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The AAS Education Newsletter June 2006, Issue 2

Setting Education Goals for the AAS Membership

Though the origin is unknown, I'm sure we've all heard the phrase (curse, blessing…), "may you live in interesting times." Today our national science research and space mission budgets are being slashed to critical levels, science education is crumbling in many classrooms due to the enormous pressure of unrelenting reading and arithmetic testing, and the public is loudly questioning the foundations of evolution as a science. Interesting times we live in, indeed.

In today's interesting times, an effective astronomy education effort has intangible values which can not be overstated. It is now clear that, on its own, brilliant research with aesthetic qualities appreciated by scientists and the informed public is wholly insufficient to motivate the voting public to demand increased funding for fundamental scientific research or for an increased emphasis for inquiry-based learning in schools from kindergarten through college. In fact, many of the most exciting scientific discoveries of the last two decades in astrobiology and evolution have been met with aggressive resistance from school boards. The larger scientific community should now realize that simply engaging in "cool science" in and of itself is insufficient to awe and inspire the general public on its own, let alone supply and maintain the pipeline of future scientists and engineers.

Fortunately, the members of the American Astronomical Society (AAS) are uniquely situated to increase both the quantity and quality of astronomy, astrobiology, and space science education efforts. At the most recent meeting of the AAS Astronomy Education Board (AEB), the board determined that, of the nearly countless aspects that could be done regarding the spectrum of education, public outreach, and scientific communication, the AAS membership should focus on five key ideas identified by the AEB mission statement. These are to promote and support: (1) training the next generation of astronomers to be successful scientific researchers; (2) training the next generation of astronomers to be successful educators; (3) research on the teaching and learning of astronomy; (4) increasing the scientific literacy of all and sharing the excitement of astronomy with the public; and (5) increasing the participation of underserved populations in astronomy. The AEB has started the long process of strategic planning for the AAS education program of the next three years. The board has not yet finalized or prioritized the specific objectives it would like to address in the near future.

Without question, each of these goals is much easier said than done. However, the AEB feels strongly that these goals, initially identified in its mission statement are still valid and are consistent with the overall mission of the AAS and that our AAS members in particular have knowledge, skills, resources, and inclination to work together to meet these goals. It is worth noting that the AEB intentionally separated the important educational activities of programs for researchers (professional astronomy research, research quality amateur and pro-am astronomy research, astronomy education research—activities that result in scholarly contributions to the refereed knowledgebase) and programs for education and public outreach for which learners are consumers. This distinction is made for the purposes of having distinct, and potentially measurable, objectives, strategies, and implementation activities. The AEB recognizes and applauds the many AAS members actively involved in integrating research and education.

The AAS already has a number of high quality programs in place to support and leverage the education efforts of its members. Examples of these include, workshops for new faculty, the digital library resources for teaching at www.compadre.org, the 20-30 yearly Shapely Lectures

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at small colleges and universities, the 2nd Century Lectures, print resources such as the AAS Career Brochure and the *Ancient Universe* booklet, the Astronomy Education Review, education sessions, dialogues, and workshops at national meetings, and of course, this *Spark Education Newsletter,* among many other important activities.

In upcoming months, the AEB will help refresh and revitalize the AAS membership to continue to expand its critical education efforts. The astronomical research community needs effective and efficient education programs now, perhaps more than ever before, and our society will support its members in providing tools, pathways, and forums for best practices and innovative approaches to extend the excitement of the astronomical enterprise to our constituents. The bottom line is that there are numerous pathways for members to have education impacts.

