INTRODUCTION TO PERSONAL RESPONSE SYSTEMS AND STUDIES OF THEIR USE

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ABSTRACT

This paper provides information about the use of a Personal Response System (PRS) in large lecture sections at West Virginia University. The authors give details on their employment of a PRS in sections of Liberal Arts Math and College Algebra, including setting up the necessary files, writing questions, incorporating questions into lectures, grading questions, and posting scores. In addition, preliminary data from two PRS studies is provided. The first study concerns Liberal Arts Math students' reactions to PRS use, and the effects PRS has on student performance. The second study involves the experiences of instructors from many disciplines using the technology. The results from the studies are generally positive, and support continued use of PRS. Finally, some plans for improvements of PRS use, and some future research questions to consider, are included.

KEY WORDS

Educational software and hardware, and student evaluation

1. INTRODUCTION

Many universities, colleges, schools, and businesses are beginning to use a Personal Response System (PRS) to help understand the needs and opinions of their students, employees, and customers (such systems are also known as group response or class response systems). Used in education, these systems allow instructors to pose questions, which students answer using handheld wireless transmitters. Software aggregates and displays a chart of the responses, usually without revealing how individual students answered. Research and literature about the need for students to actively participate in the classroom, and how PRS can accomplish this goal, has been growing.

Working as teaching consultants, Middendorf and Kalish [1] suggest that "…lectures should be punctuated with periodic activities." Similarly, Elliot [2] states that "…university teachers regularly need to consider the most effective methods of teaching large numbers of students." Elliot goes on to say that a PRS can be "…an excellent method of encouraging active learning, whilst offering a means of varying the stimuli received by students in a lecture environment." Fagen, Crouch, and Mazur [3], however, warn that "because most students are unaccustomed to active participation in science classes, some feel uncomfortable participating…."

In his research bulletin on PRS technology, Beatty [4] notes that a PRS can offer universities a chance to compete economically with online courses by emphasizing the face-to-face interaction between faculty and students. In addition, Beatty says that a PRS allows students to "take charge of their own learning" and can help instructors "…design learning experiences appropriate to students' state of knowledge and explicitly confront and resolve misconceptions." Furthermore, Beatty points out that students who have attempted a PRS question are "…emotionally invested in the problem and pay far more attention to subsequent discussion and resolution."

In their review of research, Simpson and Oliver [5] conclude that Personal Response Systems "…can support increased motivation and attainment, at least in part as a result of their ability to provide rapid feedback on the learning process." Roschelle, Penuel, and Abrahamson [6] note that a PRS can "…increase the ease with which teachers can engage all students in frequent formative assessment." With this type of formative assessment, Dufresne, Gerace, Mestre, and Leonard [7] state that "the emphasis is on finding out what isn't known, and it tells teachers and students early enough in the course that something can be done about it." For more information on the history of PRS technology, Judson and Sawada [8] give background dating back to the 1960's, and they call for more studies of the effects of current systems on academic achievement.

Over the summer of 2004, the Dean's Office in the Eberly College of Arts and Sciences at West Virginia University (WVU) purchased a PRS from the Interwrite company. For the rest of the paper, the term PRS will signify the Interwrite PRS system used at WVU unless otherwise noted. Transmitters coded with unique six digit identification numbers, receivers, and software were

installed in four classrooms that each seat about 250 students. All instructors were invited to use PRS and some training was offered before the fall semester began.

One aspect of PRS use at WVU, which the authors believe is fairly unique among universities, is that the technology is used in large section classes, but students are not required to purchase their own transmitters. Currently at WVU, the transmitters are stored in locked boxes in PRS classrooms, accessible to instructors via a key. In most classes that are using PRS, each student is assigned a transmitter to pick up at the beginning of class and return after class. The first time that students find their assigned transmitters, a teaching assistant is very useful to ensure that the process runs smoothly.

At WVU, the Institute for Math Learning (IML) is a group within the mathematics department working to improve student success in the calculus and below level courses. These courses are mainly taught in two 50 minute lectures and one 50 minute computer-based laboratory per week, with most assessments completed on the WebCT course management system. The IML has identified a lack of student engagement as a pedagogical problem in many IML courses. There are usually 200 students per section in these courses, so many possible solutions are intractable. Since PRS seems particularly suited to solve this problem, PRS use was implemented in many IML courses beginning in the Fall 2004 semester, including a Liberal Arts Math (LAM) course and a College Algebra course. The authors have used PRS in these classes for several semesters, and give specifics about using the system in the next section.

