The Virtual Observatory and Education: A View From the Classroom

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**Abstract.** The design, construction, and implementation of a national Virtual Observatory will fundamentally change the way a large portion of archival astronomical research is conducted. Such a facility will also offer teachers in grades K-12, and certainly at the collegiate level, a new tool to introduce science to their students. The task of using a virtual observatory in a classroom is not merely one of understanding how to use the facility, however, but of understanding how to use the facility to teach. As important to the teacher as the Virtual Observatory itself will be the materials and instruction available on how to turn the facility into a virtual laboratory for student learning and experiment.

1. **Introduction**

The current formulation and eventual construction of a national, or better yet, international virtual observatory (VO) is exciting to consider, especially since such an inclusive facility will likely enable researchers at smaller institutions to participate more fully in astronomical research. There is another group that can participate, too, with a national VO—students of all ages in educational settings either formal or informal.

The utility of the VO in the classroom can be great when this new portal is opened and used correctly. Children, young adults, and nascent scientists can be brought into a world of real data and compelled to confront the excitement and even the tedium of scientific research. But as we consider an ideal classroom, be it at the elementary-, middle-, high-school, or even college levels, keep in mind the fact that most students do not learn astronomy from astronomers and that the vast majority of science teachers in grades K-12 have little or no experience with astronomy. Indeed, many will confess quite openly their fear of teaching astronomy because of their ignorance of it. Organizations like the Astronomical Society of the Pacific\(^1\) attempt to work directly with teachers to lessen this anxiety and to lead them to see the wonderful opportunity astronomy as science in the classroom affords them and their students.

There are three reasons astronomy is the best of the sciences for general educational development. First, it is a field of human endeavor that is based upon our innate curiosity about the heavens; this alone makes astronomy a ter-

\(^1\)http://www.aspsky.org
rific vehicle for learning. As we are all aware, we are more interested in learning something in which we are already interested. Further, “teaching astronomy” means far more than merely teaching Moon phases or mnemonics for planetary ordering—it serves as a stage for students to see how the scientific method works, from stellar successes to humbling blunders, and the continuum of the evolution in thought in between.

The second reason is that astronomy as an academic discipline is grandly encompassing science. The physical and, increasingly, natural sciences and mathematics are included, and the manner in which astronomy can touch us opens possibility for cross-disciplinary investigations into the humanities and social sciences, as well.

Finally, astronomy is good for all ages and is ripe as a subject for perpetual, life-long learning and contemplation. Most people (except for scientists or mathematicians!) could not care less about the latest advances in algebra, but bring up the subject of astronomy, and almost everyone is enthralled.

This is what we astronomers have to work with, and the national VO will only make what we do more embracing of the rest of the population. To effectively bring the VO into the classroom so that learning may be enhanced, care on our part must be taken or else we will find ourselves in the oft-sited situation of “plenty of powdered milk, but no clean water.” Let me briefly outline the challenges to the VO’s use in classrooms at different educational levels; I will also provide some recommendations about how we should meet these challenges.

2. The VO, the Spectrum, and Educational Development

I have no doubt that a fully implemented virtual observatory will be of use to teachers, yet I do doubt the usefulness or even appropriateness of it for all levels of educational development. The VO will provide full accessibility to astrophysical data spanning the entire electromagnetic spectrum. Let us consider as an example, then, how students at different grade levels come to “see” the spectrum.

Primary School. Young children are generally aware of only the visible part of the EM spectrum. Their exposure in the classroom is to visible light as they come to understand the interaction between light and objects and the creation of shadows. Visits to planetaria and science museums can re-enforce the more sophisticated notion that “white” light is made up of “all the colors of the [visible] spectrum.” Except for classroom exercises in which a teacher uses data from the VO to exercise his or her students in pattern recognition in nature—and I stretch on the usefulness of such an exercise when using the VO—I see no use of the VO in primary school classrooms.

