Developing Demo/Teaching Kits Based on Departmental Research Strength

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ABSTRACT

We describe an innovative scheme to better realize the potential and sustainability of existing physics research project courses in undergraduate education. Its main feature is the requirement for students to further develop cutting-edge science and technology either recently developed or invented by project team members. The outcome of their research will form the basis of teaching kits in existing physics courses, and will also be presented to secondary school students to promote popular science. The scheme has been successful in providing a platform for students to strengthen their scientific knowledge, experimental construction, problem-solving, critical thinking, presentation and multimedia production skills.

Keywords

Research project courses, departmental research strength, student-led research, demo & teaching kits, promotion of a learning culture

1. INTRODUCTION

Junior/senior research project courses are key elements in most Engineering and Science undergraduate programs, and indeed in many other disciplines. Their primary objective is to enable students to integrate theoretical and practical skills gained throughout their lecture and laboratory coverage of different courses.

The underlying philosophy of our scheme is this: students learn best by doing, not listening. Our scheme aims to develop a learning culture by offering students a way to encounter a number of physical inventions successfully developed in the Department of Physics at HKUST in the past few years. In terms of the learning objectives, it provides an opportunity

for them to learn in-depth about these scientific inventions by being frontline researchers. It also encourages student-led experimental research through the requirement to develop physical hardware or software demo/teaching kits based on these inventions, using their own initiative and ideas. This helps students develop independent and critical thinking, and the various technical skills needed in carrying out scientific research. To learn in-depth about these scientific inventions, students need to do lots of reviews related to the topics themselves, in the process encouraging independent learning and critical evaluation of students' own methodologies. The "visible" outcome (demo/teaching kits) are further used in enriching undergraduate experimental physics courses and promoting science to the general public, through which students also get substantial training in designing science experiments, presentation skills and communication skills with a large and broad audience. This scheme's achievements will have a long-lasting impact on the quality of teaching and learning within the department and on promoting science education in our community.

2. DESCRIPTION

Project courses include the one offered to final year students (PHYS 398: 4 credits) and those offered to all years of UG physics students (PHYS 191/291/391: one credit). This innovative scheme has enhanced the learning experience of undergraduate Physics students in project-based courses in the following ways: (1) by introducing cutting-edge science/technologies to broaden their knowledge basis, students are provided with a dynamic and exciting learning experience; (2) by involving students in software/hardware design/fabrication of demo and teaching kits, they develop various practical skills that are not taught in traditional lectures and laboratory sessions and (3) by involving students in outreach activities where they present their research achievements in lectures or demonstrations (including talks through the science mini-lecture series in secondary schools, Outreach Day and in-campus lab visits by local/overseas secondary school students), they gain substantial training in presentation skills and communication skills with a large and broad audience. Students showing outstanding progress and with presentable topics were nominated to participate in these. Among the developed demo/teaching kits, those with good potential use as novel experimental-physics instruments can be further implemented in our existing experimental physics courses to benefit the next generation of physics undergraduates.

3. PEER SUPPORT

The Physics teaching lab has kindly provided support in terms of working space and technical support for some students involving the development of demo and teaching kits. CELT staff members attended the students' oral presentations at the end of each semester. They also helped design question sheets for outreach activities and oral presentations for onsite evaluation assessments and conducted group or individual interviews after the presentations. Some Physics faculty members visited the secondary schools with the student presenters. Prof. Alexis Lau of the Environmental Central Facility viewed the demonstration of the air pollution monitoring system developed through this approach and offered his stimulating suggestions and positive comments. The School of Science arranged a number of lab visits from overseas institutions to introduce some of our achievements and selected the projects based on the UV detection technology as a showcase at the Innovation Expo 2007.

4. ACHIEVEMENTS

4.1 Undergraduate Education

This novel approach has achieved many of the objectives of an all-round university education through equipping students with core skills and knowledge in up-to-date science development, searching, discovering, integrating and organizing knowledge, problem solving, oral and written presentation, experimental design and fabrication, team working and communicating their ideas, which are transferable into post-university experience.