Furthermore, at WVU research is currently being conducted on the effects of PRS use on students, and some of this research is described in the third section. More specifically, this paper includes results of a study on student perception of PRS in the LAM course, and some information on how students' PRS grades correlate with grades in other components of the course. To approach PRS use from a different angle, a survey was written to try to assess the ways in which PRS is being effectively used by instructors at WVU. Results from this survey and two instructor interviews are also included.

2. DETAILS ON USING PRS

In this section, specific details about preparing for PRS use, integrating PRS into class lectures, and incorporating PRS into student grades, are given. The purpose of this section is not to prepare instructors to use the particular Interwrite PRS system currently employed at WVU. Rather, the purpose is to give instructors who may be interested in using a general PRS an overview of what is involved in the process.

2.1 Preparing for PRS Use

In order to incorporate PRS into a course, questions must first be written. Upon installation, the PRS software creates a toolbar making it possible to author questions directly within PowerPoint. This feature allows use of all of the functionalities of PowerPoint, including the equation editor, symbol library, graphics import, charts, graphs, and tables, when writing PRS questions. The text of a question, including the answer choices, is simply written as a PowerPoint slide. The PRS settings (number of answer choices, correct answer, and time limit) can be adjusted using the PRS toolbar within PowerPoint. Since both authors often use PowerPoint slides to guide their lectures, this method was chosen to write PRS questions.

While PowerPoint is an easy and versatile way to write PRS questions, there are other techniques available. For example, it is possible to write questions directly in the PRS software. This method was not chosen by the authors (or other instructors in the mathematics department at WVU) because the software does not currently have an equation editor, making it difficult to write questions involving mathematical symbols. In addition, banks of pre-written PRS questions are often available for purchase, either separately or bundled with a textbook. Since the authors mainly have experience using PRS in conjunction with PowerPoint, only this method of writing and delivering PRS questions will be discussed in subsequent sections.

Writing appropriate PRS questions takes time. For example, in a study conducted by Fagen, Crouch, and Mazur [3], 13% of instructors found writing meaningful concept questions to be an impediment to teaching techniques such as PRS. There is a project at Cornell University centered on writing well-constructed conceptual questions, which can be used with PRS, for calculus [9]. Similar projects exist for other courses and disciplines. In general, the authors try to ask a mix of conceptual and computational questions in their courses.

Polling questions can also be useful in the classroom. Polling students can be accomplished by using PRS in an anonymous mode, where the percentage of students giving each answer to a question is displayed, but the specific transmitter numbers are not recorded. For example, the authors have used PRS to ask students to rate the difficulty of an exam, to vote on the course component which helped the most when studying, or to guide the lecture by voting on what topic to discuss next.

If an instructor wishes to track students' answers to PRS questions, he must assign each student a transmitter and create a class roster file. A PRS roster file is a comma separated file that ties responses to specific students by assigning each student a unique transmitter number. Using Excel or the PRS software, instructors can create a roster file by entering a student name, a unique student ID (at WVU, the WebCT username is used), and the assigned transmitter number. It is often possible to download a file

already containing student name and ID (at WVU, from the WebCT grade book) from which to work. The instructor can also modify the roster file, within the PRS software or in Excel, to add new students or reassign a transmitter if a problem arises. The lists of assigned transmitter numbers are often posted electronically in WebCT, and also made available on printouts in the classroom.

An additional reason to use PRS with a roster file (as opposed to anonymously) is that it enables the instructor to create a response map. A response map is a grid of boxes that appears on the screen when a PRS question is asked. Using the roster file and the PRS software, the instructor can create a response map that assigns each box on the screen to a specific student. When a student answers a PRS question in class, his assigned box will change color to indicate to the student that the PRS software has read his response. The PRS software gives several display options for the response map. For example, the boxes can display some combination of the transmitter number, student name, student ID, and the answer chosen by each student. The authors have chosen not to display student answer choices, because one advantage of PRS is that it allows each student to respond without being influenced by other students' answers. Thus, in this case, one benefit of the response map is that it allows students to know their answer has been received without their peers knowing which answer they have given. A second benefit is that it allows the instructor to keep a record of which answer each student selected for grading purposes.

