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## The Internet Telescope: Remote Observing for the City Astronomy Class

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### Abstract

The Latin School of Chicago is a college preparatory day school that involves its students in a number of astronomy initiatives. Here we report on our high school students' use of the New Mexico Skies Internet telescope. Using a Web browser, our astronomy students are able to control a Celestron C-14 coupled with a CCD camera to image deep sky objects. In Chicago, using the Internet telescope teaches students how to request time on a shared instrument and how to plan an observing program, and it provides many varied independent study project and classroom options. Students use this instrument during our spring astronomy project week trip, when they travel to live and work at the New Mexico Skies Guest Observatory to learn observational astronomy, remote observing, and CCD imaging. Other remote observing programs that provide similar options are referenced, some with different or multiple instruments, some with limited access, and some with open access. Sample student images taken with the New Mexico Skies Internet telescope are included.

### 1. Class Internet Telescope Use: Astronomy in Chicago

The Latin School of Chicago is a coeducational, independent college preparatory day school for junior kindergarten through grade 12 (see <http://www.latinschool.org/about/>). Latin involves its students in a number of astronomy initiatives taught by faculty who have a variety of experience in observational and theoretical astronomy (more information on the authors' astronomy background is included at the end of this article in the informational notes). Via the Internet, Latin students are able to access an automated Celestron C-14 telescope coupled with an SBIG ST- 1001E 22 x 22 arc-min CCD camera located on the

New Mexico Skies Observatory grounds in the Sacramento Mountains near Alamogordo. (Information on New Mexico Skies Observatory and its telescopes and a link to the Internet telescopes sited there can be found at <http://nmskies.com>.)

One big advantage of this remote observing opportunity is that our students are able to access the dark high-altitude skies of New Mexico to obtain images of nebulae, galaxies, and quasars studied in their astronomy and cosmology classes. Observing these objects from the city of Chicago is difficult, if not impossible, because of the combination of winter cloud cover, poor seeing, and light pollution. For some students taking Latin's astronomy classes, this might be their first opportunity to image objects discussed in class. For some middle school students, this instrument provides them a very special way to complete an eighth-grade science assignment. For former astronomy project week students who have visited the observatory, remote access to this instrument allows them to refine their deep sky imaging and image processing skills.

The Latin School purchases time on the Internet telescope from the New Mexico Skies Observatory, and all users must first obtain a login before requesting their observing time. Once approved, students simply access a Web site using a personal computer and a browser. High-speed Internet access is required, but the user interface works equally well with Macs and PCs using Netscape or Internet Explorer. Some students work alone, and others work in pairs or small groups, usually at their homes.

Within the Web interface, students have the ability to set more advanced parameters than exposure time, such as image binning, image reductions, and filter selections. The telescope can be fitted with two sets of filters: LRGB for generating beautiful color images, and BVRI for more scientific endeavors. Most experienced students use the LRGB filters to make composite color images, while the BVRI filters are used by advanced students doing photometry, usually in an independent study course.

Once students take their images, they see a JPEG representation on screen and can save their images for processing later at school. FITS images are stored on the New Mexico Skies FTP server, and students download them to school computers for image processing and analysis. Students have various software tools available for use on different computing platforms. On a dedicated PC, beginning students can use either CCDSoft or Maxim DL for image combination and rudimentary photometry. Our more advanced students have used more sophisticated software such as IRAF, which is installed on Mac OS X-based computers.

Some of our eighth-grade science students are studying Charles Messier in their history of astronomy unit. Each student will research a Messier object to report to the class, and some have chosen to image their Messier objects on the Internet telescope as part of their presentations.

This past year, we used the Internet telescope in our 11th- and 12th-grade Introduction to Astronomy class. All students in the class wrote end-of-the-semester research papers on an astronomy topic of their choice, and were then given the opportunity to use the Internet telescope to obtain an image relevant to their subject. The instructor reserved imaging time on the telescope and used his login so that all students could image without taking extra time for multiple logins, and special arrangements were made with the school to allow the class to use one of the library computers to connect to the telescope in the evening. One student imaged a quasar, another chose the Andromeda galaxy, and a student writing on black holes imaged the super giant companion to Cygnus X-1.

