Enhancing Teacher and Student Performance in Mathematics

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Abstract

The modern day applications of science, engineering and technology rest on a foundation heavily dependent upon mathematics. Prairie View A&M University (PVAMU) implemented several initiatives to enhance the teacher and student support infrastructure for education in science, mathematics, engineering and technology (SMET) disciplines. PVAMU received a $3.8M grant from the National Science Foundation (NSF) to significantly increase the enrollment and success of under-represented students in SMET disciplines. Studies have proven that students with high academic achievement in mathematics also attain high academic achievements throughout their course of study. In most SMET disciplines, mathematics is a key point of origin. Students must be proficient in mathematics before advancing to an in depth course of study in science, engineering or technology. Curriculum reform in mathematics is ongoing to ensure the course content is appropriate in various prerequisite courses. The endeavor is near completion and the basic issue still remains - How do we continue to enhance teacher and student performance in mathematics? Since the teacher is the primary facilitator of the student learning process, the teacher must utilize the optimal techniques identified to covey various concepts and subject matter. In addition, the order of presentation must be logical and well designed to offer the greatest opportunity for the student to learn. The student must be subject to a well-designed performance evaluation process, which positions the student to master the course content. This project established a team with the focus of enhancing teacher and student performance in mathematics. Dr. Freddie Frazier, Distinguished Professor of Mathematics, leads the team. The team focused on teaching techniques and methodologies, order of instruction and course content for each course. In addition, the team will develop an evaluation process designed to ensure the student has mastered the course content. The outcome of the activities will produce a model for each mathematics course. In conjunction with the classroom and support activities, the project will establish a computer laboratory with instructional and evaluation tools used within the mathematics community. The judicious integration of experienced teaching and available technology will develop the infrastructure needed to enhance teaching and student performance in mathematics at Prairie View A&M University. A preliminary study revealed that introductory courses in mathematics (algebra and trigonometry) experience a failure rate of almost fifty percent each semester. More advanced courses (calculus) experienced failure rates, which exceed fifty percent.[1]

Educational Techniques, Practices and Strategies

Prairie View A&M University is continually working to develop new and innovative ways to increase the success rates and narrow the achievement gaps in mathematics at the university level. To succeed, the university must engage in new processes and multiple constituencies in order to raise proficiency in mathematics among its students. Math proficiency really begins at the grade school level. To help future generations of students to further succeed and excel in college, the university must commence to support upper elementary and secondary school personnel, influence parents and engage mathematicians, scientists and educators at the higher education level to better prepare future public school teachers for the challenges ahead.

Mathematics Course Reform

The first step to improving teacher and student performance in mathematics was to evaluate course content and order of instruction. The initial evaluation identified several fundamental deficiencies:

1) Course content was not properly ordered,
2) Course content was incomplete,
3) Order of presentation was difficult to follow and
4) Students were not able to link various concepts.

Although such items seem fundamental to teaching, some of the younger and inexperienced professors needed help to identify with such deficiencies.

Course syllabi have been modified for prerequisite mathematics courses to better prepare students for gate-keeper SMET courses. College Algebra, Trigonometry, Calculus I, Calculus II and Differential Equations I course syllabi have been revised to ensure topic content is aligned with follow-on courses.
In addition, course content has been reorganized to provide a better subject foundation within the course itself.

Curriculum modifications are continually under evaluation. For example, an on-going initiative is to ensure that students enrolled in Engineering Physics II have passed Differential Equations I or be enrolled as a co-requisite. Students are also encouraged to satisfy College Algebra requirements before enrolling in General Chemistry.

Educational Techniques and Student Performance Enhanced through Summer Institute

The PVAMU SMET Summer Institute is an eight-week, academic intensive program designed to elevate mathematical, computer, communications and professional skills of recent high school graduates to college levels. A carefully selected team of professors and advanced students teach, evaluate and mentor first-time college freshmen in

mathematics. The advanced students are assigned to specific professors to help bridge "uncertainties" that exist between freshmen students and their professors.

Technology Infusion

In the summer of 2002, the Prairie View A&M University mathematics faculty was trained on the usage of Maple. The Maple system is an advanced, mathematical problem solving and programming environment. The analytical engine that powers Maple includes a powerful symbolic computational system that expresses and manipulates complex mathematics using automated mathematical formalisms and knowledge systems. The mathematics department at Prairie View is currently using Maple in Calculus I, Calculus II, Calculus III, Foundations, Differential Equations, and Math Model & Applications courses. Maple is used as a supplementary tool to allow students to spend more time on problem solving skills and less time on computing.

Faculty development

PVAMU mathematics faculty experienced numerous opportunities to engage in professional development activities that contribute to a vigorous and diverse mathematics teacher. Faculty members continually take advantage of each significant opportunity to engage in professional development activities relating to the initiative. Six faculty members, including the head of the Department of Mathematics, attended the "Reforming the Core Mathematics Program" at West Point, NY, and continue to meet regularly to coordinate mathematics reform throughout the department.

PVAMU instituted a carefully selected team to help facilitate a faculty "buy-in." The concept includes a faculty seminar series of special lectures in mathematics courses. The lectures are designed to reinforce techniques and applications, which will assist the student learning process. In addition, the advanced students assist the faculty member with tutorials and problem sessions, which are beneficial to the students. The faculty member and the advanced student are compensated for the additional efforts associated with the mathematics seminar series. The concept of making every possible effort to help students achieve academic excellence continues to grow throughout the University.

Successful Gate-keeper Data

Gate-keeper courses for SMET disciplines are Algebra/Trigonometry, Calculus, Chemistry and Physics. Reform in mathematics courses should enhance student performance in the respective course and the various follow-on courses. The various reform efforts have resulted in much higher student success rates than either the general university population or the student population involved in SMET disciplines as a whole.

