Science learning environment—outside-class experience: design, evaluation and challenge

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Introduction

Traditional university science (physics) teaching is based on the lecture-laboratory/tutorial delivery scheme. Also, this type of training is usually in the form of puzzle-solving strategy on a particular class of problems which comprises successful aspects of a topic/discipline (textbook-science). In addition to that the segmentation of teaching where the knowledge transferred has been broken up into separate courses (topics) increases tendency to omit as much as possible of the material that does not fit exactly the course objectives. As a result, some important in teaching and practice of science topics falls between and are not presented at all. This is especially true for issues related to contemporary, cutting-edge science.

Science and science-oriented students enrolled in two introductory physics courses presented by the Discipline of Physics at the University of Newcastle were/are exposed to a number of diverse topics (fundamental physics) with little time for expanding and overlapping their course-based knowledge with more and more multidisciplinary science environment. In order to encourage students to test and expand their knowledge a two-A4-page format bulletin was designed and widely distributed among about 450 students in these two level-one introductory physics courses (Figure 1). Qualitative evidence regarding student's perceived value of the bulletin shows that the proposed design was as a successful and valuable learning experience for a vast majority of the first year students.

Design

The primary design and topic selection principle was to confront student's course-based knowledge with their willingness and ability to absorb an outside-class message, carry it through and extend it beyond their prescribed degree-program experience. By reading the bulletin, students were exposed to topics from history of science, contemporary science, junk science, movies, books, etc. The following titles were distributed in our 2001-2002 first-year introductory physics courses:

- **The Law of the Farm or the Problem Based Learning Strategy in Physics.** A short presentation of scientific method linked to topics from 'First Things First' by S.R. Covey. Context: traditional perception of learning practice in science (especially in physics) and effectiveness of practice in everyday life and work environment.
- **The Hollywood Physics.** Text designed to verify popular-movie-based scientific knowledge with that discussed in introductory physics courses.
- **The Midas Formula.** Relationship between physics and finance—historical perspective and current practices. A brief introduction to econophysics.
- **The Extrapolated World of Science… Fiction?** The phenomenon of Sir Arthur Clark and his writing; a simple scheme to confront knowledge with creativity and imagination.
- **The Legacy of Cargo People.** Extended version of famous statement from Richard Feynmann regarding science and pseudoscience.
- **The Sound of Music.** One of the greatest scientific puzzles of contemporary science (origin of noise) and the unexposed discovery (1970s) about human's perception of music. Link to the origin and early days of quantum physics.

- **The Mystery of Ettore Majorana.** The genius of Italian physicist Ettore Majorana and his mysterious disappearance linked to early advances in nuclear physics and today's nuclear power related controversies.
- **Nanoscience, Nanotechnology... Nonsense?** The extraordinary carrier of Silicon and its uncertain future in tomorrow's microelectronics. A short introduction to nanoscience and nanotechnology; Moore's Law and current advances in molecular electronics.
- **The Good, The Bad or… just not too Pretty.** Confrontation between 'real' and 'junk' science in the context of the Alfred Nobel and Ig. Nobel Prize winning achievements.
- **The Guessing Game.** A view on science as a 'guessing game'; selected facts from the most important moments in history of science.
- **Have You Seen a Beautiful Mind?** John Nash's life story and achievements in Ron Howard's Oscar winning movie.
- **Science in the Sandbox.** Cutting-edge research a 3-year-old can do and some unexpected, surprising and intriguing outcomes.
- **The Missing Link.** Student's uni-life experience in a poster-cartoon format.

Adapted distribution strategy was based on an easy-to-catch graphical form of the bulletin (see Figure 1) and easy-to-access policy (lectures, laboratory sessions, tutorial classes, library, and the Web). While students were encouraged to read the distributed texts, they were also aware of the fact that reading the bulletin was not 'a course prescribed activity'. Students (and academics) were also encouraged to contribute to the forthcoming editions of the bulletin.

Evaluation

Surveys of students and evaluations of their responses were carried out to determine in what ways the described design was succeeding. Two distinctive groups of first-year and one group of former first-year students were targeted in the conducted surveys. Both groups of first-year students—Biotechnology, Biomedical Science, and Science students enrolled in the Introductory Physics course (lower level course with approximately 200 students), and approximately 160 students in the higher level Advanced Physics course—completed identical, end-of-semester evaluation questionnaire. Former first-year students (in 2002) completed the evaluation questionnaire. The end-of-semester first-year student's evaluation form contained the following questions:

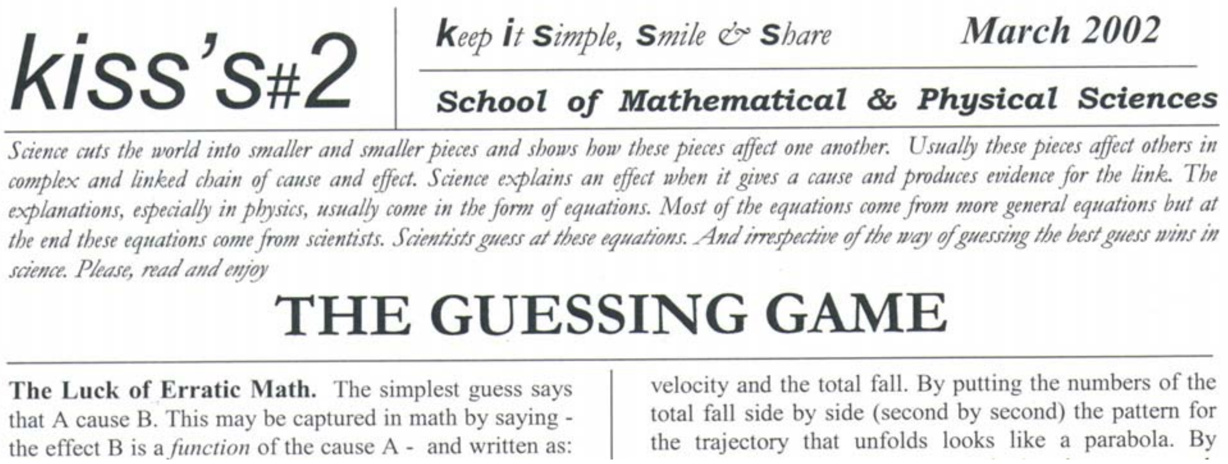
(1) Have you read (heard) about the bulletin?; (2) How many issues of the bulletin have you read?; (3) Would you recommend the bulletin to other science or engineering students?; (4) The bulletin stimulates my interest in science; (5) Would you like to comment on 'outside-course' activities in the Physics Department?

Questions (1), (3) and (4) had very high ranking in both groups of the first-year students: 90% read the bulletin, more than 80% would recommend the bulletin to fellow students, and only 8% disagreed with statement (4). This shows that the students found the bulletin to be an accessible, readable and valuable outside class learning experience. Written comments (question 4) were equally encouraging and included 'I am a big fan of the bulletin'; 'write more and often'; 'would like to read more about…'. The survey also showed (question 2) the 2001/2002 first-year students' preferences: the Advanced Physics course students ranked the texts: 'The Midas Formula', 'Nanoscience…Nonsense' and 'The Mystery of Ettore Majorana', significantly higher than the Introductory Physics class (in this group the 'The Hollywood Physics' and 'The Good, The Bad…' had the highest rank). In both groups the texts: 'The Law of the Farm…' and 'The Legacy of Cargo People', had the lowest ranking.

The evaluation questionnaire for the group of former first year students contained questions (1), (3) and (4). The survey was conducted on a very small group of students and showed that only 2 students (out of 16 responded) did not read the 2002 bulletin (issued in the first semester 2002); 12 students would recommend the 2002 bulletin to fellow students; and 10 students agreed with (5).

Conclusions

In summary, the project to design an outside-class science learning environment was generally effective in delivering most of the anticipated benefits A survey of students clearly indicates the great potential that exists for this type of outside-class-learning-environment design to bring in substantial teaching/learning advances. The evaluated design represents a valuable potential for integration between course units, different courses, as well as linking a course content with contemporary, cutting-edge science. The discussed design can also result in increased depth of learning, student teacher interaction, and development of critical thinking and communication skills. The identified main challenges to the presented design are: (a) available time for writing and editing the bulletin, and (b), lack of students (and other academic/teaching staff members) engagement in preparing and editing the bulletin.



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Science cuts the world into smaller and smaller pieces and shows how these pieces affect one another. Usually these pieces affect others in complex and linked chain of cause and effect. Science explains an effect when it gives a cause and produces evidence for the link. The explanations, especially in physics, usually come in the form of equations. Most of the equations come from more general equations but at the end these equations come from scientists. Scientists guess at these equations. And irrespective of the way of guessing the best guess wins in science. Please, read and enjoy

THE GUESSING GAME

The Luck of Erratic Math. The simplest guess says that A cause B. This may be captured in math by saying - the effect B is a *function* of the cause A - and written as:

velocity and the total fall. By putting the numbers of the total fall side by side (second by second) the pattern for the trajectory that unfolds looks like a parabola. By

Figure 1. The graphical design for the PHYS100 and Beyond and KISS's bulletins distributed in 2001, and 2002, respectively