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Colloquium

Early identification of at-risk students using a personal response system

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Introduction

We analysed personal response system (PRS) data from Biology courses. There was a significant relationship between the distribution of grades and the order in which students registered their PRS clickers. Students who registered their devices early had a much higher probability of success than those registering later. These data could identify students with a higher probability of failure as early as the 1st week of classes.

The term 'gateway' course refers to an introductory course required for continuation and matriculation in a particular major or specialty. For fields such as biology, allied health, pre-medicine, biomedical engineering and pharmacy, typical gateway courses include Introductory Biology, Introductory Chemistry, Calculus, and Anatomy and Physiology. The percentage of students who receive low grades (D or F) in these gateway courses is high (Harris, Hannum & Gupta, 2004) with up to 40% reported (Benford & Gess-Newsome, 2006). The reality of this high failure rate in what is often the first post-secondary course that a student takes has far-reaching consequences. Failure in a gateway course can result in dropping out, increased time to graduation and changes in career plans (Strenta, Elliot, Adair, Matier & Scott, 1994). The low proportion of minorities in science and medicine is likely, at least in part, as a result of such early failure (Drane, Smith, Light, Pinto & Swarat, 2005; Swarat, Drane, Smith, Light & Pinto, 2004).

Many programs and pedagogical approaches from remedial and/or supplemental instruction to peer-led problem-based learning have been developed to help at-risk students and improve success rates (Felder & Brent, 1996; Swarat *et al,* 2004). Successful early intervention will increase student learning and decrease frustration. Early intervention in gateway courses may be particularly important to alleviate the consequences discussed above (Harris *et al,* 2004; Hoyert & O'Dell, 2006). We describe a relatively simple way to identify at-risk students in Anatomy and Physiology (A&P) in the Department of Biological Sciences at the University of Cincinnati (UC). Similar results were also obtained using data from the third quarter of a three-quarter general biology course.

Methods

UC is a large comprehensive urban university. A&P is a three-quarter sequence with no pre-requisites, taught at the freshmen level, though many students are not freshmen. The course is required by many programmes including Nursing, Allied Health, Physical Therapy, Health Promotion and Education, and Biomedical Engineering. There are usually two large daytime lectures of 250–350 students each, taught by one or two full-time faculty. There are also about 25 lab sections taught by adjuncts and graduate teaching assistants. In addition to the normal fall-winter-spring sequence, there is a smaller 'trailer sequence' with about 125 students starting in winter.

Several years ago, the university equipped classrooms with an interactive PRS that has been used in most A&P lectures. Similar audience response systems (Caldwell, 2007; Hatch, Jensen & Moore, 2005) have been in use for about a decade (Hedges & Mania-Farnell, 2002). Students are required to purchase a transmitter (sometimes referred to as a response card, keypad, or clicker) for the A&P course and to register the unique number assigned to that clicker at the UC Blackboard website for the course; Blackboard is a web-based course management system. The clicker can be used for multiple courses, but for each, the clicker ID must be registered on the Blackboard site for that course. The Blackboard site generates a list of students in the order that they registered their clickers. This list is available to the professor and is typically uploaded into the classroom computer so that answers to questions asked in class can be recorded. The syllabus for the course, including the requirement for a PRS clicker and instructions to register it, were posted on Blackboard a week before classes began. At the beginning of each class during the first few weeks, students were reminded to register their clicker, and a list of students who had done so was displayed in class and posted on Blackboard so that students knew whether their registration was successful. In this paper, we examine the correlation between the order in which the PRS clickers were registered and the final letter grade in the course. These data can provide early identification of at-risk students as most students register their clickers by the 2nd week of classes.

In the A&P course, the final grade was based on performance in lecture (67%) and lab (33%). The lecture component was calculated from computer-graded multiple-choice exams and in-class quizzes administered using the PRS. In the first quarter of the sequence (A&P I) a generous curve was used to assign letter grades such that the students above the mean received an A or B. In subsequent quarters, the standard grade cuts (90% = A, 80% = B, etc.) were used, but there were more opportunities for extra credit. Below, we present data from A&P I, II and III (fall 2006–spring 2007) and from A&P I (winter, 2007) of the trailer sequence. Some of the students in the winter 2007 A&P I course had started but dropped A&P I in the previous quarter (or before). We also analysed data from the third quarter of the general biology sequence, Biology 103. In the general biology sequence, labs are taught as stand-alone courses. The grade was determined on the basis of multiple-choice exams, written critical thinking quizzes (7.5%) and PRS quizzes (5%). A&P I and Biology 103 were taught by Edwin R. Griff (ERG) and A&P II and III by a different faculty member.

