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Improving College Students' Performance in Mathematics Gatekeeper Courses Using Confucius Philosophies—A Case Study

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In this paper, we present the results of a case study on students' performance in mathematics and statistics gatekeeper courses. Having identified the gatekeeper courses in lower division mathematics and statistics that were taught at the University of West Florida (UWF), we assessed the group performance of students who took those classes during a recent four-year period. We performed annual assessment studies of group performance of students in those classes during the period of interest. Then, we applied Confucius philosophies on the lower division courses. Results of these assessment studies show that the students' performance improved dramatically when the Confucius philosophies were applied to the program. The report here also includes some procedures for assessing and reforming curricular at that level.

Keywords: mathematics and statistics gatekeeper courses, students' performance, Confucius philosophies

Introduction

In the state of Florida in the USA, a college student must satisfy the general studies (GS) as well as the Gordon Rule (GR) requirements in order to receive a baccalaureate degree. These GS/GR requirements in the area of mathematics stipulate that the student must show proficiency in two courses at/above College Algebra level. However, students who enter into science, technology, engineering, and mathematics (STEM) fields must successfully complete math courses up to the Calculus Sequence. Similarly, students who wish to get degrees in business are required to show proficiency in Calculus with Business Applications. Collectively, these lower division courses are referred to as math gatekeeper courses since they could keep students out of the various fields of study.

The question of students' performance in mathematics gatekeeper courses is a continuing topic of interest for students, educators, parents, and university administrators in today's changing academic terrain. Strategies to address lack-luster performance at that level include the use of new teaching methods coupled with emerging

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instructional technologies as well as assessment rubrics utilized to measure success.

Literature Review

We note that while some studies have attributed improved success rates to these new initiatives, other reports show that similar initiatives have not recorded significant improvements (Li, Uvah, Amin, & Hemasinha, 2009; Barnes, Cerrito, & Levi, 2004; Hauk & Segalla, 2005; O'Callaghan, 1998; Smith & Ferguson, 2005; Stephens & Konvalina, 1999). Recent studies indicate that universities and colleges are also investigating the issue of college readiness with the goal of addressing the poor performance in college mathematic courses (Allen & Sconing, 2005; Conley, 2007; Greene & Foster, 2003; Greene & Winters, 2005; Shettle et al., 2007). In order to improve the teaching and learning of math gatekeeper courses, the retention, and graduation rates, the authors who are in the Department of Mathematics and Statistics at the University of West Florida (UWF) performed a series of assessments on gatekeeper courses as reported in Li (2008; 2009).

It is well-known that the math background of students admitted to UWF is not as strong as those of some schools in the Florida State University System (FSUS), such as University of Florida (UF) and Florida State University (FSU). We were aware of that fact prior to the case study. Regardless of entry requirements, the students have to have 2.5 grade point average (GPA) in two math courses at/above MAC 1105 College Algebra, in order to satisfy the GS and GR requirements. It was a common rumor that "A" students in non-science fields would be happy if they could get "Cs" in math courses and they would celebrate it if they received "Bs." After we collected data on students' performance for previous years, we were shocked to see that the rumor had validity. These bad results were in spite of the trying a variety of ways for years to improve students' performance. The big question became how we could improve students' performance. We observed that the Chinese students were consistently strong in math and we wondered how we could use their teaching learning methods to improve American students' performance. The thoughts on an approach were guided by one of the many philosophies of Confucius: When it is obvious that the goals cannot be reached, do not adjust the goals, and adjust the action steps (Lai, Xia, & Yu, 2002).

When we explored the topic—Chinese and American education systems, or similar terms on the Internet, we found thousands of books and articles. Through this literature, we observed that Confucius philosophies were in the fabric of Chinese culture during their process of civilization throughout history, even though they may not have realized it. The Chinese have been applying these philosophies in their daily lives for 2,500 years regardless their social classes or status. Confucius, the Chinese philosopher and teacher born in 551 BC, is considered to be one of the most important figures in world history. His teachings created the foundation for the Chinese society in his day and thereafter. We decided to explore applying these philosophies selectively to the math programs to improve teaching and learning. With the approval of the department faculty, we began the case study. In the form of a concerted case study, it lasted for four years. During those four years, like Confucius, we believed that the greatest glory is not in ever falling, but in rising every time we fall (Lai, Xia, & Yu, 2002).

