Piloting a Cross-Institutional Collaborative Approach to Honours Education in Theoretical Astrophysics.

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Abstract

Astronomy in Australia has developed mainly as an "experimental" science. The availability of large national facilities such as the Anglo-Australian Observatory and the Australia Telescope have supported these developments, and Australia now has an excellent international reputation in observational astronomy.

Parallel developments in theoretical astrophysics have, however, been slow. Over the years, the Departments of Mathematics at Monash University and at the ANU have successfully introduced some courses in theoretical astrophysics into the undergraduate curricula to help redress this imbalance. However, with shrinking resources, the individual institutions are finding it increasingly difficult to maintain high level specialist teaching to small groups of students over an appropriately wide range of topics. The proposal is for the two institutions to trial the sharing of one subject each at the fourth year hounors level via video-conferencing.

Keywords: Education - Theoretical Astrophysics

1 Introduction

The lure of the southern skies which host the nearest galaxies (the Large and Small Magellanic Clouds) and the galactic centre has attracted funds both locally and internationally for the construction of large optical (Anglo-Australian Telescope) and radio telescopes (Parkes) within Australia. Not surprisingly, Australia's reputation has developed mainly in observational astronomy around these national facilities. Even now that much superior sites to Australia (eg Hawaii, Chile) have been found for the construction of a new generation of 8 to 10 metre class optical telescopes, Australian optical astronomers will still be lucky to have access to some of these overseas facilities (Gemini). Radio astronomy is also thriving through the funding of the Australia Telescope.

Clearly, as with any science, the experimental and theoretical developments go together with the former often driving the latter, and astronomy is no exception. For instance, Newton may not have discovered the inverse law of gravitational attraction if not for Kepler and Tycho Brahe whose meticulous observations had established that the planets moved in elliptical orbits around the Sun. Countless similar examples can be given in astronomy. Unfortunately, the expertise required to interpret astronomical observations, even those generated with our own telescopes, is sadly lacking in Australia. The ARC Research Centre for Theoretical Astrophysics has been the first national attempt at rectifying this "theory vs observation" imbalance. Nevertheless, the number of theoretical astrophysicists in Australia is still very small, and, as a consequence, the training in theoretical astrophysics has also lagged behind the training in observational astronomy and instrumentation.

It is therefore important that theoretical astrophysics be developed within the universities in Australia, and this can best be achieved by offering to undergraduates comprehensive honours programs. Such programs have existed on a small scale in several universities (eg. the Australian National University (Department of Mathematics), Monash University (Department of Mathematics), University of Sydney (Department of Mathematics and School of Physics). It is noteworthy that in its report to the Australian Research Council, the National Committee for Astronomy has also recommended that steps be taken, in the Australian University system, to enhance the training in undergraduate astronomy.

By the very nature of the subject, astrophysics is multi-disciplinary, and a firm grounding in mathematics, physics, and computational science is required before an "in depth" understanding of the subject is possible. This knowledge must go beyond the conceptual base, and must involve different process skills of mathematical abstraction, physical intuition and pragmatic computational methods. This means that most of undergraduate training must be in these fundamental areas, with serious courses in astrophysics being only possible late in the undergraduate career, typically in the 3rd and 4th years.

Monash University and the ANU have, for several years run a limited number of very successful courses in theoretical astrophysics. However, with shrinking resources, the individual institution have neither the staff, nor the expertise to offer an appropriately wide range of high level specialist teaching in theoretical astrophysics to the small groups of undergraduate students interested in astronomy and astrophysics.

2 The Plan

A consortium of the Department of Mathematics at the ANU and the Universities of Sydney and Queensland have applied for a CUTSD (Committee for University Teaching and Staff Development) grant to initiate a remote teaching experiment in honours year pure and applied mathematics, including some theoretical astrophysics. While the technological difficulties may be the same, the actual conceptual focus of astrophysics was seen as sufficiently different to warrant an additional separate approach. A submission to the ANU Faculties Strategic Planning Fund has already yielded the award of $17,500 in piloting this cross-institutional collaborative project exclusively in Theoretical Astrophysics between the Astrophysics Groups in the Departments of Mathematics at Monash University and at the ANU. Matching funds are also expected from Monash University.

Our plan is to "share" two fourth year honours courses. In the second semester of year 2000 we will start the piloting of this cross-institutional teaching program using video-conferencing facilities. Monash University will offer to fourth year Monash *and* remote ANU students a course in "Computational Astrophysics", taught by Prof. J. Monaghan and the ANU will offer to ANU *and* Monash students a course in "Accretion Discs", taught by Prof. D. Wickramasinghe.

An advisory committee consisting of two academic staff from each institution, and a representative of each of the Centre for Eucational Development and Academic Methods (ANU), and the Centre for Higher Education Development (Monash) will be setup to oversee the running of the project.

3 Methods

Australian universities have developed substantial infrastructure, and staff are amassing considerable expertise in developing and delivering courses using video-conferencing facilities. But so far this has been done only in a rather limited way in the theoretical sciences. The effectiveness of this method of teaching has still to be fully evaluated. We are aware of how video-conferencing facilities at the ANU are being successfully used in the teaching of Actuarial Studies courses from the University of Melbourne. This is an ongoing and well established arrangement between these two universities.

The astrophysics lectures will be fully interactive and given live. This is fundamental to good teaching practice, since it allows student-lecturer and student-student interactions. Each site will have two video screens available. One will show the lecturer almost all of the time, with small inserts showing students at the remote site. The other screen will show astrophysics material. At the lecturer's site there will be video images of the students at the remote site. The video conferencing system is such that it is possible to zoom-in on anyone who may want to "take the floor".

