ASTRONOMY EDUCATION in U.S. SECONDARY SCHOOLS: CURRENT STATUS and CONCERNS vs. the BROADNESS and EFFECTIVENESS of BEST PRACTICES

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Overview

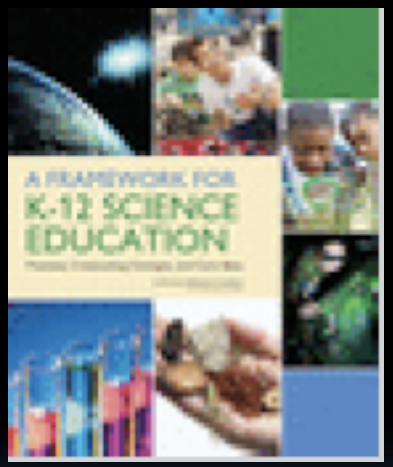
- Motivation
- An Impending Reformation of Science Standards in the U.S.
- Current Status and Concerns of High School Astronomy Courses in the U.S.
- Changes Needed Across the Curriculum
- Why Should Astronomy Continue to be Taught in High School?
- How can we retain or increase the number of astronomy courses given?
- Discussion

Motivation

- In the next year, Greece's Ministry of Education is planning a reformation of the secondary education (for the Lyceum) and the way that students will enter universities.
- This will affect the subjects taught in school, including the subject of astronomy.

Similarly in the United States...

- Common Core State Standards Initiative; state-led effort by the National Governors Association Center for Best Practices and the Council of Chief State School Officers; developed to prepare children for college & the workforce; June 2010
  - does not include astronomy at high school levels
- Conceptual Framework for the New K-12 Science Education Standards; National Research Council; Aug 2011
  - includes astronomy at high school levels through "Earth & Space Science"



Reasons for New Conceptual Framework

- Science education in the U.S. is not guided by a common vision of what students finishing high school should know and be able to do.
- Standards are long lists of detailed & disconnected facts.
- Standards leave students with fragments of knowledge; little sense of the inherent logic and consistency of science and of its universality.
- The current approach doesn't require students to engage in the practices of science and engineering to understand science.
- New knowledge in both the sciences and the teaching and learning of science in the past 15 years.

U.S. Science Education to be Built Around 3 Major Dimensions

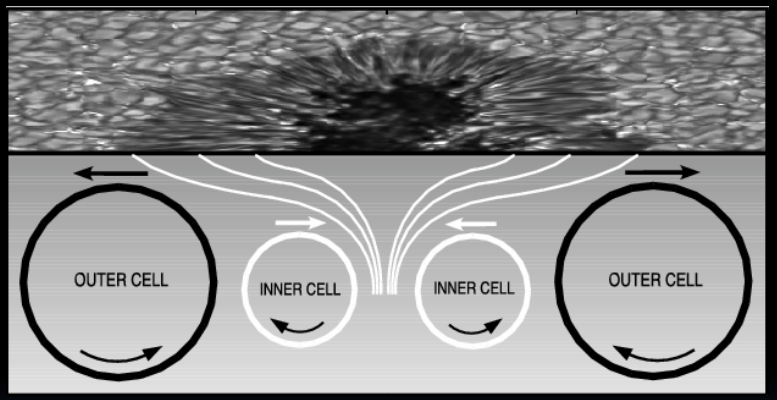
- Scientific and engineering practices
- Crosscutting concepts that unify the study of science and engineering through their common application across fields
- Core ideas in four disciplinary areas:
  - physical sciences
  - life sciences
  - earth and space sciences
  - engineering, technology, and the applications of science.
- *http://www7.nationalacademies.org/bose/Frameworks_Report_Brief.pdf*
- *http://www.nap.edu/catalog.php?record_id=13165*

Scientific and Engineering Practices

1. Asking questions & defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics, information and computer technology, and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Crosscutting Concepts

