

# QUANTITATIVE SCHOLARSHIP: *FROM LITERACY TO MASTERY*



## A Quality Enhancement Plan

Prepared For The  
Southern Association of Colleges and Schools  
October 1, 2008



This page intentionally left blank.

### ***Executive Committee of the Quantitative QEP***

Dr. David Senseman, Biology (Chair)  
Dr. Nandini Kannan, Statistics  
Dr. Nancy Martin, Education  
Ms. Joleen Reynolds, UTSA Testing Service  
Dr. Kay Robbins, Computer Science

### ***The Quantitative QEP Development Team***

Mr. Mike Anderson (SC Center)  
Dr. Stuart Birnbaum (Geology)  
Mr. Ricardo Blanco (Honors)  
Dr. Stephanie Cano (SC Center)  
Dr. Dmitry Gokhman (Math)  
Dr. Kollen Guy (History)  
Dr. Amy Jaspersen (Political Science)  
Dr. Craig Jordan (Biology)  
Dr. Jerry Keating (Demography)  
Dr. Laura Levi (Anthropology)  
Dr. Martha Lundell (Biology)  
Dr. Barbara Millis (TEAM Center)  
Dr. Marguerite Newcomb (Writing Center)  
Dr. Gail Pizzola (Writing Program)  
Dr. Jack Reynolds (History)  
Dr. Harriet Romo (Sociology)  
Dr. Ray Sadeghi (Chemistry)  
Dr. Raydel Tullous (Statistics)  
Dr. Bill VanAuken (Biology)  
Dr. Ken Weiher (Economics)

# TABLE OF CONTENTS

<b>QEP Development Team.....</b>	<b>3</b>
<b>Section I. Background and Institutional Framework.....</b>	<b>5</b>
Critical Issues Addressed.....	5
The Critical Issue of Quantitative Literacy.....	5
The Critical Issue of Quantitative Mastery.....	6
Historical Context of “Numeracy” and “Quantitative Literacy”.....	9
Best Practices.....	14
Institutional Data.....	16
The Quantitative QEP as a Mechanism to Achieve the University’s Strategic Initiatives and Goals.....	20
Relationship of the Quantitative QEP to the Report of the Blue Ribbon Committee on the Undergraduate Experience.....	21
The Quantitative QEP Directly Promotes Student Learning.....	23
Selection of Faculty and Courses for Content Development.....	27
Measurable Goals and Objectives for Improving Student Learning.....	29
Student Population Targeted.....	34
<b>Section II. Involvement of Academic, Student affairs, and Other UTSA Components.....</b>	<b>35</b>
<b>Section III. Resources Needed for Implementation and Continuation.....</b>	<b>38</b>
Budget.....	44
<b>Section IV. Assessment of the Quantitative QEP.....</b>	<b>46</b>
<b>Literature Cited.....</b>	<b>52</b>

# I. Background and Institutional Framework

## Critical Issues Addressed by the Quantitative QEP

*Education is learning what you didn't even know you didn't know.* - Daniel J. Boorstin

The title of this Quality Enhancement Plan (QEP) is **Quantitative Scholarship: From Literacy to Mastery**. Quantitative scholarship is learning how to use simple mathematics (e.g. addition, subtraction, percentages, means) in sophisticated ways to (1) analyze and interpret “data”, (2) draw appropriate conclusions from the analysis, and (3) effectively communicate these conclusions in a confident and professional manner. By “data” we do not mean contrived lists of “widgets” or other meaningless examples. Quantitative scholarship is learning how to analyze and interpret real data – real data such as home mortgage interest charges, the probability of developing breast cancer following estrogen replacement therapy, and polling data published during presidential races.

This QEP is specifically and carefully designed to help develop quantitative literacy in all undergraduates from all academic departments and from all colleges at UTSA where quantitative literacy is defined as:

*An aggregate of skills, knowledge, beliefs, dispositions, habits of mind, communication capabilities, and problem solving skills that people need in order to engage effectively in quantitative situations arising in life and work (Dingwall, 2000).*

Building upon this foundation of quantitative literacy, the QEP will also help a significant number of UTSA students reach a level of quantitative mastery where their skills, knowledge and self-confidence will enable them to compete successfully for admission into top professional and graduate schools or directly enter the data-intensive, global economy with a successful and rewarding career.

### *The Critical Issue of Quantitative Literacy*

The first critical issue addressed by this QEP is the University’s need to improve the level of quantitative literacy in our undergraduates so they can achieve a greater degree of success in their personal lives as well as participate fully and ably in their civic lives. Every student who graduates from UTSA must leave with the skills, knowledge and confidence to interpret, analyze, and act appropriately on the myriad of quantitative data they will encounter in their personal life. With the development of powerful personal computers and the World Wide Web, all Americans are

now swimming in a vast sea of numbers, from differences in diabetes rates for Hispanics, to the impact of war funding on the national debt as a function of GDP expressed in constant dollars, to more personal issues like the annual percentage rate (APR) of student loans and home mortgages. Quantitative literacy provides the educational support needed for individuals to stay afloat in this vast ocean of quantitative information.

In today's information society, individuals lacking quantitative literacy are vulnerable; they are at risk for manipulation and exploitation. For example, lacking the quantitative reasoning skills needed to critically assess medical claims, it is all too easy to fall prey to questionable treatments. Lacking quantitative reasoning skills, it is all too easy to succumb to misleading interest rate claims and predatory lending schemes. Indeed, as home foreclosures in the U.S. continue to spiral higher and higher, there has been a concomitant increase in emotional stress, depression, divorce rates and even the number of suicides. It is not hyperbole to suggest that a basic level of quantitative literacy is necessary, although certainly not sufficient, for the physical, mental and financial well-being of UTSA graduates and their immediate families.

The critical importance of quantitative literacy is not, however, limited to oneself and one's family. Quantitative literacy is also essential for the health and well-being of our city, state and nation. A fundamental requirement of Jeffersonian democracy is the active participation of an educated citizenry. As social and political policy issues become more complex and more urgent (e.g. the relationship between CO<sub>2</sub> emissions and climate change, economic and military competition with China, the funding of Social Security with retirement of the "baby boomers") many critical issues will move beyond the intellectual grasp of ordinary citizens who are not quantitatively literate (Steen 2001). To people who are innumerate, all opinions supported by "numbers" appear equally valid. To people who are innumerate, truth is relative and unknowable in a world filled with polls, statistics and graphs. Consequently, whenever there's disagreement the unknowable truth must lie somewhere in the middle, no matter how egregious and patently false the claim of one side might be. Thus, in a very real sense, the lack of quantitative literacy leads to disenfranchisement and raises the specter of a country being increasingly ruled by a technocratic elite. Indeed, Stephen Baker (2008) believes that a global math elite, who he calls the "Numerati" has started already to control our professional and personal lives.

### *The Critical Issue of Quantitative Mastery*

The second critical issue to be addressed by this QEP is the need to provide quantitative mastery to students wishing to continue their post-baccalaureate education. Whereas quantitative literacy focuses on a student's personal life, quantitative mastery focuses on a student's professional life. Quantitative mastery is built on a solid foundation of quantitative literacy but extends the skill set, competencies, and knowledge of UTSA students so they can successfully transition into professional school, graduate school or enter directly into a competitive job market upon graduation. Whereas quantitative literacy is generic, universal, and largely devoid of context, quantitative mastery stresses those skills, knowledge and competencies that are most valuable for a student's particular academic course of study albeit art history, biology, communications, English, political science or sociology.

The workplace in today's knowledge-based economy is very different than the one UTSA's first graduates entered in the early 1970's. Ready access to increasingly powerful computers, sophisticated computer programs and massive online databases has radically transformed what is expected of college graduates.

For example, consider a student graduating with a degree in biology. The word "bioinformatics" didn't appear in any textbook when UTSA first starting teaching introductory biology. Now whole chapters are devoted to this topic (Campbell and Reece, 2008) which has become one of the most important and exciting areas for biological research. Biology majors wanting to work in bioinformatics need a "toolkit" of quantitative skills, competencies and knowledge in areas such as dynamical systems, Bayesian statistics and computational analysis if they want to be competitive for admission into top graduate schools (Fig. 1).



Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings.

**Fig. 1. A student involved in bioinformatics research. The field of bioinformatics didn't exist when UTSA started graduating its first students.**

Given the University's stated desire to increase the number of its graduates earning post-baccalaureate degrees, helping undergraduates achieve quantitative mastery in their chosen field of study must be a high priority. Since quantitative reasoning and critical thinking are the *sine qua non* of scholarly inquiry, quantitative scholarship is important across all colleges and all disciplines at UTSA. Students majoring in architecture, engineering, the humanities (e.g. Anthropology, English, communications, history, linguistics), the physical sciences (e.g. Astronomy, chemistry, geology, physics) and the social sciences (e.g. Criminology, demography, psychology, political science, sociology), must all possess a personalized "quantitative toolkit" of skills, competencies and

knowledge to adequately prepare them for the rigors of graduate-level research. The acquisition of these skills and competencies can only be achieved by deeply embedding them within specific courses of the student's chosen major.

The value of quantitative mastery is by no means limited to students who wish to earn graduate degrees or who plan to study medicine or law. Students who directly enter the workforce will also benefit from course content designed to increase quantitative mastery. Data analysis is the new "coin of the realm" in our knowledge-based economy. UTSA graduates entering the workforce need to be able to reason quantitatively and communicate their conclusions effectively in a wide variety of occupational settings that require a college degree.

For illustration, consider the six following tasks which a UTSA graduate might be asked to perform: (1) develop staffing requirements for a medical practice, (2) generate budget projections based on previous sales figures, (3) create flowcharts and timelines for a manufacturing company, (4) analyze and then recommend alternative computer equipment options for purchase or lease, (5) determine the optimal inventory level for a large woman's shoe store, and (6) write a report using appropriate statistical measures to assess the periodic performance of learning outcomes at a community college. In each example, the UTSA graduate needs to have the quantitative skills to analyze data, form a plan of action and then effectively communicate their findings.



**Fig. 2. A graduate struggles trying to analyze data.**

This QEP helps nearly all UTSA students graduate with the quantitative reasoning and communication skills they need to be successful in their personal and professional lives. UTSA is not alone in this quest and the University's struggle to resolve these critical issues is by no means unique. Many colleges and universities across the U.S. are also struggling to adapt their undergraduate curricula to meet the new and formidable challenges presented by increased competitiveness in this new knowledge-based, global economy. Like UTSA, they are making serious efforts to transform their educational environments by adding "quantitatively rich" courses to their curricula. For example, MAA Notes #70 entitled *Current Practices in Quantitative Literacy*, published in 2006 by the Mathematical Association of America, lists 27 different colleges and universities with active quantitative literacy programs.



The historical roots that have led to these current efforts at curriculum reform are described in the next section. In the following section, what efforts have worked well, and what efforts have worked less well, i.e. the ‘best practices’ for developing a curriculum that supports quantitative literacy and quantitative reasoning are reviewed. Based on this abundance of information there is very good reason to believe that a significant change in the University’s educational environment can be achieved that is transformative in nature, universal in scope and enduring in its persistence.

## Historical Context of “Numeracy” and Quantitative Literacy

*In the first place, God made idiots. That was for practice.  
Then he made school boards.*-Mark Twain

The historical context underlying the current efforts to improve quantitative literacy, or “numeracy” within the American school system has been reviewed recently by several authors (Cohen 2001, Carnevale & Derochers 2001, Maguire & O’Donoghue 2002, Klein 2003, Ganter 2006, Sons 2006, Madison & Steen 2008). Through this historical lens we can chart our past trajectory and rationally determine how best to change course in order to increase quantitative scholarship at UTSA. However, any attempt at substantial curriculum reform is fraught with danger and should only be attempted after a close, cautious and well-considered plan of action. This is especially true in efforts related to math education where great harm has been done through violent swings in pedagogical approaches from one “new math” to the next.

Two themes emerge from a careful reading of the literature on quantitative scholarship. The first theme is that the skills and competencies required for a person to be considered numerate are neither fixed nor absolute, but change dynamically to reflect the larger society’s embrace of increasing sophisticated and powerful information technologies. The second theme is that state efforts to meet the challenges of the information age by requiring high school students to complete more and more math courses is leading to less and less quantitative literacy. This paradox is especially true among women and minority students who comprise a very large percentage of the undergraduate enrollment at UTSA.

### *The Concept of Numeracy*

The word “numeracy” first appeared in the Crowther Report published by the British Ministry of Education in 1959. This report focused on the secondary education of British students between the ages of 15 and 18 and the concept of numeracy was intended to mirror the concept of literacy. In the same way that literacy implies more than a mere rote ability to read and write, the word “numeracy” was intended to imply more than a mere ability to perform simple arithmetic. A numerate person possessed the skills and knowledge needed to reason quantitatively and the ability to solve problems arising in everyday life. This practical, problem-solving view of numeracy was firmly established by the highly influential Cockcroft Report published in 1982. Quantitative literacy firmly rests on a foundation of mathematics that can be applied to solve practical problems.