Middle School. By grades 4 or 5 children have been intellectually exposed to other regions of the EM spectrum. They have been told the warmth they feel from the Sun, say, is due to “invisible” light. Further, many have been introduced to the notion that too much sunlight is not good for you; in fact, teachers can use discussions of the danger of sunburn to introduce the concept of ultraviolet radiation. And if a child or one of his or her family members has had a broken bone, he or she will quite likely have heard of X-ray radiation.
At this educational level, I see the VO as a neat tool to present children with the reality of a Universe that looks different at different wavelengths. Visible, infrared, and ultraviolet views of the same region of space can be used along side similar, multiwavelength views of Earth or living creatures.

**High School.** In high school, students will have enough background in physical science to actually put the VO to work for them. The EM spectrum, in keeping with the present thread, will now appear as a continuum of energy, and teachers will be able to design or use ready-made, in-class and take-home exercises in which students essentially interrogate nature by using the VO.

**College.** The VO will be a full resource to students at the post-secondary level, its utility limited only by the students' intellectual ability to use it and that of their instructors to help the students formulate interesting exercises and/or experiments.

### 3. Using the VO in the Classroom

Teachers currently have three possible ways to bring real, or at least realistic, astronomy into their classes: simulating the sky with commercially available software packages, constructing or using exercises that employ real astronomical data, or using real telescopes. A virtual observatory as classroom learning tool can be a blend of the first two options.

Software packages like TheSky by Software Bisque\(^2\) or Starry Night Pro by Space.com\(^3\) do a superb job of presenting a simulated sky from different times and from different vantages. More importantly, however, these packages are powerful enough to serve a teacher as a virtual astronomy laboratory. Exercises are already available to teachers who want their students to investigate broad topics such as Earth’s motion through space and the life cycles of stars, and specific topics like stellar parallax and proper motion.

In the future, the level of interrogation possible with such sky simulators will only increase. Even today some college-level instructors have available to them virtual reality Caves to offer students a more intimate experience with extraterrestrial objects (*e.g.*, Indiana University’s Department of Astronomy).

Rather than being merely an observer, a student can be given a taste of astronomical research by a teacher who uses exercises based on real astronomical data. As an example, consider the increasingly robust suite of computer activities known as CLEA\(^4\) (Contemporary Laboratory Experiences in Astronomy), by Larry Marschall and his group at Gettysburg College. The activities are constructed to utilize subsets of digital sky surveys, and students are compelled by the exercises to do science. Further, the overall activity environment is one that simulates an actual observatory experience, from data of varying levels of signal-to-noise to clouds during the simulated observing session.

\(^2\)http://www.bisque.com
\(^3\)http://www.siennasoft.com
\(^4\)http://www.gettysburg.edu/academics/physics/clea/CLEAhome.html
The third way for a teacher to get some real-seeming astronomy into his or her classroom is to actually incorporate real telescopes into the lesson plan or syllabus. A discussion of this is beyond the scope of this meeting on virtual observatories, but let me mention one program in which teachers are even freed from the need of having real telescopes on-site. Mount Wilson Observatory’s Telescopes in Education program \(^5\) makes available to students and their teachers a 24-inch, research-grade telescope for use in remote observations. A simple though sophisticated user interface makes the remote observations possible with only a classroom computer and telephone line.

Each of these entries into real or simulated astronomy has elements appropriate to discussions of the VO in a classroom. Sky simulators offer teachers, students, anyone examples of easy-to-use, front-end programs like the one that must ultimately be designed for the VO. As a colleague mentioned to me recently, a program like Starry Night Pro could serve as a good, commercial interface to the VO. NASA-GSFC’s SkyView offers an example of a non-commercial interface \(^6\) and one that might, with proper guidance from the instructor, be useful to even beginning high-school students.

4. VO Materials for Teachers

Once the national Virtual Observatory is online and ready, there will remain much to do before teachers will be able or even willing to use it. Recall that most K-12 teachers had no or only limited exposure to astronomy when they were students, and it has been estimated that between 80% and 85% of post-secondary astronomy is taught by non-astronomers. Clearly, most people using the VO will need aid to and, quite likely, instruction in its use. There are a few incarnations the aid and instruction can take.

Teachers want any resource that will facilitate learning by their students, but such a resource must be designed for a given teacher’s grade level. More directly, however, a teacher must be confident that any resource/activity he or she brings into the classroom satisfies national science education standards. This means that a teacher in grade 8 who wants to use the VO for a class science exercise will (quite likely) require materials designed such they satisfy national standards.