It is proposed that the lecturer should visit the other institution twice during each course to run problem sessions, and give two lectures from the "remote" site. This will allow all students to link with their lecturer at a one-to-one level, albeit for a short period, and will encourage continued interaction even when the lectures are given remotely.

4 Limitations

The "talking head" approach to video-conferencing is dismally inadequate for the teaching of science based subjects. Electronic whiteboards only hold a very limited amount of written material which is displayed slowly and at low resolution. Document cameras are somewhat better than electronic whiteboards, but these also only hold a *very* limited amount of written material, so the lecturer will need to give careful consideration to what is displayed. One possible strategy could be that of having the lecturing material prepared in advance and distributed to students via electronic mail or the WEB. In this way, students will have the lecture notes in their hands when attending the lecture and the lecturer will not need to go through each step of a mathematical proof using a document camera.

Discovering viable and robust strategies to overcome the technical problems and the modification of lecturing techniques to overcome these difficulties lie at the heart of this project.

5 Students Assessment

Students need continuous feedback on their performance so that they can monitor their development throughout the course. Constructive comments should be given to students who are having difficulty with the course so that they can improve their performance. In general, in order to be constructive, a feedback must be (i) informative, (ii) address different ways for improving performance (iii) encourage students and point out mistakes and misunderstandings in a tactful and constructive way and (iv) be timely or the students will have moved to new topics and interests.

The idea of using classroom assessment techniques (CATs, Angelo 1991) between teaching and formal assessments to assist the lecturers to correct their teaching on a day-to-day basis, appears to be a very effective method of enhancing the teaching and learning experience. Usually, students are not intimidated and respond positively to CATs, the aim of which is to understand and improve learning.

Although lecturing via video-conferencing might seem an impersonal way to deal with the teaching and learning process, we will attempt to make this process as interactive as possible in order to fullfill the above assessments goals.

E-mail workshops will be setup to evaluate students learning and encourage student participation, while also promoting student to student and student to lecturer interaction. Messages will be posted to the course list of students enrolled in the unit so that everyone will be able to read them and provide answers, suggestions or simply comments. A discussion bulletin board on the WEB could also be setup to reach the same goal.

The formal assessment requirements which are needed for the students grading at the end of the course, will be conducted through weekly assignments and possibly with an end of semester examination.

6 Project Outcomes

6.1 Student Learning Outcomes

Students will be able to interact with peers at other institution and experience a wider range of teaching and learning practices. Here a word of caution is necessary: one needs to ensure that the increased of breadth of exposure will not be at a loss of understanding, particularly for those students located remote from the lecturer. For this reason, each lecturer will visit the other institution to give a live lecture from the "other side". This will enable comparisons of the experiences of students taught under the "live audience" and "remote audience" scenarios.

The interaction of students and staff in different institutions will allow students to learn what kind of research is conducted at the other university. Therefore, this approach will be likely to result in a greater mobility of students within the astrophysics community between undergraduate and postgraduate level programs by providing students with a wider choice of postgraduate research projects.

6.2 Support for Student Learning

The project will appraise the ways in which astrophysics at honours level can be delivered and will choose the most appropriate of available technologies for teaching and learning. The issues experienced by local and remote cohorts will enable deductions about the adequacy or otherwise of the student learning support structures used, and will lead to recommendations of cost-effective student support options viable beyond the lifetime of the project. We expect also to develop guidelines for the most efficient and effective approach to electronic archiving of course resources appropriate to student needs in our context.

6.3 Increased Outreach

Additional project outcomes are strategies for, and recommendations about, extending the range of institutions involved in the offering of such courses. For example, linking with the Special Research Centre for Theoretical Astrophysics in Sydney, or indeed, providing selected courses to institutions having no specific astrophysics expertise.

6.4 Staff Development

Academic staff in astrophysics at the participating institutions will be exposed to a broader range of teaching practices, and will have an opportunity to learn new teaching skills and approaches to support student learning. The project will appraise the ways in which theoretical astrophysics at honours year level can be delivered and will choose the most appropriate of available technologies for teaching and learning. The issues experienced by local and remote cohorts will enable deductions about the adequacy or otherwise of the student learning support structures used, and will lead to recommendations of cost-effective student support options viable beyond the lifetime of the project. We expect also to develop guidelines for the most efficient and effective approach to electronic archiving of course resources appropriate to student needs in our context.

7 Evaluation

As noted in §2, an advisory committee will be setup which will involve the assistance and expertise from each of the associated educational development units. We will evaluate for two kinds of outcomes: learning outcomes for students, and project outcomes. Students' views will be gathered during individual interviews and/or small focus-group discussions, supplemented by (simple) E-mail questionnaires as appropriate.

Formative and summative student evaluation activities will target independent cohorts of students within and between institutions. Student satisfaction with the learning experience when they are located remote from the lecturer conducting the course will be a key theme in the evaluation. Likewise, we will be aiming to explore with these students what they found worked well in the range of teaching strategies adopted, and what might have been lacking in the learning support structures offered. Subsequently, the advisory committee will meet (by video-conferencing) to review this feedback and make recommendations.

Summative analysis of the student evaluation data collected in the manner described above will permit a project evaluation in the form of a specific examination of the impact and effectiveness of the innovations and developments undertaken.

References

Angelo, T.A., 1991, "Classroom research: early lessons from success", (Jossey-Bass: San Francisco).