In the sequel, we document some of the highlights of the case study, the challenges and the opportunities that we faced, and the dramatic results.

Students' Performance in Year 0

Initially, we simply collected data on students' performance in all sections of the relevant courses. This action was in keeping with a Confucius philosophy: Success depends upon previous preparation, and without such preparation, there is sure to be failure (Lai, Xia, & Yu, 2002).

Table 1 shows the students' performance in all sections of MAC 1105 College Algebra in the spring semester of Year 0 at UWF. The overall Grade D, Withdraw, and Grade F (DWF) rate for the course was 36%. The worst section had a DWF rate of 53%. We noted here that these data were public information to be supplied on request. As a basic and foundational prerequisite course to several other lower division math courses, students who do not do well in this course are not be able to do well in other math courses.

Table 1

Students' Performance in College Algebra (MAC 1105) in Spring of Year 0

Course number	Reference number	Course title	Enrollment	DWF	DWF rate (%)	GPA mean
MAC 1105	969	College Algebra	40	18	45	2.39
MAC 1105	970	College Algebra	40	13	33	2.21
MAC 1105	971	College Algebra	40	16	40	1.67
MAC 1105	972	College Algebra	37	9	24	2.81
MAC 1105	973	College Algebra	40	10	25	2.53
MAC 1105	974	College Algebra	37	16	43	1.93
MAC 1105	975	College Algebra	34	11	32	2.38
MAC 1105	976	College Algebra	36	19	53	1.70
MAC 1105	977	College Algebra	42	12	27	2.26
Total			346	124	36	

Table 2

Students' Performance in Tri-Gonometry (MAC 1114) in Spring of Year 0

Course number	Reference number	Course title	Enrollment	DWF	DWF rate (%)	GPA mean
MAC 1114	980	Tri-gonometry	34	15	44	2.57
MAC 1114	981	Tri-gonometry	34	15	44	2.06
Total			68	30	44	

Table 3

Students' Performance in Pre-Calculus Algebra (MAC 1140) in Spring of Year 0

Course number	Reference number	Course title	Enrollment	DWF	DWF rate (%)	GPA mean
MAC 1140	982	Pre-calculus Algebra	33	11	33	2.10
MAC 1140	983	Pre-calculus Algebra	26	16	62	1.55
MAC 1140	984	Pre-calculus Algebra	36	24	67	1.61
Total			95	51	54	

Table 2 shows that 44% of students failed the Tri-gonometry classes in spring of Year 0. Similarly, Table 3 shows that 54% of students in the Pre-calculus Algebra classes received DWF in the same period. Tri-gonometry and Pre-calculus Algebra are pre-requisites to the Calculus, which is needed for most STEM majors. Consequently, failure in these classes forces students out of STEM.

The MAC 2233—Calculus with Business Applications course, is a required course for business majors. Table 4 shows that 46% students received DWF from the course in spring of Year 0. Graduation in these majors requires an acceptable grade in this course.

Table 4

The Students' Performance in Calculus With Business Applications (MAC 2233) in Spring of Year 0

Course number	Reference number	Course title	Enrollment	DWF	DWF rate (%)	GPA mean
MAC 2233	985	Calculus with Business Applications	34	21	62	1.48
MAC 2233	986	Calculus with Business Applications	37	17	46	2.24
MAC 2233	987	Calculus with Business Applications	42	17	40	2.27
MAC 2233	988	Calculus with Business Applications	21	6	29	2.65
Total			134	61	46	

Table 5

Students' Performance in Calculus in Spring of Year 0

Course number	Reference number	Course title	Enrollment	DWF	DWF rate (%)	GPA mean
MAC 2311	989	Analytic Geometry/Calculus I	41	15	37	2.77
MAC 2311	990	Analytic Geometry/Calculus I	38	17	45	1.98
MAC 2311	991	Analytic Geometry/Calculus I	43	17	40	2.01
MAC 2312	993	Analytic Geometry/Calculus II	42	21	50	1.85
MAC 2312	994	Analytic Geometry/Calculus II	36	14	39	2.25
MAC 2313	995	Analytic Geometry/Calculus III	37	12	32	2.06
Total			237	96	41	

Almost all STEM programs require courses in the Calculus Sequence. If students do not do well, they cannot survive in the programs. Many programs require minimum grade of "C." As Table 5 shows, over 41% students failed the Calculus classes.