1. Patterns
2. Cause and effect: mechanism and explanation
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter: flows, cycles, and conservation
6. Structure and function
7. Stability and change



Large-Scale Convective Cells
Bovelet & Wiehr (2003)

Core and Component Ideas in Earth and Space Sciences

- Core Idea ESS1: Earth's Place in the Universe
  - ESS1.A: The Universe and Its Stars
  - ESS1.B: Earth and the Solar System
  - ESS1.C: The History of Planet Earth
- Core Idea ESS2: Earth's Systems
  - ESS2.A: Earth Materials and Systems
  - ESS2.B: Plate Tectonics and Large-Scale System Interactions
  - ESS2.C: The Roles of Water in Earth's Surface Processes
  - ESS2.D: Weather and Climate
  - ESS2.E: Biogeology
- Core Idea ESS3: Earth and Human Activity
  - ESS3.A: Natural Resources
  - ESS3.B: Natural Hazards
  - ESS3.C: Human Impacts on Earth Systems
  - ESS3.D: Global Climate Change

Earth & Space Sciences

- Earth and space sciences is interdisciplinary in nature and interweaves astrophysics, geophysics, geochemistry, and geobiology.
- The first core idea, ESS1: Earth's Place in the Universe, describes the universe as a whole and addresses its grand scale in both space and time.
- This idea includes the overall structure, composition, and history of the universe, the forces and processes by which the solar system operates, and Earth's planetary history.

Changes needed across the U.S. K-12 science education system

- For the successful implementation of the framework and related standards,
  - curriculum
  - instruction
  - teacher preparation and professional development
  - and student assessment.

  must also align with the framework's vision.

Curriculum & Assessment

- Curriculum developers will need to design K-12 science curricula based on research and on learning progressions across grade levels that incorporate the framework's 3 dimensions.
- Assessment developers will need to develop creative, valid, and reliable ways of gathering evidence about students' progress across the domains and grade levels.
- Those who make and implement policies (professional development for state-level science supervisors, school boards, district-level leaders, principals, and curriculum specialists) will need to be "on-board".

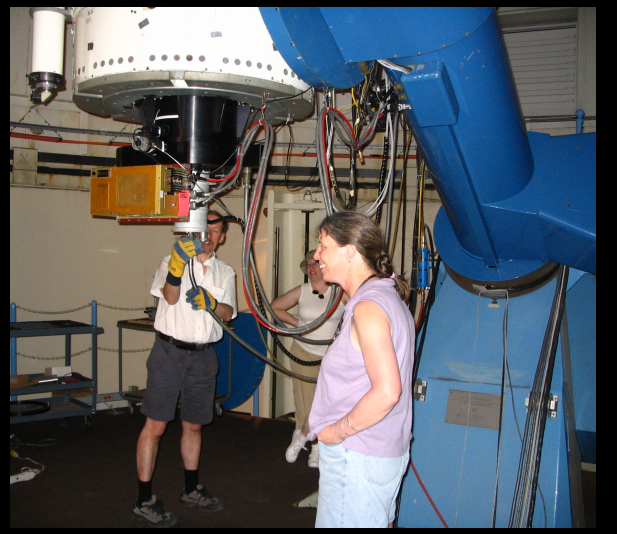
Teacher preparation programs and professional development programs will need to

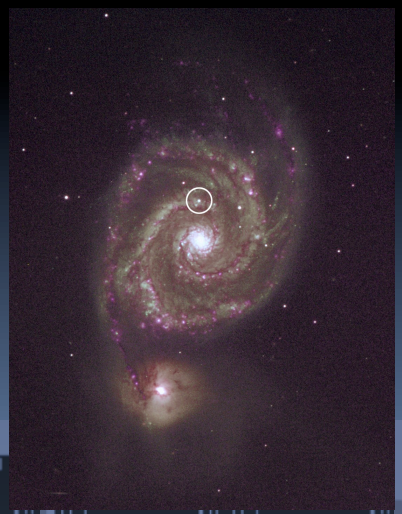
- Provide learning opportunities for teachers in order to deepen their conceptual understanding
- Engage in scientific and engineering practices
- Develop an appreciation of science as a way of knowing
- Enhance teachers' skills in investigating students' ideas, selecting effective teaching practices, assessing students' progress, & developing classroom communities & discourses

College science departments will need to attend to the needs of prospective science teachers.