## *History of Math Education in America*

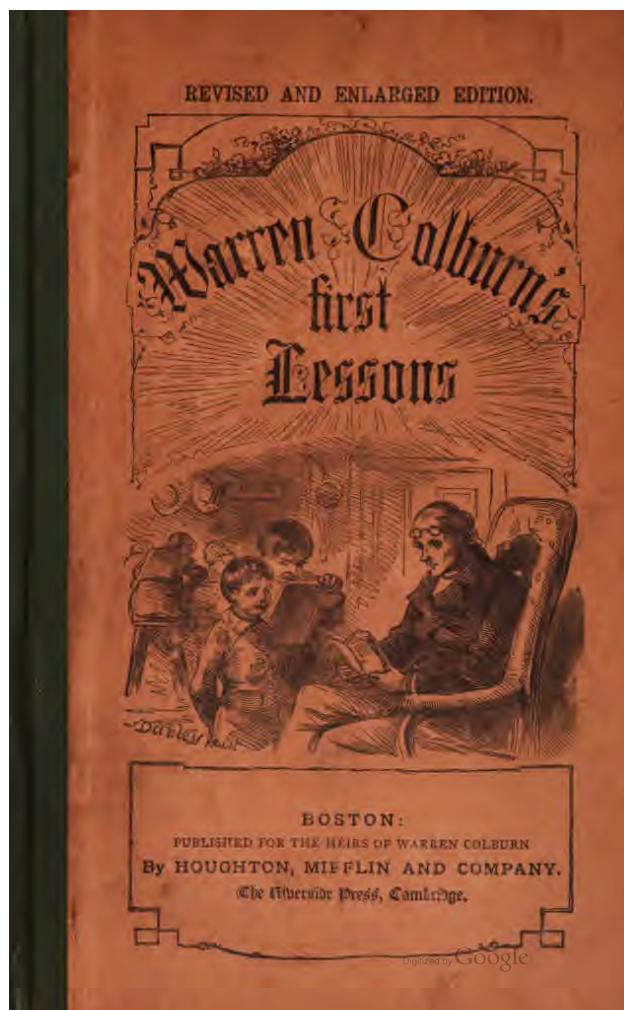
For most of its history, U.S. secondary math education has been largely applied and commercially-oriented. What parents and students now consider as being the “standard” high school math sequence of geometry, algebra, trigonometry and calculus (GATC), is actually a very recent historical development. Prior to widespread adoption of the GATC series, high school math was arithmetic, designed to help students solve practical problems that they might encounter in their personal and professional lives. Math texts in Colonial America devoted many pages to “denominate arithmetic” or the mathematics of “named” numbers used to express the complex equivalencies between English weights and measures. For example, students were taught to memorize that a firkin of butter weighed 56 pounds whereas a firkin of soap weighed 64; a hogshead of beer contained 45 gallons where a hogshead of wine contained 63 (Cohen, 2001).

Although math in 17th and 18th century America was “practical”, little emphasis was placed on comprehension and reasoning. Students learned arithmetic by rote memorization in much the same way as they memorized the catechism in church. In short, students were not encouraged to think or reason quantitatively. The obvious limitation and absurdity of this pedagogical approach can be seen in what Patricia Cline Cohen (2001) describes as the capstone of basic arithmetic during 18th century, the “Rule of Three”:

*“Given three parts, to find the fourth” was the usual phraseology. This rule and its variations (single and double, direct and inverse) covered the basic commercial problem of proportional relationships. If a man pays 1s.7d. to pasture a cow for one week, how much will it cost him to pasture 37 cows for two weeks? If nine men can build a house in five months, working 14 hours a day, in what time can nine men do it if they work only 10 hours per day? The solution required writing down the three known quantities in a certain order, multiplying the middle term by the last, and dividing the product by the first. Knowing the proper order and choosing the proper version of the rule were essential. Some books helpfully provided gimmicks to aid memory: “If more require more, or less require less, the question belongs to the Rule of Three Direct. But if more require less, or less require more, it belongs to the Rule of Three Inverse.”*

In the 1820’s there was a clear shift away from the rote memorization and a move towards a more intuitive understanding of mathematical operations and quantitative reasoning. Much of the credit belongs to a Harvard graduate, Warren Colburn, who published two influential arithmetic books and an algebra text starting in 1826. His books proved to be immensely popular and over 2 million copies were sold including several revisions (Colburn 1826, 1841, 1853). Moreover, Colburn’s popularity did not go unnoticed and other authors started publishing textbooks using Colburn’s “new math”.

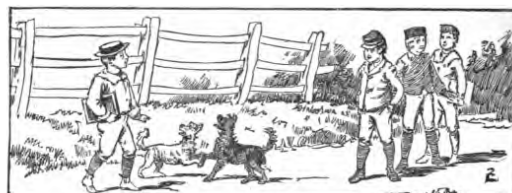
Colburn’s first arithmetic text was aimed at very young children (4-8 years). It began by presenting problems described only by words, with symbols being presented only in later problems. Colburn called his pedagogical approach “intellectual arithmetic” (Edson, 1856). There was no mention of the “Rule of Three” or any insistence on rote memorization as in earlier texts. Indeed, there were no rules at all! Colburn’s approach was completely inductive. He believed children can—and should—develop their own calculation strategies by simply working problems in their heads. In essence, it was up to each student to reinvent mathematics for themselves, *de novo*.



### A SHORT STORY

*Which brings in the numbers from ONE to TEN, inclusive.*

Harry is starting for school; his father's *two* dogs are frisking and barking before him, wishing that they could go too. A short distance off, where the two roads cross, *three* other boys are waiting for Harry to come along.



One Boy. Two Dogs. Three Boys.

The *four* boys have nearly reached farmer Brown's house, by the side of which they count one, two, three, four, *five* pretty trees; just beyond the house there are *six* hens eating.



Four Boys. Five Trees. Six Hens.

Three little girls have come from the house on the hill, and the *seven* children are talking so loudly that the sheep in the pasture near by have run up to the bars where the children sometimes

Fig. 3. Warren Colburn's influential arithmetic text aimed at very young readers. Colburn's idea of inductive learning was initially very appealing, but over time enthusiasm waned.

Not surprisingly, enthusiasm for Colburn's "new math" eventually began to wane and by the 1870's the pendulum had swung back. Axioms and definitions reappeared in arithmetic texts. Students were told that through these axioms and definitions they would learn math by deduction—Colburn's inductive approach being largely viewed as a failure (Cohen, 2001). However, in one important way these new "deductive texts" were similar to Colburn's "inductive texts". The focus on memorization was replaced with effort to engage a student's interest and understanding, which continues to this day (e.g. Hughes-Hallet 2002).

Whether inductive or deductive, secondary math education focused on solving practical problems up until the last part of the 20th century. Early in the 20th century, the entire secondary educational system in the U.S. was transformed into a more "progressive" state by John Dewey and his supporters, including William Heard Kilpatrick. Kilpatrick had majored in math as an undergraduate at Mercer College, but later received his graduate degree at Teachers College where he joined the faculty in 1911 (Klein, 2003). Kilpatrick's book, *Foundations of Method* (1925) became a standard text for teacher education. According to Klein:

*Kilpatrick rejected the notion that the study of mathematics contributed to mental discipline. His view was that subjects should be taught to students based on their direct practical value, or if students independently wanted to learn those subjects.... Kilpatrick proposed that the study of algebra and geometry in high school be discontinued "except as an intellectual luxury." According to Kilpatrick, mathematics is "harmful rather than helpful to the kind of thinking necessary for ordinary living." In an address before the student body at the University of Florida, Kilpatrick lectured, "We have in the past taught algebra and geometry to too many, not too few."*

For perhaps obvious reasons, most mathematicians did not share Kilpatrick's view. Nevertheless, Kilpatrick's "progressive ideas" prevailed, so that nearly all U.S. students completed their high school study of mathematics with "commercial arithmetic" (e.g. prices, interests, percentages, areas, etc.). Moreover, only a small percentage of students were allowed to study elementary algebra and high school geometry and fewer yet allowed to progress on to advanced algebra and trigonometry (Steen 1990, 1997, 1999, 2001).

### *Sputnik, the Missile Gap and GACT*

Things changed literally overnight with the successful launch of Sputnik in 1957 and the start of the space race (Burrows, 1998). The nation's perceived "missile gap" generated real fear among Americans with the finger of blame pointing squarely to the nation's high schools, colleges and universities. To both average Americans as well as to the nation's leadership, our country's inability to compete with the Soviet Union signaled a failure in our educational system, especially in math education. Algebra and geometry were not "intellectual luxuries" after all, but essential weapons needed for national defense and the defeat of world-wide communism. The federal government responded quickly and decisively to this new threat with a wide range of well-funded programs, including the 1958 National Defense Education Act (Klein 2003). Indeed, a substantial federal effort to bolster science and math education continues even to this day.

With respect to sheer numbers, these efforts were highly successful. The number of students enrolling in upper level math courses increased substantially. In 1955, only 25% of U.S. high students took algebra, 11% geometry and 3% trigonometry (Klein, 2003). By the 1970's 40% of U.S. high school students were taking two years of mathematics (geometry and algebra) and by 1995 this number had more than doubled again. Today, many states, including Texas, require all college-bound students to take four years of mathematics (Steen, 2001).

Fueling this math frenzy has been a steady stream of increasingly dire reports. Starting in 1983, the National Commission on Excellence in Education issued a report with the chilling title, *A Nation at Risk*. Not to be undone, the National Commission on Mathematics and Science Teaching for the 21st Century called its 2000 report, *Before It's Too Late*. These reports have served to force more and more students into the GATC gauntlet. The increase in high school mathematics has not only failed to reduce innumeracy but has actually exacerbated the problem (Steen, 1990, 1992). To understand this paradox, it is only necessary to look more closely at how the "space race" altered the landscape of high school math education from a focus that was applied and practical in nature to one that is largely abstract and theoretical in nature.

To “win” the space race, the U.S. needed to produce more scientists and engineers than the Soviet Union. From a math educational perspective, that directly translated in having more students master calculus. Calculus, developed by Sir Isaac Newton and Gottfried Wilhelm Leibniz in the 17th century, provides a rigorous way to analyze the physical motion of objects. Even today, more than 300 years after its invention, calculus retains its pride of place in the pantheon of mathematical subjects most applicable to science and engineering. Since the mathematical foundations of calculus are geometry, algebra and trigonometry, students wishing to master calculus must first master these foundational courses. It is precisely for this reason that today’s high school mathematics is presented in a strict, linear sequence of geometry, algebra, trigonometry and calculus (GATC).

This linear sequence does make perfect sense if your goal is to produce scientists and engineers—their coursework requires calculus and makes good use of its analytic power. On the other hand, it makes little sense for students majoring in other areas such as art history, English, criminal justice or sociology. As the mathematician Bernard Madison has noted (Bernard 2001):

*Throughout high school and college, a single sequence of courses—geometry, algebra, trigonometry, and calculus (GATC)—dominates the mathematics curriculum. For several decades, success in mathematics has meant staying in this linear and hurried sequence. Those who do not stay in, approximately three of four, leave with disappointment (or worse) and fragmented mathematics skills that are not readily useful in their everyday lives. In effect, the GATC sequence sifts through millions of students to produce thousands of mathematicians, scientists, and engineers. Not surprisingly, this system produces the world’s best-educated and most creative scientists and engineers while at the same time yielding a quantitative literacy level that ranks near the bottom among industrialized nations.*

The current policy requiring all college-bound students pass through the GATC ‘gauntlet’ leaves precious little time for students to acquire the skills they need to gather, manipulate and analyze realistic data sets. High school algebra in particular overemphasizes algebraic formulas and symbolic manipulation giving many students the impression that mathematics is manipulating formulas and little more. Is it any wonder then that “most students who leave mathematics do so because they fail to see any value in manipulating strings of meaningless symbols” (Steen, 2001). It is any wonder then that most students and even many faculty members dread anything connected with “quantitative”?

### *Historical Lessons for Developing the Quantitative QEP*

In developing an appropriate QEP, several points must be taken into consideration. First, while all students entering the University will have completed some, if not all of the “standard” GATC math sequence, many will view their high school math education with indifference at best and outright hostility at worst. For many undergraduates, math continues to be a useless, meaningless “hurdle” to be jumped on the way to their college graduation. If the Quantitative Scholarship QEP is to be successful, it must seek to change the attitude of students (and faculty) so that they see clearly for themselves the importance of quantitative thinking in solving realistic problems. This can only be

done by embedding quantitative content within a well-defined academic context such as an introductory course in social problems.

It is also important to remember that very few students entering UTSA have had any substantial exposure to data analysis in a realistic context. In the real world, problems rarely come with nice mathematical equations attached. While the GATC series teaches a student how to use relatively complex mathematics to solve relatively simple, unrealistic problems, quantitative literacy requires the use of relatively simple mathematics to solve realistic problems that are typically complex and ill-posed. How entering students perform on current UTSA math placement exams which largely stress symbolic manipulation, provide little insight on a student's ability to analyze and interpret data. One task of this QEP will be the creation of a new entrance exam for all incoming and transfer students to evaluate their baseline level of quantitative literacy.

Finally, the Quantitative QEP does not require, nor even suggests, changing either the existing University Core Curriculum math requirement or the current math placement examination. Students who have passed the University's Core math requirement should have achieved a satisfactory math foundation for developing quantitative literacy. What is missing from the current educational environment are specific contexts in which to use these math skills to develop quantitative literacy through the solution of realistic, data-intensive problems. Consequently, the main focus of this Quantitative QEP is on the embedding of quantitative materials and analytical problem sets within non-math courses where the content is naturally data-intensive and problem-based. Obvious candidates for course development such as architecture, biology, criminal justice, demography, economics, political science and sociology occur throughout the University's several colleges.

### *Best Practices*

The Quantitative QEP will adopt the Best Practices put forth by Deborah Hughes Hallet (2001), a universally recognized leader in mathematics education. Characteristically simple and direct, Hughes Hallet suggests only four basic principles as guides for implementing quantitative literacy programs at the university level:

#### ***Best Practices for Implementing Quantitative Literacy***

1. Teach Quantitative Literacy, not Mathematics
2. Teach in Context
3. Teach for Insight
4. Teach across the Curriculum

### *Teach Quantitative Literacy, not Mathematics*

As argued previously, simply increasing the mathematics requirements for all students would only swell the already huge number of UTSA students taking remedial math and further lower the student retention rate. It would do little to promote quantitative literacy.

The underlying goals of mathematics and quantitative literacy are diametrically opposed. Mathematics focuses on what Hughes Hallet calls the “ladder of abstraction”. Mathematics asks students to “rise above context”, whereas quantitative literacy is about staying in context. If successful, the Quantitative QEP will create student scholars with a “habit of mind” that views every academic context through a quantitative lens.

### *Teach in Context*

The first best practice principle naturally leads to the second—teach in context. In general, students first learn math principles and only later develop the skills needed to identify mathematics within a specific context. As Hughes Hallet (2001) points out:

*Teachers of mathematics and science often complain that students have difficulty applying the mathematics they have learned in another context. Part of the reason lies in the way that subjects are taught—separate from one another. But part of the problem lies deeper. Recognizing mathematics in another field requires understanding the context. A student’s ability to understand a context depends heavily on the relationship of that student to the field in question. For example, nonscience students in calculus often dislike applications from physics because they do not understand that field. On the other hand, the same students may easily grasp applications from the life sciences and economics.*

It should be noted that the University’s Department of Mathematics has been increasing the number of its context-specific course offerings within the lower division. In addition to College Algebra with Applications (MAT 1023), Algebra with Calculus for Business (MAT 1043) and Algebra for Scientists & Engineers (MAT 1073), the Department has added a new calculus course, Calculus for the Biosciences (MAT 1194) beginning Fall 2008.