Table 6

Students' Performance in Traditional Gatekeeper Math Courses: Spring of Year 0

Spring of Year 0	Enrollment	DWF	DWF rate (%)
Grand total	880	362	41

Table 6 shows the overall performance of UWF students in the traditional math gatekeeper courses in spring of Year 0 when the DWF rate was over 41%. As stated before, if students fail these gatekeeper courses, they may not be successful in their chosen majors at any college. The Elements of Statistics is one of the two most popular math courses that college students take to satisfy the GS/GR requirements in Florida. In a sense, it is a gatekeeper course since many majors do require students to complete the course successfully.

Table 7

Students' Performance in Elements of Statistics (STA 2023) in Spring Year 0

Course number	Reference number	Course title	Enrollment	DWF	DWF rate (%)	GPA mean
STA 2023	1545	Elements of Statistics	48	22	46	2.41
STA 2023	1547	Elements of Statistics	49	16	33	2.37
STA 2023	1548	Elements of Statistics	49	17	35	2.48
STA 2023	1549	Elements of Statistics	48	30	63	1.67
STA 2023	1550	Elements of Statistics	48	14	29	2.61
STA 2023	1551	Elements of Statistics	52	6	12	3.18
STA 2023	1552	Elements of Statistics	52	17	33	2.51
STA 2023	1553	Elements of Statistics	51	21	41	2.20
Total			446	147	33	

Table 7 shows that 33% of students received DWF in statistics with the range being 12% to 63%. One section had an abysmal GPA of 1.67.

Table 8
Combined Students' Performance in Math Gatekeeper Courses in Spring of Year 0

Spring of Year 0	Enrollment	DWF	DWF Rate (%)
Grand total	1,326	509	38.4

As one can see from Table 8, the combined DWF rate of math gatekeeper courses at UWF in Year 0 was 38.4%. While Table 8 shows the DWF rate, it is to be noted that a student who does not receive the DWF and who passes a course with a grade of "C" may not have met graduation requirements. Since each student must have a minimum GPA of 2.5 in two math courses to get a baccalaureate degree, a student who earns a "C" in one math course must get at least a "B" in another math course to graduate. Consequently, more than 50% of students in the group in the data for Year 0 would possibly have to retake the math gatekeeper courses to graduate. It was clear that something was wrong. As Confucius would say, "Not to correct the mistake one has made is to err indeed" (Lai, Xia, & Yu, 2002).

The financial burden and emotional stress weigh heavily on students and families that support those students. Similarly, the pressure from society and legislators on university administrators is huge. Retention and graduation rates are among the top accountability measures from funding agencies. Therefore, it is incumbent upon departments to ensure that students are successful in critical courses, such as the math gatekeeper courses.

Assessments

The Process

After we collected the data, we tried to determine areas of strength and weakness in the lower division offerings. The goal was to improve students' performance. While it was clear to us that assessment was the key to diagnosing the problem, we had two main obstacles. Firstly, we had little or no experience in assessment. Secondly, several senior faculty members were strongly against it. In fact, some thought it was just waste of time. However, others believed we could find people on campus who were experts in assessment in keeping with one of Confucius' philosophies: When I walk along with two others, from at least one I will be able to learn (Lai, Xia, & Yu, 2002).

With the help from the top administrators and a number of assessment experts, we quickly drafted an assessment plan. The plan was to:

1. Diligently articulate student learning outcomes (SLOs) in terms of what a student who successfully completes the course can do. SLOs were the same for all sections of each course;

2. Assess students' performance in all sections of the course once a year using the common end-of-semester (final) examination. Questions on the examination were matched to SLOs;

3. Arrange data of group performance per problem (therefore, per SLO). If a group lost 40% or more on a given problem, the group was deemed to be deficient in the corresponding SLO;

4. These results were presented to the department faculty who made recommendations for addressing topics in which deficiencies existed. The faculty also suggested strategies for addressing deficiencies;

5. Recommendations were implemented, and after a period of at least one year later, a new assessment cycle began.

We collected data again at the end of the fall semester of Year 1 and completed the first assessment. From then, we conducted assessments annually for four years. At the end of every fall semester, we collected data from all sections of two GS courses (except College Algebra and Elements of Statistics in which we collected data for two and three consecutive years, respectively). The department had its faculty meeting in January to discuss the assessment results. Recommendations were made and tentative strategies were discussed at this time. At the April department meeting, the faculty would make final plans for the following year according to the recommendations. The coordinator of lower division courses in the department would implement the changes accordingly and monitor all lower level courses. The progress was slow and steady, but we believed in the approach, because it relied on Confucius' philosophy: It does not matter how slowly you go as long as you do not stop (Lai, Xia, & Yu, 2002).

