Discussion

L.C. Hill: *Have you found students who performed at a significantly different level (either better or worse) in their project as opposed to their performances in other academic work?*

D. McNally: By and large, good academic students do well on their projects. However, some 2rd and 3th class students have turned in professional, polished projects. You also find that some 1st class students (on examinations) find projects frustrating because progress is slower than they are accustomed to.

Comment

Jay M. Pasachoff: We have a similar program of research projects at Williams College, and we view it as a major enticement for students to come to Williams and to major in astronomy. Still, the students often come up against the same problems so perceptively listed by Professor McNally. I think that giving Professor McNally's article to new undergraduate thesis students, as I shall surely do, will help them greatly.

MAXIMIZING THE EDUCATIONAL VALUE OF STUDENT RESEARCH PARTICIPATION

Emilia Pisani Belserene
Maria Mitchell Observatory, 4 Vestal Street,
Nantucket, Massachusetts 02254, U.S.A.

1. Introduction

The Maria Mitchell Observatory monitors variable stars photographically and has lately begun to receive photometric data remotely. The staff consists solely of the director and undergraduate student assistants during summer and January vacations. Research topics are chosen for both their scientific interest and their educational potential.

The scientific goal is to improve variable-star statistics by answering any unresolved observational questions. Lately the emphasis is on pulsators in the Cepheid instability strip. Can we watch the stars grow older? We look for deviations from a single, constant period.

The educational goal is to give the student assistants a realistic sense of the research process, beyond what is usual in early undergraduate years. The selection criterion is a university record such that a career in astronomy is a realistic pos-

https://doi.org/10.1017/S0252921100086541 Published online by Cambridge University Press

sibility. The observatory is a memorial to America's first woman astronomer. In the selection of students and in the assignment of tasks, the program tries to be especially careful to give women equal opportunities and equal encouragement.

How, then, to divide the work among the students? Not necessarily for the greatest astrophysical efficiency. No darkroom specialists, programming specialists, *etc.* They should all sample a variety of tasks. Each student is put in charge of at least one star.

Typical tasks:

- Inspecting plates. Measuring magnitudes.
- Computer processing.
  - Data entry.
  - Period search (Fourier, *etc.*).
  - Graphic output (Light curves, O-C diagrams, ...)
  - Least Squares.
  - Data-base management.
  - Computer-program revisions.
- Astrometry.
- Library search for other observations, theory.
- Writing and presenting a paper.
- Blinking for additional variable stars.

All students also work cooperatively at some of the tasks, such as taking and developing plates, presenting colloquia to each other, and running programs for the public. The key feature of the division of labor, however, is that each student is, in effect, the principal investigator for a portion of the project.

What does science gain?

- Improved variable-star statistics
- Potential talented recruits.

What do the participants gain?

- Exposure to research methods and the professional literature.
- A preview of a potential career.
- Contact with students from other campuses and with visiting astronomers.

Does the research suffer from the educational emphasis?

Not much. There is some loss of efficiency, since all assistants are learning all parts of the work. There may be a slight observational bias in the variable-star statistics, since variable stars are put on the program at least in part for their educational usefulness.

How do former participants view their research experience? A survey elicited these comments:

The Maria Mitchell experience was ...

...research on a level suitable for undergraduates ....

...our first shot at publishable science ....

...a perspective on the scientific process ....

...not just data entry and number crunching ....

...real research with all its joys and discouragements ....

...nurturing and encouraging to budding scientists ....

It was valuable to ...

...get experience with real data ....

...be able to complete an entire project ....

...work for a woman ....

...become familiar with important reference works ....

...collect and analyze data when the results are not known in advance ....

...follow a project through from taking plates to publishing results ....

...see how real research is done ....

...realize early that research isn't quick and glamorous all the time ....

We learned to ...

...do literature searches ....

...write up results for journals ....

...use computers, view plates, look up sources ....

I work on Crays now but first became comfortable with computers on the little one at MMO.

We were exposed to ...

...the need for careful, meticulous work ....

...the satisfaction of getting scientific results ....

...a valuable historical perspective ....

...an opportunity to try a research job ....

https://doi.org/10.1017/S0252921100086541 Published online by Cambridge University Press

...the example of scholarship set by Dorrit Hoffleit.

The MMO experience was an important factor in making the decision to become a professional astronomer.

Appendix: The Survey of the Participants

The responses are from a survey that attempted to reach as many as possible of the alumnae and alumni of the program. Responses came from nearly one-third of the 100 or so students, all but three of them women, who worked under Dorrit Hoffleit during 1957–1978 and from nearly half of the 58, 60 per cent of them women, who worked under the present author from 1979 to date.

The respondents did, as was to be expected, include a large number working or studying in astronomy and related fields. The percentages were 68 per cent working and 7 per cent studying among the students from 1957–1978; 14 per cent working and 46 per cent studying among the students from 1979–present. For the purposes of these statistics, "related fields" are defined to include physics, mathematics, and history and philosophy of science. The percentage of respondents who identify themselves specifically as astronomers or as graduate students in astronomy or astrophysics are 26 per cent and 14 per cent, respectively.

