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A Universal Learning Tool for Classrooms?

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Abstract: Questions and answers are used commonly in instructions to provide immediate feedback and reinforcement that are key elements of active learning. However, in a normal class, not all students can be asked to respond because of time limitations. Moreover, many would rather not be called upon so as to avoid the risk of being embarrassed by an incorrect or improper answer. If the class is large, some may not even pay attention. The situation could be improved significantly with the use of an electronic student response system (SRS) which empowers all students to respond to a question in private, records all responses, and displays the statistical results immediately for feedback and reinforcement. At HKUST, a wireless SRS called the Personal Response System (**PRS**) has been developed and the prototypes tested in several classes in fall 1997. The wireless, pocket-sized, low-cost and ID-encoded features of the **PRS** transmitter handset make it feasible for students to own their unit and bring it along to use in any classroom. The receiver is equally portable and the Windows-based software is easy to use. This combination of features endows the **PRS** with the potential of being a universal learning tool for classrooms. In other words, the **PRS** can facilitate the practice of interactive engagement for active learning in the classroom and, thereby, make the practice accessible to all wanting to adopt the approach. Also, the ease of use would free the instructor to concentrate on pedagogy and content, and not be distracted by the tool. Described here are the details of **PRS**, the results of the field tests, and the implementation plan for a campus-wide system at HKUST.

1. Introduction

Today's society wants and needs better and more educated citizens in order to maintain its vitality and upgrade its quality of life. It also wants and deserves cost effectiveness for its investments in education. Advances in information technology suggest the possibility of individualized instruction. But there are the high costs of hardware, software, and associated labor for incorporating interactive personalized contents. Also, peer instruction is deemed to be important and there are the societal needs for civic education and political indoctrination. For these reasons, the present mode of synchronous classroom instruction will be with use for quite some time. The challenge to the stakeholders like us is not only to successfully educate more and more students but also to do so with quality. A place to start is in the traditional classroom where there are only teaching tools like chalk and blackboards, an overhead projector, and audiovisual equipment. The development of a classroom tool that facilitates learning by all students and not just a few could greatly assist our efforts to meet the challenge.

2. Feedback and Reinforcement

Education is about learning - the synthesis and integration into knowledge of information received and experiences gained. Timely feedback and reinforcement are vital to the synthesis and integration processes. In the classroom, these normally take the form of lecture followed by questions and answers (Q&A). However, not all instructors practice Q&A and not all students can be asked to respond due to time limitations. Moreover, many students would rather not be called upon so as to avoid the risk of being embarrassed by an incorrect or improper answer. If the class is large, some may not even pay attention. This situation could be alleviated with the use of an electronic student response system (SRS) that empowers all students to answer a question in private, records all responses automatically, and displays the statistics of answers immediately for feedback and reinforcement. A comparison between the traditional and electronic approaches to Q&A is shown on Table - 1. The advantages of the electronic approach are seen to outweigh those of the traditional approach.

The availability of a classroom learning tool like an electronic SRS also opens up a new dimension for exploring pedagogical approaches that lead to active learning. In a recent study using the standardized test scores of more than 6,000 students in the subject of mechanics, Hake [AJP 1998] showed that the

approach of interactive engagement (IE) is twice as effective as the traditional lecture approach. The most familiar type of IE perhaps is the regular involvement of all students in concept clarifying Q&A [PH 1997].

