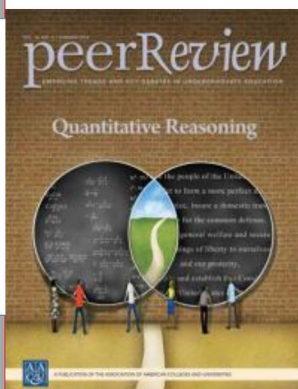




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Peer Review

## Improving Success of Students in Introductory Mathematics and Statistics Courses

By: David F. Brakke and Linda Cabe Helpert

We live in a world of enormous complexity and are surrounded by quantitative problems, awash in numbers and information. This era of "big data" came quickly upon us, forcing us to re-think how we prepare our students to think and reason analytically, for life before and after graduation.

James Madison University (JMU) is a large, public, selective, comprehensive university in Virginia. Our goal is to prepare educated and enlightened citizens who will lead productive and meaningful lives. We believe that we need to enhance quantitative literacy, and to do so in a context of ethical decision making. To that end, a decade ago, we reported in *Peer Review* on multiple approaches being used to improve quantitative skills at James Madison University (Brakke and Carothers 2004). In that article we addressed first-year advising, support, assessment, curricular changes, minors and majors, and interdisciplinarity. We have continued those efforts and recently expanded them to address specific courses.

### Placement for Success and Not for Failure

We cannot overemphasize the importance of placement into mathematics courses while also recognizing the landscape has become more complicated since our article was published. We must start with placement for success, not for failure. Students are entering universities with a wide range of skills and degrees of preparation. We recognize the importance of strong algebra skills regardless of what more advanced topics students were introduced to through IB, AP, and other courses and base our placements mostly on algebra. We have carefully studied the success rates of students in a range of mathematics courses in relation to their SAT and mathematics placement scores. Where necessary we have developed new courses designed to prepare students to be successful and have worked hard to improve advising about mathematics courses.

In other cases, we have begun conversations between the mathematics and statistics faculty and programs relying heavily on them. Examples include an engineering program now beginning its seventh year, working with biological mathematics, mathematics and the physical sciences and data analytics. These conversations may occur across one or more departments and in some cases cross multiple colleges.

Rather than providing an update on all of the areas addressed by Brakke and Carothers (2004) or describe conversations in early stages, we want to report on outcomes for two specific projects that we hope will illustrate ways that focused efforts

can achieve very positive results and improve student learning outcomes. In so doing, we will suggest ways to structure collaborative efforts that lead to cooperation, increased understanding across programs, and improved student success.

### **Increasing Student Success in Two Gateway Mathematics Courses**

In 2009, as part of the strategic planning process required by the state and coordinated by the State Council of Higher Education in Virginia, JMU undertook a project to increase student success in the two gateway mathematics courses with the largest undergraduate enrollments. These were Math 205, Introductory Calculus I—the three-credit calculus course taken by many students in the College of Business as well as a variety of other majors—and Math 220, Elementary Statistics, which is required by a large number of majors. Over 20 percent of new first-year students take one of these two courses in their first semester. In 2009–2010, the year this project started, the total fall and spring enrollment across these two courses was 3,823 students. In the same year, JMU enrolled 3,952 new first-year students and 669 new transfer students. Even allowing for some retakes and some students taking both courses, it is clear that a very large percentage of our students take at least one of these courses in their first-year. Improving student success in these two courses, therefore, had the potential of having an impact on a very large number of JMU undergraduates, making it a powerful project for improving overall student success.

### **Investigating Causes for Student Failure**

In the fall of 2009, two task forces, one for each course, were formed to investigate causes of student failure—defined as students completing the course with grades of D, F, or W (withdrawn)—and design possible strategies to increase success. Five years later, the very notable achievements of this project, and its general applicability to a number of undergraduate institutions, have led us to share project details. Before the project began, A, B, and C grades in Math 205 ranged from 62.3 to 71.7 percent and reached 83 percent in 2013–14. For Math 220, the percentages were from 70.8 to 76.0 percent prior to the project and reached 86 percent in 2013–14.

One important aspect of the formation of the task forces is that they included faculty from the departments whose curricula build on the two mathematics courses under review. So, for example, the initial task force examining student success in Elementary Statistics included faculty from biology, health sciences, justice studies, and psychology, as well as a faculty leader from the general education program. This breadth of representation allowed the group to consider not only what students needed to be successful in the gateway mathematics class but also what they needed to retain to be successful in a subsequent class in their major. A similar approach was taken for the one-semester calculus course. Both task forces were promised modest support, but it was clear that JMU could not provide significant new funding. Initial recommendations of both faculty groups and ongoing work on this project fall into three broad areas: student preparation and placement, course augmentations, and alignment.

### **Student Preparation and Placement**

One immediate finding related to Elementary Statistics was that both our math placement test and preparatory courses were

more closely aligned with calculus than statistics. Faculty began working immediately on a new section of our existing math placement test that would focus on the preparation students would need to succeed in statistics and also developed a quantitative literacy course that both matches the student learning outcomes of our general education program and provides focused preparation for further study in statistics.

After analyzing data on the relationship between math placement scores and student success in Introductory Calculus, we found that DWF rates were significantly higher for students who did not follow placement advice and took a higher math class than was recommended by their first-year advisors, so the task force recommended much tighter enforcement of placement scores as first-year students registered for classes.