The process of taking the images was in itself a valuable educational experience. A student wishing to image a particular object first had to learn where to find his or her object in the sky, and had to locate and interpret star charts. Students also had to determine if their objects would be visible from New Mexico during the Chicago observing session. Would it be visible from New Mexico's latitude, or was it too far south? Would it be lost in the Sun's glare? Would it be well above the horizon during our evening observing session? Would the Moon be in the way? Students had discussed all of these questions in class, but actually using the telescope gave them the opportunity to apply that knowledge in a very practical way. Moreover, taking the images gave students a basic introduction to digital cameras and image processing techniques.

From these activities, we found that student expectations about what the Internet telescope can and cannot do vary greatly. Some students think that they will be able to "see" through the telescope in real time, and are a bit disappointed when they discover that they can only see the target object after taking an exposure. Other students new to astronomy wonder why there is no color unless images are taken through a filter.

Overall, we find the Internet telescope to be a powerful tool for our astronomy students, allowing them to explore the Universe from the light-polluted and often cloud-covered skies of downtown Chicago.

## **2. Project Week: Astronomy in New Mexico**

We offer a unique opportunity for Latin School students to spend one week during the spring semester living and working at an astronomy observatory in New Mexico, where the skies are very clear and dark. Many of our Chicago-area students have never seen the stars without light pollution, and this project week trip allows them to really explore the dark night sky. Students travel to New Mexico Skies Amateur Guest Observatory in the Sacramento Mountains (near Alamogordo) with Lor Gehret and Wayne Winters, who lead this project in March of each academic year.

The astronomy trip usually has 6 to 10 students ranging in age from 14 to 18, who travel with Ms. Gehret and Dr. Winters. There are no prerequisites for this trip, and we find that we often have as many students who are familiar with astronomy as those who have no knowledge of the topic. The male-female ratio varies each year, but we usually have students from each of the four upper school grades.

Students choose their projects in November and meet at school in January and February to prepare their observing lists of deep sky objects. Time is spent in pretrip meetings answering student questions about group living, meal planning, and packing requirements, and discussing astronomical coordinate systems, use of star charts, and general logistics. We also try to arrange a trip to the Adler Planetarium for a private sky show, where the planetarium technician shows the group the New Mexico night sky as it will appear on the dates of our visit. Basic astronomy concepts are introduced in preparation for the trip, but observing techniques and image processing are taught on-site during the actual trip.

At New Mexico Skies, students first use a 30-inch Dobsonian telescope with a Star Commander to locate and view stars, galaxies, and nebulae. Students are then shown how to make deep sky images of these objects using telescopes fitted with electronic CCD cameras. Students first work directly at the telescope consoles in each of the domes, and then learn to control the telescopes remotely from the observatory library. They also control the Internet telescope from the library, and are able to see the actual instrument, its building, and satellite dish, and understand how their electronic commands translate into physical movements of the telescope and the CCD camera. The hands-on experience in the domes also helps

students better understand some of the physical limitations of the individual instruments when they are working remotely.

