Interactive Astronomy in Elementary Schools

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ABSTRACT
Studies about the universe are exciting for children in elementary and junior high schools. They approach such work with energy and curiosity but they also hold naive ideas that may be difficult to dislodge. Schools now can obtain access to scientific-grade telescopes for educational purposes via the Internet. Using students' questions as a basis for projects, teachers can provide first-hand science experiences in the study of astronomy and help build scientific understanding.

Keywords
Astronomy, Constructivism, Elementary education, Misconceptions, Remote telescope

Astronomy for young students

Prior to computer and Internet capabilities becoming available to educational systems, astronomy was not taught well in schools. As computers became easier to use and affordable, and access to the Internet became a reality, teachers have gained more choice in the type and quality of resources available to their classrooms, particularly those in science. Astronomy resources, especially websites developed for general audiences, have proliferated and are both informative and topical. In addition, astronomy and space studies have gained prominent places in both elementary and secondary school curricula.

As improved technology for research into astronomy became available, scientific institutions acquired equipment and software tailored to their precise needs. As one outcome, they have been able to retire telescopes ancillary to their requirements. Some of these instruments have now been refurbished and placed in observatories dedicated to educational purposes and accessible via the Internet. There are now several models for schools' educational use of these scientific-grade telescopes.

NASA (National Aeronautics and Space Administration) in the United States has developed programs with many excellent resources, such as images of objects in the universe not seen by most people outside the research area. One NASA program, Telescopes in Education or TIE, has developed learning activities that allow school classes to access telescopes and CCD (charge-coupled device) cameras via telephone lines and modems. Access to these telescopes is supported by age- and curriculum-appropriate projects for work that can be done in real time. Schools can obtain software and workbooks to help students with their TIE projects. In addition, exciting summer programs 'on site' at the telescope location add enrichment to children's space studies.

An alternative, the Bradford Robotic Telescope in Great Britain, differs from TIE in that it is an autonomous system using software developed at the University of Bradford. Schools accepted by the system can submit one or more observation requests online. The software schedules the request and, when the images have been obtained, sends notification as to their location so the school can download them onto their own computers. Schools can use this robotic system to obtain images for students to study and manipulate in relation to internal projects.

Another project, A Journey through Space and Time, has been developed specifically to meet the needs of learners within elementary and junior high schools' Science curricula. Sponsored by Charles Sturt University (CSU) in Australia, it is the brainchild of a science teaching specialist who is sensitive to the dearth of practical science activities for younger students. Using learning materials developed by science teachers, appropriate packages are available to schools that sign up for participation in any of the following programs: Grades 5-6 (ages 10-12), Grades 7-8 (ages 12-14), and senior high school (Please note that the term 'Year' is used in the Australian education system in place of 'Grade'). The curriculum requirements for each of these levels vary considerably with regard to student skill development and depth of understanding. High schools do not generally
suffer the paucity of science resources experienced by elementary schools. Thus, Phase One of *A Journey through Space and Time* concentrates on the development of learning activities for Grades 5 and 6 that provide teachers at their level of experience with support for social constructivist learning in the field of astronomy. While working through the study activities of a 10-week block of time, students develop a proposal for the use of a software-controlled telescope and CCD cameras located in Bathurst, Australia. They then take control of the equipment via the Internet and take pictures of the celestial objects they have chosen to study.

Phase Two of *A Journey through Space and Time* is aimed at the science curriculum needs of classes in Grades 7 and 8 and is 6 weeks in length, whereas Phase One provides integrated cross-curriculum activities. In contrast, the senior high school materials have been developed for individuals and small study groups rather than for classes; the duration of the study period is decided by the participants. All three phases are part of a program (Astronomy in the Schools) that allows telescope access to the Southern skies and is fully supported in both educational and technical terms. The package of appropriate learning activities guide the exploration of many aspects of astronomy supplemented by access to a teaching expert available for consultation as needed. This consultant can suggest extra resources or can identify barriers to learning that must be addressed. When a class receives acceptance of its proposal for the use of the telescope, a technician helps with any technical difficulties that might be encountered during the time when the class takes control of the equipment via the Internet. The program has been tested for two years and is now available to schools anywhere in the world with computers and access to the Internet. For many schools, this project is a first because it encourages students to use computers for real time work with scientific equipment that responds to their commands.