Recommendations that we implemented included: curriculum shifts (to spend more time on problematic topics), utilizing a mix of modes of instruction (face-to-face, blended, and online), providing a variety of homework formats (paper and pencil *vs.* web-based), and tutoring help outside the classroom. We first assessed the two most popular GS/GR courses: College Algebra and Elements of Statistics. We discussed pair-wise comparisons of students' performance in College Algebra and Elements of Statistics courses among three instruction formats: the traditional face-to-face lecture without technology enhancement, the blended face-to-face lecture with web-based homework, and the fully online. Overall, there was no evidence of a difference in the students' mastery of College Algebra concepts between instruction given in the traditional and blended modes. Students in the blended Elements of Statistics classes out-performed those in the traditional format.

However, students in the fully online classes performed significantly worse than those who had the face-to-face lectures in the blended and traditional formats. The analysis also illuminated nuances. There was evidence that the attributes of face-to-face instruction with web-based homework systems and fully online classes that make these formats beneficial to the high-performing students may be detrimental to the lowest performing students (Li, 2008). We offered suggestions to rectify the situation by reforming the curricula based on the assessment result. In particular, we used advanced technology in some classes and developed more efficient teaching methods. Furthermore, we introduced permission codes to all online courses that required us to interview students before they could register for the classes, to make reasonably sure that those students were mature and had the requisite background to engage the courses from a distance.

Some Issues

An issue that consistently concerned us was the college readiness of students in College Algebra. In the Year 2, we undertook a comparative study of students' performance in College Algebra for the fall semesters of the Years 1 and 2. We used assessment results from the fall semester of the Year 1 to make schedule shifts in Year 2, to address areas of weakest performance. In addition, we went from the solely traditional mode of teaching and learning in Year 1 to the blended format of face-to-face lecture with web-based homework in the Year 2. We analyzed students' performance during this transition to measure the combined effect of the adjustments and learning enhancement. The results showed that students' performance improved in Year 2 when the curriculum developments were implemented. However, we identified some topics that continued to pose a challenge. In order to check the validity of the placement criteria, we also analyzed correlations between students' performance in College Algebra and four factors, namely, cumulative college GPA, high school GPA, scholastic assessment test (SAT) scores in mathematics, and American College Test (ACT) scores in mathematics. There was a correlation between performance in College Algebra and each of the four factors that we considered. Cumulative college GPA, followed by high school GPA, exhibited the strongest correlation. Standardized test scores showed low correlations with success rates in College Algebra (Li, Uvah, Amin, & Okafor, 2010). We proffered suggestions regarding curriculum development in College Algebra as well as placement criteria for the course.

We conducted assessments for the Elements of Statistics course in each of the Years 1, 2, and 3 to predict the performance. There were 1,405 students registered in the classes. Since there are several methods for placing students into Elements of Statistics, the thrust of this study was to determine students' readiness and the factors that best predict students' performance in the course. Among other things, the analysis showed that:

1. There was a significant correlation between students' performance in Elements of Statistics and each of the other factors in that study. The highest correlation values were recorded between performance in Elements of Statistics and college GPA, followed by College Algebra and Intermediate Algebra grades.

2. The correlations between performance in Elements of Statistics and the standardized test scores (SAT and ACT) were much weaker than college GPA, College Algebra, or intermediate Algebra grades. These findings were in alignment with studies, such as those of Geiser and Santelices (2007) that indicated good predictors of college performance.

3. Cumulative college GPA was the best predictor of students' performance in Elements of Statistics. The stability of prediction was strongest when college GPA was used in combination with either the ACT or SAT scores. Under these conditions, the pre-requisite Algebra courses appeared to have no differential effect on the predictor models.

4. High school GPA was seen not found to be a viable tool for predicting performance in Elements of Statistics.

We concluded that college GPA was the best predictor of students' performance in Elements of Statistics. It made sense that when combined with standardized test scores, it provided the most stable prediction for students' performance because of the nature of statistics. The word problems that dominate statistics tests require the students' comprehension aside from skills in symbolic manipulation. The study concerning college readiness for College Algebra also showed that college GPA was a better predictor of students' performance than scores on standardized tests. However, unlike College Algebra, the standardized test scores appeared to be a viable predictor of performance in Elements of Statistics only when considered along with college GPA (Li, Uvah, & Amin, 2012).