### *Teach for Insight*

Hughes Hallet (2001) makes the point that a student’s mathematical “common sense” and their ability to apply their mathematical knowledge is fragile. By this she means that simple mathematical concepts that a student can easily work in one context easily evaporates when the same mathematical principle needs to be applied within another context. Most students lack quantitative literacy not only because it is not widely taught in the curriculum, but because students find it hard.

A big part of what students find difficult about quantitative reasoning is what Hughes Hallet calls “insight”. As an example, Hughes Hallet offers the following real event that occurred during an airing of *Talk of the Nation* (PBS, 2000). According to the British government, since £8 out of every £10 spent on petrol went to the British treasury as tax, the taxation rate was therefore 80%. The rate cited by the British government was, of course wrong—a caller correctly pointed out that the real tax rate was 400%. What the caller had, and apparently the British government lacked, was *insight*, the ability to understand quantitative relationships in an unfamiliar context.

As an experiment, this same problem was recently presented to a class of UTSA students enrolled in CS 1173 (Computation for Scientists and Engineers). Only 4 out of 32 students calculated the correct tax rate. The vast majority of students fared no better, or worse, than the British government, thinking the tax rate was 80%. Acquiring insight is hard. Harder still is knowing the best way to teach students to help them develop insight. Not surprisingly, “insight” is rarely listed as a learning outcome or even emphasized as an explicit goal (Hughes Hallet, 2001).

For the Quantitative QEP, developing insight is a major learning objective. At present there are no commonly accepted methods for achieving this goal other than exposing students to as many quantitative problems as possible and allowing students to develop insight individually through inductive logic. If this sounds suspiciously like Warren Colburn’s approach discussed above, it is. In our opinion, the fact that “teaching for insight” is difficult is more reason, not less, to emphasize this important but admittedly elusive goal.

### *Teach across the Curriculum*

Cooperation between academic department is rare at most colleges and universities. At the University of Arizona where Hughes Hallet teaches, students view efforts to teach quantitative methods across the curriculum as a “conspiracy” (Hughes Hallet 2001). She argues that a “good-natured conspiracy” is precisely what’s needed to develop quantitative scholarship:

*Quantitative literacy is achieved when students readily use quantitative tools to analyze a wide variety of phenomena. This requires constant practice. It also requires seeing such behavior as commonplace. This will not happen unless teachers model it. Verbal literacy became universal when it was perceived to be essential; quantitative literacy will be the same.*

Working in partnership with the University Core Curriculum Committee, the Quantitative QEP will support and nurture a “good-natured conspiracy” across the campus in which students will see the same quantitative approaches being used over and over in both their lower and upper division courses. If this conspiracy is successful, it will magically disappear...students will take for granted that the ability to reason about data in a quantitative manner is simply how college education is suppose to be taught in an enriched educational environment.

## **Institutional Data**

### *UTSA Enrollment Data*

The University of Texas at San Antonio is the second-largest component in The University of Texas System and has been one of the state’s fastest-growing public universities for much of the last decade. UTSA has 28,534 students enrolled in 128 undergraduate and graduate degree programs. UTSA offers 64 bachelor’s, 44 master’s and 20 doctoral degree programs.

Table 1 provides enrollment data for 2003-2007 for first time, full-time undergraduate students,



also referred to as “native students” by the Texas Higher Education Coordinating Board (THECB). The University has enjoyed a steady increase in enrollment and this trend is expected to continue in the near term.

**Table 1: First Time Full Time Undergraduates (2003-2007)**

Year	Fall 2003	Fall 2004	Fall 2005	Fall 2006	Fall 2007
Enrollment	4,132	4,246	4,367	4,694	4,836

Table 2 provides enrollment data for students who are seeking a degree from UTSA by gender. The data excludes students who are part of the Coordinated Admissions Program (CAP) with the University of Texas at Austin as well as students who are non-degree seeking. The accompanying graph (Fig.4) provides a graphical view of these data.

**Table 2: First Time Full Time Cohort Information (2003-2007)**

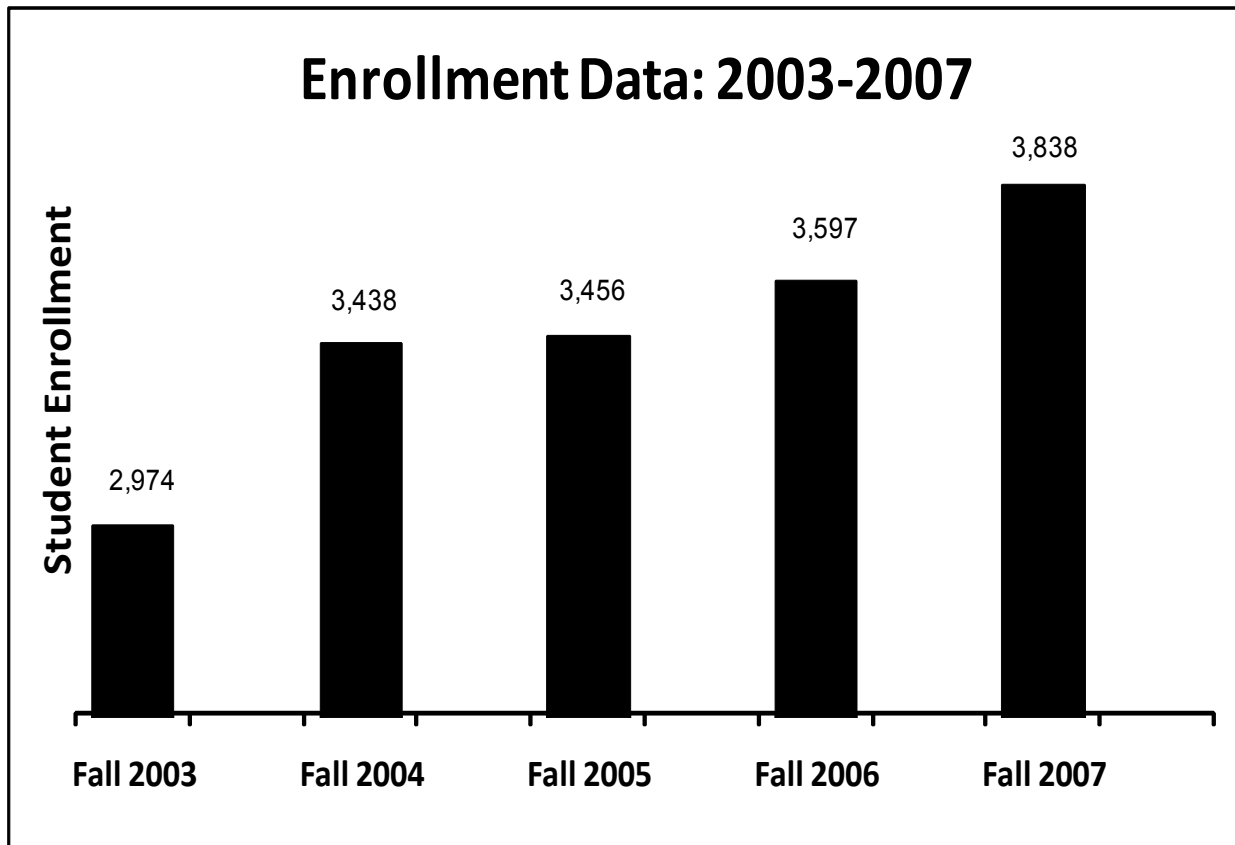
	Fall 2003		Fall 2004		Fall 2005		Fall 2006		Fall 2007	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Female	1,524	51%	1,753	51%	1,767	51%	1,853	52%	1,842	48%
Male	1,450	49%	1,685	49%	1,689	49%	1,744	48%	1,996	52%
Total	2,974	100%	3,438	100%	3,456	100%	3,597	100%	3,838	100%

### *University Core Curriculum*

All native students must satisfy specific semester credit hours (SCH) requirements of the University Core Curriculum. These requirements includes courses in several domains: *Natural Sciences: Level I* (3 SCH), *Natural Sciences: Level II* (3 SCH), *Political Science* (6 SCH), *Social and Behavioral Science* (3 SCH), and *Economics* (3 SCH). The Quantitative QEP would embed quantitatively-enriched materials in courses falling under all of these Domains. This exposure to quantitative reasoning and critical thinking in different contextual setting would help students break the walls of compartmentalization and is a one of the 4 main principles of the Best Practices described above.

The most appropriate institutional data supporting the critical need to improve the level of quantitative literacy at UTSA is lacking. The University simply does not have any appropriate assessment tools in place to provide data that directly addresses the current level of quantitative literacy in the undergraduate (or graduate) student body. This omission will be corrected with the development and administration of a Quantitative Literacy (QL) Entrance Exam to all incoming students (described below) as part of this QEP. However, the very fact that University has failed to assess this important metric is symptomatic of the general lack of attention that has been paid to quantitative scholarship up to this point in time.

In the absence of direct supporting evidence, is it reasonable to assume that undergraduates arrive at UTSA with an acceptable level of quantitative literacy and that a QEP focusing on quantitative scholarship is unnecessary? There are two reasons to respond to this question in the negative. First,



**Fig. 4. Enrollment of native students at UTSA between 2003 and 2007. Increases in enrollment are expected to continue, at least in the near term.**

every national study of quantitative literacy in the U.S. reveals very serious and worrisome deficiencies in college students across the country (e.g. OECD 2001). Since UTSA rightfully celebrates its role in providing access to students who are often the first generation in their family to attend college, coupled with the fact that UTSA draws students from some of the most impoverished school districts in the nation, it seems highly unlikely that somehow our students arrive at the University better prepared than their cohorts at other colleges and universities. Indeed, the number of students entering UTSA who require one or more remedial courses, especially in mathematics is extremely high (Fig. 5). The number of native UTSA students required to participate in remediation courses has increased over the years with 1,581 students enrolled in some type of remedial course in Fall 2007.

Data from Institutional Analysis also suggests that the graduation rates are significantly lower for these students. Students coming in from high schools with poor math skills will benefit from a curriculum that puts quantitative concepts in the framework of problem-solving. We believe that this will have a positive impact on graduation rates.

There is also anecdotal information that suggests our students lack an acceptable level of quantitative literacy. A large number of faculty from a variety of departments were interviewed as part of the development of this QEP. Included in this group were Drs. Stuart Birnbaum in Geology, Kollen Guy in History, Amy Jasperson in Political Science, Craig Jordan in Biology, Laura Levi in

## Remediation Course Enrollment: 2003-2007

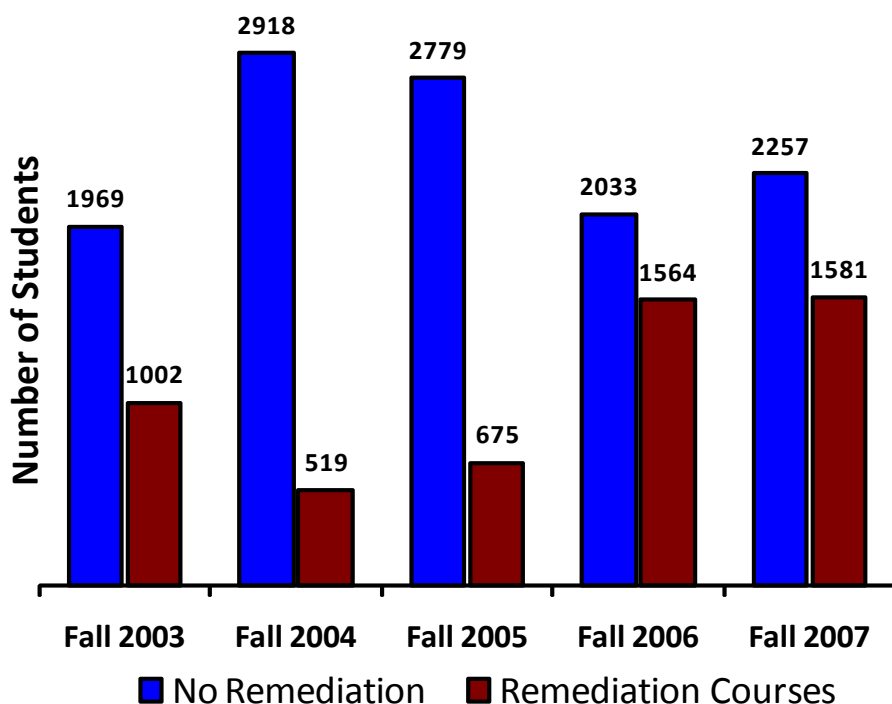


Fig. 5. Relative populations of UTSA between 2003 and 2007 requiring remediation. Note that in the most recent year that data is available, that more than 1/3 of incoming UTSA students required some remediation.

Anthropology and Harriet Romo in Sociology. In every case, the faculty member lamented their students' lack of skills when it came to the analysis and interpretation of data. Most even had their favorite "horror story" concerning some hapless student's struggle with a simple graph or a table of numbers.

### *Transfer Students*

The goal of this QEP is to reach all undergraduate students at UTSA. As will be discussed below, this is problematic since a high percentage of students transfer into the University after they have completed some or all of the University Core Curriculum requirements at another institution. While all native students at UTSA will benefit from the Quantitative QEP, the data also suggest that a large number of transfer students will also benefit. The percentage of UTSA graduates who attempted the Core Curriculum Level 2 Science and Economics courses at UTSA is currently 49% for economics courses and 52% for science courses. Moreover, this number has been increasing in recent years. Taken together, the data suggest that the QEP will in fact, impact a significant number of students at UTSA.

# The Quantitative QEP as a Mechanism to Achieve the University's Strategic Initiatives and Goals

*Education is simply the soul of a society as it passes from one generation to another.* -Gilbert K. Chesterton

In the latest iteration of its strategic plan, UTSA 2016: Sharing the Vision, the University identified the following strategic initiatives and goals:

- A. Enriching Education Experiences to Enable Student Success
- B. Serving Society through Creativity, Expanded Research, and Innovations
- C. Promoting Access and Affordability
- D. Serving the Public through Community Engagement
- E. Expanding Resources and Infrastructure

These initiatives and goals are the culmination of an intense 18-month process involving faculty, students, staff, alumni, community leaders, and others committed to helping UTSA become a premier public research institution. These initiatives and goals serve as sign posts for the next decade as the University continues its development and maturation. In addition, they loudly reaffirm the University's commitment to excellence in higher education within the context of a knowledge-based economy that is increasingly competitive in nature and global in scope.