The most recent statistics at the end of the 2001 fall term showed that SMET-EP Program students.[2]

- Had a 26 percent higher success rate (100% to 74%) in MATH 1115 than the SMET population. (Table 1)
- Had a 37 percent higher success rate (92% to 55%) in MATH 1124 than the SMET population. (Table 3)
- Had a 12 percent higher success rate (79% to 67%) in PHYS 2013 than the SMET population. (Table 3)
- Had a 28 percent higher success rate (71% to 43%) in CHEM 1033 than the SMET population. (Table 3)

A further measurement of student success can be found by comparing cumulative GPAs. Since the aptitudes of SMET participants and non-participants are close, as measured by SAT and ACT scores, increases in cumulative GPA can reasonably be attributed to the individualized treatment which SMET students enjoy over their non-SMET counterparts.

The Fall 2000 SMET Cohort showed a cumulative GPA of 3.03 compared with a GPA of 2.66 for non-participating students not receiving financial support or receiving SMET program treatment. (Table 4)

The Fall 2001 SMET Cohort showed a cumulative GPA of 3.21 compared with a GPA of 2.55 for non-participants. (Table 5)

Conclusions

Student pass rates and grade distributions are the primary metrics used to evaluate student and professor performance in gate-keeping courses. The PVAMU program evaluates:

- Instructor-conducted tutorials
- Seminar and lectures to integrate real applications of theory
- Frequent student evaluations and examinations to monitor progress
- Student-conducted problem sessions.
- Bi-weekly meetings for student feedback.

Course syllabi have been extensively modified for prerequisite mathematics courses to better prepare students for gate-keeper SMET courses. In addition, course content has been reorganized to provide a better subject foundation within the course itself. Curriculum modifications are continually under evaluation.

An evening lecture series has been developed which integrates and illustrates mathematics applications through follow-on courses. The series is a “forward-looking” approach to educating students, helping them to identify with the importance of course content.

Source: "SMET Enhancement Program 2002 Annual Report, Prairie View A&M University, Tables 1- 2, July 26,2002.

[2] *Source: "SMET Enhancement Program 2002 Annual Report, Prairie View A&M University, Tables 3-5, July 26, 2002.*

Biographies

DR. KELVIN K. KIRBY: Doctor of Engineering, Systems Engineering and Management, Texas A&M University (1998); Master of Engineering, Electrical Engineering, Texas A&M University (1987); Program Manager, National Science Foundation SMET Enhancement Program, Prairie View A&M University; Managing Director, NASA-Sponsored Center for Applied Radiation Research (CARR), Prairie View A&M University.

DR. FREDDIE L. FRAZIER: Distinguished Professor of Mathematics, Ed. D. Mathematics Education, University of Houston (1975); Master in Mathematics, Prairie View A&M University (1966); Coordinator of Engineering Mathematics, Prairie View A&M University (1973-Present); Coordinator and Instructor, Federal Aviation Administration Institute; Mathematics Director, M.I.T.E.; Mathematics Coordinator, E.C.I.

MR. JOHN GARDNER: Master of Science in Mathematics, Prairie View A&M University (1994); Bachelor of Science in Mathematics, Prairie View A&M University (1992); Doctorate in Mathematics in progress, University of Houston; Instructor, Mathematics Department, Prairie View A& M University (1997-Present).

		General SMET Population				SMET Participants			
	Gate-Keeper Courses	F01 ABC	F01 DFWI	F01 Success	F01 Failure	F01 ABC	F01 DFWI	F01 Success	F01 Failure
MATH 1115	Algebra/Trigonometry	64	23	74%	26%	54	0	100%	0%

Table 1 - Math 1115 Summer 2001 and Fall 2001 Consolidated

Table 2 – Gate-Keeper Courses

		SMET Population		SMET Participants		SMET Population		SMET Participants	
	Gate-Keeper Courses	ABC F00	DFWI F00	ABC F00	DFW F00	ABC F01	DFWI F01	ABC F01	DFWI F01
CHEM 1033	General Chemistry	159	187	49	12	159	209	42	17
MATH 1113	College Algebra	417	287	4	0	335	363	*	*
MATH 1124	Calculus w/Analytic Geom I	55	96	26	21	94	78	45	4
PHYS 2013	Engineering Physics (Spring)					89	44	15	4

	Gate-Keeper Courses	F00 Success	F00 Failure	F00 Success	F00 Failure	F01 Success	F01 Failure	F01 Success	F01 Failure
CHEM 1033	General Chemistry	45%	55%	80%	20%	43%	57%	71%	29%
MATH 1113	College Algebra	59%	41%	100%	0%	48%	52%	*	*
MATH 1124	Calculus w/Analytic Geom I	37%	63%	55%	45%	55%	45%	92%	8%
PHYS 2013	Engineering Physics (Spring)					67%	33%	79%	21%

Table 3 – Gate-Keeper Courses

SMET Students with SAT 900+ and ACT 19+				
	Freshman Students	SAT Average	ACT Average	Cumulative GPA
SMET Participants	73	1019	22	**3.03**
Non-Participants	102	988	20	2.66
Population	175	999	21	2.83

Table 4 – SMET Population of SAT 900+ and ACT 19+

Fall 2000 Cohort

SMET Students with SAT 900+ and ACT 19+				
	Freshman Students	SAT Average	ACT Average	Cumulative GPA
SMET Participants	64	1019	21.03	**3.21**
Non-Participants	116	991	19.60	2.55
Population	180	993	20.34	2.79

Table 5 – SMET Population of SAT 900+ and ACT 19+

Fall 2001 Cohort