Most of UWF students are from the local areas. In order to understand their math readiness for college, we embarked on another study. In the study, we assessed the group performance of 970 high school students in mathematics using data from the American mathematics competitions tests administered at UWF for five consecutive years. The main aim was to identify areas of strength and weaknesses in high school mathematics for the group. A secondary objective was to assess the college readiness of the students in the area of mathematics. Aside from identifying some factors known to affect students' performance at the high school levels, we offered a range of suggestions on individual and institutional remedies that could be implemented in Grades 11 and 12 when most students take the standardized tests in preparation for entry into institutions of higher education. We believed that students who are properly equipped in Grades 9 and 10 are more likely to be prepared for college by the time they complete the Grade 12. Moreover, such students are also likely to perform well on the standardized tests that many colleges and universities use for placement in to courses. The results of that study could be used to advise grade teachers to place emphases on some topics in Grades 9 and 10, and in Grades 11 and 12 curriculums. For details (Uvah & Li, 2017).

Curriculum Reform

After the assessments, we reformed the curricula based on faculty recommendations. Advanced technology was used in the classes to promote learning. We standardized the operations in the lower level math and statistics courses as follows:

1. All lower level math courses had uniform syllabi with weekly topics covered and homework assignments. A faculty member could teach more, but not less than what was decided collectively. Every faculty member followed the schedule, at least approximately. The entire faculty who were teaching these classes were treated equally, according to the Confucius principle: What you do not want done to yourself, do not do to others (Lai, Xia, & Yu, 2002).

2. College Algebra and Elements of Statistics that most UWF students take to satisfy GS/GR requirements had uniform comprehensive final examinations given at the end of the semester. The instructors did not see the final exam questions until the final week. The exams were made by the coordinator of lower division courses every semester. The problems on the exams were chosen to correspond with the SLOs from the test banks that we had built over the years. The difficulty level of the exams was maintained year-in and year-out. Like Confucius would say, "It is easy to hate and it is difficult to love. This is how the whole scheme of things works. All good things are difficult to achieve and bad things are very easy to get" (Lai, Xia, & Yu, 2002). The final exams were graded uniformly, so that no instructor graded his/her students' exams solely.

3. After the end of the semester, we collected data from each class and conducted an assessment. The data was presented to the instructors in the January department meeting. All instructors knew how their students did in comparison to students from other sections.

4. We modified the curricula according to the assessments results. In the April department meeting, we made the plans for the following year.

Indeed, the methodical approach is captured succinctly in the Confucius' philosophy: The more man meditates upon good thoughts, the better will be his world and the world at large (Lai, Xia, & Yu, 2002).

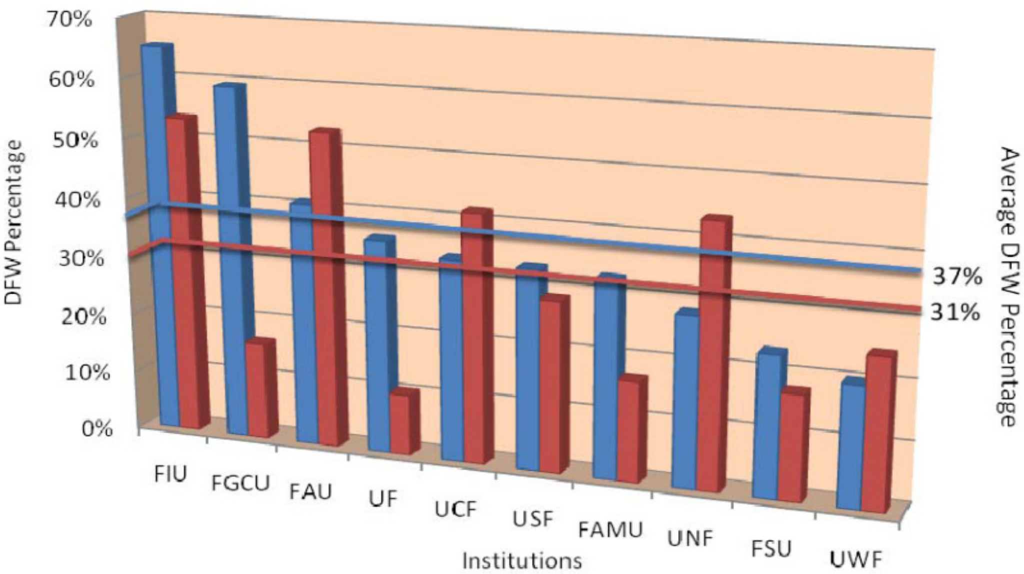
Clearly, every instructor was doing his/her best to make sure his/her students' performance was not at the bottom of the list every semester. The annual evaluation of such faculty factored in the faculty members and students' performance. The students were doing better since the faculty members were working harder to help the students in the class and to improve teaching and learning. They helped their students to practice after classes and had regular workshops to help students master those challenging problems. They made their students understand that they should "acquire new knowledge whilst thinking over the old and you may become a teacher of others" and "I hear and I forget, I see and I remember, and I do and I understand" (Lai, Xia, & Yu, 2002).