From an institutional perspective, the Quantitative QEP provides a robust mechanism to realize the University's first and arguably its most important strategic initiative, to enrich the educational experience to enable student success. The draft UTSA Strategic Implementation Plan includes many strategies and tactics that are directly supported in the Quantitative QEP. The first strategy for implementing *Initiative A* on student success is to improve instruction of courses at UTSA. The tactics for implementing this strategy include expanding the number of full-time faculty at UTSA (both tenure track and non-tenure track), improving teacher development training for faculty and graduate students, improving the evaluation of teaching, expanding the use of technology to enhance instruction, and nurturing and recognizing outstanding teaching.

All of these tactics are directly addressed by this QEP. The centerpiece of the Quantitative QEP is to provide the institutional infrastructure for developing courses that have sound educational objectives and are carefully assessed to make sure that they meet their learning objectives. The QEP course development initiative will require the commitment and cooperation of full-time faculty, departmental curriculum committees and department chairs. It will provide financial and other incentives for departments to stabilize their teaching staff and course content in key courses in the core curriculum. The quantitative QEP will provide training in curriculum development and instructional delivery to faculty as well as to graduate and undergraduate teaching assistants.

Additional funding for TAs and expanding on-campus employment opportunities are mentioned as part of *Initiative C* on access. A central component of the Quantitative QEP is the funding and training of undergraduate and graduate TAs who will provide grading and assessment help to students as well as one-on-one assistance and workshops.

*Initiative E* mentions developing faculty career ladders for NTT faculty and also supporting leadership development for faculty. The Quantitative QEP implementation will provide opportunities for faculty to lead curriculum development efforts that have recognized institutional importance. Furthermore, the QEP will provide a richer evaluation fabric for these activities than was proposed in the strategic plan implementation.

On a deeper level, the tools and techniques that students will be required to master as freshmen in core curriculum courses, as upperclassmen completing the requirements of a major, and as teaching assistants are exactly the tools needed for pursuing research. When fully implemented, the QEP should result in an increased pool of “graduate-school-ready” students who are capable of effective participation in research.

## **Relationship of the Quantitative QEP to the Report of the Blue Ribbon Committee on the Undergraduate Experience**



In 2007, UTSA President Ricardo Romo appointed a “Blue Ribbon Committee”—the first of its kind in the history of the University—to study issues related to the current undergraduate educational environment. The committee was composed of 25 faculty and staff members drawn from across academic disciplines and administrative units as well as 3 undergraduate student representatives. Dr. Nancy Martin, Associate Dean, College of Education & Human Development, served as Chair for the Blue Ribbon Committee and more recently as a member of the Executive Committee responsible for the development of this QEP.

The creation of the Blue Ribbon Committee was an outgrowth of the University’s 2006 Strategic Plan and it was given the following charge:

The charge of the Blue Ribbon Committee on the Undergraduate Experience includes identifying the knowledge and skills that a UTSA undergraduate should have upon graduation in order to be competitive and successful in a global society made even smaller by technological advances, making recommendations for changes to the undergraduate curriculum that will help our students achieve the identified knowledge and skills and obtain an improved quality of education, and formulating proposals for transformations to enhance the quality of the overall educational experience of UTSA undergraduates.

These include: (1) an evaluation of the University Core Curriculum, (2) on-going assessment and over-sight of the University Core Curriculum by the University Core Curriculum Committee, (3) an increase in institutional support for quality undergraduate instruction by tenured and tenure-track (TT) faculty and full-time non-tenure track faculty and (4) a decrease in University dependence on part-time instructors for undergraduate courses, especially courses in the University Core Curriculum.

With regard to this last area of concern, the Blue Ribbon Report cites the worrisome statistic that while 87% of the University's students are undergraduates, they are taught by tenured and tenure-track professors less than 1/3 of time they spend at UTSA. Most of the time, undergraduates see only non-tenure track faculty who are not evaluated as often, or to the same high standards, as the tenured faculty. As the Blue Ribbon Reports notes:

Recent research by Audrey Jaeger at North Carolina State University (Glenn, 2008) has demonstrated that students are more likely to drop out when their "gatekeeper courses" – i.e., large introductory, core courses – are taught by part-time faculty.

After careful analysis of the undergraduate educational environment, the Blue Ribbon Committee determined six key knowledge and skills that every undergraduate should have upon graduation. The first three knowledge and skills, cited below, were the primary impetus for the development of the Quantitative Scholarship QEP:

### **KEY SKILLS AND AREAS OF KNOWLEDGE A UTSA UNDERGRADUATE SHOULD HAVE UPON GRADUATION**

UTSA graduates should be prepared for life-long learning from a holistic perspective. They should be well prepared to live full, healthy lives and make quality contributions to society. UTSA graduates should be able to cope with the ever-changing world around them by developing leadership skills and understanding of and respect for diverse views. It is imperative that, upon graduation, each UTSA undergraduate is prepared to contribute productively to a world growing closer via the use of technologies. In order to be successful in tomorrow's world, the graduating senior must be able to:

#### ***1. Effectively use oral, written, presentation, and listening skills to communicate and interact with others***

The ability to communicate effectively is key to becoming a leader who promotes progress and a global citizen mindful of diverse perspectives. To function well in a global society and promote diversity, UTSA graduates must be able to interact effectively by understanding and valuing the perspectives of those who hold very different cultural and personal values.

UTSA graduates must be able to read critically, write and speak clearly and correctly and listen reflectively. Effective use of technology skills will also enhance the sharing of ideas with people around the world. Upon graduation, students will have had multiple

opportunities to interact effectively with persons different from themselves in order to build consensus, reach out to resolve conflicts, and, when necessary, disagree respectfully.

## **2. Use quantitative reasoning**

Quantitative reasoning skills are necessary in order to solve problems that currently affect the world as well as new issues that arise. Therefore, UTSA graduates will be able to interpret mathematical and statistical models, analyze data and make judgments concerning the validity and accuracy of the data. They need to be able to represent mathematical information symbolically, visually, numerically, and verbally. They must understand the process of using data to make decisions that impact their lives and the lives of others.

## **3. Evaluate information and apply it to problem-solving and research**

UTSA graduates will be able to cope with an ever-changing world around them by researching problems, analyzing relevant information and formulating solutions. This requires an ability to think about the “whole picture” and how the problem exists in the larger context. Our graduates will understand how differing life experiences and values of individuals can impact both the problem and possible solutions. As transformative leaders, they will be able to consider multiple perspectives in approaching complex and ambiguous problems.

Advances in education and technology have helped pave the way for new, efficient ways of accessing information. UTSA graduates will be able to utilize appropriate and up-to-date technologies to provide creative, new ways of addressing issues and solving problems. They will have the ability to effectively identify, select and use appropriate research tools. Further, graduates will be able to evaluate the information they find to determine whether it is accurate, current, credible, and relevant to their needs.

In summary, the Quantitative QEP directly supports the University’s first strategic initiative to enrich the educational experience to enable student success. It provides a structured framework in which to implement the first three recommendations of the University’s Blue Ribbon Committee on the Undergraduate Experience. It will accomplish this by strengthening the very heart of undergraduate education, the University’s Core Curriculum.

## **The Quantitative QEP Directly Promotes Student Learning**

*Education is a progressive discovery of our own ignorance. -Will Durant*

The relationship between the Quantitative QEP and student learning is immediate, direct and obvious. Learning outcomes are the knowledge, skills, and competencies students gain through active participation in an educational experience, most commonly through the completion of a course of study. Explicit enumeration of learning outcomes provides a mechanism to overcome the nega-

tive or view students have of coursework outside of their chosen field of study, primarily courses needed to fulfill their University Core requirements. This perception often reaches a zenith when students majoring in the arts, business, humanities and the social sciences are required to take University Core math and science courses that require extensive use of mathematical analysis.

If the Quantitative QEP is to be successful, it will be necessary to clearly and honestly demonstrate the benefits to be gained by a student's active and focused participation. In other words, most students will try harder and thus gain more from an educational experience if they clearly understand "what's in it for them". It is important that University Core courses supported by the Quantitative QEP not be viewed as hurdles to be cleared on the way to graduation, but rather, as important opportunities to gain knowledge, skills and competencies that the student will actually need and use in their personal and professional lives.

Student learning, as defined by the development of quantitative literacy and quantitative mastery, will result as a direct consequence of the following activities of the Quantitative QEP:

1. Design, validation and administration of a QL Entrance Exam
2. Selection of faculty and courses for content development
3. Creation and embedding of quantitative content and assessment rubrics
4. Training and support for undergraduate and graduate teaching assistants (TA's)

#### *Design, Validation and Administration of a QL Entrance Exam*

The first activity leading to student learning will be the design, validation and administration of a QL Entrance Exam for all students entering the University including transfer students administered by the UTSA Testing Service. The QL Entrance Exam will be separate from, and independent of, the current Math Placement Exam. The QL Entrance Exam is not a placement exam, but an assessment tool to determine each student's baseline-level of quantitative literacy prior to their enrollment at the University.

Creation and validation of the QL Entrance Exam will be carried-out by the QEP Implementation Committee in close consultation with the UTSA Testing Service, the Statistical Consulting Center, the Writing Center and the Teaching and Learning Center. Questions on the QL Entrance Exam will assess a student's skills, knowledge and competencies in specific areas of quantitative literacy as described more fully below.

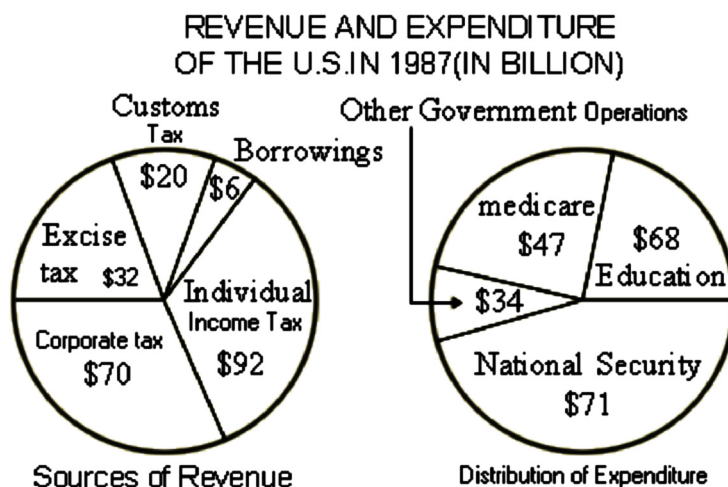
Not only will each student's score on the QL Entrance Exam be recorded, but more importantly, the Testing Service will track each student's performance on an item-by-item basis. This is important since it will provide a mechanism to assess the degree of student learning after completion of each quantitatively-enriched course the student takes.

The key idea here is to insure that each and every quantitatively-enriched course use the same battery of questions as those on the QL Entrance Exam. In this instance, the word "same" does not mean a word-for-word copy of the QL Entrance Exam questions, but questions formulated to test the same ideas and/or concepts.



Questions on the QL Entrance, designed to test a student's ability to solve a variety of data analysis problems, will be drawn from a variety of sources, including the type of questions UTSA graduates will see on the Graduate Record Examination (GRE). For illustration, consider the following GRE practice questions available at <http://www.bestsamplequestions.com/gre-questions/data-interpretation/data-interpretation-2.html>.

**Question 8 refers to the following figure:**



8. Of every dollar received by the federal government, how much (in cents) is from corporate sources?
- A. 32
  - B. 70
  - C. 30
  - D. 35
  - E. 29

This question requires a student to read quantitative information presented in graphical form and then interpret the data. The student must first figure which graph has the correct data and then calculate the percentage income from corporate sources by dividing the revenue from corporate income tax (\$70) by the sum of all revenue sources ( $\$20 + \$6 + \$92 + \$70 + \$32 = \$220$ ) to give  $\$70/\$220$  or 32%. The student must then realize that 32% is equivalent to 32 cents per dollar and select answer "A".

Here is another example GRE problem from the same web site:

**Questions 10 - 11 refer to the following table:**

**DIRECTIONS:** The following questions are based on the below table, which shows per capita Mean Expenditure, Per capita Food Expenditure, Number of Households and Per capita Cereal Consumption, in both quantity and value, for different expenditure classes of rural India. The sampled 41,597 households are divided into 12 expenditure classes, starting from less than Rs.65 per month per capita and ending at more than Rs.385 per capita per month.

PER CAP. EXP. CLASS		PER CAP. MEAN EXP.	PER CAP. FOOD EXP.	NO. HSS	TOTAL CEREALS QUANT	PER CAP. VALUE
FROM	TO	(Rs)	(Rs)		(Kg)	(Rs)
Less than	65	53.7	39.51	1,400	9.75	23.49
65	80	73.25	54.44	2,142	11.82	31.2
80	95	87.74	64.87	3,175	12.85	34.88
95	110	102.56	74.44	4,067	13.64	38.42
110	125	117.45	84.33	4,076	14.19	40.69
125	140	132.58	93.17	3,710	14.64	42.12
140	160	149.3	102.5	4,354	15.1	43.92
160	180	169.67	113.89	3,516	15.4	45.24
180	215	196.36	126.74	4,023	15.9	46.07
215	280	212.77	147.88	4,722	16.3	47.92
280	385	321.32	177.64	3,249	16.91	51.08
More than	385	628.52	262.28	2,483	20.32	62.3
<b>ALL</b>	<b>CLASSES</b>	<b>158.1</b>	<b>100.82</b>	<b>41,597</b>	<b>14.47</b>	<b>41.33</b>

10. According to the results of this sample survey, what is the proportion of total expenditure on food to total expenditure for all the sampled households taken together?

- A. 58%
- B. 36.7%
- C. 63.8%
- D. 71%
- E. Cannot be determined

11. What is the difference, approximately, between the gross expenditure of the sampled households in the Rs.95-110 expenditure class and in the Rs.180-215 expenditure class?