Tim Slater, University of Arizona, incoming AAS Education Officer

Education Updates from AAS Divisions & Committees

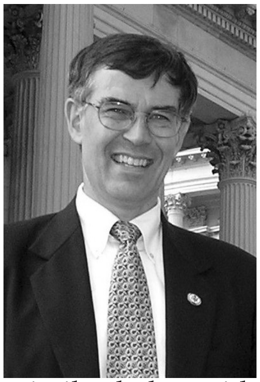
Solar Physics Division

The Solar Physics Division (SPD) has formally approved the creation of a standing Education and Public Outreach (E/PO) committee. An exploratory committee composed of various SPD members, was established and tasked with writing a proposal for such a committee including a charter and mission statement to help guide the founding E/PO committee members in the implementation of an SPD E/PO program. The final report, once formally approved, will be posted on the SPD website (http://spd.aas.org/navbar_edout.html)

Committee members: Emilie Drobnes (chair), David Alexander, Craig DeForest, Dave Dooling, Zoe Frank, Cheri Morrow, and Thomas Zurbuchen.

The chairs and education representatives of all AAS Divisions and Committees are invited to submit updates to the editors.

Science Education in the 21st Century



I am a member of the Sputnik generation. In 1957, when the world's first artificial satellite sailed over the United States, it signaled a warning: not only were the Soviets close by, but they had quietly, efficiently, and effectively passed the U.S. in terms of scientific innovation and dominance. Launching satellites meant they could launch ballistic missiles laden with nuclear weapons. The space race began in earnest, with America creating a new agency—NASA—to help focus our national effort to regain the technological initiative in the superpower contest. Underpinning that effort was a sweeping change in our nation's education system.

President Eisenhower declared the training of scientists and engineers to be a critical need for our nation. The National Defense Education Act (NDEA) passed quickly in 1958, and it paid for student loans, scholarships, and scientific equipment for public and private schools. The emphasis was on mathematics, science, and foreign languages.

While the Sputnik era achieved many successes, it also had its limitations. For example, it focused on engaging the "best and the brightest" rather than engaging all students. The result of decades of teaching only to the top ten percent is a society that does not appreciate, and too often even fears, science.

Another error of the NDEA is that it turned the focus from teacher-training and content mastery to a curriculum that was once referred to as "teacher proof" – if you had the best visuals (filmstrips at the time), an activity, and a book, even if the teacher was afraid of science, he or she could still do a good job with the resources available. Alan Friedman, Director of the New York Hall of Science, has pointed out that "A good teacher without any help will manage to do a good job. The real formula for a good science classroom is a well-trained, up-to-date teacher who's supplied with materials that kids can get their hands on."

Science does not stand still; science teacher training can't either.

Telescoping the laboratory-to-classroom pipeline will require practicing scientists to share the advances of their work with current teachers. In general, most scientific research grants have an education or an outreach requirement. To meet this requirement, scientists often craft a web site, write an article in a magazine, or mail materials of some kind to teachers to use in their classroom. Yet each of these activities fails to satisfy the needs of the group they are aimed to serve. The result? A gap between those doing science and those teaching it.

Teachers from pre-kindergarten through the twelfth grade need to have hands-on exposure, instruction, and experiences with the material and content in order to integrate the new material into a somewhat rigid curriculum. Local scientists must reach out to the school districts and the teachers near them to offer their time, energy, equipment, expertise, and enthusiasm to assist our teachers in getting kids excited enough about science to consider becoming a scientist themselves.

Teachers must also be current on the latest scientific research on how children learn. Current research shows that the perception of students as empty or partially full vessels needing to have the knowledge poured into their brains by a teacher is outdated. Students enter school with a working perception of the world, and the expectation of the teacher as distributor of information is replaced by the role of the teacher as guide. Students must discover new knowledge, with the teacher functioning as tutor when the new information is in conflict with a student's current world vision. In many ways, this is a far more prestigious and demanding concept of teaching. As an instructor, an immense amount of time is devoted to discovering where each student in the classroom rests with the current content, keeping in mind the required end goals of what knowledge, skills, and integrative concepts must be mastered to move to the next level—be that the next chapter, the next grade, or the next step in life. Constant personal feedback is required rather than simply notes and checkmarks on homework and papers.

