The ideal development team will include expertise in all of these areas with further help coming from the engagement of a *broad group of teachers* in all (*pre-*, *main* and *post-*) *development* stages.

Astronomy Data Visualization with WorldWide Telescope and Glue

Speaker: Patricia Udomprasert, Center for Astrophysics | Harvard & Smithsonian, USA

Collaborators: Alyssa Goodman (CfA), Harry Houghton (CfA), Peter Williams (CfA, AAS), Jonathan Carifio (CfA), Nicholas Earl (University of Illinois Urbana-Champaign), Mary Dussault (CfA), Susan Sunbury (CfA), & Jonathan Foster (CfA)

We showcase astronomy curricula that engage learners with authentic data through the use of powerful open-source tools, WorldWide Telescope (WWT) and glue. WWT is a rich visualization environment that functions as a virtual telescope, allowing anyone to make use of real astronomical data to explore and understand the cosmos. WWT users navigate through 3-dimensional and 2-dimensional views of planets, stars, and galaxies, giving them a better mental model of our universe. Glue is a suite of modular tools for multi-dimensional linked-data exploration that allows users to visualize relationships within and among related datasets.

Talk link: https://youtu.be/vSWxw8dMjko

Data visualization with WWT:

In this presentation, we briefly present features in WWT that allow users to view astronomical images in a contextualized view of the night "sky." We provide information about three online interactives built using the WWT web engine and demonstrate usage of the Solar System Explorer interactive. Key features include being able to fly to any major object within a 3-D view of the solar system, scale the planet sizes to their "true" sizes or enlarge them, and speed up time to make solar system motions easier to visualize. WWT's open-source web engine allows the curriculum designer/developer to identify key views and features within WWT that we want the learner to focus their attention on, so we can provide a customized WWT experience targeted to those pedagogical goals. Links for the WWT resources are provided below.

Data visualization with glue and WWT:

We provide a brief overview of how glue is used to visualize data in a research context and how the Cosmic Data Stories team is bringing that functionality, along with WWT, to online interactives that will allow the public to practice data science skills. We share screenshots from the prototype Hubble Data Story and discuss highlights of this activity, which is intended for use in high school and introductory college level classrooms. Students will explore a sky view in WWT to select galaxies they wish to "observe," and will use spectra and imagery data from the Sloan Digital Sky Survey to measure their galaxies' velocities and distances (using a standard ruler technique). After completing measurements for about five galaxies, the students will visualize their velocity and distances in a scatter plot using glue and will fit a line to their data to obtain a value for the Hubble constant and age of the universe. They will then aggregate all the data from their class to obtain Hubble and age values using the larger data set. They will be able to view the distribution of age estimates from individual students who have used the Hubble Data Story and compare that with the distribution of age estimates from entire classes, which will be significantly narrower, to obtain an intuitive understanding of why using a larger data set can reduce random uncertainties in a measurement. Finally, students will view their results in conjunction with historical and modern science data, including Hubble's own 1929 Hubble plot, to see how their own measurements are contextualized within a broader scientific story. Links to glue and the CosmicDS website are provided.

WorldWide Telescope links:

- WorldWide Telescope: `worldwidetelescope.org`
- WWT Ambassadors Educational Resources: `wwtambassadors.org/educational-materials`
- WorldWide Telescope Interactives: `wwtambassadors.org/astronomy-interactives`
  Solar System Explorer: `https://wwtambassadors.org/solar-system-explorer`
  Star Life Cycle: `https://wwtambassadors.org/Life-Cycle-Of-Stars`
  Hubble Law & Big Bang: `https://wwtambassadors.org/Hubble-Big-Bang`
- GitHub repository for WWT Interactives: `http://github.com/wwt-ambassadors`

glue & Cosmic Data Stories links:

- glue: `glueviz.org`
- Cosmic Data Stories: `cosmicds.cfa.harvard.edu`

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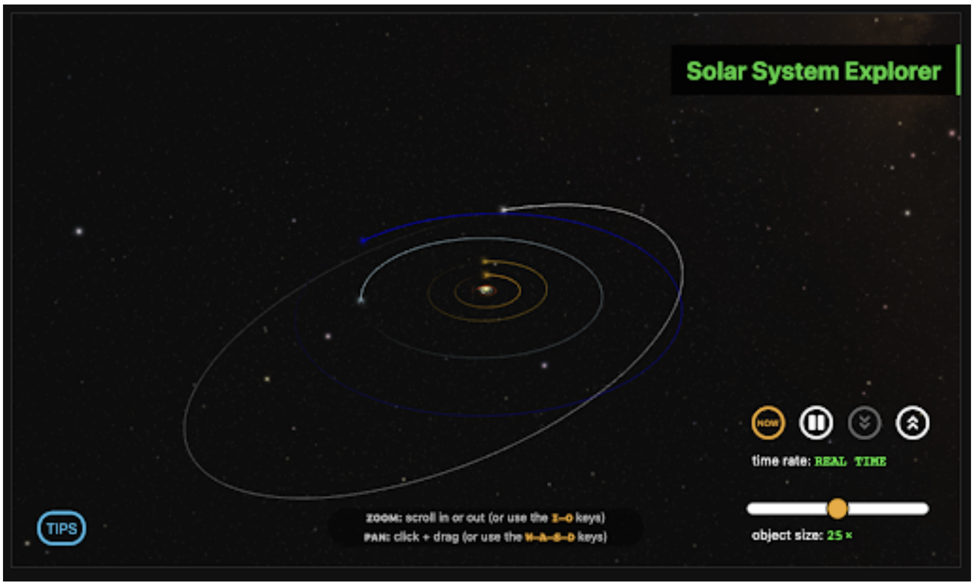
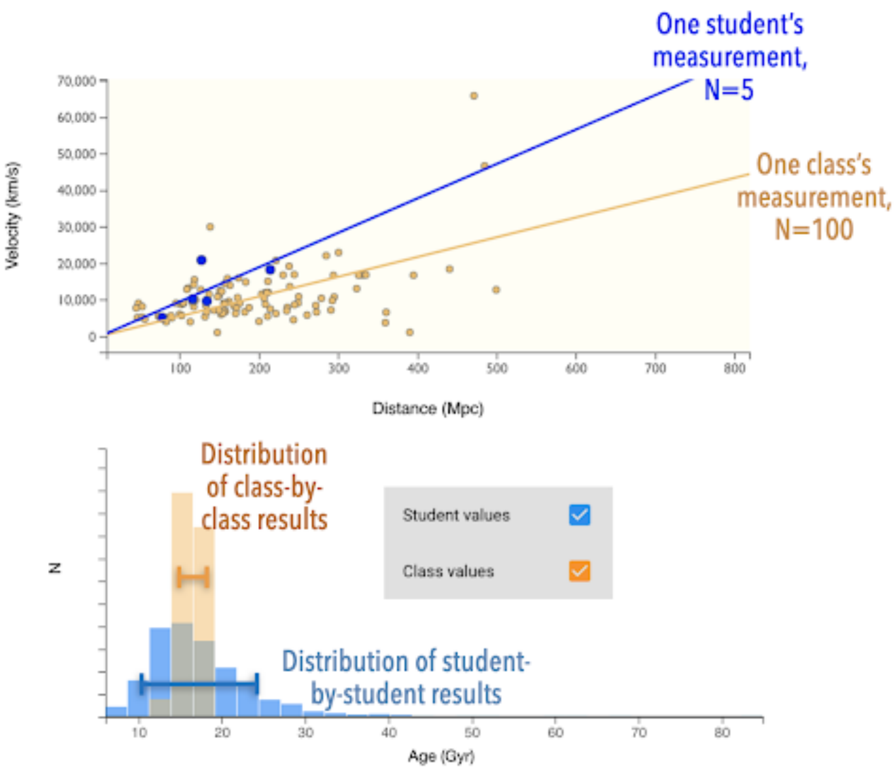