**Learning about Astronomy**

Hollingworth & McLoughlin (2001) examined the difficulties science students demonstrate when they reach university level. In particular, these authors identify difficulties with problem-solving and reflection on learning. They suggest that students need experience with both well- and ill-structured problems within a constructivist framework so that they develop a variety of cognitive skills. Selley (1999) notes that, if students can develop these skills early in their education, it is likely they will cope better with whatever learning they must do. Selley (1999) offers strategies to help teachers diverge from the transmission style of teaching and to become confident of students’ abilities to develop meaningful cognitive structures. Selley (1999) recommends the practice of “open-minded conversation” or exploration of meaning around a shared observation, to be conducted by students and teacher. Similarly, Tinkler (1993) thinks that teacher interventions should occur at the level of helping students deal with complexity in purposeful two-way communications so that students take responsibility for learning new things and correcting past misconceptions. Kearney & Treagust (2001), looking for effective teaching methods for computer learning, decided that social constructivist approaches help individual students to establish meaning while discussing their observations and findings in a social setting, which can be on- or offline. They suggest that students should articulate their learning and reflect upon it in the presence of focussed, helpful feedback, a view shared by Selley (1999).

The literature about children learning astronomy at school shows that a central problem lies in misconceptions held by adults that may reinforce those held by students. Skamp (1998) has shown that adults, including teachers, carry misconceptions about astronomical phenomena, such as gravity on the moon, moon phases, planet composition and the shape of stars. Unless these ideas are replaced with scientific explanations, Skamp (1998) argues that teachers cannot help students understand the phenomena. Skamp (1998) also observes that students have problems understanding scale and distance and postulates that first-hand experiments that help them explore these concepts are much more effective than textbook diagrams, poorly-scaled models or other second-hand learning experiences. Dunlop’s (2000) survey of the literature on adult misconceptions agrees with Skamp’s findings, especially where adults become teachers. Dunlop (2000) postulates that one source of children’s misconceptions could be those held by the teacher.

Dunlop (2000) has studied the pre- and post-visit knowledge demonstrated by children who went to a planetarium in Auckland, New Zealand and finds that children’s ideas about astronomy are better expressed by tests that require them to make drawings to illustrate their answers than the use of multiple choice questions, especially in the 7-14 age group in his study. Dunlop (2000) suggests that specific interventions to help children understand phenomena, for example the occurrence of day- and night-time, are not completely successful with students loyal to personal observations that differ from the demonstrations provided by 3-D models, especially when their beliefs are supported by out-of-school experience.
As Hollingworth & McLoughlin (2001), Selley (1999) and Tinkler (1993) have shown, pedagogical methods should centre around constructive methods for both in-class and on-line work so that students are exposed to well- and ill-structured situations and can explore these in social ways. The CSU program is designed to enhance a learning environment in which discussion, exploration and problem-solving will take place. The program recognizes several curriculum levels and provides each level with a learning package about astronomy with emphasis on the use of an online telescope. Each package includes access to, and control of, a scientific-grade telescope and its CCD cameras via the Internet, as well as a CD-ROM containing help with the scientific study of astronomy such as advice on the location of celestial objects in the sky, control of the telescope and cameras, ways to obtain sophisticated digital images, and teaching material appropriate for the age group. For those in Grades 56 or Grades 7-8, teachers’ guides are also supplied that address the curriculum for those grades, with the 5-6 guide showing how astronomy can be taught across all subjects in the curriculum. Besides access to a science teaching specialist and a technical advisor, the University provides a website containing learning material, resources, and technical information as well as showcasing images obtained by student groups at http://www.csu.edu.au/telescope.

**First-hand Telescope Experiences**

During the 2001 autumn term, five classes of Grade 5 (or mixed Grades 5 and 6) students in the Australian State of New South Wales used the telescope and engaged with the integrated theme of a *Journey through Space and Time*. The reaction has been wholly positive from both students and teachers, and interesting research data is accumulating. Because the research also looks at long-term outcomes, only some aspects of the findings are reported here.