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The Science of Astronomy Education Research

As an observational science, astronomy suffers limitations not encountered by other sciences. All we can do is **observe**—sure we have tools that give us different information but fundamentally we are not allowed to touch or control. As an example, consider an astronomy publication; "The Gemini Deep Deep Survey. I. Introduction to the Survey, Catalogs, and Composite Spectra" by Abraham et.al[1]. The Gemini Deep Deep Survey (GDDS) targets galaxies in the redshift interval between z=1 and z=2. For this publication, the **purpose** of the study was "to constrain the space density at high red shift of evolved high mass galaxies." This purpose guides not only the paper, but also the entire research agenda. Of course this scholarship includes a careful **literature review** to contextualize the research. There is also a clear discussion of how the **measurements** were taken including what checks and calibrations were completed to guarantee the **accuracy** and **precision** of the data. In this example, the Gemini Multi-Object Spectrograph was used to collect 309 spectra, but only 225 are considered secure. The next step in the process is to make **inferences** from the data. For the GDDS, the red shifts were categorized and explained, such as the 29% of the galaxies in the GDDS at 0.8 < z < 2 which are inferred to be young starbursts. As is the nature of any modern science, these results have undergone **peer review** to check the validity of the inference before dissemination. As an extra level of review, all the data from the GDDS are made available for the public. This access to the data would allow another scientist to **replicate** the analysis or even allow a **continuation** of the work.

The underlined terms in the above example are some of the key concepts and principles in conducting astronomy research. They are also the key concepts and principles for conducting Astronomy Education Research (AER). AER is a science and as a science it is bound by the same traditions and expectations of any other science. The purpose of this paper is to allow an interested astronomer or teacher to understand how the process of science occurs in AER specifically within its two broad traditions.

The 1970's brought an expansion of what qualified as education research. Gone were the days of treating students like factory workers or educational reform created and implemented by fiat. Advances in psychology and computer science encouraged educational researchers to understand learning and how students interacted with their newly gained knowledge. Researchers began to collect data to determine the impact of reform instead of relying on opinion. Given these profound changes, educational research bifurcated into two stable research traditions, each with unique philosophical traditions (which the pragmatists can ignore) and standards of research. The traditions are generally identified as **Quantitative** and **Qualitative** research, although there are subfields within each.

Quantitative research is predicated on the belief that there is an objective reality and it can be measured.

Quantitative research is probably the most familiar to scientists. Quantitative research is predicated on the belief that there is an objective reality and it can be measured. Examples include pretesting & post-testing, surveys, and quasi-controlled studies. Accuracy and precision are usually determined statistically and large numbers of students are involved in this research. It is common for inferences to be supported with statistical tests such as multiple regressions and ANOVA, although care must always be taken not to

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1. "The Gemini Deep Deep Survey. I. Introduction to the Survey, Catalogs, and Composite Spectra." R. G. Abraham, K. Glazebrook, P. J. Mccarthy, D. Crampton, R. Murowinski, I. Jørgensen, K. Roth, I. M. Hook, S. Savaglio, H-W Chen, R. O. Marzke and R. G. Carlberg. *The Astronomical Journal*, 127:2455-2483, 2004 May confuse correlation with causation. Before causation can be claimed, many replications of the study need to be performed. The most common use of quantitative research in AER is done with educational reform. Consider the work of Edward Prather and colleagues in assessing the effectiveness of Lecture-Tutorials in Astro101[2]. In this national study, a test of astronomy concepts was given early in the term (a pretest) and the same test is given again after the innovation was used (a post test). The students who had the innovation of Lecture-Tutorials scored significantly better on the post-test then they did on the same test before the innovation. Results such as these are useful because they demonstrate fairly convincingly that the innovation worked.

The purpose of such [qualitative research] is to understand the perspectives and experiences of the people involved in the study, which can include the perspectives of the researchers.

