

Tools of the Trade

Suggested Grade Level(s): 9-12

Estimated class time: 2-3 class periods (depending on how much research time is given in-class, and length of time given to each student/group for presentations to the class)

Summary

This activity allows students to gain a more authentic understanding of the process astronomers follow when they seek funding to construct and launch a new observatory. Students play the role of an astronomer (or team of astronomers if the activity is assigned to a group) who is trying to answer a question that cannot be answered with existing data. Obtaining the data requires the use of an instrument that *does not exist*. The student astronomer will research an existing or recently proposed observatory to learn: the question(s) that astronomers hope to answer with data it collects, the instruments housed in the observatory and what each does, the cost to construct and launch, the orbit characteristics and power source for space-based observatories. Using this information, the student will develop a proposal that will be presented to the class. The class controls funding and will decide if they feel the project is well defended and worthy of funding.

Objectives

- Students will understand the process used by astronomers to design, construct, launch, and fund an observatory.
- Students will understand the relationship between advances in technology and improved understanding of the universe.
- Students will discuss the type of data their observatory collects and the question(s) it can provide the answer(s) to.
- Students will provide a persuasive argument in support of their project.

National Standards

National Science Standards

- NS.9-12.1 SCIENCE AS INQUIRY
As a result of activities in grades 9-12, all students should develop
 - Abilities necessary to do scientific inquiry
 - Understandings about scientific inquiry
- NS.9-12.4 EARTH AND SPACE SCIENCE
As a result of their activities in grades 9-12, all students should develop an understanding of
 - Origin and evolution of the universe
- NS.9-12.5 SCIENCE AND TECHNOLOGY
As a result of activities in grades 9-12, all students should develop
 - Abilities of technological design
 - Understandings about science and technology

- **NS.9-12.7 HISTORY AND NATURE OF SCIENCE**
As a result of activities in grades 9-12, all students should develop understanding of
 - Science as a human endeavor
 - Nature of scientific knowledge
 - Historical perspectives

National Language Arts Standards

(From the National Counsel of Teachers of English)

- **NL-ENG.K-12.7 EVALUATING DATA**
Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and non-print texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience.
- **NL-ENG.K-12.8 DEVELOPING RESEARCH SKILLS**
Students use a variety of technological and information resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.

Knowledge Prerequisite

Students must have a solid understanding of the Electromagnetic (EM) Spectrum. They should know that different forms of radiation provide different types of information about objects in space. It is also important that they have a clear understanding of the limitations of Earth-based observatories as well as the limitations of space-based telescopes (weight, volume, damage from high energy radiation).

Teacher Background

This activity is designed to challenge students to find relevant, meaningful, and correct information about observatories that have been constructed and placed in service over the past twenty years. Some of the information they find will be quite technical and for that reason, not particularly useful. You will need to monitor the research phase closely to ensure they are only using information they understand and to encourage them to extend their research to answer any and all residual questions.

Students may need coaching to polish their presentation skills.

Materials

- Students will need access to the school library and/or the internet to conduct research.
- A projection system for student PowerPoint or video presentations.

Procedure:

I. Engagement

Ask students if they are planning on asking their parents for a car sometime in the future. After they have responded, you will demonstrate “how not to ask parents for a car.”

Ask the students to play the role of a parent and you (the teacher) will play the role of the petulant teenager. Walk into the classroom with your arms folded, scowl a bit for effect, and then make the following demand to your “parents” ...“*you need to give me a car.*”

Have the students discuss why this is probably not a good approach and then encourage discussion, where they will bring up all the important reasons why it is in the parents’ best interests to give the teenager the car. Point out to the students that they have just modeled the type of persuasive argument astronomers must engage in when they require funding for a new observatory.

II. Exploration/Explanation

In this phase, students will collect information about observatories that are presently in operation or which are scheduled for launch in the future.

1. Explain to students that they are taking on the role of a young, passionate astronomer who is trying to answer an important question. The astronomer is frustrated because a specialized observatory is needed to answer the question. Either a new observatory is needed to collect the data, or funding must be continued for an existing observatory and it is the astronomer’s job to develop a proposal to receive funding to design, construct and launch this new observatory, or to keep an existing observatory in operation.

(Clarify that they will simulate the actions of real astronomers who are responsible for the design, construction and launch of new observatories, or the continued operation of existing ones.)

2. Students should select an observatory, or they may be assigned. The following is a suggested list of observatories they may select from:

EXISTING

- Hubble Space Telescope
- Chandra X-Ray Observatory
- Spitzer Space Telescope
- SWIFT
- HESSI
- ACE
- Wilkinson Microwave Anisotropy Probe (WMAP)
- Fermi Gamma-ray Space Telescope

PROPOSED

- SNAP
- ADEPT
- Destiny
- International X-ray Observatory (IXO)
- Laser Interferometer Space Antenna (LISA)

3. Schedule time in the library or a computer lab for students to discover the following about their observatory.
 - A. What important question or questions will be answered using data obtained by this observatory?
 - B. What instruments will be used on the observatory? What type of data will each instrument collect? What part(s) of the EM spectrum will be collected and studied?
 - C. The characteristics of the orbit of the observatory
 - D. Power source for the observatory
 - E. The cost to design, construct, and launch the observatory.

