

An Activity-based Approach to Teaching Astrophysics at the Level of General-education Course

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ABSTRACT

Physics 002 is a general-education course on Introductory Astrophysics and Astronomy for non-physics majors at HKUST. The number of students enrolled each semester ranges from 250 to 370, a relatively large class by HKUST standards. The types of student enrolled are very varied, coming from all University departments. To design a course to educate such a large variety of students effectively, we have decided to make use of a combination of teaching strategies and methodologies: Activity-based Approach, Personal Response System, and WebCT. In this article we shall describe how we succeeded in implementing the above teaching methodologies in Physics 002. We will also discuss both the advantages and disadvantages in developing a general-education course such as Physics 002 using the above teaching methodologies.

INTRODUCTION

It is well accepted that modern university education should be broadly based, and university graduates should have an appreciation of a multiplicity of disciplines well beyond their major subjects. Science, being the systematic study of nature and the basis of all modern technological development, constitutes an important component in the general-education course of non-science majors in the university. Its scale of impact is well illustrated by the transformation of China from a medieval empire to a respectable modern nation, after a century which saw the injection of scientific ideas and civic awareness of the scientific attitude. Astronomy, the study of objects from planets, stars, to the universe, is one of the most fascinating science subjects to both laymen and scientists. Its starting point is as easy as the observation of the sky, and it can go deep into philosophical issues about origins and destinies. Realizing the need to promote an appreciation and awareness of science among university students, physicists at HKUST introduced the general-education course *Introduction to Astrophysics and Astronomy* (PHYS002) for non-physics majors, using an activity-

based approach. In this paper, we share from our experience how this approach contributed to the success of the course.

PHYS002 is a general-education course given to undergraduate students of a variety of backgrounds at HKUST. The course was usually well received and the number of students varied from 250 to 370, depending on the semester when it was offered. When designing and delivering a course, especially a general-education course, to a large audience with such a wide variety of backgrounds, the instructors are faced with many constraining factors. First and foremost is the decision on the level of difficulty of the subject and, second, class control. The latter can take several forms: to capture the attention of the audience in the lecture; to run and organize activities; and to set and run quizzes online; to set and administer mid-term and final exams. To ensure that all these factors are accomplished and delivered in a systematic way, a sufficient number of Teaching Assistants (TA) must be available together with the appropriate use of software packages for delivering certain components of the teaching materials, in our case the quizzes and videos of the lectures.

COURSE STRUCTURE

The level of material for this course is based on a popular textbook, which is generally considered appropriate for a wide variety of audience. So for this reason, the book has been adopted as one of the main reference texts for our present course.

The course materials are organized in MS PowerPoint format with an average of about thirty slides per lecture, consisting of a mixture of text and illustrations. The reason for using MS Powerpoint is partly because of the convenience and availability. Considering these and other factors such as upgradability and multimedia capability, PowerPoint is considered the most preferred lecture-delivery software throughout the campus. The PowerPoint files are made available for download and print via the web site well before each lecture is delivered. The students can therefore preview and review the lectures in their own time by simply downloading the PowerPoint files to their computers at home or print a hard copy to carry around.

ASTRONOMICAL ACTIVITIES

The course is organized around a set of activities, mainly for motivating the students' interest in the subject as well as to enable them to explore certain aspects of the subject only lightly touched on in the lectures, or simply not covered at all in the course because of shortage of time. The activities therefore help to fill up the missing topics or sections of a topic. These activities come in a variety of formats: visits to local astronomy institutions and museums, astronomy camps, and public lectures. At present there are over a dozen of such activities distributed evenly throughout the semester. The types of activity offered depend on the semester the course is being held. Some examples of such activities include:

Sky Show "New Frontiers of Space Exploration"- HK Space Museum

Astronomy Seminar and Observation I – HKUST Astronomy Club
Film Show “ Star Dust” – HK Space Museum
Leonid Meteor Shower Observation – Course instructor and TAs

Each student is required to attend at least two activities and submit a report at the end of each activity. Each report will be carefully graded by the TA in charge of the activity. From the students’ responses and evaluations, these activities have been shown to be informative and enjoyable.

PERSONAL RESPONSE SYSTEM (PRS)

When it comes to class management, getting responses from such a large class of students often proves to be time-consuming and nearly impossible. To overcome this impossibility, we have made use of an ingenious device called the Personal Response System (PRS) [2]. This electronic device was first conceived and produced by a team of staff at HKUST, headed by Nelson Cue, and was first put to use in 1999. The aim of the device is to enable the instructor to ask the class a question and get a definite response from each student, instead of getting a show of hands with no clear answers. The electronic device is convenient because of its small size. It is a handheld electronic voting machine with computer-assisted results-gathering and analyzing capabilities at the instructor’s end. At the end of each voted question, the results are gathered and displayed on the screen so that the instructor can see at a glance how the students have performed in a particular question and take the necessary course of action right after the question. PRS has proven to be invaluable in managing question sessions especially with large classes such as PHYS002.