Qualitative research takes on a different approach than quantitative research. The qualitative researcher understands that an objective reality does not exist, but each person creates a perception of reality which is unique to him or her. Examples of tools used include think-aloud or critical interviews, case studies, and observations. The purpose of such research is to understand the perspectives and experiences of the people involved in the study, which can include the perspectives of the researchers. Typically, very few subjects are used, but the information collected tends to be very rich and deep. From this rich data, inferences are drawn which seem to account for the trends in the data. Accuracy and precision can be established by checking the inferences with the research subjects. And, consistent with the qualitative research philosophy, accuracy and precision cannot be strictly determined, but rather each user of the research alters their experiences and values based upon the material. It is extremely rare for qualitative research to make any broad laws or theories. Typically this research uncovers previously unknown issues or concerns in our classrooms, which are then further investigated. Pure qualitative research is rare in AER, but the work of Zeynep Gürel and Hatice Acar[3] has many of the elements. Gürel and Acar provide their students with open-ended questions to determine the perceptions of high school students and future teachers concerning weightlessness. After considering the data, the paper concludes that students have trouble with scale. Whether or not this conclusion would be every reader's conclusion is not important. Enough data is provided that any teacher could draw their own conclusion and apply it to their classroom. Qualitative research results open our minds to new possibilities.

This article was an introduction to the amazingly complex science of AER. As a science, AER needs to be held to scientific standards and as a community most impacted by it, astronomy instructors should demand it. Only then can we have confidence in our discoveries about how our students learn and understand astronomy.

2. "Research on a Lecture-Tutorial Approach to Teaching Introductory Astronomy for Non–Science Majors" by Edward Prather, University of Arizona, Timothy Slater, University of Arizona, Jeffrey Adams, Montana State University, Janelle M. Bailey, University of Arizona, Lauren V. Jones, Gettysburg College Department of Physics, and Jack A. Dostal, Montana State University. *AER* Issue 2, Volume 3:122-136, 2004.

3. "Research into Students' Views About Basic Physics Principles in a Weightless Environment" by Zeynep Gürel, Marmara University, Turkey, and Hatice Acar, Marmara University, Turkey. *AER* Issue 1, Volume 2:65-81, 2003

Tom Foster, Southern Illinois University

Goals for "Astro. 101": What Leaders in the Astronomical Community Recommend

What are our aspirations when we start to teach "Astro. 101"? (I'll use this as a generic title for introductory astronomy courses for nonmajors.) What do we want our students to have gained when they leave our classes? These questions motivated a proposal to the National Science Foundation to undertake a study and formulation of goals for "Astro. 101" courses. Those of us involved in the proposal (the AAS, George Greenstein, Doug Duncan, Andy Fraknoi, and I) had no intention that the outcome of this study would be a codified or canonical curriculum; we were interested instead in defining and assessing a broader set of skills that we might hope or expect our students to pick up.

The NSF funded two intense meetings, one on each coast, at which the goals for "Astro. 101" were debated and refined. In what may seem a counter-intuitive move, those invited to the meetings were primarily department chairs from large research universities, along with a smaller number of recognized experts in astronomy and physics education. Why department chairs, and why big research universities? A partial answer is that these large universities do teach a substantial number of students in introductory astronomy classes. But the more appropriate answer is that these astronomers are leaders in the field, and we hoped that their views on what "Astro 101" should accomplish would carry weight in the community.

There was remarkable unity in the conclusions reached by the two meetings. Indeed, every single person who attended either of the meetings signed on to the list of goals given below. Please note the emphasis on skills and on broad understanding of science rather than specific content (who really needs to know OBAFGKM?). George Greenstein and I have prepared a longer report on the conclusion of these two meetings for the Astronomy Education Review (http://aer.noao.edu/cgi-bin/article.pl?id=64). Here they are, in short form: see what you think.