4.2 Demo/Teaching Kits

During the past two years, a wide range of topics has been offered, including UV Science, lithography based on laser holography, sonic band-gap structures, nano science & technology, leaky bucket simulation of multi-service mobile network and ER fluid, etc. This approach has resulted in six software- and five hardware-demo/teaching kits. So far, one (sonic bandgap experiment) has been developed into an experimental setup with an integrated lab manual, which was added as a new topic in the course PHYS311 (Advanced Experimental Physics) in the summer semester, 2007. Two other hardware systems (the air pollution monitor and ER-fluid demo kit) are potentially suitable as new topics for either PHYS311 or PHYS211 lab courses.

4.3 Outreach Activities

Most activities promoted science either through offering mini-lecture series in a number of local secondary schools, or through HKUST Outreach Day (2006 and 2007) and in-campus lab visits by local/overseas secondary school students. In particular, the achievements arising from projects based on the UV detection technology were selected by the Science School for the Innovation Expo 2007 held at the Hong Kong Convention and Exhibition Centre from September 14 to 18, 2007. A participating student also described his research during a physics seminar which all our undergraduate physics students attended. His presentation stimulated their interest in scientific research. A representative of Taiwan's teachers' union recently visited us and expressed strong interest in collaborating in the development of teaching kits to be promoted in the educational sector in Taiwan and worldwide.

5. EVALUATION

The evaluation of the projects was implemented through the following means.

5.1 Presentation Assessment Checklists

At the end of each semester, each student gave a 20-minute presentation for the project course (PHYS 191/280/291/391/398), to an audience of professors and students in the Department of Physics. During this, they shared their research findings and outcomes. Presentation assessment checklists were distributed to the audience for the evaluation of the research work and the students' performance. They contained 20 multiple-choice questions and one open-ended question covering five general aspects: content, organization, delivery technique, challenging situation and language. Five was the top score for all aspects and their sub-aspects.

Figure 1 shows the response summary of the five aspects of the project presentations. All responses are positive. It shows that the audience was well satisfied with the planning, management and handling of the projects, as well as the performance of the student presenters. As an example, Fig. 2 displays the detailed response summary of the sub-aspects. Responses are overwhelmingly positive. The audience agreed that our projects are interesting, capable of introducing up-to-date scientific discovery and the research ideas are supported with relevant scientific knowledge.

5.2 Demonstration Assessment Checklists

During our outreach activities, such as the HKUST Outreach Day and the science mini-lecture series in secondary schools, students demonstrated the demo/teaching kits resulting from this scheme. Assessment checklists containing six multiple-choice questions and one open-ended question were also distributed to teachers and pupils at the end of the demonstration. Fig.3 is the summary of that evaluation. They agree that installation of such a setup in their school could stimulate learning and that our demonstration aroused their interest in scientific research.