- A. 372000
- B. 448000
- C. 496000
- D. 93.8
- E. 52.3

These last two questions require a student to read quantitative information presented in tabular

form and again interpret the data using simple arithmetic. In Question #10, the student must first read the correct data from the table and then determine the ratio of total food expenditure to total household expenditures by dividing 100.82 by 158.1 to give answer “C” or 63.8%.

In Question #11 the student has to realize that gross expenditure cannot be read directly from the table, but must be calculated by multiplying the per capita expenditure by the total number of households in that expenditure class. In the expenditure class of 180 to 215 rupees (Rs), for example, the gross expenditure would 196.36 Rs/household X 4,023 households or 789,956 Rs. The equivalent calculation for the 95 to 110 Rs expenditure class yields a gross expenditure of 417, 111 Rs to give answer “A” or 372,000 Rs difference.

It is important to note that solving these questions requires only basic arithmetic (addition, subtraction, multiplication and division), not algebra, geometry, trigonometry or calculus. Being quantitatively literate does not require a student be a virtuoso in the manipulation of mathematical symbols. But it does require a student to be able to think clearly and work methodologically through the problem in a step-by-step manner.

## **Selection of Faculty and Courses for Content Development**

A serious problem in undergraduate education is the tendency for students to “compartmentalize” knowledge and skills. This is especially problematic with mathematics. Students who can readily work a problem in a math course are completely dumbfounded when presented exactly the same type of problem in a different academic context, such as a history course. The only way to break down the walls of compartmentalization is to present students with data-intensive problems in as many academic contexts as possible. For this reason, University Core Courses targeted for development must be spread across colleges and departments.

While the long-term goal of this QEP is to embed quantitative materials into most, if not all courses where it would be appropriate, this is clearly unrealistic in the short-term due to budgetary constraints. To insure that the University receives maximum benefit from its expenditure of precious resources, courses selected for development will be limited to Core Courses with very large enrollments and offered every semester with multiple sections. They must also lend themselves naturally to problem-based inquiry through the analysis of data sets representative of the course content. For example, a course in Texas Politics (POL 1133) might integrate the analysis of polling data taken from the 2008 Presidential Election into the lecture discussion. Other possible candidates for the QEP Development Grant Program would be Contemporary Biology II (BIO 1243), Introductory Macroeconomics (ECO 2013), Earth History (GEO 1123) and Introduction to Sociology (SOC 1013).

An important additional consideration in course selection will be the level of support and commitment of the Department Chair, the department’s Undergraduate Curriculum Committee (or similar body) and the faculty at large with respect to the aims and goals of the Quantitative QEP. For the QEP to be maximally effective in both its educational and SAC’s assessment goals, it is essential that all course sections incorporate the same quantitative materials, rubrics and assessment tools. Faculty charged with teaching these modified courses must “buy-in” to the idea that the benefit to

be gained by the student far exceeds any perceived loss of their “academic freedom”. Therefore, it will be left up to the departments to put forward the names of those faculty members they believe will best represent the interests of the department.

## **Embedding of Quantitative Content and Assessment Rubrics**

The centerpiece of the Quantitative QEP is the QEP Development Grant Program. The objective of the Development Grant Program is to present supported faculty members with a “tool box” of ideas and materials (e.g. learning objectives, exam questions, rubric templates, examples of exemplary case studies, online testing options and database resources, assessment tools, etc.) and train them in the best practices for using these ideas and materials to make their course an enriched educational environment for developing quantitative skills and competencies. However, it remains the sole responsibility of the faculty member to determine how this quantitative material can be deeply embedded into the course so as to enhance the learning process and not act as a burdensome distraction.

Faculty training will be carried-out during the summer using the staff and facilities of the University’s Teaching and Learning Center. Funds to hire a full-time, doctoral-level STEM specialist (Science, Technology, Engineering & Mathematics) to perform this training is included in the QEP’s budget. Assisting the STEM specialist will be experts from the UTSA Writing Program, UTSA Writing Center and the Statistical Consulting Center. It will be these experts who will provide the faculty member the actual “tools” for building quantitative material into his or her course as well as instructions for the appropriate use of these tools. Funds to support both the Writing Program and Statistical Consulting Center are also included in the QEP budget.

## **Support for Undergraduate and Graduate Teaching Assistants**

Typically, faculty feel “rushed” when teaching large introductory courses that would be targeted by the Quantitative QEP for development. Consequently, it will be very important for new quantitative material to be integrated as deeply and as seamlessly as possible so that the new material does not distract or expend too much time. This can best be done by requiring students to work on the quantitative material outside of class, either as regular homework and/or as small projects and/or case studies which ever format is judged as being most suitable for a particular academic setting. If the quantitative homework problems and case studies are designed with care and with close attention to the lecture material, working through these quantitative problems can greatly add to a student’s understanding of the lecture material as well as demonstrate the relevance and practical value of the quantitative work itself

Although the regular assignment of problem-based homework is common in lower division courses in math, physics, chemistry and engineering, it is much less common in other lower division University Core courses like anthropology, biology, history, political science and sociology. The reason for this is partly “cultural” and partly practical. Working homework problems is part of the “culture” of math courses and math-intensive courses like physics, chemistry and engineering. Faculty teaching these courses are expected to assign homework and support structures are in

place to hire and pay student teaching assistants to grade the assigned homework.

On the other hand, faculty outside of these “hard-core” disciplines are not generally expected to assign quantitative homework problems so that support structures and money to hire TA’s are lacking. Faculty teaching these large introductory sections rightly point out that it would be difficult to regularly grade hundreds of homework problems every week without TA support.

The Quantitative QEP would fund approximately 20 graduate and 80 undergraduate teaching assistants each year who would be trained by the Teaching and Learning Center and managed by the QEP Program Coordinator. These TAs would be responsible for grading the quantitative case studies and for offering training workshops on technology and techniques of interest.

Classroom logistics and lack of computer teaching classrooms for large lecture classes are significant barriers for implementation. A large lecture course could successfully implement quantitative objectives by requiring a combination of online learning modules for teaching and assessing basic quantitative skills combined with a certain number of case studies in which the student would be required to perform some analysis and write about the results. These later assignments could be graded by undergraduate or graduate TAs, provided that these TAs were trained and given structured grading rubrics.

TAs could also deliver scheduled workshops on a set of standardized activities in the computer classroom in the library. Suppose a case study required students to analyze and plot their data in Excel. The instructor could require that students complete an Excel Workshop for a certain number of points in the course grade. Students would be told at the beginning of the semester that they would have to complete the Workshop before a certain date to receive credit. These workshops would alleviate the need to spend class time demonstrating software.

In order for TAs to be successful, they must be trained to grade case study assignments using a structured rubric. They must also understand the quantitative analysis that they are grading. Furthermore, if giving workshops, they must be provided with the curriculum for the workshop and that curriculum must align with the needs of the courses. TAs would be required to attend Teaching and Learning Workshops designed especially for them. They would learn about the elements of technical writing and how to grade it. They would also receive individual help on the rubrics that they are given for grading. The Teaching and Learning Center would also give them assistance in learning to present workshops.

## **Measurable Goals and Objectives for Improving Student Learning**

To assess the learning outcomes for individual students, the Quantitative QEP has articulated specific measurable skills in three areas:

### ***Basic quantitative and numeracy skills:***

1. A student should be able to understand and interpret data in graphical and tabular form in a variety of contexts.
2. A student should understand units of measurement and scale and be able to perform conversions and simple dimensional analysis.
3. A student should be able to construct effective graphical representations of data including line plots, scatter plots, bar charts and pie charts from tabular data using software tools.
4. A student should understand and be able to interpret basic statistical indicators such as mean, median and standard deviation in a variety of contexts.
5. A student should be able to perform *back of the envelop calculations* to estimate scale and scope and to determine reasonableness and feasibility.

***Advanced quantitative skills:***

1. A student should understand the concept of uncertainty and be able to identify sources of error in measurement.
2. A student should be able identify flaws and misleading representations in data.
3. A student should understand how data is collected and to reason about potential confounding factors.
4. A student should be introduced to concepts of modeling and simulation to support hypothesis generation and summarization.
5. A student should understand basic concepts of hypothesis testing.

***Critical thinking and communication skills:***

1. A student should be able to make correct and meaningful verbal assertions about data.
2. A student should be able to translate verbal assertions about data into quantitative expressions.
3. A student should be able to identify risk and cost-benefits in making decisions.
4. A student should be able to describe coherently how particular data supports foundational principles in a discipline.
5. A student should be able to write a coherent and correct technical report.

## **UTSA Students Will Develop Basic Quantitative Literacy Skills**

Improvement in basic quantitative skills will be assessed through a pretest-posttest mechanism. Working through the UTSA Testing Center, the Quantitative QEP will rigorously assess the level of quantitative literacy and numeracy of all incoming students. Transfer students, as well as first time freshmen, will be required to take a quantitative literacy entrance examination. This assess-

ment tool will provide diagnostic data concerning various aspects of quantitative literacy such as the student's ability to read and interpret data presented in different graphic formats.

The student's performance on each item of the placement tool will be tracked in Banner during the student's tenure at the University. Using the individual's itemized performance on this entrance exam provides a simple, robust and objective baseline against which to assess any subsequent change in the student's skills and knowledge portfolio.

All courses that participate in the Quantitative QEP initiative will be required to embed appropriate post-test questions in their final examinations so that performance improvements of students in quantitative literacy areas can be tracked.

In addition, the UTSA Testing Center will administer the VARK Inventory (Visual, Aural, Read/Write, Kinesthetic) as part of student admission process. This inventory will become part of a student's Quantitative QEP record and be provided to instructors teaching various courses.

The Quantitative QEP will also track the number of students who complete various software workshops (such as the Excel workshop), the library's information validation workshops, and various Basic Online Data Analysis Suite (BODAS) modules. All results from BODAS will be tracked.

***UTSA students will analyze problems, conceptualize theses, develop arguments, weigh evidence, and derive conclusions.***

Advanced courses participating in the Quantitative QEP will be required to incorporate more advanced quantitative skills. They will develop specific assessments for these activities and organize the assessment results in a way that can be combined and tracked. The Teaching and Learning Center will lead the development of assessment templates to help instructors gather this information.

UTSA will do a yearly cross-sectional administration of the Collegiate Learning Assessment or CLA ([http://www.cae.org/content/pro\\_collegiate.htm](http://www.cae.org/content/pro_collegiate.htm)) to evaluate high-level cognitive growth of students as a result of their college experience. The CLA will provide UTSA with benchmarks about how higher order cognitive skills such as critical thinking, problem-solving and effective writing have been impacted by the Quantitative QEP. The CLA is designed to reliably measure institutional effects and to correlate programmatic features to student learning.

***UTSA students will demonstrate critical thinking by effectively communicating results of their quantitative analysis in writing or by other means.***

All courses participating in the Quantitative QEP will be required to have a writing component.

Rubrics for evaluating this component will be developed and validated by the course instructors with the help of the Teaching and Learning Center. The writing component can vary from one sentence observations about the characteristics of a graph or chart to full-fledged technical reports. A key to improving critical thinking is that students receive accurate and relevant feedback.

TAs will perform post-mortem analysis keeping track of the types of errors that occurred on each assignment that they grade. They will provide a summary of these errors to the instructor to assist in course improvement.

***UTSA students will have many opportunities to develop quantitative literacy and quantitative mastery skills, knowledge and competencies in numerous academic contexts throughout their university experience.***

Courses that have a Quantitative QEP component will be specifically tracked by Institutional Research with respect to enrollments, drop rates, and grade distributions. The number of quantitative courses taken at the core and advanced level will be tracked by student and broken down by demographic categories such as race and gender.

***UTSA students will receive better instruction guided by well-formulated goals and objectives. They will participate in more hands-on and critical thinking activities. They will receive more frequent and higher quality feedback on their work and have more opportunities to interact with instructors and TAs.***

Courses that participate in the Quantitative QEP development effort will be required to link specific course objectives to the articulated objectives of the QEP. These courses will report on the number and types of critical thinking activities used during each semester. They will also be required to delineate the specific real-world examples that serve as major focal points of these courses.

Institutional Research will track the number of full-time faculty teaching all sections of courses that have undergone quantitative development and compare these numbers to historical data for these and comparable courses.

***UTSA students will also see applications that are directly applicable to their fields of study and to their everyday life.***

The Quantitative QEP program coordinator will maintain a website in which each course participating in the QEP has a page of information based on a template developed by the QEP Implementation Committee. Each course page will have an organized entry for each semester. The entry will describe the specific case studies, real-world problems and data sets used that semester to incorporate student learning. These descriptions should appear on the course syllabus as well as on the QEP web site entry. These web sites will be used as a vehicle for student recruiting as well as for raising community awareness and support.

***The Quantitative QEP will promote student engagement and decrease the number of first-time, full-time, “native” students who drop out.***

National Survey of Student Engagement (<http://nsse.iub.edu/html/origins.cfm>) will be administered during every spring semester at UTSA. This survey provides estimates of how undergraduates spend their time and what they gain from their college experience. The data gathered from this



survey will allow UTSA to measure the level of student engagement and to compare itself with other institutions nationwide. Students participating in different types of QEP experiences will be over-sampled to allow comparisons of level of engagement.

***UTSA students will be better prepared to face the real-world challenges they will encounter after graduation.***

UTSA will begin doing a post-graduation survey of selected UTSA students to see how students perceive the value of their UTSA education after they are in the workforce. The survey will ask specific questions about how they use quantitative and critical thinking skills.

UTSA Career Services will also conduct an annual survey among employers of UTSA students who work through their office. The survey will be designed to assess employer perceptions of how well prepared UTSA students are to apply critical thinking on the job. A similar survey will be administered to employers providing internships to UTSA students.

***UTSA students will develop a “quantitative analytic toolkit” that will better prepare them to perform quality research at both the undergraduate and post- baccalaureate levels. A larger pool of qualified students will become available to participate in research opportunities.***

Admissions of UTSA undergraduates to UTSA graduate programs will be tracked. In addition, students on the UTSA payroll will be tracked as far as job classification and number of hours worked at UTSA and participation in Quantitative QEP experiences. UTSA students receiving stipends will also be tracked for similar information.