GOALS—Content

Students should gain:

- a cosmic perspective—a broad understanding of the nature, scope and evolution of the Universe, and where the Earth and Solar System fit in
- an understanding of a limited number of crucial astronomical quantities, together with some knowledge of appropriate physical laws
- the notion that physical laws and processes are universal
- the notion that the world is knowable, and that we are coming to know it through observations, experiments and theory (the nature of progress in science)
- exposure to the types, roles and degrees of uncertainty in science
- an understanding of the evolution of physical systems
- some knowledge of related subjects (e.g., gravity and spectra from physics) and a set of useful "tools" from related subjects such as mathematics
- an acquaintance with the history of astronomy and the evolution of scientific ideas (science as a cultural process)
- familiarity with the night sky and how its appearance changes with time and position on Earth.

GOALS—Skills, values and attitudes

1. Students should be exposed to:
   - the excitement of actually doing science
   - the evolution of scientific ideas (science as a cultural process).
2. Students should be introduced to how science progresses, and receive training in:
   - the roles of observations, experiments, theory and models
   - analyzing evidence and hypotheses
   - critical thinking (including appropriate skepticism)
   - hypothesis testing (experimental design and following the implications of a model)

- quantitative reasoning (and the ability to make reasonable estimates)
- the role of uncertainty and error in science
- how to make and use spatial/geometrical models.

3. We should leave students:
   - more confident of their own critical faculties
   - inspired about science in general and astronomy in particular
   - interested in, and better equipped to follow, scientific arguments in the media.

I should add that a draft of these goals was extensively discussed at the winter meeting of the American Astronomical Society in 2002, and there has been further discussion of the final list at subsequent AAS meetings.

Our hope is that a list like this will prove useful to "Astro 101" instructors in colleges as well as universities—perhaps particularly to those planning their first such course. Equally, we hope textbook writers, their publishers and reviewers would take to heart the advice of the community leaders who attended the two meetings. Less is indeed more, and textbooks need not stuff in every last detail, from P Cygni profiles to Tycho's silver nose.

Bruce Partridge, Haverford College

Science Education in the 21st Century continued from page 3

Done properly, education is an ongoing conversation among a community of learners, with the teacher as much a part of the community as any student. Because they are no longer seen as the source of all knowledge for the student, the teacher may take the lead as guide, or hand the lead to any student, or a group of students. Don't forget that as they facilitate this learning community, each teacher has to keep abreast with the advances in science and how those advances affect the world. This is where scientists, scientific organizations, national laboratories, institutions of higher education, and informal education agencies must join forces to provide support, on-going professional development, and resources for the science and mathematics teachers of our nation.

All of this matters because we are in a crisis that mirrors the Sputnik era. The world is changing (or "flattening" as Thomas Friedman states), and the vertical boundaries between nations are being replaced by new forms of horizontal connectivity, particularly in the realm of economics. The emerging global knowledge economy will eventually force each nation to make choices on where they will fit into the new structure. Some nations will lead in technology and science, some will lead in manufacturing (dependent on the technology and scientific leader to provide the ideas and innovations), some will lead in agriculture, and so forth. The uncertainty of the situation is that we do not know how we will restructure societies and economies to interact in ways not yet imagined.

As it was with the Sputnik generation, the level of our national commitment to education will determine the place America will hold in the in the world. The National Academies' report *Rising Above the Gathering Storm* and The Business Roundtable's *Tapping America's Potential* both stress the criticality of a modernized education system in securing our nation's place in the emerging global knowledge-based economy. Politicians (myself included) are crafting legislation in response to these and similar reports. Creating the cultural paradigm shift that will be necessary to meet this challenge will require collaboration among politicians, scientists, and educators. For their part, scientists must go beyond simply being knowledge creators and become active participants in the political process.

Representative Rush Holt earned his Ph.D. in Physics at NYU. He was Assistant Director of the Princeton Plasma Physics Laboratory prior to his election to Congress in 1998. Rush Holt represents New Jersey's 12th District in the US House of Representatives. He serves on the Committee on Education and the Workforce and the House Permanent Select Committee on Intelligence; he also served on the National Commission on Mathematics and Science Teaching for the 21st Century chaired by former Senator and astronaut John Glenn.