Screenshot from the WWT Solar System Explorer



Screenshot from the prototype Hubble Data Story

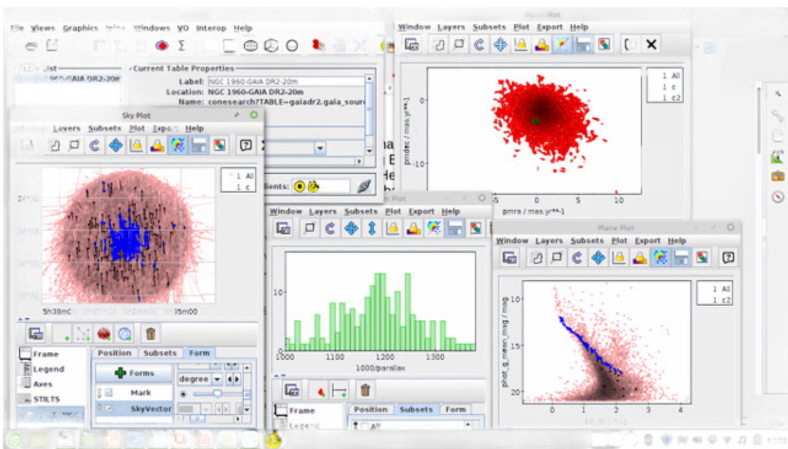
GaiaDemos@School

Presenter: Priya Hasan, Maulana Azad National Urdu University, Hyderabad, India

Gaia with its unprecedented accuracy has revolutionised our understanding of the Milky Way. It not only provides a three dimensional picture of our universe, but also shows its dynamic nature. Using tools like TopCat and ESASky, we can demonstrate the school students the power of Gaia and change misconceptions of students of a static never-changing universe. Data has the potential to convey and convince young inquisitive minds.

Poster link: `https://youtu.be/0dbEz0moadU`

Gaia is an ESA astrometric and photometric survey that studies a billion stars of our Galaxy. We shall study the importance of using Gaia data to study stars and their three-dimensional distribution in the galaxy. A constellation is a group of stars that appears to form a pattern or picture like Orion the Great Hunter, Leo the Lion, or Taurus the Bull. Constellations are easily recognizable patterns that help people orient themselves using the night sky. There are 88 recognised constellations. These stars may not be at the same distance and may not be gravitationally bound. We can demonstrate to students the association of stars in a constellation. We shall demonstrate the use of TopCat to download and plot Gaia data for the analysis of the star clusters. We can also use ESASky to help students visualize data.



References:

- Hasan P., Hasan S.N., Astronomy Data, Virtual Observatory and Education,arXiv:2104.10088
- Hasan P., Hasan S.N., Astronomy Education in Covid Times, arXiv:2104.06305

Connecting to Learn Together

Presenter: Carolina Escobar, Galileo Teacher Training Program, Colombia

Our approach is educational, targeting mainly elementary, middle and high school teachers and members of astronomy communities as well, who wish to expand their knowledge and skills through the Project Based Learning methodology, using the robotic telescope network of Las Cumbres Observatory as well as free use resources during our workshops. Participants provide input from their experience, actively participate in the observations programming and analyze the obtained results, which empowers them during the workshop by applying the knowledge acquired. This motivates them to apply the knowledge acquired in their classrooms, showing their students that doing science has a deep relationship with their personal learning.

Poster link: https://astro4edu.org/siw/p38

Helios is an initiative of the Galileo Teacher Training Program and started its operation in early 2018.

Helios conducts face-to-face and virtual outreach activities focused on teachers, astronomy associations and for the general public, because it is aligned with the United Nations Millennium Development Goals such as reducing the knowledge gap and increasing the participation and inclusion of women.

Helios GTTP group has been a member of the LCO's Global Sky Partner program since 2019, when the proposal Study of Transient Phenomena in Solar Stars was presented, to develop workshops with PBL (Project-Based Learning) methodology focused on teachers and people interested in astronomy, so that these in turn, can transmit the knowledge to their students and thus increase interest in astronomy. With its admission to the Global Sky Partner program in 2019, Helios GTTP was the first Colombian group to participate in the Global Sky Partners program of Las Cumbres Observatory (LCO).

HELIOS GTTP has also participated in national and international conferences where the advances and results of the workshops are presented, and in this way has achieved such an interest in these Project-Based Learning workshops that some of its participants have applied to the LCO Global Sky Partners with their own projects. To date, Helios GTTP has made 438 observations using the robotic telescope network during its workshops. The direct and indirect audience of its workshops and outreach activities is more than 150 people.

We have contacted the Office of Astronomy for Education in Colombia, the Global Office of Astronomy for Development and the Office of Astronomy for Development in North America, who have been informed of the intention to expand HELIOS GTTP coverage to impact the Spanish-speaking community. We are working towards constructing a network that will help achieve the desired vision for HELIOS GTTP.

Discussion summary

We were joined by our speakers for two live discussion panels. One important topic that was discussed was how much context to include in an activity. What information should be included to give students the right amount of knowledge to carry out an activity and what unnecessary, possibly confusing information to exclude. This section of the discussion also touched on how best to curate datasets so that students are able to carry out their activities without getting lost. This discussion also included how linked visualizations can be used to bring in extra information both to allow students to explore the data more, or to counteract misconceptions.

The panel also discussed how to build activities to match curricula. This can often be a problem as curricula can change within and between countries. The panel discussed how activities can be based on common elements found across curricula.

The panel also discussed the importance of working with a wide range of teachers to learn what sort of activities would be most useful in the classroom.

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