The authors have primarily used PRS in very large (200 student) classes. Unfortunately, a response map with 200 boxes on display at one time is not easy for students to read. In this case, the PRS software allows the option of having the response map alternate between grids with smaller numbers of boxes. The authors have successfully alternated among four grids with 50 boxes in each grid. The PRS software also allows one to choose how often to alternate the boxes. The authors have found three seconds to be an appropriate time for each grid of 50 boxes.

After the roster and response map files are created, the instructor places these files in their eponymous folders in the PRS folder on the classroom computer. The PRS software automatically creates all of these folders when it is installed. This step finishes the preparation for in-class PRS use.

2.2 PRS Classroom Use

To begin class, the instructor opens the PowerPoint slide show containing the PRS questions. The PRS software detects that there are PRS question in the presentation, and automatically opens. The instructor is then prompted to choose the class that will be using the PRS, based on the roster files that are on the computer, or to choose the anonymous mode. The instructor then proceeds with the PowerPoint lesson normally. When the instructor advances to a slide with a PRS question, the PRS software automatically opens the response map.

The instructor can adjust the settings so that students can begin responding immediately, or so that students must wait until the question is started manually. The authors have found that approximately two minutes is a reasonable time limit for 200 students to answer a PRS question. When time runs out or the instructor stops the question, a bar graph showing percentages of students giving each answer is displayed. After the instructor closes this display, the PowerPoint presentation continues as usual.

As students adjust to the process, there are very few problems. Occasionally a transmitter is missing or damaged. Because there are always several extras in each classroom, the instructor can assign any students with unusable transmitters new devices for the day. The instructor must then modify the roster file or record the new transmitter number issued to track the change.

2.3 Grading PRS Questions

The authors have found that students are particularly motivated to participate in PRS questions when they are allowed to work together and when part of the course grade depends on their answers. Research by Fagen, Crouch, and Mazur [3] supports this claim. When an instructor wishes to grade a PRS session, he takes the PRS session file from the classroom computer and puts it in the PRS session folder on the computer where the grading will take place. Opening the PRS software, the instructor can then choose the class and the session to grade. The instructor can also select how many points to offer for correct and incorrect answers and which answer(s) are correct for each question asked in that session. One option is to grade the session giving all students participating credit, regardless of the correctness of their answers. Another possibility is to give students who answer correctly two points and students who answer incorrectly one point. The authors have used both methods successfully.

After the session is graded in the PRS software, the instructor can find the graded session file in the grade book PRS folder. This file is also in the comma separated format, and can be opened in Excel and uploaded to WebCT so students can track their PRS points. Occasionally, an instructor might want to alter a session file manually in Excel because he assigned a student a new transmitter for the class and did not have time to make the change in the roster file. Unfortunately, the most current version of the PRS software does not allow users to alter the session file (doing so results in the PRS software recognizing the file as corrupt). In this case, the instructor must keep track of the change himself.

3. STUDIES ON PRS USE

In this section, results from two Spring 2005 PRS studies are given. For the first study, students in two sections of LAM were given a survey regarding their views of various course components, including PRS. For the second study, instructors at WVU in a variety of departments were given surveys about their PRS use. Interviews with two faculty members who heavily use PRS were also conducted. Both of the surveys, the interview questions, and sample PRS questions can be found in [10].

3.1 Effects of PRS Use in LAM

In the Spring 2005 LAM course, PRS was used in almost every class and usually around three questions were asked in each lecture. PRS points made up 10% of the students' final grade. Students received one point for participating in each PRS question and an additional point if they gave the correct answer. Because the PRS slideshows were available to the students for download from WebCT, students were able to read the PRS questions before class. One reason for making the slides available is that having the PRS questions to think about ahead of time might be helpful for students with learning disabilities.

A survey on student perception of the LAM course components was given in Spring 2005, in which 206 students participated. Students responded to each statement on a Likert scale from 1 to 5, with 5 being "strongly agree" and 1 being "strongly disagree." The text, mean, and standard deviation for each survey question concerning PRS are listed below.

1. I would often think about the PRS questions before class. (M=2.1748, SD=1.3210)
2. I would usually talk to other students in class before choosing my answer to a PRS question. (M=3.0340, SD=1.4563)
3. I thought the PRS questions were helpful for preparing for exams. (M=2.9469, SD=1.2196)
4. I thought the PRS questions were one of the most helpful aspects of the course. (M=2.8204, SD=1.1569)

According to the survey results, students found fostering in-class discussion to be a relatively positive aspect of PRS use. Students also thought the PRS questions were moderately helpful in preparing for exams and overall in the course. Based on the surveys, it does not seem that a significant portion of students thought about the PRS questions before coming to class.