TASK/ISSUE	TRADITIONAL	ELECTRONIC
Question & answer	raise hands to be called	answer in private with a keypad
Collect answers	one at time - tedious	nearly parallel - in minutes
Question type	no restriction	alphanumeric strings/multiple choice
Involvement	a few students	all students
Risk of embarrassment	high	none
Gender-blind	no	yes
Color-blind	no	yes
Feedback to Lecturer	takes effort	convenient
Feedback/Reinforcement	occasional - some	histograms of responses - all
Voting tabulation	manual	automatic
Polling tabulation	manual	automatic
Attendance check	manual	automatic
Monitoring performance	tedious	convenient
Teaching style	lecture	key on concept clarifying questions
Grading answers	manual	software assisted

Table - 1: Traditional approach versus electronic approach to questions and answers in the classroom

3. The PRS

With clear evidence that IE does promote active learning in the classroom [AJP 1998], we have experimented at HKUST with the question-centered approach of IE. Tried initially was a two-way classroom communication system called Classtalk (available from Better Education, Inc., Yorktown, Virginia 23692, USA) which uses telephone wires to connect the student handsets (graphing calculators like TI82) to the instructor's MAC computer. Although the experience was a positive one, the relative high costs of equipment and installation for Classtalk discourage many who otherwise would want try out the IE approach. We, therefore, spent some efforts in finding ways to make the practice of IE affordable and accessible to those who want to adopt it. The efforts finally led to the development of a wireless SRS called the Personal Response System (**PRS**) that is based on a free-forming one-way communication network. The wireless, pocket-sized, low-cost and ID-encoded features of the **PRS** transmitter make it feasible for students to own their units and bring them along to use in any classroom. The receiver is equally portable and the Windows-based software is easy to use. This combination of features endows the **PRS** with the potential of being a universal learning tool for classrooms. Moreover, the ease of use would free the instructor to concentrate on pedagogy and content, and not be distracted by the tool. Information on the use of **PRS** at HKUST can be found at the web site http://phms02.phys.ust.hk/prs/. Also, the technology has been licensed exclusively to a manufacturer (Varitronix Ltd. (HK), TKO Industrial Estate, Hong Kong) in order to make the system available to the community at large.

4. The HKUST Experience

Prototypes of the **PRS** have been tested in several classes at HKUST during the fall semester of 1997. Surveys of users' opinions show that both students and faculty view the tool as being helpful to student learning. The field tests led to the final version that became available after classes started in the fall semester 1998. As a consequence, only few classes were able to try out the new version. The results of student evaluations of **PRS** usage in some of these few classes are described below.

The students were asked to respond to a series of statements using a scale of 1 to 5, with 1 = "Agree Strongly" and 5 = "Disagree Strongly". These classes were two physics survey courses for non-science students (Phys001 and Phys002) and two sections of a course on corporate strategy (Mgto321). The enrolment figure for the respective courses/sections was about 35, 250, 50 and 50. The results for the statement "I attend PRS classes more regularly than I would the more traditional lecture classes" are shown in Figure - 1. The distribution is peaked at "Agree Strongly" for Phys001 and, perhaps, for Mgto321-1. In contrast, the other two distributions is centered nearly at "Neutral". The contrasting results for the two physics courses can be attributed to the following three factors:

a) **PRS** was used in almost every class meeting of Phys001 but only at most once a week in the case of Phys002
b) The identities of the student respondents were recorded ("known" mode) in Phys001 but not in Phys002 which operated in the "anonymous" mode; and
c) **PRS** was used occasionally to conduct quizzes (weighted as 10% of the course grade) in Phys-001 but not in Phys002.

