Variable Stars for Scientific Initiation: An Educational Experience

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Abstract Within the conventional educational structure in Latin America, we find a gap between the basic undergraduate formation and the early steps in research activities. To bridge this gap, we essay a solution based on the close interaction between students and researchers in variable star research. We have called our experience the Scientific Initiation Program, and this program reflects a changing methodology, continuously modeled by the whole group. In this paper we describe our experience over 15 years.

1. Introduction

Within the Instituto Copérnico, the Scientific Initiation Program (PIC, the acronym in Spanish) was created in 1987 (Garcia *et al.* 1992) in response to the need for an incentive for scientific research in the early stages of university education.

The PIC is oriented towards astronomical science (especially variable stars) and related fields, based on the experience of university groups with similar aims, which have existed in other countries for several years. After years of experience, we have started two extensions: one focused on high school level, and other based on e-learning.

Assuming that the questioning of established beliefs is essential to the evolution of science, activities at the PIC constantly stimulate critical thinking and creativity.

2. Description of the problem

The problems we have found in the conventional educational structure are:

- The lack of contact with research during the beginning of the undergraduate university programs. The student generally does not know what research really is, until he confronts his seminar dissertation.
- The students also are not familiar with the mechanisms of the scientific world and the general methodology of science.
- There are also vocational problems related to that lack of knowledge. The student doesn't understand when he chooses a scientific career, what his job will be.

- Lack of information about disciplines in sciences during high school.
- Lack of critical thinking. And a consequence of this problem is the lack of creativity, because there is a tendency to accept the formal paradigm instead of questioning everything.

3. Scientific and educational goals

We think Astronomy exhibits some special advantages for satisfying simultaneously scientific and educational goals, because it is possible to make important contributions without a deep knowledge of the matter.

But we also think that it is only possible to achieve significant results if our educational goals don't go beyond astronomy and cover other sciences, like mathematics, physics, and informatics.

We have planned our goals as follows:

- Establishing a first contact with science by means of scientific research.
- Understanding how to do research and take an taking active part in the research process.
- Fortifying critical thinking skills during the learning process, which are most important for developing any scientific work.
- Achieve a special attitude for differentiating and evaluating the hypothesis assumed in a work and to establish the frame of validity of a certain theory and its degree of predictability.
- Knowing the mechanisms relevant for the production of an acceptable scientific publication.
- Understanding the historical development of science as pillar for the execution of a real research.

4. Implementation: our past experience

Two stages can be distinguished. In the first stage, the beginner is introduced to the researchers' working fashion while he acquires fundamental background knowledge. The second stage—obviously the more interesting one—has as its goal to develop research material in accordance to the group's potentials. The group has a limited number of members, to ensure the quality of the learning process. An essential and very remarkable quality in the groups' organization is its need for general agreement or consensus, in every level of its self-functioning procedures.

The specific field of study is astrophysics. Within it, variable stars are the best choice for this Program, because:

- We have lot of data not analyzed yet
- Variable stars are relatively easy to observe with modest equipment.
- There are several tools available for analyzing data.
- We have enough experience in this field

During this year, the first investigations have begun, and once finished, they will be subject to judgment by active professionals independent of the group. This avoids the possibility of biased scientific research and increases communication with the outer world leading to the publication of results in international reviews and journals.

The importance of publishing is, therefore, the focus of work for the initiating members and requires training young students to be co-authors of a scientific research paper.

5. Pragmatic evaluation of the PIC

Remembering the words of Charles S. Pierce (1931) stating that every act finds its sense nowhere but in its own practical substance, we ask ourselves: What do we expect to achieve with the PIC? It is at this point where we wish to pose our deeper motivation, in which we find the broad justification for this kind of learning experience. First, we should mention their formative features, which are realized on a wide variety of themes, covering from the proper writing of an article to the overall administration of a project like this, and including knowledge of the structure of our galaxy and variable stars. Another important contribution is the profound conviction, in the part of the beginning members, about the scientific world's internal functioning's and the scientist's role in a free society, in the sense of Paul Feyerabend (1978). This conviction motivates the occasional insertion of epistemological discussions.

6. Our results

Some alumni of PIC are nowadays relevant scientists working in Universities and scientific research centers in different parts of the world. Among them are Juan Raúl Cebral (George Mason University), Francisco DiGiorgio (Universidad de Buenos Aires, Argentina), Román Scoccimarro (New York University), Martín Zimmermann (Uppsala University, Sweden).

A series of published papers in scientific journals and the participation in several scientific congresses clearly tell us that our experience has given us very good results.

On the other side, we must take into account that several young people have perceived that the scientific work wasn't the way they felt fulfilled. Then the PIC had helped to decide a vocational definition, a result that is no less important.

7. The new experience

The Internet establishes a brand new challenge, and this year, for the first time, we have launched the e-learning version of the PIC, combining the in-house version (our established experience) simultaneously with the remote version. Nowadays, we have students all around our country (Argentina), separated by thousands of kilometers.

The Virtual Campus is an indispensable tool for the development of the Program's first stage, because the beginner not only finds in it the basic material for developing the Work Program but also is assisted in his academic performance tracking.

Since the Internet gives multimedia possibilities, it is possible to find in the Virtual Campus additional support such as specific films from other courses or colloquiums, references to internet activities, images and animations, bibliography, etc.

PIC's second stage will incorporate interactive virtual work where the students will analyze scientific data in real time, using image and mathematical processing tools.

The third stage of the Program will provide direct access to a telescope on our campus, in order to manipulate it through the Internet and, in this way, making it possible to obtain the data in real time and acquire training in astronomical observation, without being physically present.

8. Conclusion

We succeeded with our goals in the past, but now we have a different challenge: to do the same but in a virtual world!

We expect to bring this kind of Scientific Initiation to a very different sort of student: one who has a better technological background.

References

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