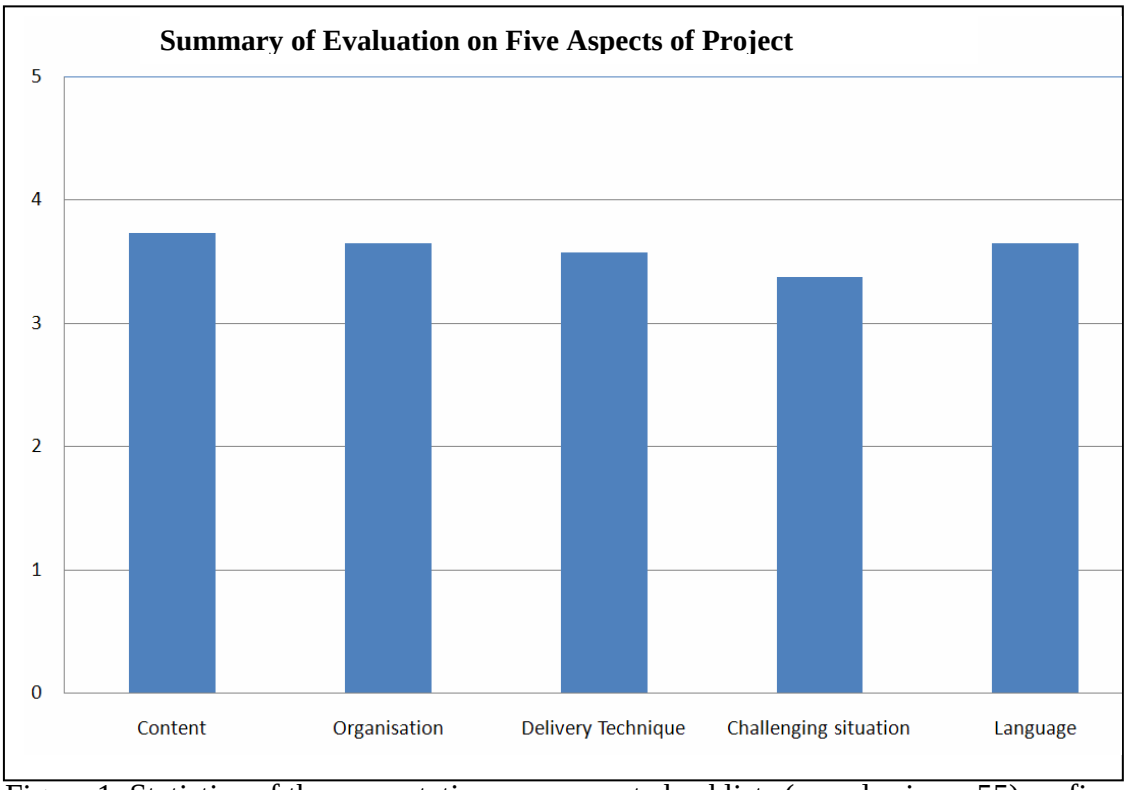

Figure 1: Statistics of the presentation assessment checklists (sample size = 55) on five aspects of the project presentations.

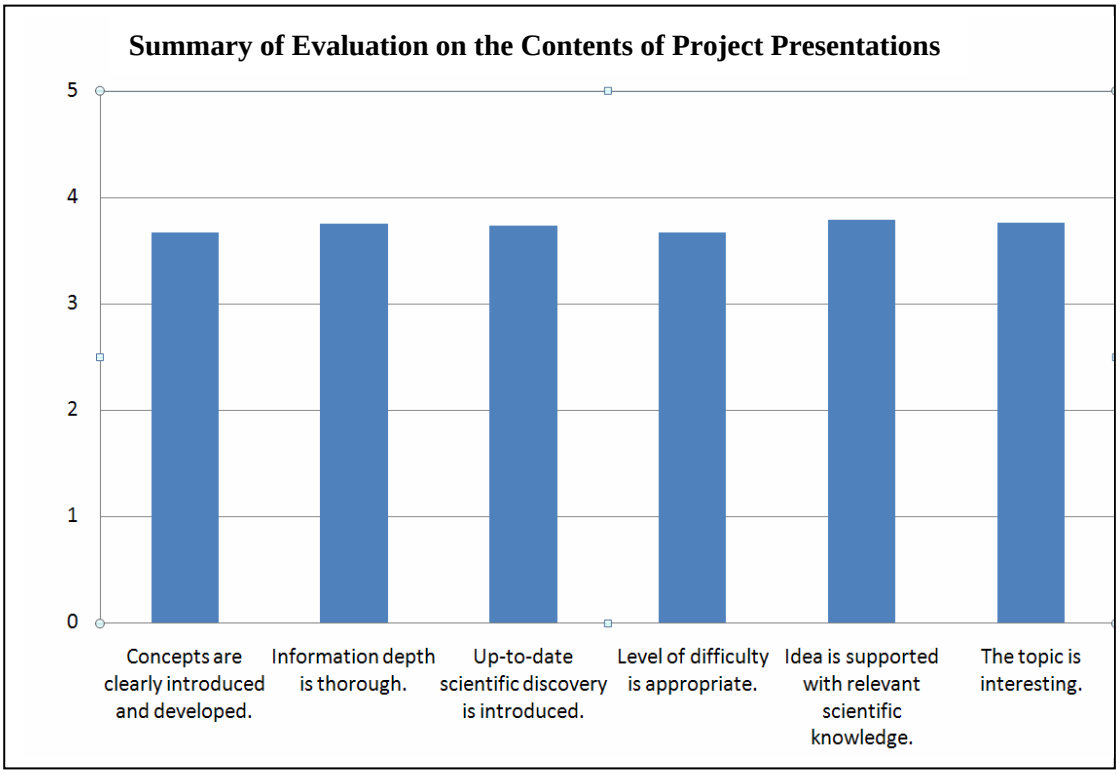

Figure 2: Statistics of the presentation assessment checklists (sample size = 55) on six sub-aspects of the content of the project presentations.