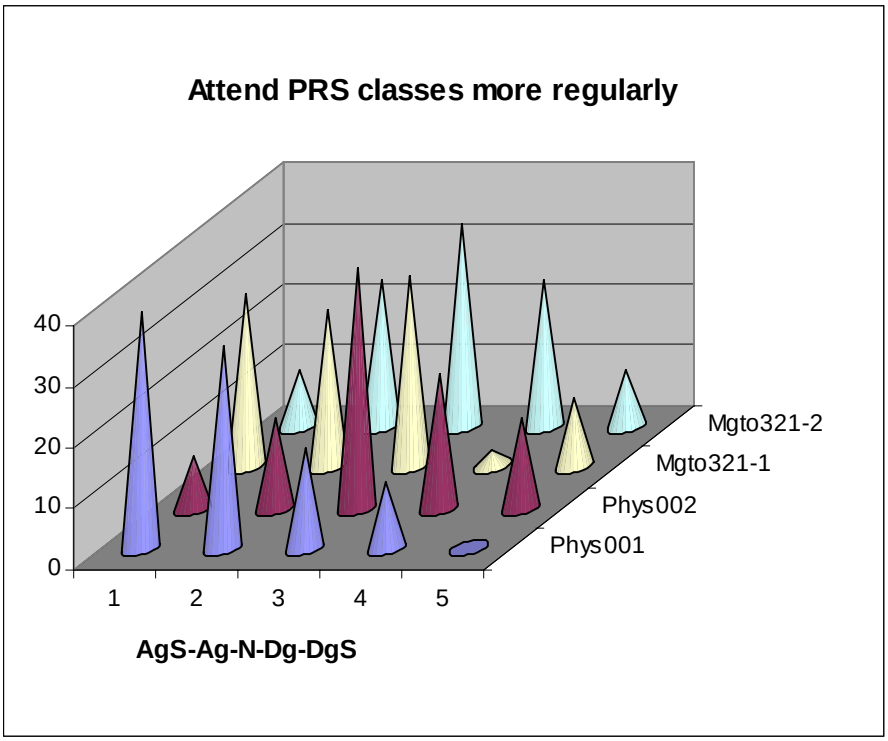

Figure – 1: Percentage distributions of student responses.

Less divergent and equally positive responses for the different courses were obtained for the other statements. Those on "I do more thinking in PRS classes than in lecture classes" are shown in Figure – 2. "Knowing how my classmates respond to questions in class increases my interest in the subject matter" are in Figure – 3. "PRS helps me learn the subject matter of this course in greater depth" are in Figure – 4.

The survey results, although limited, do support the conclusions of Hake [AJP 1998] and, furthermore, illustrate the considerable room available for individual innovations in the pedagogic use of **PRS**.

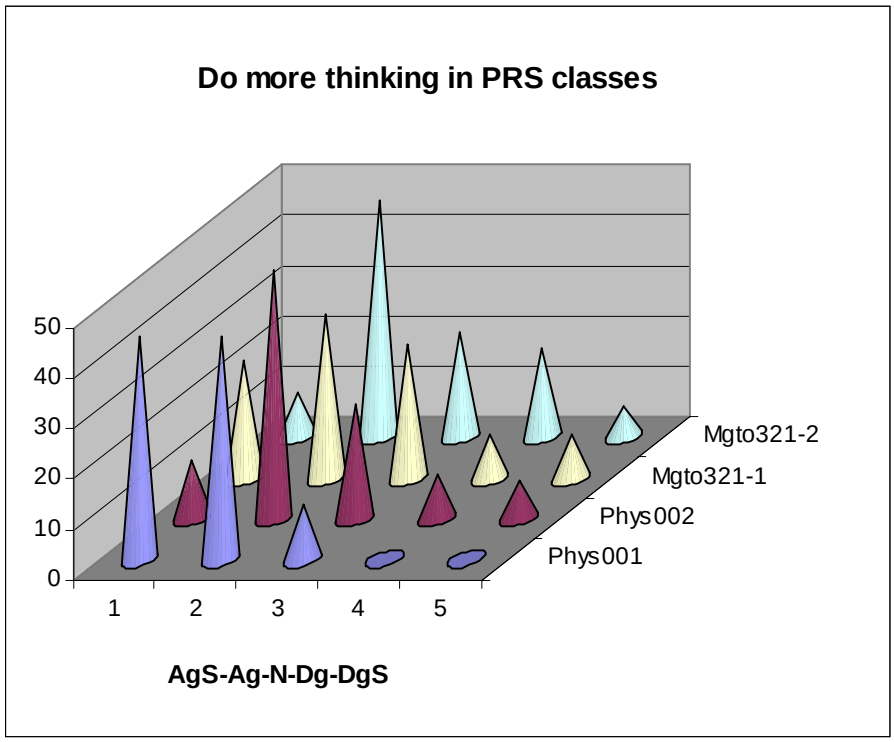

Figure – 2: Percentage distributions of student responses .