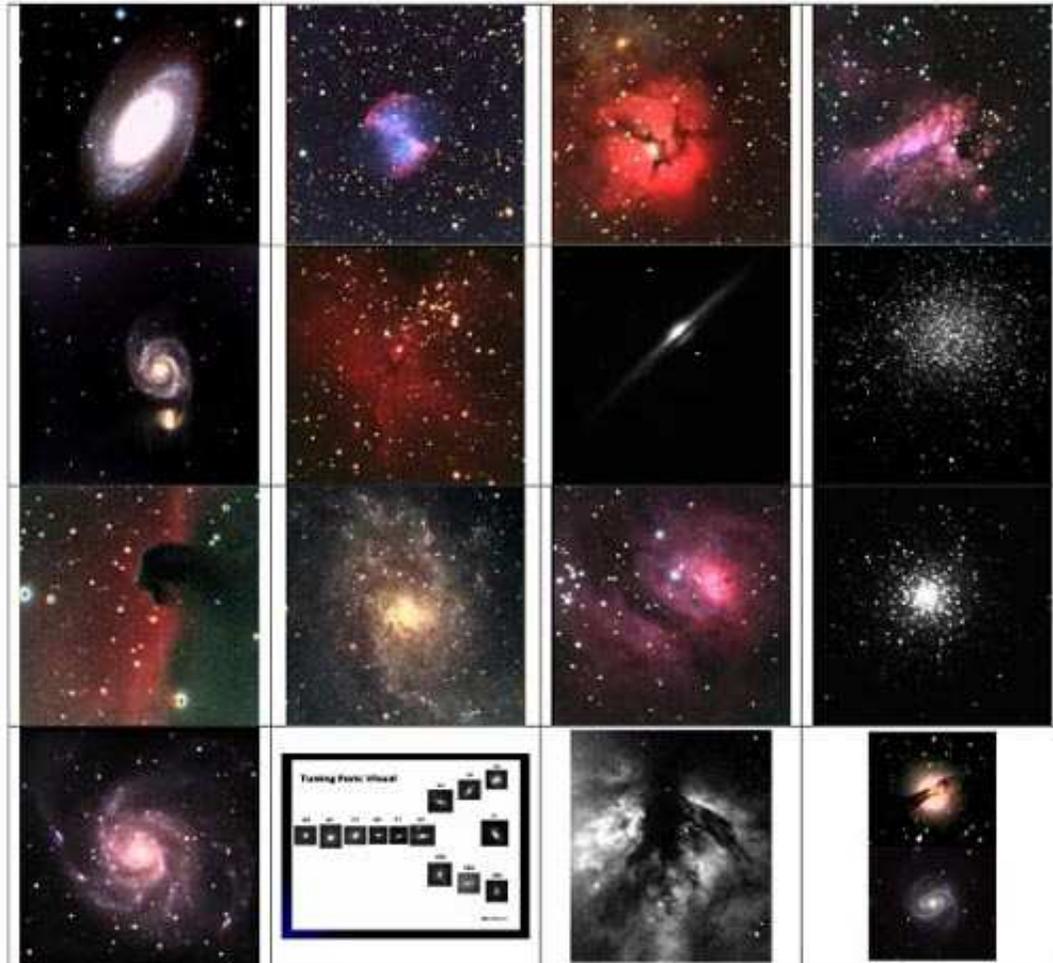
Most important, students are self-directed. They choose their own observing partners but usually move around to work with everyone in the group. As students develop their own observing projects, they become strongly invested in their individual plans, and as a result, learn from and teach their peers very effectively. Ideas generated by one student are often shared with another, and several project ideas develop as the students work. A student's own interest usually drives the direction of his or her project. By watching the dark skies for several nights, students begin to learn the motions of the stars and planets and can easily locate constellations. As the week progresses, they begin to know which objects are visible at what times, and they learn to negotiate with each other for their evening telescope time.

All students use image reduction software to enhance their images, and many choose to concentrate on making color images with the LRGB filters available at the observatory. Some go on to experiment with photometry and the BVRI filter set. Still others explore false color and create beautiful images for their art classes. Some students prefer remote imaging with the Internet telescope, others like imaging in the domes, and some enjoy looking through the eyepiece of the large Dobsonian instruments and challenging themselves to a Messier Marathon.

Student images (see Figure 1) and daily journals are viewed each day by parents and friends on the Latin School project week Web site (<http://www.latinschool.org/academics/projectweek/projectweek2003/astronomy/index.html>). All students post text and images to this site. This alternative learning experience gives many city students a chance to share their unique experiences with friends and family through the Internet.

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### Sample Student Images



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The Latin School of Chicago

**Figure 1.** Sample Student Images.

The relatively small group size ensures that all students have extensive time in the domes on the 14- and 16-inch telescopes equipped with CCD cameras, and time to use the Internet telescope remotely from the observatory library so that they are able to do quality visual observing on the 25- and 30-inch Dobsonian telescopes. Having two students working together on an instrument with two teachers rotating through the groups provides many opportunities for students to teach each other and to teach the faculty any new technology that they learn. There is always much to learn in each visit, and the real educational value in this trip lies in the fact that all participants, including faculty, learn skills together and teach each other. It also allows students direct access to professional astronomers, national observatories, and highly technical equipment to challenge and inspire them.

### **3. Independent Study Projects**

Independent study projects with the Internet telescope allow students who are excited about astronomy to explore their interests and experience science in a fundamental way. The middle school student collecting images of all of the Messier objects has just as much invested in his or her project as the upper school student working on a complex cosmology project. They both gain tremendous experience and satisfaction collecting and reducing their own data, and have much invested in drawing scientific conclusions based on their own observations. We have found that Internet-based astronomy opens up a universe of fascinating projects for city-bound students.