Astronomy from the AAPT

As you have probably heard by now, the upcoming Winter AAS Meeting in Seattle will be held jointly with the American Association of Physics Teachers (AAPT).

Before I tell you about the exciting astronomy-related sessions and workshops that AAPT will host in Seattle, let me give you a bit of background about the organization itself, for those of you who aren't familiar with it. AAPT is celebrating its 75th Anniversary this year! Founded in 1930, to disceminate physics knowledge through teaching, the AAPT now boasts more than 11,000 members in 30 countries.

There are two annual meetings—January and August—plus a number of workshops and smaller conferences. In addition to various committees to address issues of membership, award nominations, publications, etc., AAPT has 17 "area committees" that help suggest and organize sessions and workshops relating to topical interest areas. I am currently chair of the Space Science and Astronomy (SSA) committee.

Workshops will be held on Saturday and Sunday prior to the main conference, and there are typically about 40 of these that run parallel for either ½ or 1 day. Six of the Seattle workshops have an astronomy focus; all six are either sponsored or co-sponsored by SSA. Donna Young of the Chandra X-Ray Observatory's Education and Public Outreach (E/PO) Program will lead a workshop on the "Physics of Supernovae," focusing on how to use supernovae to teach fundamental physics concepts. David McDonald will lead participants through beginning image processing in "Making Pretty Pictures: How Astronomers Make Images."

You may have already read in this newsletter about astronomy education research – if you enjoyed it and want to know more, Tom Foster will lead a workshop on this same topic in Seattle. Kevin Lee's popular "Teaching Astronomy Effectively Using Technology" workshop will be co-sponsored by SSA and the Committee on Educational Technologies. Mary Kadooka will lead participants through the "Voyages Through Time" curriculum in her workshop, while Jordan Raddick will teach about "Using Large Data Sets to Teach Astronomy." The Educational Technologies committee is also sponsoring a "Using Open Source Software to Teach Special and General Relativity" workshop.

In addition to the workshops, area committees sponsor focused topical sessions that will run parallel to the AAS sessions. Sessions that may be of interest to the AAS community include "Virtual Observatories," "Innovations in Teaching Astronomy," "Mentoring Graduate Students in Astronomy," and "Demonstrations for Teaching Astronomy," all sponsored by the SSA committee. "Impact of Women in Astronomy" will be co-sponsored by SSA and the Women in Physics Committee.

You can probably imagine that our committee is very excited about the upcoming joint meeting. But not just us! Several other committees have taken it upon themselves to host sessions that focus on issues of interest to astronomers (and astronomy lovers) of all levels. The Committee on Apparatus will host an oral session called "Hands-On Astronomy Labs" as well as a poster session, "Apparatus for Astronomy Education."

The Committees on Physics in High Schools and Physics in Undergraduate Education (PUE) will co-sponsor "Space Science and Astronomy as Contexts to Teach Physics Concepts." PUE will also host sessions entitled "Undergraduates in Astrophysics Research" and "Undergraduates and LIGO."

The Committee on History and Philosophy in Physics will host two sessions of interest, "Early Space Science" and "History of Astronomy." "The Role of Astronomy in Courses for K-8 Teachers" will be sponsored by the Committee on Physics in Pre-High School Education, while the Committee on Physics in Two-Year Colleges will host "Astronomy and the Two-Year Colleges."

The NASA Center for Astronomy Education (CAE) also be a lunchtime meeting, "Astronomy Education Research Town Hall," in which the presider will facilitate a dialogue on the future direction of research.

In addition to all this astronomy, there will be many sessions on physics concepts, physics teaching and learning, physics education research, and more. Please take this opportunity to see what the AAPT has to offer!

