Predicting Final Grades in Calculus using Pre- and Early-Semester Data

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It is well-known that too many students abandon a STEM career because of their calculus requirement. Therefore, being able to identify early on which students may be at risk of failing is important. Using indicators of mathematical readiness (SAT/ACT and PCA) and attitudes toward mathematics (MAPS), we build models predicting final grades. Our analyses show that all three indicators are significant predictors of success in calculus.

Keywords: PCA, MAPS, calculus, student success

Historically, first-year calculus courses have high D-Fail-Withdraw (DFW) rates and because of these many STEM majors, including STEM education majors, are driven away (Bressoud & Rasmussen, 2015). This situation is highly detrimental for the U.S. as its economy is increasingly reliant on STEM workforce (Olson & Riordan, 2012). In this study, we investigate how to predict success in calculus using pre- and early-semester data. Having such a model would enable instructors to identify early on which students are at risk of failing.

To explore our question, we have combined two approaches used in the literature. First, we have assessed students' mathematical readiness for calculus using the Pre-Calculus Concept Assessment (PCA) developed by Carlson *et al. (2010)*. Second, we have evaluated students' confidence and attitudes toward mathematics using the Mathematics Attitudes and Perceptions Survey (MAPS) (Code, Merchant, Maciejewski, Thomas, & Lo, 2016). We have also controlled for SAT/ACT scores. The population is students in two introductory calculus courses in a large private research university in the Northeast. Data was collected in Fall 2017 and Spring 2018. Students completed the two surveys in the first two weeks of the semester.

Linear models using only one indicator (SAT/ACT, PCA or MAPS scores) indicate that taken individually, these variables are all statistically significant predictors but explain relatively little of the variation of the final exam grades (adjusted R^2 of 0.26, 0.07 and 0.14, respectively). Using a multiple regression model (N=531), we found that SAT/ACT scores ($b = 6.21$, beta = 0.4007, $t(527) = 10.69$, $p<0.001$), PCA scores ($b = 0.57$, beta = 0.206, $t(527) = 5.382$, $p<0.001$), and MAPS scores ($b = 14.42$, beta = 0.208, $t(527) = 5.823$, $p<0.001$) are all significant predictors of final exam scores. Moreover, this model explains a larger variation of the final exam grade (adjusted $R^2 = 0.36$) than linear models using only one of these indicators. Looking at the beta scores, it is interesting to note that the PCA and MAPS have nearly the same effect on the final grade. This supports the idea that both mathematical preparedness and attitude toward mathematics are important for being successful in introductory calculus. The implication for classroom practice is that instructors should not only help students reinforce their mathematical knowledge *but also* support them in developing an expert attitude toward mathematics. A multiple regression model using the MAPS sub-scores (that evaluate different aspects of attitudes and perceptions of math) indicate that Confidence in one's ability to successfully engage in mathematical tasks and Persistence when solving non-routine exercises are the most important of these aspects.

References

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