One class of 30 students had covered a number of topics in astronomy prior to enrolling in the project. The pre-treatment questionnaire examining their conceptions of certain astronomical phenomena showed little difference from other enrolled classes that had not encountered the topic before. According to their teacher, they had produced many interesting reports based on their excursions over the Internet and to their library to collect materials. Yet there had been little effect on their immature alternative conceptions as measured by the questionnaire. During their engagement with the project – working with the materials, learning how to control the telescope over the Internet, plus the motivation derived from actually taking control -- changes in their thinking were illustrated by the questions they began to ask. For example, some students wanted to know why, if the Earth was moving so fast around the Sun, we did not fall off. Others wanted to know the difference between an asteroid and a planet. Their questions went beyond their teachers' knowledge yet the children managed to find answers in terms that they could understand and which were aligned with accepted science conceptions. Data from the pre- and post-treatment questionnaires administered to all school classes in the project are being used by one of our Bachelor of Education (Honours) students in her thesis examining changes to children’s alternative conceptions brought about by engaging in the project.

One school held an on-line observation session using the telescope that, because it occurred in Australia, necessarily took place during the evening hours. To offset the problems of getting students back to school at night, the teachers invited interested parents and organized a supper. One of the teachers wrote the following in an email:

> “Thanks again for last night. We had some very excited kids (and adults) here. There were lots of “oos” and “aahs” and “what’s that?” during the evening. We had the computer connected to a data projector, and part of the classroom set up as a little cinema so that everyone who wanted to could watch what was going on, and supper and a Scientific American video on preparing astronauts for living on Mars happening in the adjoining room. We downloaded the images this morning, and there are kids processing them as we speak. We begin holidays tomorrow, for two weeks, so some time after that when they have completed the processing we will put some of those pics onto our website. I will tell Margie and Sally to check out the [CSU] telescope page after lunch.”

The last sentence refers to an interaction between Margie and Sally (both age 11) and one of the authors of this paper, just prior to their turn to take the image that they had planned for (see the email transcript below). Their image was posted to the CSU telescope website as the picture of the month.
Margie and Sally: Hello this is Margie and Sally.
DMcK: Hi there Margie and Sally...what is your object?
Margie and Sally: M4
DMcK: Another beautiful but different globular cluster ...go for it.
Margie and Sally: OK (Both send the telescope to M4 with no help required)
DMcK: Try 45 secs. (They had set the exposure time at 30 seconds.)
Margie and Sally: Thanks-
DMcK: It is quite different to M14 (Taken by an earlier pair of students).
Margie and Sally: And quite beautiful. Lots of stars.
DMcK: Over 100,000
Margie and Sally: Cool

The benefits of remote observing with telescopes located in other parts of the world were made evident in April, 2001 when the Royal Canadian Astronomical Society took control of this telescope during Astronomy Day in Canada. President David Lee demonstrated the ease with which the CSU Remote Telescope and cameras could be controlled to produce images. The download time over the Internet from Bathurst, Australia to a school in Victoria, Canada took approximately three seconds. Schools outside Australia need not plan to have their students return to school after dark to use such instruments. Rather, remote telescopes can be controlled in real time during the daytime class.

Additional qualitative data collected from teachers indicate that some of the mathematical activities included in the elementary school package may be too advanced. One such activity (to be conducted over the course of a month) centred on using a five-cent coin and a tape measure to measure the shape of the Moon’s orbit around the Earth and to calculate its distance. The scaffolding support for this difficult activity used a scale model car and a metre ruler to measure the distance to a car in the school playground. The students found the concepts of scale and the mathematical calculation too difficult without additional work by the teacher. Nonetheless, the teacher felt that she achieved success in helping the students to understand the mathematical concept of ratio through the concrete activities in the playground.

It is obvious to the authors that there will be many opportunities to collect research data on students’ understandings in a variety of curriculum areas. The outcomes of this research will be used to modify activities for future iterations of the project. The project will most likely continue to be dynamic and motivating for the students who work through the activities that lead to proposal development, telescope control and presentation of their results to their school peers and their parents.

Summary

A Journey through Space and Time is an engaging way for students to accomplish curriculum objectives and gain first-hand experience with student-planned work on a scientific-grade remote telescope. During the time they work in small groups in the classroom, they engage in discussions and refine their ideas through interactions with other suggestions and ideas. Their hands-on work brings them digital images of celestial objects that they can use for study and display while developing a better understanding of the world in which we live. On-going research into children’s learning with this project will lead to an improved appreciation of the value of first-hand experiences in the displacement of naïve ideas and the development of scientific understandings.
References