Under both directors, most of the work was photographic research on variable stars, usually leading to the presentation and/or publication of a paper. Some of the students' time was devoted to running open nights at the telescope, giving lectures for children, and hosting a series of lectures by visiting astronomers. There was also a weekly seminar on variable-star astronomy at which each participant presented at least one paper.

The questionnaire asked about present and former occupations and invited answers to four questions:

1. What aspects, if any, of the Maria Mitchell student internship program in your day were most useful to astronomy, in your opinion?
2. What aspects, if any, of the Maria Mitchell program in your day were most educational for the student participants, in your opinion?
3. Which part(s) of the Maria Mitchell program would you encourage me to change to increase the benefit to science?
4. Which part(s) of the Maria Mitchell program would you encourage me to change to increase the educational benefit to the assistants?

The summary given above and presented in the poster version of this paper drew on those portions of the answers to question 2 that addressed the educational benefit of the research portion of the work. Many of the respondents also mentioned the educational benefits of meeting the visiting astronomers, working with the public, and giving seminar papers.

The other questions, while not strictly related to the topic of this paper, elicited interesting responses that seem worthy of being summarized are here for use of astronomers planning out-of-the-classroom activities for students.

In addition to improved data on variable stars, two other benefits to astronomy appeared among the responses to question 1. The Maria Mitchell program was viewed as aiding astronomy by encouraging potential recruits to the profession, and also, through the public programs, by increasing the appreciation of astronomy among members of the public.

Among the suggestions for increasing the benefit to science (question 3) were to introduce newer technologies and/or topics closer to "cutting edge" astronomy than survey projects on variable stars. Respondents whose data reduction had been done in the years of desk calculators were pleased that the Observatory now has computers.

Newer technology also occurred among the suggestions to increase the educational benefit (question 4). Other requests: lessons in Fortran; more understanding of what the computers are doing; more opportunity to write programs; the preparation for publication of joint papers on larger aspects of variable star astronomy; reading assignments on the topics presented to each other at the seminars; more guidance about choosing graduate schools and advisers; hard information about being a woman in astronomy.

The suggestions elicited by question 4 raise two interesting questions. How much are we losing, in terms of student understanding of the research process, when we use the power of computers in an educational setting? And, considering that some of the requests are for activities available on the campus, are the usual academic techniques, after all, more useful to students than simply doing research tasks as research assistants? I answer confidently, from the enthusiastic response to the research program, that a taste of research is a very valuable addition to classroom and laboratory study. But we should be careful to consider the educational aspects of our use of student assistants and work hard to encourage understanding of the techniques to which we introduce them.

What does our project suggest to others employing students in research? If you are working on a hot topic, use your student assistants in any way at all; they will be glad to contribute in no matter how routine a way. Otherwise be willing to sacrifice some efficiency. Set up the tasks to maximize educational benefits. Your data will be useful even if unspectacular, and your assistants will have a realistic, early taste of research. Whether or not they become astronomers, they will carry this knowledge of scientific processes into their future lives. The value of the program should not be measured solely by the number who go on in astronomy, I heard from some of the respondents who are not astronomers. The lessons of scholarship are useful to parents, educators, and others.

Finally, what did the survey reveal about the later career paths of women who were students of astronomy in 1958–1987? Some revealing comments:

...astronomer 100 per cent, housewife 40 per cent — we all work 120 hr weeks ....

...managed to have a career in astronomy while being a mother to three children

https://doi.org/10.1017/S0252921100086541 Published online by Cambridge University Press

— it has been difficult, however ....

...engineer 40 hrs/week (=50 per cent of time) + mother (more an art than a science) ....

...worked half time for 12 years while children were small ....

And, from someone identifying herself as a housewife/programmer analyst, "my husband's job and the two children have taken precedence."

Acknowledgments

Variable-star research at the Maria Mitchell Observatory has received funding from the National Science Foundation, currently under AST86–19885, which includes an allotment from the program Research Experiences for Undergraduates. Since 1979, one of the students each summer receives support from the Dorrit Hoffleit Assistantship Fund of the Maria Mitchell Association. The use of remote photoelectric observing was funded by a Theodore Dunham, Jr., grant for research in astronomy.

THE EDINBURGH ASTRONOMY TEACHING AND EDUCATIONAL PACKAGES

M.T. Brück and S.B. Tritton[1]
Department of Astronomy, University of Edinburgh
[1] U.K. Schmidt Telescope Unit, Royal Observatory Edinburgh, Blackford Hill, Edinburgh EH9 3HJ, Scotland

1. Introduction

In this paper we describe our experiences with film copies of original astronomical photographs taken with the 1.2-meter U.K. Schmidt Telescope (UKST) in Australia, and used as teaching material in the Department of Astronomy of the University of Edinburgh. Two packages are intended for undergraduate use; the Education Packages are designed as visual aids for colleges, schools, and amateur groups.

The original purpose of the telescope (which was commissioned in 1973) was to carry out a Southern Sky Survey to match the Northern Survey done by the Palomar 48" Schmidt Telescope. The telescope has a very wide field — 6.5 x 6.5 degrees, or equivalent to over a hundred and fifty full moons, and the photographs reach objects of 23rd magnitude: they record stars like the Sun to the very edges

https://doi.org/10.1017/S0252921100086541 Published online by Cambridge University Press