Data were analysed using nominal logistic regression (Agresti, 2002). The null hypothesis for this type of analysis is that the frequency of events occurring in one of several classes is not a function of another variable. In our case, we examined the frequency of students receiving grades from A to F versus the order of PRS registration. Similar to logistic regression, a predicted response can be calculated from the independent variable. The significance of the regression was based on likelihood ratio tests following a Chi-square distribution with degrees of freedom equal to one minus the number of categories (grades), four for all of our tests. The proportion of variance explained by the regression was examined using Nagelkerke's pseudo-R^2. All analyses were performed in SPSS 15.0.

Results

For both courses and all sections, there was a significant relationship between the distribution of grades and the order in which students registered their PRS clicker (Table 1). In all cases, the frequency of A's sharply decreased and D's and F's increased with the order of registration of PRS clickers (Figures 1 & 2). The frequency of B grades generally peaked near the mid-point of the order of registration, while grades of C peaked in the final third of the order. Averaged across all classes and sections, the probability of the first student to register their PRS device receiving an A was 0.52, while the probability that they would receive an F was 0.02. In contrast, the last student to register had a probability of 0.09 of earning an A and a probability of 0.22 of earning an F. While there were significant relationships in all cases, as might be expected, the overall amount of variation in grades explained by the order of PRS registration was fairly low, ranging from 6–24%. Classes also showed significant differences in the proportion of students receiving each grade ($\chi^2 = 58.3$, $df = 16$, $p < 0.01$; Table 2).

Figure 1A shows the expected probability of a course grade in A&P I (fall, 2006) as a function of the order of registration of the PRS clickers. There were 222 students in the class who registered clickers, and 182 (81%) had registered a clicker by the second lecture and 206 (93%) by the third lecture. At the end of the quarter, there were 59 A's, 54 B's, 46 C's, 17 D's and 17 F's; 29 students withdrew from the class (Table 2). At UC, students are allowed to withdraw until the 8th week of the 10-week quarter. In these analyses, we included all students with grades of A–F, but a similar result is observed if

Table 1: Nominal regression statistics. The proportion of grades received was compared versus the order of registration of PRS devices

Class	χ^2	*df*	*p*	*Nagelkerke pseudo-R^2*
A&P 201	11.32	4	0.02	0.06
A&P 202	37.15	4	<0.01	0.24
A&P 203	17.93	4	<0.01	0.14
A&P 201 (Trailer)	12.85	4	0.01	0.12
Intro Bio103	20.94	4	<0.01	0.18

A&P, Anatomy and Physiology.

Table 2: Number of students and grade distribution in each course

Class	*# students*	*A's*	*B's*	*C's*	*D's*	*F's*	*W's*
A&P 201	222	27%	24%	21%	8%	8%	13%
A&P 202	154	31%	29%	17%	9%	6%	8%
A&P 203	135	39%	33%	18%	4%	1%	6%
A&P 201 (Trailer)	116	17%	26%	25%	12%	9%	11%
Intro Bio103	119	18%	29%	25%	13%	7%	8%

A&P, Anatomy and Physiology.

W's are also included. Because there are many reasons why a student chooses to withdraw from a course, a W is not necessarily an indication of a low grade. However, the expected proportion of W's correlated with D's and F's.

Panels B (A&P II winter, 2007) and C (A&P III spring, 2007) of Figure 1 show similar patterns. For these courses, students had to register their PRS clickers anew at the Blackboard site for that course. Because most of the students in A&P II and III were continuing the sequence, they had already purchased their PRS clickers for A&P I. Thus, a delay in purchasing a clicker, for example, because of financial considerations, cannot explain the correlation between grades and order of registration. The result also does not depend on the instructor or the specific curve used to assign letter grades, since A&P II and III were taught by a different professor who used a standard grading scale.