Astronomy Research-Based Science Education

- Epitomized best practices as a teacher enhancement program designed to bring active astronomical research into the classroom
- The program focused on the acquisition of astronomical data & knowledge and the use of appropriate data reduction skills and computer skills to enable the teachers to lead true research projects.
- Over 160 teachers over 12 years; 90 teachers still actively using the data in classroom for student research.





Astronomy Research-Based Science Education (A-RBSE)

- A 12-week distance learning course covering astronomy content, research, mentoring and leadership
- A two-week summer workshop with 4 nights on Kitt Peak observing with 4 different telescopes
- Each research group presents their results on the final day of the workshop

- More observing opportunities for students and teachers on Kitt Peak, Arizona and remotely from an observatory in New Mexico
- To reach a wider audience, data for the research projects were put on-line
- Opportunities to submit research articles to the project's journal
- Travel to the National Science Teachers Association conference

Example: the last year: 2008

- 18 teachers (of 60) were accepted (very competitive)
- a challenging 12-week online class that included lessons in image processing, spectroscopy, and basic astronomy
- A 10-day workshop held in June included four nights observing on Kitt Peak with the 2.1-meter, the Coudé Feed, the 0.9-meter, and the McMath-Pierce Solar Telescope.

- Research projects to bring back to schools: novae searches, membership of open clusters, spectroscopy of variable stars, identification of AGNs, and measuring solar magnetic fields strengths.
- Documentation and data sets available
- RBSE students won honors at several science fairs (regional & national).
- A student from Oil City High School, PA won 2nd place in the Physics and Astronomy Division, the AAS/ASP Pricilla and Bart Bok Award, & second place at the INTEL International Science & Engineering Fair.

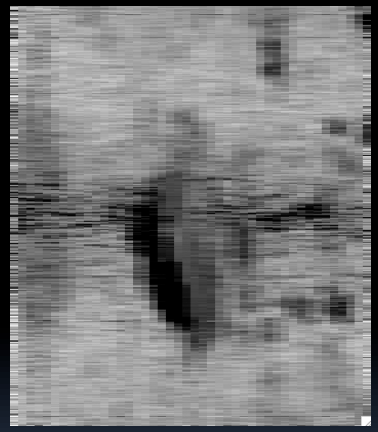
Some RBSE Journal Papers

The Correlation Between Sunspots and Solar Flare
2 Students at Graves County High School, Mayfield, KY (*V. Dowdy)*

Association of Solar Magnetic Field Strength Variation with Sunspot Area
3 Students at Lincoln High School, Stockton, CA (*B. Sepulveda)*

Effect of Sunspot Size & Latitude on Magnetic Field Strength in Sunspots
2 Students at Linwood Holton Governor's School (*S. Rapp)*

Horizontal Evershed Flow Velocities Of Ni I And Fe I Within Sunspots
2 Students at Belmont High School, Belmont, New Hampshire (*T. Morin)*

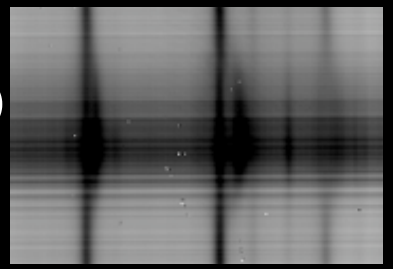


Magnetogram
7 Dec 2006

Some RBSE Journal Papers

Active Longitudes
3 Students at Cranston High School East, Cranston, RI (*H. Chun)*