***UTSA graduate and advanced undergraduate students will receive training in both quantitative reasoning and effective communication for their role as teaching assistants. These skills will enhance their personal ability to pursue their own graduate studies and thesis research.***

The number and distribution by discipline of students receiving training as TAs will be tracked. Student TAs will be asked to fill out an experiential questionnaire at the end of each semester that they participate in the Quantitative QEP. Focus groups will be conducted periodically to receive formative feedback for improving training and administration.

Through the QEP’s direct support of the University’s Teaching and Learning Center, Writing Center and Statistical Consulting Center, the Quantitative QEP will create a cadre of highly-motivated faculty dispersed throughout the University’s many colleges and academic departments that: (1) embrace the need to build quantitative thinking into their coursework, (2) teach quantitative material using best practices, and (3) appreciate the importance and benefits of timely and accurate assessment.

The number of faculty participating in the Quantitative QEP will be tracked. Focus groups for faculty participants will be held to obtain both formative and summative feedback. In addition, UTSA will begin administering the Faculty Survey of Student Engagement (<http://fsse.iub.edu/>

html/about.cfm) to the UTSA faculty. A detailed report will be produced and made available to the UTSA community as a whole.

## Student Population Targeted

In principle, the Quantitative QEP is intended to develop an acceptable level of quantitative literacy in all students who graduate from UTSA. However, in practice, enriching the environment of all UTSA undergraduates may be difficult since a high percentage of undergraduates are transfer students. A more accurate description of the targeted student population is what the Texas Higher Education Coordinating Board (THECB) classifies as “native students”. The reasons for this distinction as well as its consequences for the Quantitative QEP are as follows.

In contrast to institutions such as the University of Texas at Austin, UTSA has two distinct populations of undergraduate students, at least from the perspective of the THECB. The population, referred to as being “native” is defined as those students who matriculated as freshmen and started their studies with a full academic load (i.e. > 12 semester credit hours). For this reason, native students are sometimes referred to as being “first-time, full-time” students.

All other undergraduates—primarily students who transferred into UTSA from community colleges and “part-time” students who enrolled with less than 12 semester credit hours per semester—are considered as being “non-native” by the THECB. Although most universities and colleges have transfer students, the percentage of these “non-native” undergraduates is usually very small. At UTSA, the percentage of non-native students is very large, comprising perhaps more than half of the undergraduate population that eventually graduates from the University.

With respect to the Quantitative QEP and the student population that it will directly effect, the problem is that students transfer into UTSA with a wide range of credit hours, from only a few courses to essentially the entire freshman and sophomore years already completed. Since the largest component of the Quantitative QEP is directed towards freshman- and sophomore-level courses within the University Core Curriculum, it is difficult to accurately predict *a priori* what percentage of non-native students will be affected by the QEP. Some transfer students will take enriched Core Courses at UTSA and will benefit from the QEP; some transfer students will have already completed an equivalent course before coming to UTSA and will not benefit. A further confounding variable is the fact that some fraction of our native students chose to fulfill some part of their University Core Curriculum requirements at other institutions, especially at the local community colleges. These students would not benefit from the QEP if they substitute courses that are not enriched. Data from Institutional Research does however indicate that the number of students fulfilling Level 2 Science and Economics requirements has been increasing over the past 5 years.

Finally, some percentage of transfer students who matriculated with all of the UTSA Core Curriculum course work completed will have an opportunity to benefit from upper division courses that have been enriched as part of the Quantitative Mastery component of the Quantitative QEP. The Quantitative QEP will make every effort possible, limited only by the constraints imposed by its budget, to enrich the educational environment for as many UTSA graduates as possible.

## II. Involvement of Academic, Student affairs, and Other UTSA Components

*The simplest schoolboy is now familiar with truths for which Archimedes would have sacrificed his life. -Ernest Renan*

In developing the Quantitative QEP, it was decided to resist the temptation to create new administrative structures and simply tailor the initiative to make full use of existing structures as appropriate. This was done in an effort to maximize the effectiveness of resources committed by the University for the QEP, by minimizing the proportion of funds needed for administrative overhead. The use of existing administrative structures also offered the advantage of decreasing the ramp-up time of the QEP since new hires and logistical issues required by new structures could be largely avoided. Finally, and perhaps more importantly, the inclusion of as many University components in the Quantitative QEP as possible was seen as a way to significantly extend the number of stakeholders in the initiative with a vested self-interest for its success.

### Involvement of Academic Affairs

#### *Quantitative QEP Implementation Committee*

The Quantitative QEP will require the creation of one new administrative body, a new standing committee to be called the QEP Implementation Committee (hereafter called the “QEP” Committee). The QEP Committee will be appointed by the Provost and shall report directly to the Provost as required. The QEP Committee will be composed of both faculty charged with implementation of the QEP as well as members of the Administration most directly involved in the QEP process, such as the Vice Provost for Accountability and Institutional Effectiveness, as well as directors of participating components (Teaching & Learning Center, Writing Program, Writing Center, Statistical Consulting Center), as well as the Chair of the University Core Curriculum Committee. The QEP Committee physically embodies the unusually wide distribution of talent, expertise and resources that will be harnessed for the successful execution of the QEP. Additional details about the participating University components and offices are presented below.

#### *Office of the Vice Provost for Accountability and Institutional Effectiveness*

An important function of the Office of the Vice Provost for Accountability and Institutional Effectiveness is the regular collection of assessment data for Reaffirmation by the Southern Association of Colleges and Schools (SACS). Beyond the obvious connection between the QEP and SACS Reaffirmation, the Quantitative QEP will directly support the assessment efforts of this Office in less obvious ways. By virtue of their importance to undergraduate education as well as their large student enrollment, undergraduate courses contained within the University Core Curriculum are especially important targets for SACS assessment efforts. Since a substantial percentage of Uni-

versity Core Courses will benefit from the embedding of powerful assessment elements as a result of the QEP's course development activities, assessment data gathered as part of the QEP effort will be made freely available to the Office of the Vice Provost for Accountability and Institutional Effectiveness for their own assessment efforts.

### *Teaching and Learning Center*

The Teaching and Learning Center, formerly the TEAM Center, will play a major role in the Quantitative QEP. The Teaching and Learning Center, under the new leadership of Dr. Barbara Millis, will be the focal point for instructional development for the Quantitative QEP. A STEM (Science Technology Engineering Mathematics) specialist at the Ph.D. level will be hired and, together with the Teaching and Learning Center director and staff, will coordinate and deliver most of the training elements of the Quantitative QEP. The Teaching and Learning staff will have expertise in assessment as well as curriculum development.

The Teaching and Learning Center will run QEP Curriculum Development Workshops to help faculty develop quality curricular materials supporting the development of quantitative literacy. Each workshop would be held over multiple sessions. During an initial two-day session offered at the end of the spring semester, participants would bring their initial ideas and would learn about various strategies for adaptation and assessment. During the summer, they would meet individually as needed with different resource faculty from the Teaching and Learning center, the Statistical Consulting Center (SCC) and the Writing Center to get feedback on their curriculum as it is being developed. In a second workshop session at the end of the summer, the participants would again meet as a group and peer review and make suggestions on each other's curriculum. In a final session during the fall semester, the group would again meet and evaluate their progress and discuss lessons learned. All Quantitative QEP Development Grant awardees would be required to attend this workshop. Other faculty could also participate.

### *Writing Program and Writing Center*

The Quantitative QEP will provide funding to the Writing Center to provide support for faculty in designing and assessing assignments and rubrics. The money will support faculty and graduate students in the program. The Center will provide walk-in hours for one-on-one support for students in these classes. Both the Director of the Writing Program, Dr. Gail Pizzola and the Director of the Writing Center, Dr. Marguerite Newcomb, have participated in several meetings with the Quantitative QEP Executive Committee to determine the best use of these vital resources.

### *Tomás Rivera Center for Student Success*

The Quantitative (Q) Lab of the Tomás Rivera Center is ideally suited to offer help and support for undergraduates enrolled in quantitatively-enriched courses, especially lower division University Core Courses with issues related to the quantitative aspects of homework assignments, research projects and/or case studies. The Executive Committee of the Quantitative QEP has been in contact with Ms. Cyndi McCowen, Associate Director of the Tomás Rivera Center, who directly super-

vises the Q Lab. How best to leverage the expertise of the Tomás Rivera Center in general, and the Q Lab in particular for the successful implementation of the Quantitative QEP is still under development.

### *University Library*

The Executive Committee of the Quantitative QEP has been in contact with the Library's Head of Electronic Information and Reference Services, Ms. Dell Davis concerning how best to leverage the Library's expertise in on-line data retrieval and data analysis with the development of quantitative-enriched courses, especially at the upper division level. Ms. Davis and other Library representatives will be asked to participate in workshops sponsored by the Teaching and Learning Center for faculty and teaching assistants supported by the Quantitative QEP.

### *University Testing Service*

The importance of the University Testing Service for the Quantitative QEP is evidenced by the fact that the Director of the University Testing Service, Ms. Joleen Reynolds, serves as one of the five members of the QEP's Executive Committee. The Testing Service, working in close collaboration with the QEP Implementation Committee, the Statistical Consulting Center, the Writing Center and the Teaching and Learning Center will assist with the development, validation and administration of the Quantitative Literacy Entrance Examination to students entering the University, including transfer students. Questions on the QL Entrance Exam will assess a student's skills, knowledge and competencies in specific areas of quantitative literacy and serve as the primary baseline against which evidence of student learning will be assessed. Additional information about the University Testing Service and the Quantitative Literacy Entrance Exam is provided below.

## **Involvement of Student Affairs**

Reaching the spectrum of students involved in this initiative will require the efforts of the Student Affairs to support the learning being introduced from the Academic units. Student Affairs will be able to help build the bridges from learning to the real world. Career Services with the career interest inventories and employer fairs provide opportunities wherein students can access their interests versus their skill sets and link students with academic resources to build those skills. Career Services has the most recent data on the gaps between student learning and actual skills needed in the workplace. Such information can be used to inspire and motivate students toward higher levels of quantitative learning. Learning Communities and Supplemental Instruction (SI) also provide opportunities to enhance learning. They are ideal venues for overcoming 'math anxiety'-- providing a launching pad for improved quantitative instruction. Orientation and housing can provide forums and venues for testing and student/teacher focus groups. The office of Disability Services and Counseling Services are vital in this QEP to access and provide services to those with learning disabilities who may feel particularly in need of support.

## **Involvement of Other UTSA Components**

### *Statistical Consulting Center*

The Executive Committee of the Quantitative QEP has worked extensively with the Director of the Statistical Consulting Center (SCC), Dr. Stephanie Cano, in the development of the QEP. The SCC will be tasked with development of the various templates and assessment tools, under the supervision and direction of the QEP Implementation Committee. In addition, the SCC will also assist in the collection, analysis and archival storage of the assessment data obtained as part of this QEP initiative. Faculty supported by the QEP will be able to consult with SCC staff without charge. The Quantitative QEP will fund a full time Master's level professional with expertise in statistical assessment as well as two quarter time PhD level statisticians as senior research associates.

The SCC personnel have extensive experience in developing, delivering and assessing quantitative curriculum. They have broad knowledge of available data sets and simulations in many areas. They will provide one-on-one consulting for individual faculty in developing quantitative curriculum. They will also assist in the development of a set of online tutorials and assessments developed for WebCT to teach basic data analysis and interpretation skills. These will include a test bank of examples and exercises from everyday life as well as examples and exercises from specific disciplines. QEP Development Faculty will be encouraged to contribute examples to the test bank.

The SCC will also develop quantitative placement tests that will be administered to all incoming freshmen. They will provide test questions for potential inclusion in courses with quantitative objectives so that students can be tracked in subsequent courses relative to their performance on the placement examination

## **III. Resources Needed for Implementation and Continuation**

### *Time Line for Implementation and Completion*

The QEP has a five-year timetable. 2010 will be used for implementing a pilot study and collecting the baseline data needed to assess the progress and performance of the QEP. The program will start in the Fall of 2011 with 6-8 development grants awarded to faculty teaching courses in the core curriculum. Faculty awarded the grants will receive summer support to work with the Teaching and Learning Center in redesigning the courses and developing lesson plans, online modules, and assessment rubrics. Additional courses will be phased in over the remaining four year period: in year 5, we anticipate funding 15-18 proposals.