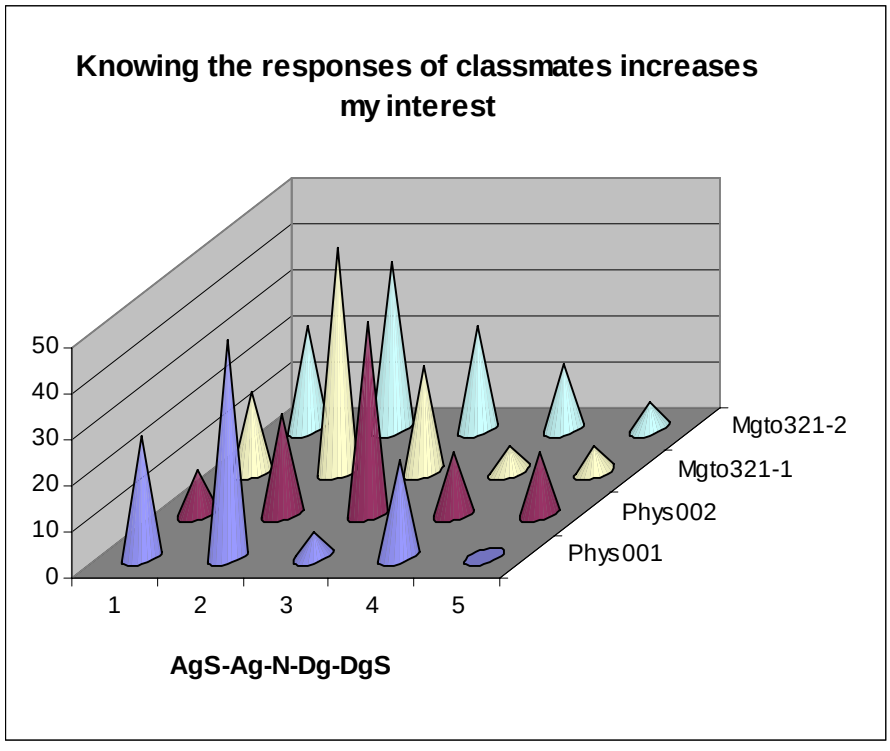

Figure – 3: Percentage distributions of student responses.