Sunspot Area vs. X-Ray Intensity
11 Students at Lincoln High School, Stockton, CA (*B. Sepulveda*)



Magnetic Field Strength Comparisons Between Lone Sunspots and Clustered Sunspots Of Similar Size
3 Students at Cornerstone Community Christian School, Kelso, WA *(D. Young)*

Magnetic Field Variations Across Solar Active Region AR 396
J. Myers, Warren Central High School, Bowling Green, KY
I. Merriot, Abaetern Academy, Bozeman, MT
M. Stuart, Bozeman High School, Bozeman, MT
K. van Klaveren, Golden West Middle School, Fairfield, CA
D. Young, Cornerstone Community Christian School, Kelso, WA

Spitzer & WISE Research Program for Students and Teachers

- NASA-funded programs built on the RBSE program
- Spitzer teachers wrote research proposals w/ scientists.
- They presented their results at the January 2009 AAS meeting
- They provided professional development other teachers in their district or state.
- In just a 2 years, 32 teachers received training, participated in research projects with over 1400 students participating, & presented posters at AAS meetings on science results from their observations.

Current Status and Concerns of High School Astronomy Courses in the U.S.

- There are some good programs like RBSE for in-service teachers, but only address a few.
- Currently there is not enough pre-service preparation in astronomy.
- How well a teacher is prepared (pre-service or in-service) to teach any subject has a bearing on whether or not the course is successful (especially in student outcome).
- There is no teacher certification program in teaching astronomy.

Current Status and Concerns of High School Astronomy Courses in the U.S.

- Astronomy courses do not hold a prominent place in the U.S. education system.
- Over a century ago, astronomy was often required, as in many European countries today. Every educated person expected to know.
- Now, created by an interested teacher or by an administrator perceiving it as an easier or more advanced science elective.
- A half-year survey of the universe
- Standards for astronomy courses are often not planned or required.

Current Status and Concerns of High School Astronomy Courses in the U.S.

- 2500 with regular sized astronomy classes in the U.S
- 12-13% of all schools
- 3% of all students (80,000 ± ~3000).
- 35% of all students take physics; 60% of all students take chemistry; more than 90% take biology.
- Class sizes steady since the 1980s; may be starting to decrease because of influences like "No Child Left Behind" (NCLB).
- Schools with astronomy courses occur more in schools with an Adequate Yearly Progress (AYP) status of Pass.

Current Status and Concerns of High School Astronomy Courses in the U.S.

- No Child Left Behind (NCLB) has caused teachers to teach to the test in math and language arts to pass the Adequate Yearly Progress (AYP).
- Until now science has not been included in the AYP analyses. That is supposed to change.
- Course cancellations and decreased enrollments in astronomy courses due to NCLB
  - Math and language courses draw away the students & teachers.
- Pressure to put students into the traditional science courses (biology, chemistry, physics) is also a factor.

Master Teachers Focus Group

First Name	Last Name
Eileen	Grzybowski
Natascha	Cox
Lara	Cross
Debbie	Soltis
Manju	Prakash
Jonathan	Bretan
Tom	Doyle
Peter	Guastella
Tom	Hyde
Adam	Keeton
Tony	Maranto
Peter	Pitman
David	Temple
Mit	Wanzer
John	Blackwell

Why Should Astronomy Continue to be Taught in High School?

1. Astronomy easily hooks students into science and inherently invokes passion.


M32


M101


M65


M109


M82


M51


Arp 282


NGC4565

Why Should Astronomy Continue to be Taught in High School?

"Isfahan Milky Way" by Mehdi Momenzadeh (www.photographyblog.ir). The 2nd winner of Against the Lights category in the 2011 International Earth and Sky Photo Contest. The arc of the Milky Way rises above central Iran, and it is faded away in the north east by light of the historic city of Isfahan. Date: 2010 April 14

Simply viewing the Milky Way galaxy in which a thousand stars can be seen invokes an awe that leads to an interest that leads to questions that lead to awareness and understanding.