With the 14-inch New Mexico Skies instrument, our students continue to learn remote observing and image processing over the Internet, and complete projects started during project week. This telescope also enables some of our students to pursue independent study projects in their junior or senior years. Past independent projects include galactic morphology studies, photometry, mosaic imaging, and development of computer software that completely automates the imaging process during the night.

### **4. Other Remote Observing Programs**

The Faulkes Telescope Project (<http://faulkes1.astro.cf.ac.uk/home.htm>) has made remote observing on large instruments available to schools, museums, and undergraduates throughout the United Kingdom. The 2-meter Faulkes telescopes, much larger than the New Mexico Skies instruments, use a clamshell design for their domes that provides the option of rapid slewing (2 degrees per second) of the instruments. The remote telescope in New Mexico uses rails to completely roll back the roof of the telescope building, providing the same slewing advantage. The other telescopes at New Mexico Skies used during our astronomy project week have the same clamshell design as the Faulkes telescopes.

One of the good features of the British program is that the telescopes are located in Hawaii and Australia, and this time difference makes it possible for students to observe during class hours. We have a slight disadvantage in Chicago because our Internet telescope is only one time zone to the west, and our facility department requires that the school building be vacated by 9 p.m. This gives us a window of about 1.5 to 2 hours for group class observing, but does not impact students working individually or in smaller groups on their own computers at home.

The Faulkes Telescope is roughly twice as expensive to use as the New Mexico Skies Internet telescope, but the Dill Faulkes Educational Trust funds most of the school's use of the Faulkes telescopes in Britain. Our program is not currently supported by an outside trust, but must be funded from our budget at \$50 per observing hour, purchased in 100-hour packages. One funding option for schools with limited science

budgets is to join with three or four other schools in purchasing 100 hours of telescope time to share. This would also provide a small network of colleagues with common interests for curriculum development.

In the August 2004 issue of *Sky & Telescope*, Stuart Goldman's (2004) article about online telescopes mentions three of the robotic instruments located at New Mexico Skies. In addition, Lawrence Hall of Science has a very useful astronomy education Web page at <http://www.lawrencehallofscience.org/sii/URLs/URLs-AstroEd.html>, which contains a list of links to other online telescopes. To further enrich the observing experience, the Harvard-Smithsonian Center for Astrophysics MicroObservatory site (<http://mo-www.harvard.edu/MicroObservatory/Challenges/index.html>) has a very useful list of "challenges" for students and teachers that encourage use of their network of five 6-inch telescopes for solving specific problems in astronomy. This project is sponsored by the National Science Foundation, which makes it a good low-budget choice for teachers; however, observing time is limited on this site, and users must submit an online proposal to obtain guest observer status. Priority for access is given to educators, and a summary report is also expected at the end of each observation period.

We have found that using the Internet telescope at New Mexico Skies and offering the astronomy in New Mexico project week significantly enhances our astronomy program at Latin, and enriches the individual students' learning. The opportunity for students to see the actual telescope and work on-site, coupled with the convenience of its continued availability throughout the academic year via the Internet, makes it a very powerful teaching instrument.

### **Informational Notes**

Lor Gehret ([lgehret@latinschool.org](mailto:lgehret@latinschool.org)), who started Latin's astronomy in New Mexico project week program in 2000, has an A.B. in astronomy from Smith College and an M.A. from Vassar. Before joining The Latin School, she worked as a researcher in the astronomy department at Yale, and as a science analyst for NASA, calibrating cameras and reducing data on space missions.

Wayne Winters ([wwinters@latinschool.org](mailto:wwinters@latinschool.org)) completed his doctoral dissertation in 2003 at the University of Virginia, modeling planetary gap formation in accretion disks of stars. He currently teaches AP and honors physics, along with an introductory cosmology course, to Latin's junior- and senior-level students.

Steven Coberly ([scoberly@latinschool.org](mailto:scoberly@latinschool.org)) has a B.A. in physics from Brown University. He teaches physics, astronomy, and chemistry, and is an avid amateur astronomer.

### **Resources**

"About Latin." The Latin School of Chicago.  
<http://www.latinschool.org/about/>.

"Astronomy in New Mexico." Project Week 2003. The Latin School of Chicago.  
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