The teaching experience showed that PRS introduced a new kind of learning dynamic, when a commonly misconceived answer by a significant fraction of students was revealed to be wrong. It assisted the instructor in understanding how the students think and what should be emphasized to avoid common misconceptions. Follow-up action to such revelations are very important to clarify the misconceptions of students, and can contribute to their learning at a deeper level and long-term memory retention. When carefully handled, it can also contribute to an active discussion in class and a feedback to improved question design.

WEBCT

WebCT is short for **Web Course Tools**, developed by a team in the Department of Computer Science at the University of British Columbia, headed by Murray Goldberg. The software package was first released in May 1996 and it is now being used by more than 900 universities around the world. For the present course, we have not yet made full use of WebCT as our only platform for online course design, delivery, and management. What we have so far made use of has proved to be invaluable in terms of course management and integration of components. Two

components of the course have been put on WebCT for trial in the last two semesters: Quiz and Lecture Videos.

All quizzes are of multiple-choice format so that they can be marked by computer for instant delivery of results together with comments and answers. From the student's point of view this is considered user-friendly and convenient in that the student does not have to wait a week for the quiz to be marked and returned.

Each lecture is video-recorded and put online via WebCT using a specially chosen streaming software for efficient delivery. In order to make videos of the lectures suitable for online delivery, we have to take into account several crucial factors such as availability of computer software and network bandwidth. In determining which computer software to use, we also take into account which software is less likely to cause a computer crash during network delivery. As a result, the software chosen for delivering the videos of the lecture is RealMedia by RealNetworks.com. The advantage of using RealMedia for video and audio streaming is its capability to encode and reduce the original file size to a relatively smaller file with only a slight drop in quality. With its small file size and superior network protocol, the videos of the lectures can be viewed in the campus or at home with broadband access 24 hours a day.

VIDEOS, COMPUTER ANIMATIONS, AND DEMONSTRATIONS

To provide a better visualization of the more abstract concepts, and to present about the most updated developments in the subject, selected videos are shown on several topics, including Newtonian mechanics, telescopes, stellar evolution, and black holes.

Besides, many computer animations illustrating the principles of astrophysics are available from many sister courses in universities worldwide. They are helpful in making difficult concepts much more palatable, and save the students much effort in visualizing their occurrence in different contexts. In some cases, they are presented in a form similar to computer games, so that a student can be chosen to do the show. This in turn increases the students' sense of participation.

Real-life demonstrations are also important in conveying concepts to the students. They are carefully prepared by the TAs, and the database of demonstrations in the University of Maryland provides a rich source [3]. Experience also showed that demonstrations which get the demonstrators wet are especially welcomed by students, and hence enhance the participative atmosphere of the class!

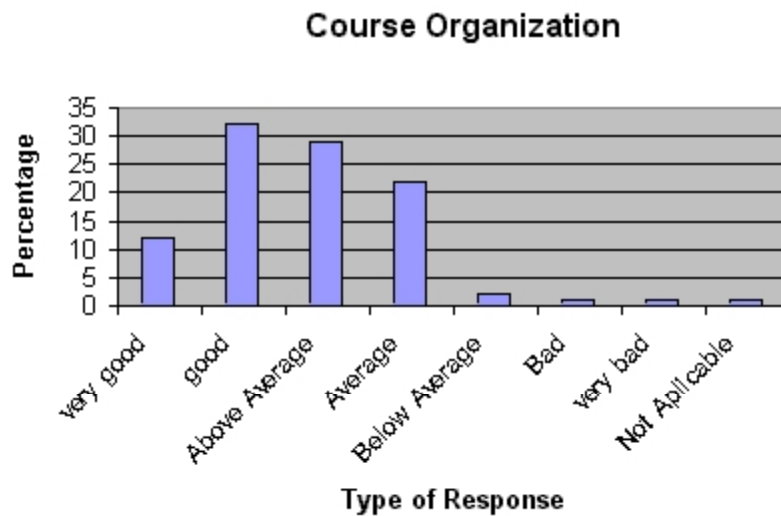
All of these activities constitute an alternative mode of presentation other than lectures. Hence, they engage the students' interest in the course, making them realize that astrophysics can be very lively indeed.