In addition, the survey contained space for students to write comments about the use of PRS in LAM. Both authors independently read the student comments, in order to identify common idea blocks. One idea block that the authors agreed on is that many students said that the PRS questions helped them to stay alert during lecture and to prepare for tests. For example, one student said of the PRS questions, "…they forced me to kind of pay attention in class, which helped me on tests and quizzes." Another common idea block is that some students thought PRS questions were not worthwhile because students did not try to figure out the questions themselves. One student said, "PRS questions are no good, people just look at whatever everyone else wrote…." Other students expressed that they liked PRS but found the technology frustrating. Many other students liked that they could earn points with the PRS questions. One student said PRS was a "very good way to get points and prepare for tests."

Finally, Pearson correlation coefficients were computed for students' homework quiz average, lab average, exam average, attendance average, PRS average, and total course average. All course components were significantly correlated to each other, $p<.01$. Good correlations were found between PRS average and exam average (.675), attendance average (.934), and total course average (.841).

3.2 Instructors' Reaction to PRS and Use of PRS

The first author has been the PRS contact person for the Department of Mathematics at WVU since July 2004. In Spring 2005, she wrote an anonymous survey to find out how instructors feel about PRS use and to find ways in which the technology is being used. In the Eberly College of Arts and Sciences at WVU, there is a PRS listserv. A message was sent out asking for volunteers to fill out the survey. Approximately ten faculty members responded affirmatively. Fifty surveys were then sent out via campus mail. Ten surveys were sent to contact people in biology, chemistry, and physics, with a note asking for the surveys to be distributed to interested faculty. Surveys were also sent to instructors in the mathematics department who responded to the request e-mail or who were known to use PRS. Eleven surveys were returned via campus mail. The exact results of the survey and survey questions are given in Table 1.

On the survey, responses were somewhat mixed about the ease of use of the technology. However, none of the instructors strongly disagreed with the statement "The technology was easy to use." Overall responses indicate that, in the instructors' opinion, PRS helped students identify trouble areas and helped to engage students in their classes. Furthermore, no instructors thought that the students in general disliked using PRS.

It seems important to note that one instructor disagreed with the statements "I found that using PRS was worth the time," and "I found that using PRS was worth the effort." This same instructor strongly disagreed with the statement "I used PRS almost every class." All of the other

respondents said that they used PRS almost every class. Similarly, all of the other instructors agreed or strongly agreed that PRS was worth the time and effort. These results suggest that, for instructors, a sporadic use of PRS might not be worthwhile, but regular use could be worth the extra time and effort.

Table 1: *Instructor PRS Use Survey Responses*

Question	Number of Respondents Who Chose Each Answer 1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree				
	1	2	3	4	5
The technology was easy to use.	**0**	**2**	**2**	**5**	**2**
I think that the PRS helped alert students to topics that they needed to study more.	0	0	4	4	3
I think that the PRS helped my students to understand concepts in the course.	**0**	**0**	**4**	**5**	**2**
I think that the PRS helped my students to gain new skills in the course.	0	0	7	2	2
I found that using the PRS was worth the time.	**0**	**1**	**0**	**7**	**3**
I found that using the PRS was worth the effort.	0	1	0	7	3
I hope to use PRS in future classes.	**0**	**0**	**1**	**3**	**7**
I think that my students enjoyed using the PRS.	0	0	2	5	4
I think that the students were more engaged in the course because of PRS use.	**0**	**1**	**1**	**3**	**6**
Because of PRS use, I was more aware of student difficulties.	0	0	1	6	4
I used PRS questions almost every class.	**1**	**1**	**0**	**3**	**6**
I almost always used more than one PRS question per class.	0	0	1	2	8
PRS questions usually took up more than 15 minutes of class time.	**1**	**4**	**2**	**4**	**0**
Thinking of PRS questions was difficult.	4	4	2	1	0

A set of instructor interview questions on PRS use was also written. After the surveys were collected, two interviews with faculty members in the mathematics department at WVU were conducted. These faculty members were selected because they have experience both teaching with the system and with mentoring other instructors in PRS use. The interview responses were read through in an effort to identify idea blocks.