Janelle M. Bailey, AAPT Space Science & Astronomy Committee Chair, University of Nevada, Las Vegas

New Issue of Astronomy Education Review Is Published

The latest (eighth) issue of "Astronomy Education Review," the web-based journal/magazine for everyone involved in astronomy education and outreach, is now ready at the web site: http://aer.noao.edu

The featured papers and articles in this issue include:

Using Role-Playing Games to Teach Astronomy: An Evaluation, by Paul Francis (Australian National U)

Promoting Undergraduate Critical Thinking in Astro 101 Lab Exercises, by Michael Allen & Diane Kelly-Riley (Washington State U)

The Need for a Light and Spectroscopy Concept Inventory for Assessing Innovations in Introductory Astronomy Survey Courses, by Erin (Weeks) Bardar (Boston U), Edward Prather (U of Arizona), Kenneth Brecher (Boston U), & Timothy Slater (U of Arizona)

Assessment of Large General Education Astronomy Classes, by Thomas Robertson & W. Holmes Finch (Ball State U)

2006 Survey of Introductory Astronomy Textbooks, by David Bruning (U of Wisconsin-Parkside)

Good Reading from Other Sources on Astronomy Education and Outreach (Published in 2005), by Andrew Fraknoi (Foothill Coll. & Astronomical Society of the Pacific)

Astrobiological Themes for Integrative Undergraduate General Science Education, by Bor Luen Tang (National U of Singapore)

Working with State Science Teachers Associations, by Julie Lutz (NASA Space Science Network Northwest, U of Washington)

Plus three book reviews and announcements of conferences, awards, and other opportunities.

When you go to the AER site, you may see that the next issue is already under way. If so, you can find the full 8th issue by clicking on "back issues" and then on "vol. 4, no. 2". The first two articles in the next issue will be concerned with astronomy podcasts in general and with the podcast "Slacker Astronomy," in particular.

AER actively solicits interesting papers and articles on all aspects of space science education and outreach. We are particularly interested in increasing the number of papers relating to education outside the formal classroom. The site gets between 150,000 and 200,000 hits per month from 91 different countries.

Sidney Wolff and Andrew Fraknoi
Editors

A Paradigm Shift from Teaching to Learning: The Role of Education Research & Development

Those of us who are astronomy education researchers, no doubt, are familiar with Richard Hake and his revolutionary Hake Plot. He showed us (and, I would like to say, rather conclusively) that, in physics, there is only so much we can do to foster conceptual understanding through traditional instruction. His data analysis of results from the Force Concept Inventory, Mechanics Diagnostic Test, and Mechanics Baseline Test (all multiple-choice tests) helped us see that it was possible to understand the nature, and effectiveness, of our instruction—*emphasis on our instruction*—through the use of conceptually-rich multiple-choice tests. In addition, he is motivating in physics education a "paradigm shift from teaching to learning." The following is Hake's executive summary of an article he recently wrote on the need for "education research and development" to create similar multiple-choice tests in other domains so that this revolution can continue.

Gina Brissenden, Editor

A Possible Model For Higher Education: The Physics Reform Effort (Author's Executive Summary)

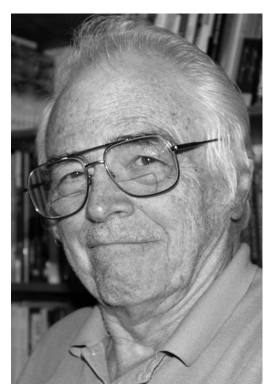
By Richard Hake, Emeritus Professor of Physics, Indiana University. (Originally published in the National Teaching & Learning Forum Newsletter, 15(1); http://www.ntlf.com. Please see original for references.)

Investigation of the extent to which a paradigm shift from teaching to learning in higher education is taking place requires measurement of students' learning in college classrooms. But the time-honored gauge of student learning—course exams and final grades—typically measures lower-level educational objectives such as memory of facts and definitions rather than higher-level outcomes such as critical thinking and problem solving. And the claim that student evaluations of teaching (SET's) are valid measures of student learning rests largely on modest correlations of SET scores with course exams and final grades.

