worked well in the south suburban Chicago area. The course offerings are rotated so that each course is repeated once every two years. The class notes are revised each time a course is offered. New activities are integrated into the material whenever possible.

The student response to the courses has been excellent. Most students who complete one course come back for additional courses, and many have completed the entire sequence. The enrollments have ranged from twenty to sixty. The courses will be offered again during the 1988–89 school year on selected Saturdays.

Daily schedules for each class may be obtained by writing to the author.

THE TRAINING OF PRE-COLLEGE TEACHERS THROUGH WORKSHOPS IN ASTRONOMY

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Most pre-college teachers in the United States have not been trained in astronomy. In Texas, astronomical concepts enter the pre-college science curriculum at all levels.

During the last six years, I have presented two different types of workshops: intensive three-week summer institutes for rather small numbers of teachers, and shorter 6- to 18-hour workshops for larger groups.

The University of Texas Astronomy Department and McDonald Observatory have hosted five of the intensive institutes. The institutes were established to offer an opportunity to learn astronomy through hands-on activities (Texas education regulations mandate that 40 per cent of all pre-college science classes should be laboratory oriented), and to introduce the teachers to modern astronomical research and facilities.

The teachers bring a variety of scientific experiences to the institute. Unlike most teachers in Texas, 52 per cent of them have had an astronomy course. Since most pay all their own expenses, they demonstrate a high interest in astronomy. In five years, a total of 44 teachers have attended a three-week institute with six teachers attending more than once. Their background preparation showed that only 12 per cent had had an astronomy laboratory course, while 30 per cent had attended astronomy workshops. Astronomy as a separate subject was taught by 18 per cent.

The institute is an intensive experience with about 100 contact hours spread over the three weeks. Although the participants attend some lectures on current research by other faculty or research staff, the main focus of the institute is to provide them with hands-on activities and experiences that they can use in the classroom. The activities performed by the participants are taken from *Modern*

Astronomy (Robbins and Hemenway 1982).

Participants begin by learning about measuring errors by building and using a cross-staff and quadrant. They use these instruments to measure the Earth's rotation rate through night-time observations of stars. Depending upon their own interests and scientific training, they choose from a variety of other experiments, with each participant receiving individual attention from the instructor. The most frequently chosen activities concern lunar surface features, the apparent motion of the sun, optics, using small telescopes, photography, and spectroscopy. For the past three years, the students have had an observing run at McDonald Observatory near Fort Davis in west Texas during the third week. Part of the two weeks in Austin is spent preparing to use the 76-cm Cassegrain reflector, with a 4" x 5" (10 cm x 12.5 cm film size) film camera. In west Texas, besides observing and developing film, they enjoy tours of the observatory complex and an opportunity to stay with professional astronomers. Thus the institute offers the pre-college teacher both classroom oriented exercises as well as a chance to share the experiences of research astronomers.

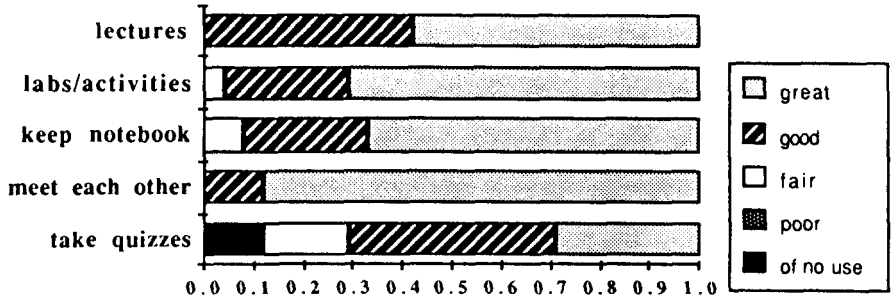

Fig. 1: Participants perceptions of summer institutes, 1984–87, based on 71 % — complete survey of 34 participents.

Results of a follow-up survey showed very positive perceptions of the institute. Participants especially valued the opportunity to meet other teachers with similar interests, and liked the discipline of maintaining a lab notebook. More importantly, 97 per cent of the participants used information from the institute in their classes. The activities themselves were used by 87 per cent in their classes.

With shorter workshops and different audiences, time constraints alter the structure and content of the workshop. Over six years, I gave 9 workshops to about 200 secondary-school teachers and 16 workshops to almost 450 elementary-school teachers.

Elementary-school teachers often have had poor preparation for science teaching. In Texas, prior to 1984, they needed no science courses to receive their certification, and now only need two courses. Science teachers major in science in preparation for teaching at the secondary level, but often teach outside their field. Workshops are often the only formal training in astronomy that a typical teacher

receives.

In a lecture-demonstration format, a lot of information is conveyed but little real understanding occurs. Changing adults' pre-conceptions is difficult. Pre-tests show that most elementary-school teachers can't explain ideas like the seasons, lunar phases, apparent motion of the sun, or how a telescope works (see also a paper by Sadler, this volume). In order to improve understanding, the workshop emphasized activities rather than lectures. Even in one day, teachers can measure solar shadows and angles, demonstrate phases of the moon with balls, compare relative sizes of solar system objects, and classify lunar surface features or galaxies. Activities for secondary teacher workshops were taken from *Modern Astronomy*, while elementary teachers' activities came from *Astronomy Adventures.* During a recent elementary teacher workshop, the pre-test grade on such concepts was 50 per cent, which improved to 68 per cent after the workshop. A shorter workshop allows larger numbers of teachers to learn some astronomy and to observe teaching by the discovery process. The cost per participant is quite low compared to a three-week workshop. Unfortunately, the size of the larger group precludes individual attention. Although elementary-school teachers teach 22 students per year (while secondary-school teachers may teach up to 300), the elementary teachers probably have a stronger influence on their students' attitudes toward science.

There is a need and demand for short workshops for teachers of all grade levels, and for intensive institutes.

References

Robbins, R.R. and Hemenway, M.K. *Modern Astronomy: An Activities Approach.* University of Texas Press (Austin, Texas 78712), 1982.

Astronomy Adventures. Ranger Rick's Nature Scope, vol. 2, #2, National Wildlife Federation (1412 16th St., Washington, D.C. 20036, U.S.A.) 1986.

Discussion

D. McNally: *Could you please tell me the price a teacher has to pay for a 3-week summer institute — U.K. teachers are most unwilling to pay anything for any form of course.*

M.K. Hemenway: Tuition and fees, text, notebook = $130 (out of state students pay an additional $300; only 2 of the 44 have been from outside Texas). Room and board for 2 weeks in Austin range from $240 to $300 (some stay with friends or relatives in the Austin area, or live there). Room and board at McDonald Observatory (3 nights) ≈ $110. Transportation varies. Most participants carpool to the McDonald Observatory and pay a portion of the gasoline (about $25) to the driver. Six of my participants have attended more than once, so they paid double the above estimates. Summary: minimum $200, maximum $860 + transportation to and from Austin.