Both faculty members said they enjoy using PRS, plan to use it in the future, and believe that students enjoy using the system. Both, however, also mentioned that it took time to get comfortable using the system (more so for the instructor than the students). When asked what he liked least about the system, one faculty member mentioned that "you need someone to help you at first."

Another complication that both instructors mentioned was the extra time involved in using PRS. Neither thought that writing questions was difficult, but both noted that uploading and downloading grades, keeping track of student points, and preparing the class in PRS format is time consuming. One instructor thought he averaged six hours of preparation for four class hours containing PRS use (but he thought that he would need less time after the development phase).

Overwhelmingly, however, both interviewees found the extra time spent to be worthwhile, mentioning the "tremendous opportunities for engagement and formative assessment," and that the students were "studying, but found it fun." Similarly, both mentioned that the PRS "motivated students to come to class, stay in class, and pay attention" (PRS points were part of the grade in these courses). Furthermore, one faculty member said that he was better able to show students when they didn't know how to do something and to point out where the error occurred.

The other faculty member was in the unique position of teaching two sections of the same course, one with PRS and one without. From this perspective, he mentioned that the PRS class "had a nicer atmosphere." In addition, the number of students attending class in the PRS section was regularly twice that of the non-PRS section. Furthermore, after asking a question in the PRS section and having 135 of 138 students select the correct answer, the instructor asked the same question in the non-PRS section. Students were asked to raise their hands to demonstrate which answer they picked. Based on the fact that the students in the PRS class had overwhelmingly selected the correct answer, the first author predicted the same thing would happen in this class. In the non-PRS section, however, only about half the students raised their hand in support of any of the choices.

Both instructors aimed for concept questions, and often found themselves asking skill questions that built toward an important concept. One instructor said that he felt his most successful use of PRS was when the class was discussing statistical sampling techniques. The instructor would provide a real-life sampling situation and then ask the students to decide which sampling technique was being described. This instructor also mentioned that his least successful use of the PRS was when he asked the students if it was possible for the greatest common divisor of two numbers to equal the least common multiple of the two numbers. He felt that the students didn't really learn anything from this question and he mentioned that he had trouble thinking of conceptual questions for that unit.

Finally, the instructors were asked what advice they would give someone who is just beginning to use PRS. The first instructor said to "make the grading scheme clear to the students" and to use the system regularly (which corresponds to results found on the survey). The second instructor encourages first time users to work with someone who has used the system and to realize that,

while PRS is an excellent tool for increasing student engagement, appropriate usage needs to be developed and this takes "time, work, and effort."

4. CONCLUSION

While some data from the LAM student survey suggests that more work needs to be done to better integrate PRS into the course, much of the data from the instructor survey indicates that the introduction of PRS has been a positive step. The authors expect that as usage of the system in courses is improved, results from student surveys will become more positive. Initially there were difficulties learning to use the system and some technology problems, but the advantages of using PRS seem to outweigh these initial struggles. Based on their experiences using PRS in LAM and College Algebra, the authors feel that PRS improves classroom atmosphere, increases student attendance, and encourages more class participation.

Although the implementation of PRS at WVU is considered mostly successful, there is still much work to be done on this subject. It is important to continue developing questions which probe student understanding of key concepts, as is done in [9]. Research shows that PRS is most effective when it encourages student discussion ([3] and [4]), but much of the PRS use by students at WVU is individual. For this reason, it would be beneficial to develop activities which foster student discussion. Research concerning the effects of PRS on attendance and student attitudes should also be conducted.

Efforts to make PRS simpler to use will encourage more instructors to use the technology, which will benefit students. The ability to compose PRS questions spontaneously could also be very successful. As technology companies begin to produce banks of PRS questions, instructors need to maintain a dialogue with the manufacturers about whether the questions are appropriate, worthwhile, and easily accessible.

In addition, new PRS systems and improvements to the current technology are being developed. For example, the Interwrite company has developed a PRS system in which the transmitters have a display, so students can see exactly what they have entered. In addition, there are systems in development in which students can use cell phones or Personal Digital Assistants (PDAs) to transmit answers, instead of transmitters. In their research article, Liu, Liang, Wang, and Chan [11] discuss advances in PRS technology. An important research question would be what difference, if any, these technologies have on the effects of PRS use.

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