## Implementation of the QEP

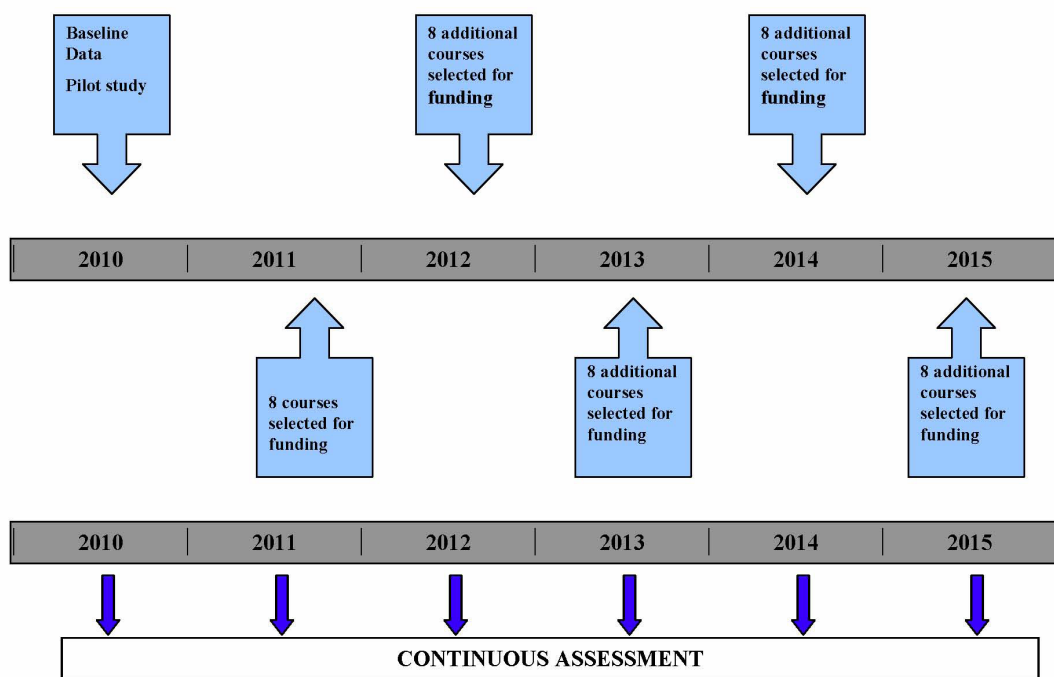


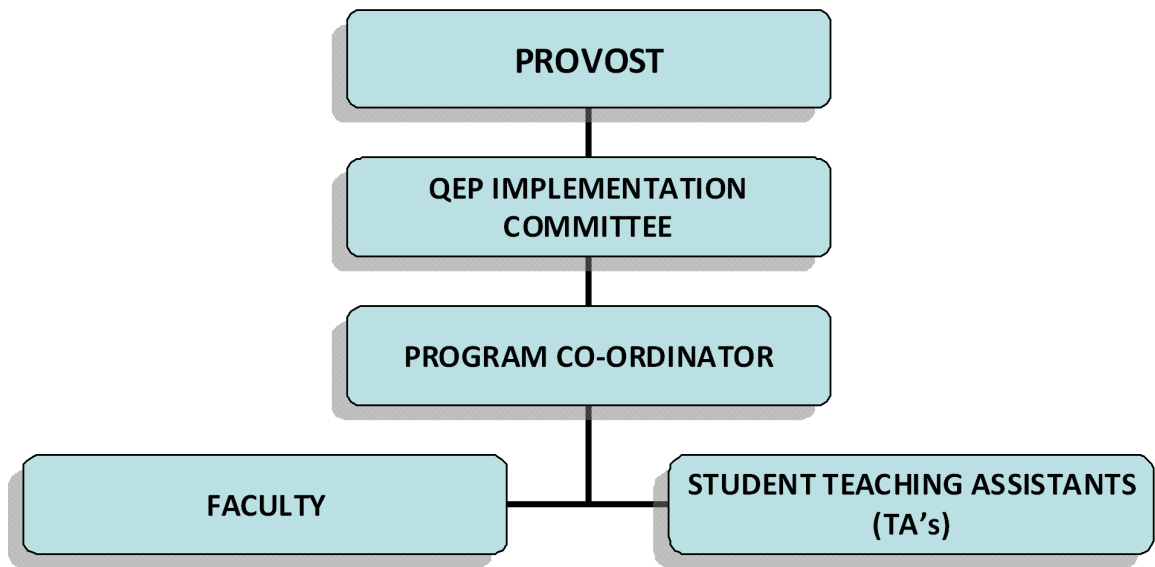
Fig. 6. Time-line for the implementation of the Quantitative Scholarship QEP.

### Administration and Oversight

The Quantitative QEP will be managed by a new standing committee to be called the QEP Implementation Committee (hereafter called the “QEP” Committee). The QEP Committee shall include both faculty charged with implementation of the QEP as well as members of the Administration most directly involved in the QEP process, such as the Vice-Provost for Accountability and Institutional Effectiveness, as well as directors of participating components (Teaching & Learning Center, Writing Program, Writing Center, Statistical Consulting Center), as well as the Chair of the University Core Curriculum Committee.

The QEP Committee will be co-chaired by faculty Quantitative QEP Co-Directors. The Committee will be responsible for the selection of the grant awardees. An administrative assistant will be responsible for handling the paperwork associated with the various programs as well as the

paperwork for hiring the teaching assistants and graders. A Program Coordinator will be hired who will work with the faculty and students to track the requirements of the QEP. The program coordinator will handle the requests for data, tracking students for needed assessments and compile the assessment results.



**Fig. 7. Organizational structure for the Quantitative Scholarship QEP**

## Academic, Financial and Physical Resources

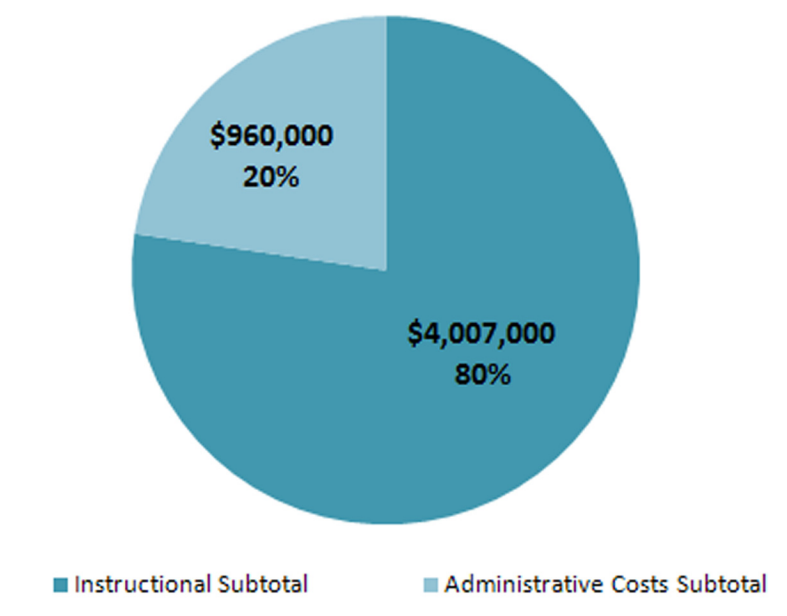
The fundamental objective of the Quantitative QEP is a transformative change in the University’s educational environment that is both systemic and permanent. It is an ambitious goal that will require considerable time and effort from administrators, faculty and students if it is to be successful. It will also require a very significant financial investment from the University. The budget provided below requests a total of \$4,967,000 over the 5–year project period and has been subdivided into Instructional Costs and Administrative Costs. As appropriate for an initiative focused on student learning and student success, the largest share of the budget, 80%, directly supports instructional costs with only a modest 20% budgeted for administrative overhead. A categorical breakdown of the instructional and administrative costs is provided below.

### *Faculty Summer Stipends*

Importantly, the Quantitative QEP does not require any new courses be added to the University Core Curriculum. Instead, the program encourages and supports faculty to redesign existing courses in order to incorporate a significant quantitative component and effective assessment rubrics that are amenable to transfer to other sections of the same course. To engender faculty support, and to compensate individuals for efforts well above and beyond their normal teaching obligation, the Quantitative QEP will provide substantial, multi-year development grants to participating faculty.



## Total 5-year Budget \$4,967,000



**Fig. 8. Relative proportion of total instructional costs to total administrative costs**

Faculty receiving development grants will be given a stipend of \$10,000-\$20,000 a month, for two months, during the summer semester. Summer support may be renewed for a second year. In order to insure that any change to course content funded is of the highest quality (i.e. effective, transferrable and sustainable), development grants will be limited to just 8 faculty/courses in the plan's first year (2011). With the benefit of experience and programmatic assessments (see below) generated during the first year, the number of faculty supported in years 2–4 will be increased to maximum of 16. In the 5th and final year, the number of faculty grants awarded will again return to 8.

During its 5-year tenure, the QEP Development Grant program will target both the development of quantitative literacy in lower level University Core Courses as well as quantitative mastery in selected upper division courses with a total budget for faculty stipends of \$1.28 million. Additionally, some travel funds are also budgeted to assist faculty wishing to attend conferences and workshops focusing on relevant aspects of teaching and assessment.

### *Student TA Support*

A significant number of courses in the core curriculum are taught in large auditorium formats with limited opportunities for student to participate in lab or recitation sections. Table 1 shows enrollments for courses in Geology, Sociology, Chemistry, and Economics for Fall 2008. With classes in large lecture halls, there is limited opportunity for faculty to interact with students and

assign homework or projects that can be graded. A very small number of the courses have lab or recitation sections, but the enrollments are low. A large lecture course could successfully implement quantitative objectives by requiring a combination of online learning modules for teaching and assessment combined with assignments/ projects/ case studies that require the students to create simple graphs, perform simple data summaries and write appropriate conclusions. These assignments would be graded by graduate or senior undergraduates.

The QEP budget includes significant support for faculty in the form of graders and teaching assistants. This request is for additional new funds for student support. We believe that the existing resources are inadequate to successfully implement the QEP and really help the students to succeed. These TA's and graders will also receive training to help them work with the students. The budget includes both undergraduate and graduate student support. We are requesting support for 1 TA for every 100 students. TA support will be required from year 2. The graduate funding is at \$13 per hour and the undergraduate funding at \$7. In Year 2, we have requested funding for 8-12 students. In Years 2–5 we are requesting funds for 16–24 positions. Total request is \$1,312,000.

Course	No. of Sections	Ave Class Size	Min. Enrollment	Max. Enrollment
GEO 1103	3	115	58	167
GEO 1123	1	136	-	-
SOC 1013	12	90	17	185
ECO 2003	7	142	50	302
ECO 2013	7	104	20	280
ECO 2023	6	140	41	280
CHE 1103	5	142	26	252

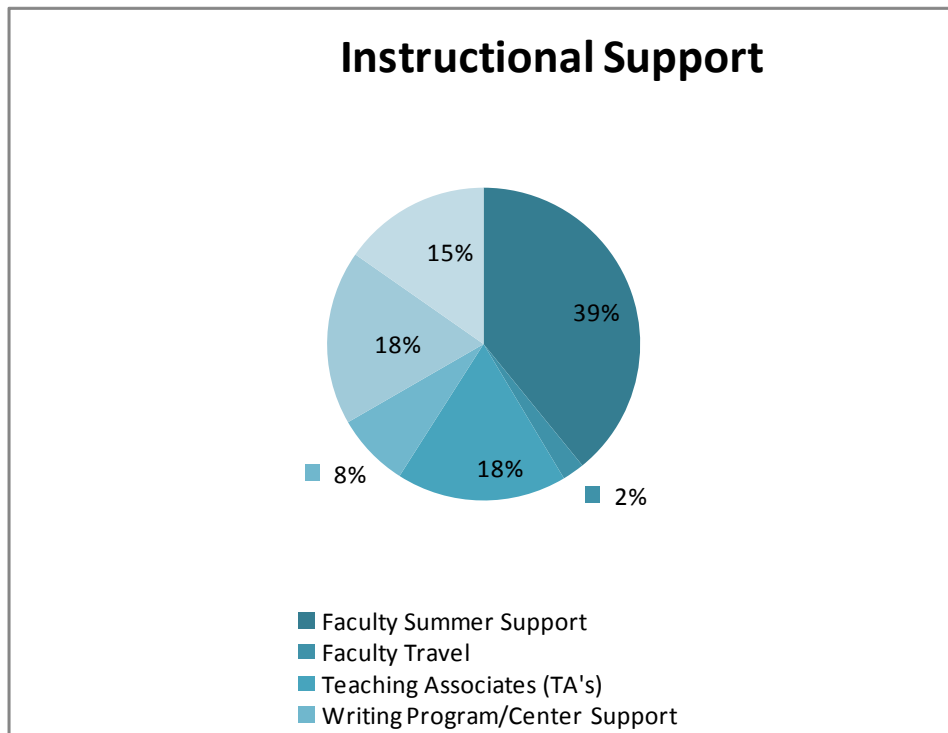
### *Teaching and Learning Center*

The Teaching and Learning Center will play a major role in the Quantitative QEP. The Teaching and Learning Center will run QEP Curriculum Development Teaching and Learning Workshops to help faculty develop quality curricular materials. Each workshop would be held over multiple sessions. During an initial two-day session offered at the end of the spring semester, participants would bring their initial ideas and would learn about various strategies for adaptation and assessment. During the summer, they would meet individually as needed with faculty from the Teaching and Learning center, the Statistical Consulting Center (SCC) and the Writing Center to get feedback on their curriculum as it is being developed. In a second workshop session at the end of the summer, the participants would again meet as a group and peer review and make suggestions on each other's curriculum. In a final session during the fall semester, the group would again meet and evaluate their progress and discuss lessons learned.

The budget includes funds for the Teaching and Learning Center to hire a STEM (Science Technology Engineering Mathematics) specialist at the PhD level who will coordinate and deliver most of the training elements of the Quantitative QEP. The Teaching and Learning staff will have expertise in assessment as well as curriculum development.

*Statistical Consulting Center*

The Statistical Consulting Center will be tasked with development of the various templates and assessment tools, under the supervision and direction of the QEP Implementation Committee. In addition, the SCC will also assist in the collection, analysis and archival storage of the assessment data obtained as part of this QEP initiative. Staff of the SCC will be available for direct consultation by faculty supported by the QEP without charge. They will provide one-on-one consulting for individual faculty in developing quantitative curriculum. They will also assist in the development of a set of online tutorials and assessments developed for WebCT to teach basic data analysis and interpretation skills. These will include a test bank of examples and exercises from everyday life as well as examples and exercises from specific disciplines. QEP Development Faculty will be encouraged to contribute examples to the test bank. The budget includes funds for a full time Master’s level professional with expertise in statistical assessment as well as two quarter time PhD level statisticians as senior research associates