How then can we measure students' higher-level learning? Several indirect (and therefore in my view problematic) gauges have been developed; e.g., Reformed Teaching Observation Protocol (RTOP), National Survey Of Student Engagement (NSSE), Student Assessment of Learning Gains (SALG), and Knowledge Surveys (KS's).

On the other hand, direct, general-ability measures of student learning have been developed that "evaluate students' ability to articulate complex ideas, examine claims and evidence, support ideas with relevant reasons and examples, sustain a coherent discussion, and use standard written English" (Hersh & Klein et al.).

In sharp contrast to the above mentioned invalid (course exams, final grades, SET's); indirect (RTOP, NSSE, SALG, KS's); or general-ability measures (Hersh & Klein et al.) discussed above, is the direct measure of students' higher-level domain-specific learning through pre/post testing using (a) valid and consistently reliable tests devised by disciplinary experts, and (b) "traditional" courses as controls.



Such pre/post testing has rarely been employed in higher education, but it is gradually gaining a foothold in introductory astronomy, economics, biology, chemistry, computer science, economics, engineering, and physics courses.

I see no reason that student learning gains far larger than those in traditional courses could not eventually be achieved and documented in other disciplines from arts through philosophy to zoology if their practitioners would (a) reach a consensus on the crucial concepts that all beginning students should be brought to understand, (b) undertake the lengthy qualitative and quantitative research required to develop multiple-choice tests (MCT's) of higher-level learning of those concepts, so as to gauge the need for and effects of non-traditional pedagogy, and (c) develop Interactive Engagement methods suitable to their disciplines. Why MCT's? So that the tests can be given to thousands of students in hundreds of courses under varying conditions in such a manner that meta-analyses can be performed, thus establishing general causal relationships in a convincing manner.

Teaching and Learning Astronomy: Effective Strategies for Educators Worldwide

(Pasachoff & Percy, Eds.; 2005, Cambridge Univ. Press; $120)

This book is really the record of a conference held at a meeting of the International Astronomical Union. However, compared to many scientific conference proceedings, it reads fairly smoothly. That can be attributed to the good writing in the introductions of each part that effectively tie the papers together within a part as well as set up a framework that gives the parts a logical sense of progression from one the next.

Teaching and Learning Astronomy covers nearly every aspect of teaching and learning astronomy from the very formal to informal and casual, from elementary to college and graduate level, and from the perspective of many different places in the world – and not just from developed countries, but from the perspective of nations just beginning to address the issues of science education. *Teaching and Learning Astronomy* does not solely focus on American practices of teaching astronomy, nor does it focus solely on teaching astronomy at the college (or even near-college) level. There are papers reporting on primary school astronomy education in Europe and Asia. The enthusiasm of many of the authors is refreshing, too.

Each paper is, in itself, a lot to digest. As a whole, therefore, the book is dense. It is not an easy read, nor one I would recommend for the faint of heart. One must be curious about these topics to really enjoy reading this book. But if you are curious – even just a little – you will not be disappointed. I found each paper to be full of useful information and interesting ideas. In addition, posters are highlighted in a paragraph or more, each. These, too, appear to be well written and are thought-provoking.

The conclusions are hopeful – full of advice and guides. Of course there are the usual plugs for the programs that exist and are sponsored by the IAU and other organizations, but these are, at the least, helpful to someone beginning to have an interest in participating in this discussion.

Overall, I would recommend this book to anyone who is interested in teaching astronomy at any level anywhere in the world. I think it can serve as a valuable resource to a teacher (although, not necessarily one that is easy to navigate). Also, this book is a valuable resource to anyone who wants to understand more about the learning of astronomy (that is, participate in astronomy education research). The information and references included in the papers create a good framework for beginning to understand what are some of the problems that need attacking and some methods that might work, as well as some that didn't work in the past. This book is a good way to get one's bearings in astronomy education research.

Book review by Lauren Jones

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2000 Florida Avenue, NW
Suite 400
Washington DC 20009