This requirement for standards-satisfying materials is not to be taken lightly. Such materials are critical to the VO’s use in a classroom. Grade K-12 teachers have precious little time for new material in their often crowded curricula, especially if it means considerable time for them to learn the material and more time to determine how to integrate it into their lesson plans. Hence, what will be needed for a successful implementation of the national VO as a classroom tool is carefully designed exercises and teachers’ materials at the least.

To make use of the VO in the K-12 classroom more likely, teachers would ideally also have training in the Observatory’s use. Training could take the form of regional teachers’ workshops—like those the ASP has been conducting

\(^{5}\)http://tie.jpl.nasa.gov

\(^{6}\)http://skyview.gsfc.nasa.gov
around North America for the past 20 years\textsuperscript{7}—or even regional centers of teacher support, like the ASP’s Project ASTRO sites spread around the country\textsuperscript{8}. Web-based instruction, be it live or not, and tutorials are other ways to reach teachers and provide requisite training in the use of the VO for education.

I cannot stress strongly enough the importance of materials and training for teachers if the national Virtual Observatory is to work in the classroom. And even with these resources available, we still have a big marketing challenge—making teachers aware of them and the VO and convincing the teachers the VO can work in the classroom! Consider, for example, all the educational materials that have been produced by NASA missions of the past. A good portion of that effort was wasted for a couple of reasons. First, only within the last decade has good effort gone into answering the questions, \textit{“How is the information from [a given NASA mission] useful to teachers?”} and \textit{“How can a teacher use this information to teach [and satisfy national science standards]?”} A second reason for the limited success in turning the science of NASA missions (in keeping with my example) into classroom learning experiences is that the shelf-life of the materials produced was too short. Some excellent materials were produced, but they simply faded from view. They were produced but were never effectively marketed to teachers. Counter examples from the past decade include the successful education and public outreach (E/PO) activities and initiatives of the Space Telescope Science Institute\textsuperscript{9} and the SIRTF\textsuperscript{10} and SOFIA\textsuperscript{11} missions.

It is imperative, therefore, that an E/PO capacity be built into the national Virtual Observatory or that extant organizations be included in the formulation and planning of the VO to ensure that the facility and its educational materials are actually usable by non-professionals. Given that a VO will be brickless, having a formal E/PO staff may be impossible, but it is critical that organizations be chartered with serving as sources of E/PO information and expertise. Much as the ASP’s Project ASTRO sites do, regional centers could provide localized workshops for teachers, standardized materials—lesson plans, suggested exercises, etc., all created to satisfy national science standards—for teachers’ use, and serve as a repository of expertise in the use of the VO in classrooms.

\section{5. First Light for the Virtual Observatory}

Coming within the next several years is, at the least, a modification of the way astronomy can be done. And combined with a greater emphasis on queue observing at national observing facilities, we are quite possibly on the verge of a paradigm shift in the way astronomy has been practiced for quite a long time. As the professional astronomical community confronts these changes, it is important

\textsuperscript{7}http://www.aspsky.org/education.html

\textsuperscript{8}http://www.aspsky.org/project_astro.html

\textsuperscript{9}http://oposite.stsci.edu/pubinfo/edugroup/educational-activities.html

\textsuperscript{10}http://sirtf.jpl.nasa.gov/SSC.EPO.html

\textsuperscript{11}http://sofia.arc.nasa.gov/education/in-dex.html
that we not neglect the on-going advantage our science has in the classroom—be it a class of grade 4 children or a seminar for advanced undergraduates.

The creation of a national Virtual Observatory suggests much promise for the facility as a tool for enriching our children's educations by opening up the Universe to them from their classrooms. Yet this is more easily written than done. Considerable effort will need to be expended to create interfaces between the VO and teachers and students, and materials designed explicitly for classroom teachers' easy use, created under the guidelines of national science standards, are clearly required before the VO becomes a classroom fixture. When such materials are available and when teachers have easy access to instruction and support in their and the VO's use, we will see a powerful new tool for teaching science and for kindling a life-long excitement for astronomy in our children.