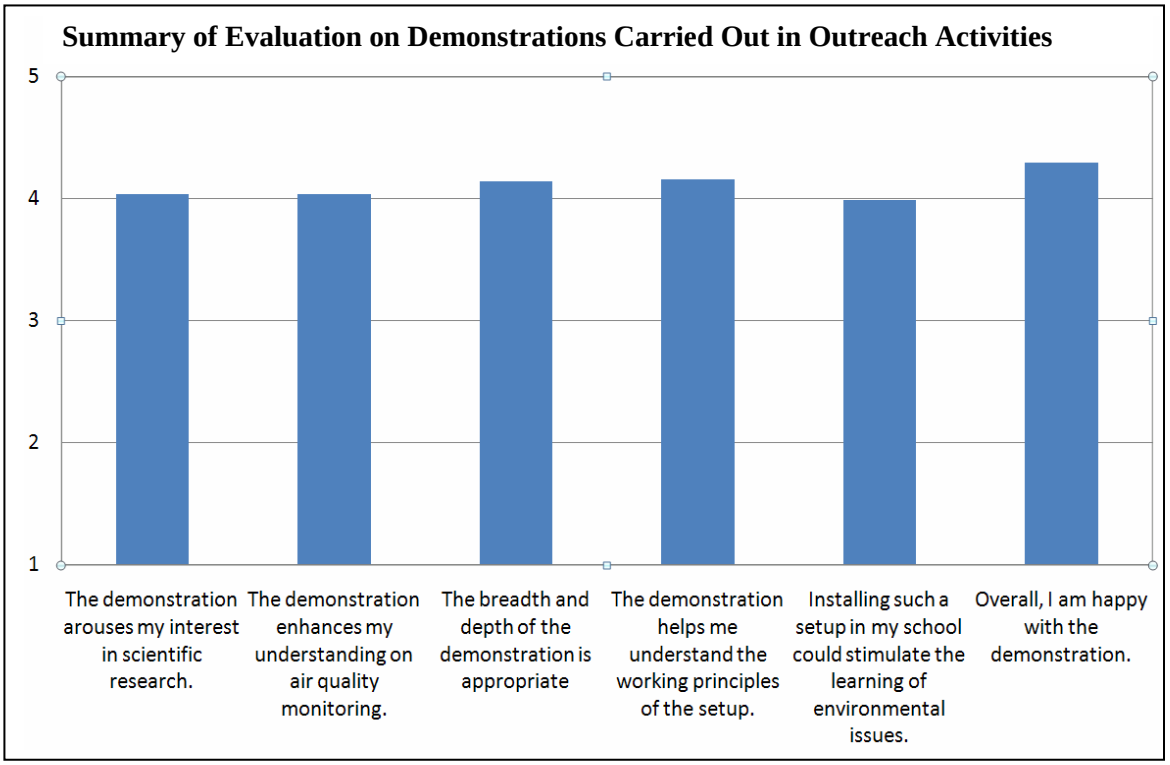

Figure 3: Statistics of the evaluation (sample size = 143 from 23 schools) on six aspects of the demonstrations during outreach activities.

6. CONCLUSION

We describe our experience in introducing an innovative learning and research scheme at program level to undergraduate Physics students. The scheme was successful in providing a platform for students to strengthen various aspects of the learning culture. It also resulted in six software- and five hardware-demo/teaching kits. These have been used in outreach activities and one has been implemented as a new topic in our advanced experimental physics course, PHYS311. This scheme provided our undergraduate students and secondary school pupils and teachers with the most updated scientific knowledge, and aroused their curiosity in science. The methodologies and experience gained through this approach can be easily adapted to other fields of university education.

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