Why Should Astronomy Continue to be Taught in High School?

2. Astronomy is the oldest of sciences with much of its initial development credited to Ancient Greece.
3. Astronomy encompasses one of the newest sciences as it is always changing through new discoveries and advancements.

"Astronomy is the most fundamental science of them all. From the time of the earliest humans we have been looking to the night sky with curiosity. Now that we have the technology to answer many of the questions our ancestors asked, it would be a shame to stop wondering. At its heart, Astronomy is about who we are, how we came to be, and where our place in the universe lies. The sense of wonder it engenders is one of a kind."

--- Teacher at a school in Connecticut, USA

Why Should Astronomy Continue to be Taught in High School?

4. Astronomy is the one science that people experience on a daily basis: seasons, day/night, lunar phases, ties present to past, etc. It has explanations for the world around us.

Why Should Astronomy Continue to be Taught in High School?

5. Astronomy is the only science that encompasses most all of the other basic sciences (biology, chemistry, physics, geology, etc.), as well as mathematics, engineering and technology.

   Upon seeing how these sciences are related, students gain a better intuitive grasp of the physical and biological sciences.

   The mere learning of facts cannot provide intuition; that is something that is learned by understanding the relationship between facts.

Why Should Astronomy Continue to be Taught in High School?

6. Astronomy improves student's skills in math, reading, note taking, belief systems versus evidence. It teaches very useful skills to students (e.g., cognition, graphing, algebra, 3D thinking, building on prior knowledge, making inferences, team work, presentation skills, etc).

Why Should Astronomy Continue to be Taught in High School?

7. Astronomy is one of the few sciences where students can make a real difference.

   Students have made discoveries through research and have had those discoveries published in professional astronomical journals (e.g. AAVSO, RBSE, AAS) and recognized.

Why Should Astronomy Continue to be Taught in High School?

8. Astronomy is one of the easiest, most accessible and most inexpensive science courses to teach hands-on, minds-on research (e.g., remote observing on-line through free programs already set-up).

Fig. 2: Images of the asteroid Psyche, taken with the remote controlled telescope at New Mexico skies. Students will be able to measure brightness, colors ...

Why Should Astronomy Continue to be Taught in High School?

9. Astronomy teacher professional development programs (especially research TPDs) model for students that teachers are lifelong learners.

Why Should Astronomy Continue to be Taught in High School?

10. In countries that need more engineers and scientists to maintain or improve its internal and international status, more courses like astronomy are needed, which embody science and engineering.

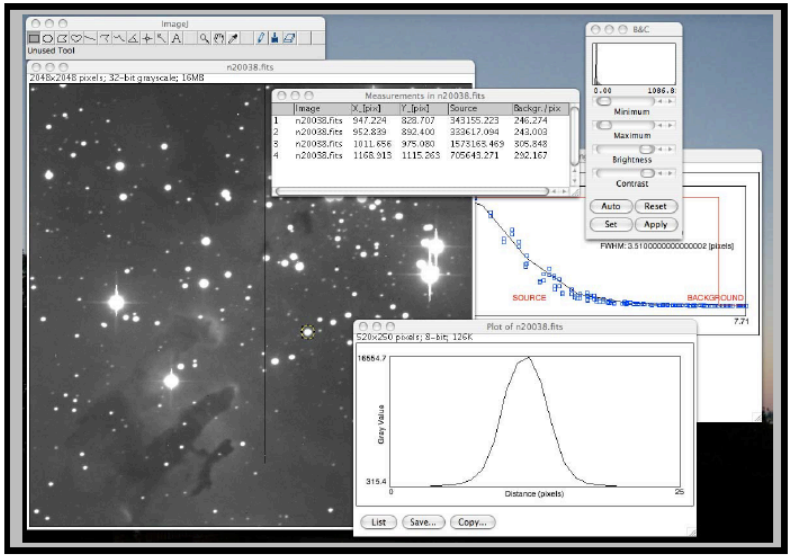


Fig.1: A screen shot of ImageJ, an image processing program available by download, used to analyze an image of a star cluster M16, the "Pillars of Creation" taken at Kitt Peak by teachers in the RBSE program

Why Should Astronomy Continue to be Taught in High School?