### **Course Augmentation**

Mathematics faculty on both task forces also began work on supplemental materials that students could use to develop their skills. Over several summers, JMU has provided modest summer funding for mathematics and statistics faculty to develop homework questions and problem sets using WeBWorK, an open-source online homework system that is supported by the Mathematical Association of America and the National Science Foundation. Faculty believed the homework system would improve student learning and retention, and that it had the potential to reduce the workload on individual instructors because faculty are assigned to develop homework problems their colleagues could share. They have continued to build the test bank and increase the number of faculty using the homework system.

JMU had existing student support in supplemental instruction, as well as a comprehensive Science and Mathematics Learning Center providing tutoring and homework help for students in both courses. Even so, the group looking at statistics implemented more robust training for student tutors and both task force groups encouraged their colleagues to make greater use of the Supplemental Instruction program.

One of the most creative augmentation efforts has been the development of a one-credit "booster" course for students who do not place into Introductory Calculus, but whose scores fall into a range just below the cut-off point. The course is designed as a self-paced, primarily online supplement taken in the same semester as Introductory Calculus, allowing these students to avoid a three-credit full semester preparatory course. The benefits are many, including the fact that these students are able to move into calculus a semester earlier, and their success in calculus has improved.

### **Alignment**

Both task force groups recognized divergence across sections of the same course as a problem. Faculty in the calculus group proposed to increase alignment through promoting the WeBWorK homework system and through fostering, in the words of their report, "an environment that promotes open discussion opportunities between faculty who teach Math 205." Both courses are also making use of peer study leaders.

Statistics faculty implemented a number of specific initiatives designed to improve alignment across sections. These included instituting a Math 220 coordinator in the department, having statistics faculty approve a core list of course content topics to

be covered in all sections, and analyzing the grade variance for greater consistency in grading. Because each of these initiatives came from the statistics group and were not mandated, they were widely embraced. The course coordinator worked so well that the same model was adopted by the calculus group.

Another move undertaken across the department of mathematics and statistics was an effort to align faculty enthusiasm and commitment with their course schedules and teaching assignments. This move also more clearly defined the roles of faculty in teaching not only Math 205 and Math 220 but also other courses.

### Results

The results to these combined efforts have been stunning. As one faculty member noted at the beginning of the process, JMU started with success rates that many departments around the country would be proud to match. The current success rates (grades of A, B, or C) of 83 percent in Introductory Calculus and over 85 percent in Elementary Statistics exceed the targets we set by a great deal, and represent an extraordinary achievement by a dedicated group of faculty. Equally notable is the scale at which this has been achieved—in 2013–14 there were ninety-eight sections enrolling over 3,800 students during the fall and spring semesters. While reporting the major gains in student success, we need to emphasize that there was no change in course content or rigor of the courses. One of the instructions to the task forces from the very start was that they not back away from content, but instead focus on ways students can be more successful.

Because the project to increase student success in these two math courses was undertaken as part of a state-level strategic planning process, it started with specific targets by which the improvement would be considered successful. Table 1 lists actual student performance in these courses beginning in 2000, and compares those results with the established targets and thresholds. In each course, large increases in student success followed the implementation of the improvement strategies described in this article.

Table 1. Student Performance in Math 205 (Calculus) and Math 220 (Statistics)

Math 205				Math 220		
Year	Actual1	Target	Threshold	Actual1	Target	Threshold
2000–01	62.3%	—	—	73.4%	—	—
2001–02	71.4%	—	—	74.7%	—	—
2002–03	66.4%	—	—	73.9%	—	—
2003–04	65.9%	—	—	71.8%	—	—
2004–05	63.0%	—	—	70.8%	—	—
2005–06	64.2%	—	—	71.6%	—	—

2006-07	69.1%	—	—	72.5%	—	—
2007--08	71.1%	—	—	76.0%	—	—
2008-09	71.7%	70.7% <sup>2</sup>	67.7%	76.4%	75.0% <sup>2</sup>	72.0%
2009-10	70.2%	70.7%	67.7%	79.8%	75.0%	72.0%
2010--11	76.0%	70.7%	67.7%	79.1%	75.0%	72.0%
2011-12	80.0%	71.7%	68.7%	84.3%	76.0%	73.0%
2012-13	80.2%	72.7%	69.7%	85.5%	77.0%	74.0%
2013-14 <sup>3</sup>	83.0%	73.7%	70.7%	86.0%	78.0%	75.0%
2014-15	—	74.7%	71.7%	—	79.0%	76.0%
2015-16	—	75.7%	72.7%	—	80.0%	77.0%

Mathematics and statistics faculty are proud of the success of these efforts, and are continuing to seek ongoing improvement. For 2014-2015, they have expanded the use of the one-credit booster course and are considering the model for other more specialized introductory math courses. They continue to expand the problem sets used in WeBWork. We may reach a point where the university's goal will be to maintain our level of student success in these courses rather than continued improvement in success rates, but we hope to see further progress in the near future.

#### Acknowledgments

*We would like to acknowledge the leadership of our colleagues in the department of mathematics and statistics. The task force promoting student success in Math 205 was led by Debra Polignone Warne, professor of mathematics; the task force promoting success in Math 220 was led by Hasan Hamdan, professor of mathematics, and Kane Nashimoto, associate professor of mathematics. David Carothers, mathematics department head, has supported their efforts throughout the process.*

#### Reference

Brakke, David F., and David C. Carothers. 2004. "[Multiple Approaches to Improving Quantitative Skills at James Madison University](#)." *Peer Review* 6 (6): 19-21.

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