The most important thing that instructors could do for their students was to show them that they really cared about them and their education, and that they would do whatever they could to assist their students to make their dreams come true. This was exactly what the faculty did. The friendly learning environment made students feel comfortable to seek help when needed. As Confucius said, "Wisdom, compassion, and courage are the three universally recognized moral qualities of men" (Lai, Xia, & Yu, 2002)

Results at Year 4

During the four years, we completed cycles of assessment, research, curriculum reform, improvement, assessment, etc.. All gatekeeper courses were assessed and curricula were reformed. This became a routine in the department. Most of what we did to improve the lower division curricula has been maintained since the end of the study. It is now a part of the culture to assess the curriculum and see places that need adjustments. The gains we made in improving of learning and teaching are not lost on the faculty. This is in agreement with Confucius: Choose a job you love, and you will never have to work a day in your life (Lai, Xia, & Yu, 2002).

At the end of the fall semester of the Year 4, we received a report from Enlace Florida (2009). Enlace Florida is a statewide network promoting college readiness, access, and success for Latinos, African-Americans, and other underrepresented students in Florida through non-partisan research, communication, advocacy, and support. In their report on students' performance in gatekeeper math courses among the ten state (public) universities in Florida, UWF ranked Number 4 in each course. However, the UWF students' overall performance ranked Number 1. Figure 1 shows that UWF students' DWF rate was the lowest. The DWF rate dropped from 41% in the spring semester of Year 0 to 20% in the fall semester of Year 4, which was dramatic improvement.



	FIU	FGCU	FAU	UF	UCF	USF	FAMU	UNF	FSU	UWF
Traditional Track	65%	59%	41%	36%	34%	33%	33%	28%	23%	20%
Math courses for Liberal Arts Track	54%	16%	53%	10%	42%	29%	17%	44%	18%	25%

Figure 1. DFW rate for students in math gatekeeper courses by academic track and institution.

The Elements of Statistics was not included in the *Enlace Report* since this course is not a traditional math gatekeeper course. However, after the course was standardized and then redesigned, the students' performance also improved. Table 9 shows students' performance in Elements of Statistics in the spring semester of Year 4. Compared with the students' performance in the same course in the spring semester of Year 0 (see Table 7), it is evident that there was significant improvement in this course as well. Once upon a time, before a student registered for a math class in lower division, he/she would first check out whom the instructor was in a bid to shop for an "easier one." Now, all the classes cover the same materials at the same pace with similar tests and a uniform final exam. This new scheme has gone a long way to diminishing the need to shop for easy instructors.

Table 9

Students' Performance in Elements of Statistics (STA 2023) in Spring 2009

Course number	Reference number	Course title	Enrollment	DWF	DWF rate (%)
STA 2023	1657	Elements of Statistics	42	12	29
STA 2023	1658	Elements of Statistics	128	21	16
STA 2023	1659	Elements of Statistics	128	23	18
STA 2023	1660	Elements of Statistics	123	30	24
STA 2023	2533	Elements of Statistics	44	18	41
Total			465	104	22

Conclusion

As Confucius would say, "The will to win, the desire to succeed, the urge to reach your full potential ... These are the keys that will unlock the door to personal excellence" (Lai, Xia, & Yu, 2002). Using the math gatekeeper courses at UWF, we have shown that this statement is fundamentally true for an academic department. It is the conviction that any academic units experiencing wholesome lack-luster students' performance can replicate or adapt some of the strategies with good results, provided the faculty are diligent and patiently relentless in their quest.

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