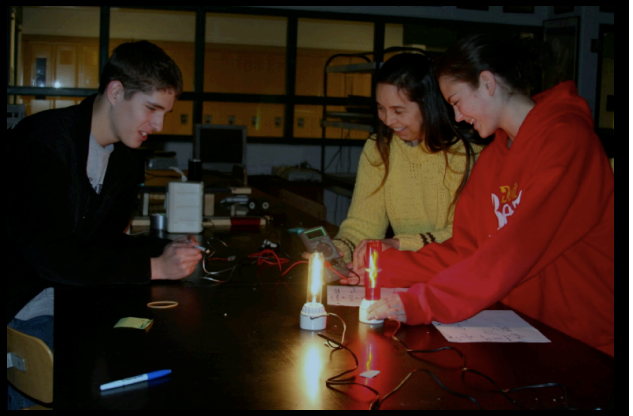
Themes Teachers Use to Defend the Course

Theme Responses	Number	Percentage of
Defending with the nature of the course	137	32
Defending with effects on students	88	21
Defending with cultural linkages	78	19
Helps improves students, school, AYP	54	13
Defend with traits of science	24	6
Institutional benefits	22	5
Other	25	6

Krumenaker, L., (2008). *The Status and Makeup of the U.S. High School Course in Astronomy in the Era of No Child Left Behind. Unpublished doctoral dissertation., University of Georgia, Athens.*

How can we retain or increase the number of astronomy courses given?

- To succeed, a course must have
  - the support of the administration
  - the fulfillment of science standards,
  - the dedication of teachers and
  - the interest of students.



- The following points are from the focus group discussion with the master teachers, as well as adapted from Krumenaker, Astronomy Education Review, 2010.

How can we retain or increase the number of astronomy courses given?

- Make astronomy important and acceptable to various groups (Federal- and State-level personnel, including both Department of Education officials and legislators at both levels as well as colleges officials).
- Grow the enrollment numbers if an astronomy course like the Advanced Placement course in the U.S was created. Municipalities may then start requiring astronomy.
- Acquire more teachers and more help for teachers (e.g., course supplies, professional development workshops, preparation for teaching astronomy and certification). A more secure foundation for the teachers translates into a better education in astronomy for students.

How can we retain or increase the number of astronomy courses given?

- Get more collaborations with colleges, more technology support, and more astronomy on exams and in the standards; improve the prior science and astronomy knowledge of students before entering high school.
- Include opportunities to collaborate with other institutions that have learning opportunities outside of the school (e.g., planetariums, museums, astronomical societies)
- Collaborate with astronomical educational programs between schools in your country and with other countries (e.g., Global Hands-on-Universe), especially those that offer research for students.

Summary

- The effectiveness of the newly proposed Conceptual Framework for the New K-12 Science Education Standards will be determined in the next few years.
- Presented the summary of this program, along with a discussion on the
  - Current Status & Concerns of High School Astronomy Courses in the U.S.
  - Changes Needed Across the Curriculum
  - Why Should Astronomy Continue to be Taught in High School?
  - How can we retain or increase the number of astronomy courses given?

  in hopes that it might benefit planning for the changes to come in Greece.

Contact Information

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Interesting Phrases...

- A more secure foundation for the teachers translates into a better education in astronomy for students and a more enjoyable learning experience for all.
- Astronomy provides a common string on which pearls of knowledge from physical and life sciences can be strung.