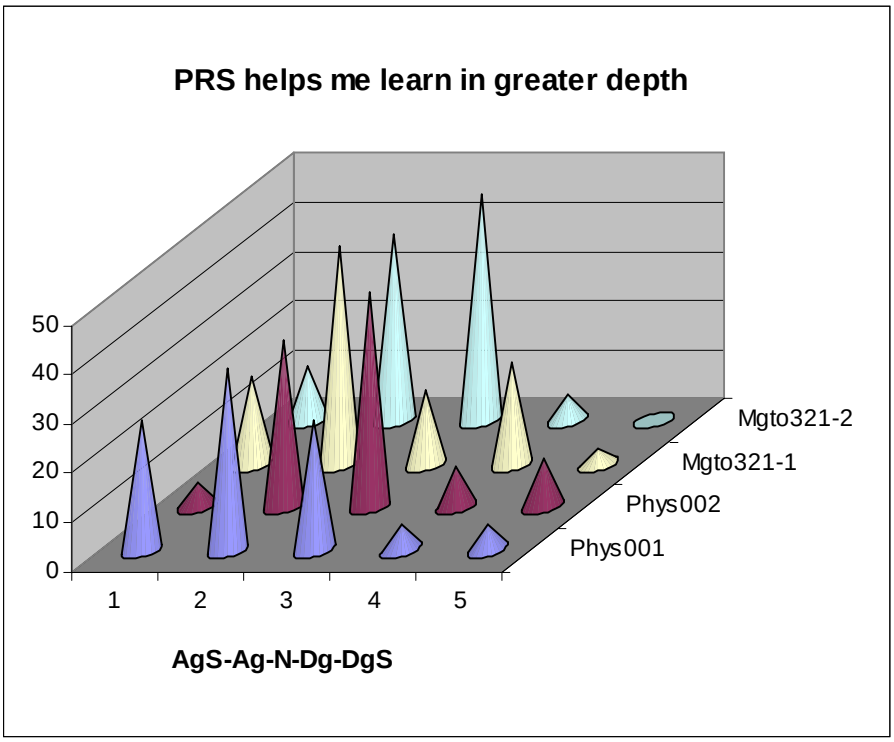

Figure – 4: Percentage distributions of student responses.

5. Campus-wide Implementation

The proven effectiveness of IE for active learning in the classroom, as documented by Hake [AJP 1998], and the combination of low-cost, easy-to-use and flexibility of the **PRS** are compelling reasons for making **PRS** available campus wide. There are other points as well that may be beneficial. These include:

a) A new dimension for the instructors to explore effective pedagogy ;
b) **PRS** is easier than most information technology systems to adopt for those instructors making the first-time switch from a traditional lecture approach to an IE approach;
c) **PRS** provides a convenient means to monitor the academic performance of each student throughout the semester since the student responses are recorded in the computer files; and
d) Students can use **PRS** in their extra-curricular activities such as electing officers, voting resolutions, and canvassing opinions.

It is one thing to convince people of the effectiveness of the IE approach and another to convince them to adopt IE for their next class if our previous experience in introducing the classroom use of the overhead projector, computer and other audiovisual equipment are of any guide. Thus, no effort was spared to make the use of **PRS** as convenient as possible. The implementation plan consists of the following:

a) Students are loaned a **PRS** transmitter for the duration of their study at HKUST. They can check out their own ID-encoded unit from the Circulation Desk of the Library the first time they take a course that uses **PRS**;
b) **PRS** receivers and software programs are installed in all Lecture Theaters and classrooms that have been equipped with a PC and a large screen projector. The instructor needs only to turn on the PC and run the **PRS** program in these facilities;
c) **PRS** receivers are installed in all other classrooms that have a TV monitor. For these facilities, the instructor is expected to bring along a PC Notebook (pre-loaded with the **PRS** software programs)

and to make connections to the receivers and TV. The use of a portable large screen projector is advisable if one is available;

d) Conduct regular hands-on workshops for faculty members and teaching assistants.
e) Assign a trained teaching assistant to sit in as a back-up technical helper to new faculty users the first few times they use **PRS** in their class.

Beginning in the spring semester 1999, **PRS** will be available at HKUST to any class that wants to use the system. Already about 20 new faculty users from all four schools are preparing to try **PRS** in their class. This number is expected to grow as the teething problems of implementation are solved and more people gain familiarity with this learning tool.

6. Summary

Recognizing the effectiveness of the interactive engagement (IE) approach for promoting active learning in the classroom, a question-centered form of IE, using electronic means for feedback and reinforcement to students, was tried in several classes at HKUST. The positive experience motivated us to enlist our colleagues to adopt the IE approach in their teaching. We were reasonably successful with this task only after we have a) developed a wireless, pocket-sized, low-cost and flexible system called the Personal Response System (**PRS**), and b) made the system easy to use and available in any classroom on campus. The experience with the campus-wide application, although limited in scope at present, nevertheless suggests that the **PRS** could become a helpful universal classroom learning tool.

7. References

[AJP 1998] Richard R. Hake, American Journal of Physics **66** (1998) 64-74.
[PH 1997] Eric Mazur, Peer Instruction – A Users Manual, Prentice-Hall, NY, 1997.

Acknowledgement

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