We also analysed the data from the trailer course of A&P I that ERG taught in winter, 2007 (Figure 2A). Twenty-four of the 116 students had taken A&P I in the fall and had received a W; other students may have withdrawn early in the fall quarter, before the official class list was finalised. Nonetheless, the same trend as described above is evident; students who register their clicker later are at higher risk for doing poorly in the course.

To compare these data to a different population of students, we analysed data from another course taught by ERG, specifically the third quarter of a three-quarter general biology sequence that is required for biology majors and is also taken by students who plan to apply to medical or pharmacy schools. As shown in Figure 2B, the same trend exists. Since the A&P sequence cannot be used to fulfill course requirements for the major in the Department of Biological Sciences, and since nursing, biomedical engineering, and allied health majors are not likely to take the introductory biology sequence, there is little overlap between the students in the A&P sequence and the students in the introductory biology sequence. Thus, the relationship between registration order and grades does not depend on the specific major of the students, and is not restricted to A&P courses.

Discussion

The correlation between grades and the order in which students register their PRS clickers is not surprising. Better students are probably more motivated, better organised,

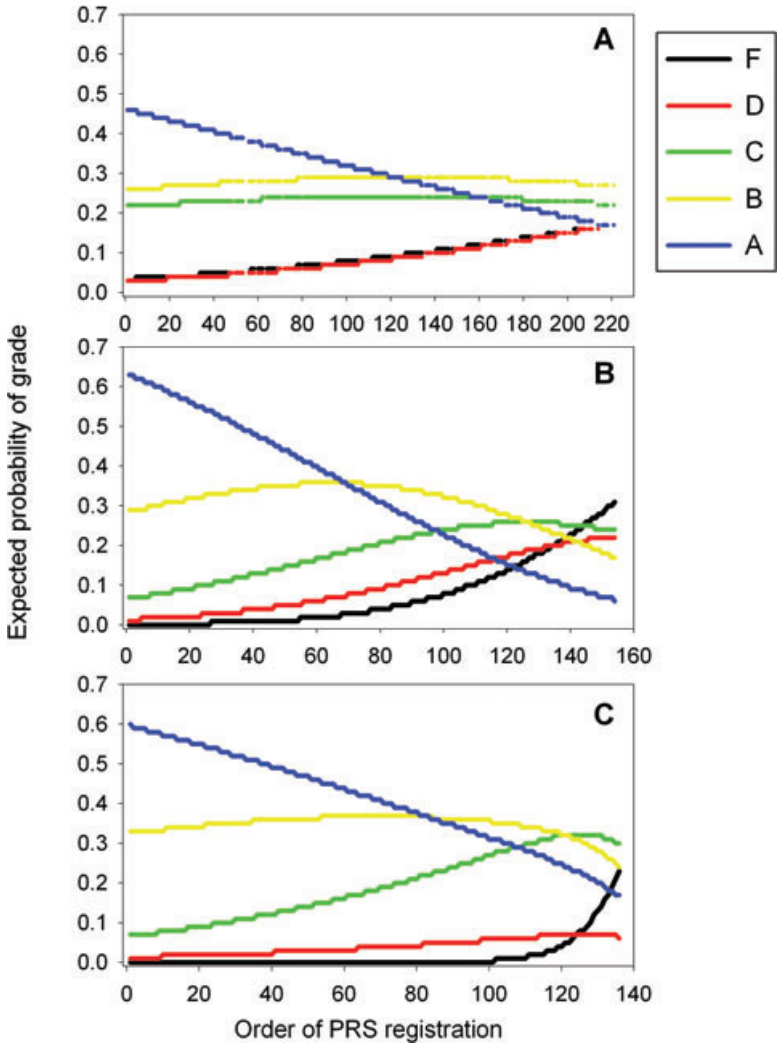

Figure 1: Expected probability of a grade plotted versus the order of registration of personal response system clickers
Data are shown for Anatomy and Physiology I, II and III (Panels A–C respectively). Expected probabilities were generated using binomial regression.