If the costs for each of these categories can be found, students should report them individually, otherwise a total cost may be given. If an existing observatory is selected, students should also research the annual cost to keep the observatory in operation.

Students may have some difficulty finding cost information. If not found, they should still provide all other required information and present their proposal.

4. Students will use this information to create a proposal designed to:
 - educate the class about the properties of the observatory and the cost, and the question that will be answered with data collected.
 - persuade the class to authorize and fund their observatory.

Students should create a technology-based product (PowerPoint™ or video or podcast) to use in their presentation to the class.

III. Evaluation

Have students present their proposal to the class. The teacher will score the presentation with one rubric that evaluates the accuracy and completeness of the information (see suggested rubric below), the quality of the visual product and the persuasive quality of the presentation.

Students will also score the persuasive quality of the presentations on a separate rubric. The student scores will be combined with the teacher's score to derive a final score.

Optional

When all students have presented, explain to the class that we can't afford to keep all of the existing observatories in operation and build all the new ones. In fact we can only afford to fund a total of six (or we can only afford to fund \$1 billion in new missions). Using their rubrics for each presentation, have students write a brief essay explaining which six they feel should be funded and clearly state why they selected each one.

SCORING RUBRIC – For use by Teacher

	Excellent	Good	Fair	Poor
Question(s) to be answered	The question or questions are clearly stated in language the student and class can recognize and understand.	A general idea of the question(s) is presented, but language used is somewhat technical or too vague for good clarity.	Questions are not complete or clear. Language used is too technical or vague for clarity.	Question is not presented or is so technical, vague or confusing as to be meaningless.
Instrumentation	All instruments on the observatory are accurately identified and their operation/function is clearly explained.	Most of the instruments on the observatory are accurately identified and a good attempt is made to explain their operation and function.	Some of the instruments are identified but minimal attempt is made to explain their operation and function.	Some instruments are inaccurately identified, no attempt is made to explain their operation or function.
Data/EM spectrum to be collected	All forms of data to be collected are given and their relevance to the question is discussed.	Most forms of data to be collected are given, and some attempt is made to discuss their relevance to the question.	Most forms of data to be collected are given. No attempt is made to discuss their relevance to the question.	Inaccurate and/or incomplete information about the data is given. No attempt is made to discuss relevance to the question.
Orbit Characteristics	The properties of the observatory's orbit are explained in clear language that the student and class can recognize and understand. A quality graphic is also used to present this information.	The properties of the observatory's orbit are explained, but language used is somewhat technical or too vague for good clarity. A graphic is also used to present this information.	Properties of the observatory's orbit are explained in confusing or unclear language. An irrelevant graphic or no graphic is used.	Properties of the observatory's orbit are not explained, or a graphic is not used.
Power Source	The power source is accurately identified and a clear explanation of how it works is given.	The power source is accurately identified. Some attempt is made to explain how it works, but language is somewhat technical or too vague.	The power source is accurately identified. No attempt is made to explain how it works.	The power source is identified incorrectly. No attempt is made to explain how it works.

Costs	A detailed explanation of costs is given. For existing units, this includes: design, construction, launch costs in addition to yearly operational costs. Proposed units do not need to include yearly operational costs.	Most costs are clearly and accurately identified.	Most costs are clearly identified, but some are not accurate.	Few costs are identified, and/or many are not accurate.
Persuasive Argument	A solid argument is given that demonstrates how the data collected will be used to answer the question(s). The benefit of having the question(s) answered will also be clearly explained. If other advances could depend on this new knowledge, they should be presented	A good attempt is made to show how the data collected will be used to answer the question(s) and to discuss the benefit of having the question(s) answered.	An attempt is made to show how the data collected will be used to answer the question(s), but the explanation is overly technical and/or too vague to have much meaning for the student and the audience. Minimal discussion of the benefit of answering the question(s) is presented.	Minimal attempt to show how the data collected will be used to answer the question(s) and the explanation is so technical or vague as to be meaningless to the student and the audience. No or little discussion of the benefit of answering the question(s) is apparent.
Presentation Product	The product is highly effective and appropriate. Graphics and text are clear, links are functional and supportive. Sophistication is evident in the design of the presentation, and excessive or irrelevant animation and sound is avoided. No more than two mechanical errors (spelling, grammar, etc.).	The product is effective and appropriate. Graphics and text are generally clear, links are functional and supportive. Modest sophistication is evident in the design of the presentation, and limited irrelevant animation and sound is used. No more than five mechanical errors.	The product is marginally effective and appropriate. Graphics and text are difficult to see or follow, and some links do not function or the relevance is unclear. The design is inconsistent and there is excessive use of sound effect and animation. In excess of five mechanical errors.	The product is more distracting than supportive. Graphics and texts are very difficult to see or follow, some links do not function and the relevance of those that do is unclear. Design is unclear and distracting and there is excessive use of sound effect and animation. Little attention to mechanics is evident.
TOTAL SCORE				