FORUM

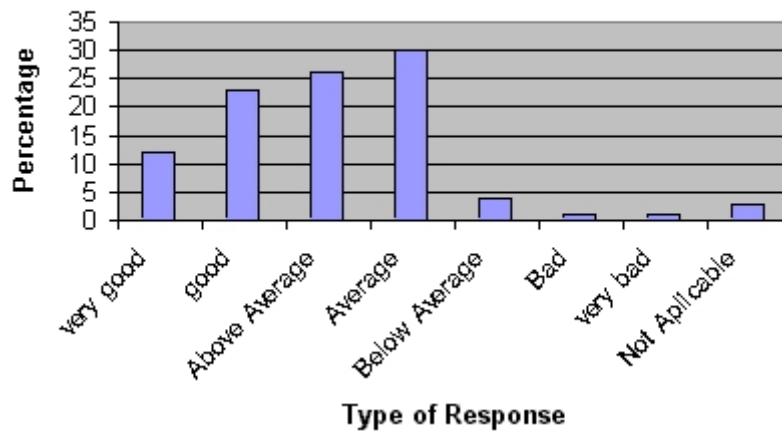
To encourage student participation, the course also set up a forum on the course web site for students to ask and answer questions. Participation marks are counted and the best questions and answers are occasionally awarded a certificate. The forum was very successful in encouraging students to ask all sorts of astrophysics questions, many of which are not directly related to the course materials that were taught already. Students also answered questions using their own words, thus creating an atmosphere conducive to free discussion and academic inquiry.

STATISTICAL RESULTS

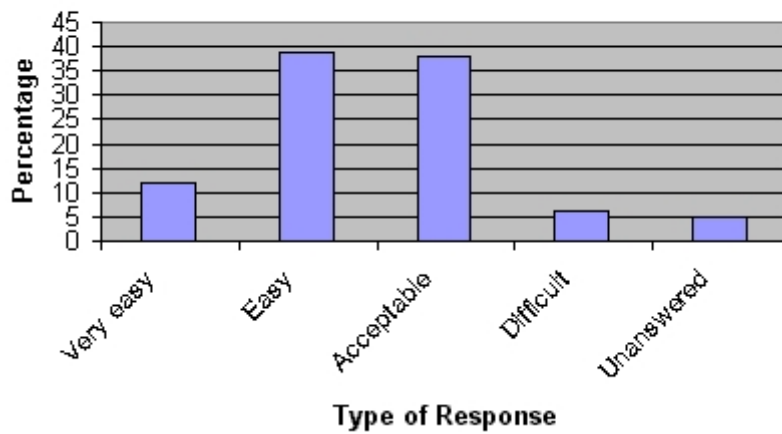
To round up the discussion let us take a look at some of the responses to a set of questionnaires called COSSET, designed by a team of staff at HKUST's Center for Enhancement of Learning and Teaching (CELT) [4]. From the following charts we can conclude that both the organization and the quality of teaching materials are of above-average rating, especially in course organization, which is very encouraging considering the wide variety of student backgrounds. The WebCT component also shows an encouraging response in its usability and enhancement in learning.



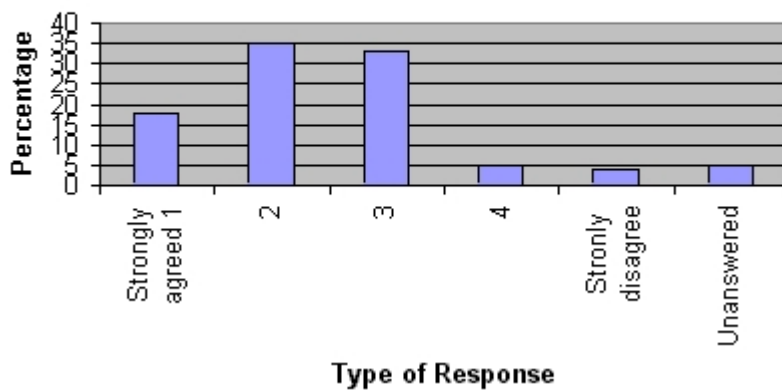
Usefulness of Teaching Materials



WebCT: Usability



WebCT: Online Quiz Helps me to Learn More About the Subject



CONCLUSION

In summary, we have shared our experience in teaching astrophysics at the level of a general-education course using the activity-based approach. Besides the normal mode of lectures, students can watch videos, computer animations, and demonstrations. To learn in an active mode, students participate in astronomical activities, answering PRS questions, doing self-assessed WebCT quizzes, and discussing in the forum. This multiple approach has made the course very interesting, and very effective in conveying otherwise difficult scientific concepts. We believe that this approach can be generalized to enrich other general-education courses with a similar level of student enrolment. In the next semester, we will also implement the web version of this course in the CyberU project of the university, serving elite upper-form students in local secondary schools.

REFERENCES

[1] Seeds, Michael A. (2001), *Foundations of Astronomy*, 6th edition, Brooks/Cole, Pacific Grove.

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[3] The University of Maryland Physics Lecture-Demonstration Facility,
<http://www.physics.umd.edu/>

[4] COSETT - <http://www.ust.hk/celt/otev/Takha.ppt>