purchase their textbooks and supplies sooner and follow directions more carefully (Martens, Gulikers & Bastiaens, 2004). Motivated students are more likely to download the syllabus from Blackboard before classes start and will purchase and register their PRS clicker using the directions on the syllabus. What is important is that the order of PRS registration can be used to predict a student's success in the course before any evaluation and as early as the 1st week of class. We imagine, but did not test, that

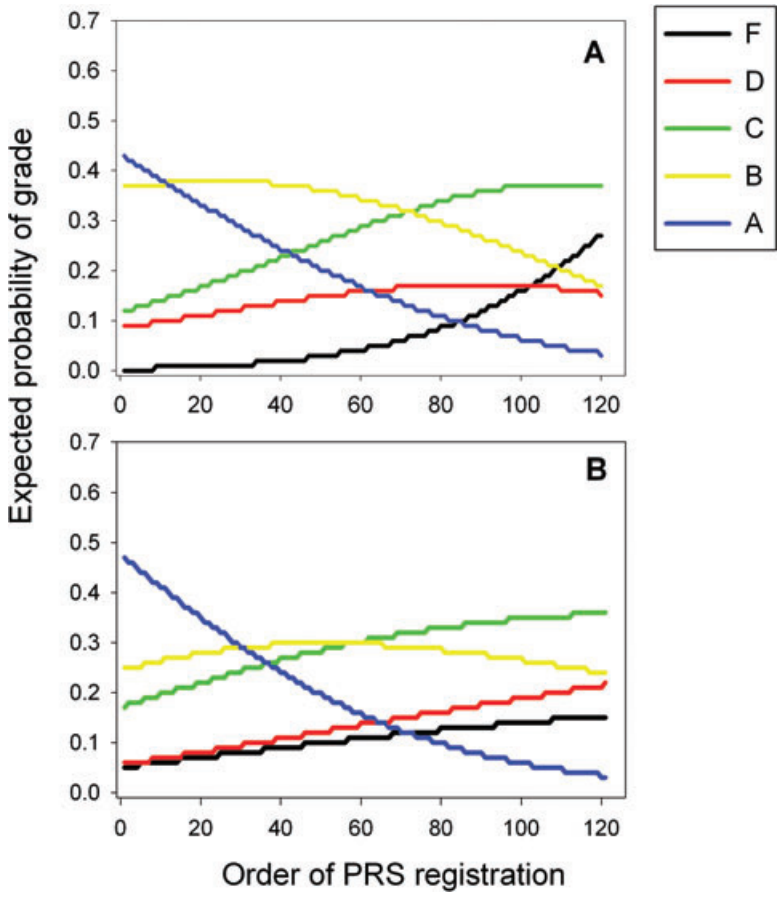

Figure 2: Expected probability versus registration order for two additional populations of students
Data here are for Anatomy and Physiology I taught in winter, rather than fall (A) and for the first quarter of Introductory Biology for majors (B).

similar results could have been obtained with almost any required task where the students could be identified and the order of their response tallied.

How can these data be used to help at-risk students succeed? Comparing the class list to the PRS registration list, one can easily generate a list of students who have not yet registered their clickers by the end of the 1st week of classes (One can use programs such as Excel with functions such as vertical look-up, or simply put both lists in alphabetical order and copy and paste the appropriate names). Using this list of at-risk students, emails reminding students that they need to register their clickers may provide needed encouragement. Often, simply knowing that a professor cares or is paying attention to their performance is sufficient motivation (Wentzel, 1994). Our university also has several programs to tutor and mentor students, and one could send

extra emails to these at-risk students urging them to enroll. Also, many textbook publishers have websites available that provide supplemental material, quizzes and audio-visual material. This year we plan to see whether simply informing students early in the quarter that they may be at risk can positively affect the grades of these students. While there have been few examples, early intervention in specific courses has been shown to be effective in reducing failure (Hoyert & O'Dell, 2006). Care must be exercised in how at-risk students are informed of their 'status' (Wentzel & Wigfield, 1998), but it is our hope that early identification of these at-risk students combined with availing them of programs designed to increase success will be sufficient to improve learning and prevent the attrition seen in these gateway courses.

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