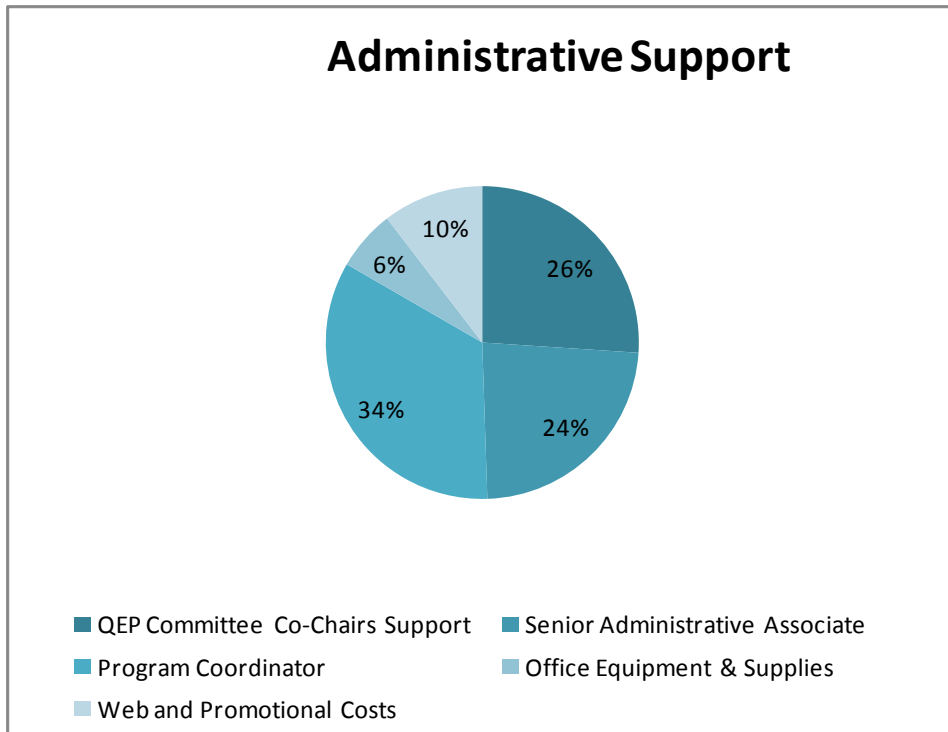


**Fig. 9. Breakdown of instructional costs for the QEP**

## Budget for the QEP: Range of Summer Support and TA Support

Instructional Support	FY 2011-12	FY 2012-13	FY 2013-14	FY 2014-15	FY 2015-16	Total (all 5 years)
Faculty Summer Support*	120,000-160,000	240,000-320,000	240,000-320,000	240,000-320,000	120,000-160,000	960,000-1,280,000
Faculty Travel	15,000	15,000	15,000	15,000	15,000	75,000
Teaching Associates (TA's)*	12,000-32,000	48,000-80,000	108,000-240,000	168,000-400,000	304,000-560,000	640,000-1,312,000
Writing Program/Center Support	50,000	50,000	50,000	50,000	50,000	250,000
Statistical Consulting Center	118,000	118,000	118,000	118,000	118,000	590,000
Teaching and Learning Center	100,000	100,000	100,000	100,000	100,000	500,000
<b>Instructional Subtotal</b>	<b>475,000</b>	<b>683,000</b>	<b>843,000</b>	<b>1,003,000</b>	<b>1,003,000</b>	<b>3,015,000- 4,007,000</b>
<b>Administrative Costs</b>						
QEP Committee Co-Chairs Course Buyout and Summer Support	50,000	50,000	50,000	50,000	50,000	250,000
Senior Administrative Associate	45,000	45,000	45,000	45,000	45,000	225,000
Program Coordinator	65,000	65,000	65,000	65,000	65,000	325,000
Office Equipment & Supplies	12,000	12,000	12,000	12,000	12,000	60,000
Web and Promotional Costs	20,000	20,000	20,000	20,000	20,000	100,000
<b>Administrative Subtotal</b>	<b>192,000</b>	<b>192,000</b>	<b>192,000</b>	<b>192,000</b>	<b>192,000</b>	<b>960,000</b>
<b>Grand Totals</b>	<b>667,000</b>	<b>875,000</b>	<b>1,035,000</b>	<b>1,195,000</b>	<b>1,195,000</b>	<b>3,975,000-4,967,000</b>

\* The figures presented for Faculty and TA support are based on a median number of courses and a median salary for the TA. The faculty summer support would reduce to \$960,000. The TA support would reduce to \$640,000. Total Budget=\$3,975,000.



**Fig. 10. Breakdown of administrative costs for the QEP**

#### *Writing Program/ Writing Center*

The Quantitative QEP will provide \$50,000 per year to be shared between the Writing Program and the Writing Center. These funds will provide support for faculty in designing and assessing assignments and rubrics. The money will support faculty and graduate students in the program. The Center will provide walk-in hours for one-on-one support for students in these classes.

The total budget for instructional support is \$4,007,000 or 80% of the total Quantitative QEP budget.

#### *Administrative Budget*

In addition to support for faculty and students, funds are requested for the administrative oversight of the plan. We are requesting course releases for the co-chairs of the committee. Funds are also requested for a Program Coordinator who will be responsible for the day-to-day operations of the QEP, handling requests for data, and producing the annual report for assessing the program goals. Additional budget items include supplies and marketing costs. The total requested for administrative support is \$960,000.

## Facilities and Physical Services

### *Physical Space*

The Quantitative QEP does not require significant resources in terms of space. Only two small offices would be needed, one for the Program Coordinator and one for the administrative assistant.

Ideally, the University should consider the possibility of constructing an additional computer laboratory to support the Quantitative QEP. In addition to normal PC workstations, this facility should also offer separate spaces for TA's to work with students in small groups. In the same way space was provided to the Tomas Rivera Center by simply enclosing the existing overhang of the MS building, perhaps a similar approach could be used with either the Science Building or the HSS Building. Again, the creation of a new student lab would be very helpful, but is not necessary, for the success of the Quantitative QEP.

## IV. Assessment of the Quantitative QEP

*Education is the ability to listen to almost anything without  
losing your temper or your self-confidence. -Robert Frost*

The overall goal of the Quantitative QEP is to transform the educational environment of the University to one in which the quantitative analysis of data is the norm, not the exception in both upper and lower division classes. The overall success or failure of the QEP will be obvious to everyone to see and easily measured by a single metric—in the years following the end of the QEP, did the number of courses using quantitative content increase or decrease? In other words, to be successful, the quantitative content and assessment tools developed for one course need to be modified and transplanted to similar courses. Like a living thing, Quantitative Scholarship must either take root and grow, or it will wither and slowly die.

### *Maintaining Progress*

It would be wonderful, but naïve to think that faculty and department chairs would want to embrace quantitative scholarship in the future based solely on the benefits afforded to student learning and success. Success varies considerably from student to student as well as from course to course. It can be determined statistically for a population of students but in an actual classroom, the notion of “student success” is usually too ephemeral to be a significant motivator even to the most dedicated faculty. The question then is, “what will motivate faculty to utilize the wealth of quantitative content and assessment tools developed during the 5–year QEP period, after the program has ended”?

Three factors are likely to sustain the transformation of UTSA after the 5–year QEP period are (1) student testimonials, (2) support for teaching assistants, and (3) inertia.

### *Student testimonials*

Every professor who demands that their students perform at a high level, so-called “hard professors”, has experienced the following situation. Long after a particular course has ended, a student will contact the professor to thank them for making the course so challenging. This realization usually comes after the student has entered medical school, graduate school, or taken a high-powered job and is in a position to make use of what he or she learned in the classroom. The fact that the praise has taken so long in coming is completely understandable. Like most things in life, we cannot see the true value of things we hold most dear without the perspective of time.

All too often, students in large University Core Courses communicate with their teachers only to beg for extra-credit to change a failing grade into a passing one. Given this backdrop of student demands, complaints and excuses, it is remarkable how cathartic one heartfelt testimonial can be for a dedicated teacher.

One obvious incentive for professors to continue teaching courses that are quantitatively-enriched would be the positive feedback from students who have made good use of their data analytic skills learned in their class.

### *Support for Teaching Assistants*

A more immediate incentive for offering quantitatively-enriched courses would be to maintain the accompanying TA support. Even after the developmental grant program has ended, quantitatively-enriched courses will require a continuing level of TA support. Maintaining quantitative scholarship requires an indefinite University commitment to provide support for teaching assistants to any course that seriously incorporates quantitative scholarship and assessment into its course content.

Pressure to continue quantitatively-enriched courses would likely come from department chairs, departmental curriculum committees, the University Core Curriculum Committee and from the Office of the Vice-Provost for Assessment and Institutional Effectiveness. Most department chairs would likely welcome the additional financial support especially in departments with nascent doctoral programs and limited opportunities to support doctoral students via large extramural grants such as NIH Training Programs. Department chairs would likely insist on maintaining quantitative content in selected courses if it meant losing TA support.

Curriculum Committees at the department level would likely support maintaining and perhaps even expanding course offerings that are quantitative enriched since it would improve the overall caliber of students entering upper division courses and/or applying for admission into their graduate programs. The University Core Curriculum Committee would very likely support maintaining quantitatively-enriched core courses since embedded assessment tools would greatly reduce the burden of their periodic assessment of the Core. Finally, the Office of the Vice-Provost for Assessment and Institutional Effectiveness would also appreciate the value and efficacy of the embedded assessment tools within quantitatively enriched courses vis-à-vis the SACS reaffirmation process.

## *Inertia*

When discussing curriculum reform, the image of the University as a large, ocean going ship is often evoked. All universities, even comparatively young ones like UTSA, exhibit an extraordinary level of “inertia” when it comes to changing the curriculum. Like a large passenger liner, it is possible to change the course of the University, but the change will be slow and require extraordinary effort to overcome this inertia. The SAC’s QEP provides a unique opportunity to muster the financial and personnel resources necessary to make this extraordinary effort over a relatively slow, 5–year period.

While inertia will work against the implementation of the Quantitative QEP, it will also work to maintain the quantitative scholarship at UTSA after the QEP has ended. Making quantitatively-enriched courses an integral part of the University Core Curriculum, and providing TA’s support to these classes, it becomes a part of the University’s culture. Faculty experienced with teaching quantitatively-enriched classes will have grown accustomed to assigning homework problems and class projects making them somewhat reluctant to revert back to the “old ways”. The large number of new faculty expected to be hired between 2011 and 2016 will only know the “new ways” of teaching quantitatively-enriched courses. In short, it will be inertia that underlies the enduring cultural change the Quantitative QEP is designed to produce.

## **Evaluation**

*I like a teacher who gives you something to take home to think about besides homework.* -- Edith Ann, [Lily Tomlin]

### *Internal Evaluation Measures*

1. Pre-Test: All courses participating in the QEP will administer a pre-test of quantitative literacy that will be used to establish baseline data.
2. Course Embedded Assessment: All courses participating in the Quantitative QEP will be required to embed questions in assignments and exams that address the different learning objectives. The results will be used for on-going assessment of the course as well as the overall program.
3. Focus Groups: The Teaching and Learning Center will conduct focus groups of faculty, teaching assistants and students to identify barriers, attitudes, and perceptions about the course and program. Both qualitative and quantitative data will be collected.
4. Surveys: Student and faculty surveys will be conducted to determine the response to the QEP and the effectiveness of the program.
5. Review by Stakeholders: Deans, Department Chairs, Career Services will provide feedback on the program.



### *External Evaluation Measures*

1. **Consultant:** An outside expert on quantitative literacy and assessment will be invited to participate in the program review. This individual will provide feedback to the QEP Implementation Committee on issues such as sustainability, best practices, and progress toward program goals.
2. **Collegiate Learning Assessment (CLA):** UTSA will do a yearly cross-sectional administration of the CLA to evaluate high-level cognitive growth of students as a result of their college experience. The CLA will provide UTSA with benchmarks about how higher order cognitive skills such as critical thinking, problem-solving and effective writing have been impacted by the Quantitative QEP.
3. **Graduate School Exams:** Scores of students on GRE and GMAT will provide a measure of intellectual growth and allow comparisons of students in QEP courses to students who had limited or no exposure to the QEP.

### *Assessment Methodologies and Instruments*

A combination of existing and new instruments will be used to measure student learning and assess the overall progress of the Quantitative QEP. Table 2 provides a summary of the different instruments that will be used. Table 3 provides the learning outcomes, assessment methods and criteria for the 3 main goals of the Quantitative QEP.

**Table 2. Summary of Assessment Instruments to Be Used**

<b>Instrument</b>	<b>Target Population</b>	<b>Method/forum</b>	<b>Outcome</b>
Pretest of Quantitative Literacy	Cohort of first time, full-time freshman considered native to UTSA.	Orientation testing sessions.	Establish baseline data for use in growth measurements.
Collegiate Learning Assessment	Cohort of freshman and graduating seniors on a yearly basis.	Targeted samples of qualifying students sent g-mail invitations.	Cross-sectional data collected on performance and analytical tasks.
Course Embedded Assessment (See Tables)	Beginning cohort of first time, full time freshman who were initially given pretest. Students in key core curriculum courses wherein course enhancement has occurred.	Select courses imbedded assessment in courses. Invitations to students in beginning cohorts to test in Testing Services office after taking key courses.	Growth data collected across content areas.
Administer QEP surveys	Students, faculty and graduate TA staff.	Focus groups and on-line forums.	Continuous improvement of QEP mission.

**Quantitative Literacy Goal:** UTSA students will develop basic quantitative literacy and numeracy skills.

**Table 3. Summary of Learning Outcomes, Assessments and Criteria**

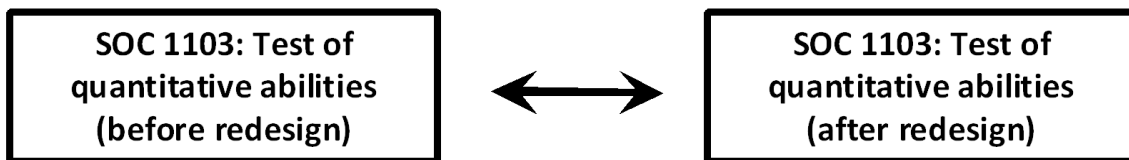
<b>Student Learning Outcome (3-6)</b>	<b>Assessment Method</b>	<b>Criterion</b>	<b>Schedule/ Frequency</b>
Students will be able to understand and interpret data in graphical and tabular form in a variety of contexts.	Assignments and exams will require students to (a) compare and contrast two datasets using graphical and tabular displays (b) determine simple percentages from tabulated data.	70% of students score > 70% on the specified questions.	Data collection will occur in the Fall and Spring of each year.
Students will be able to understand units of measurement and scale and be able to perform conversions and simple dimensional analysis.	Assignments and exams will require students to (a) identify different scales of measurement (b) understand the difference between frequencies and percentages	70% of students score > 80% on the specified questions	Data collection will occur in the Fall and Spring of each year.
Students will be able to construct effective graphical representations of data including line plots, scatter plots, bar charts and pie charts from tabular data using software tools.	Assignments and exams will require students to (a) construct pie charts, bar graphs, histograms and time plots for different datasets. (b) construct a frequency or contingency table based on quantitative or categorical data. (c) determine which graphical procedure is best representative of different types of datasets	70% of students score > 80% on the specified questions.	Data collection will occur in the Fall and Spring of each year.
Student will be able to understand and interpret basic statistical indicators such as mean, median and standard deviation in a variety of contexts.	Assignments and exams will require students to (a) compute measures of location and dispersion from data (b) compare means and standard deviations of two groups to determine the difference between populations (c) determine the most appropriate descriptive measures for quantitative and qualitative data	70% of students score > 80% on the specified questions.	Data collection will occur in the Fall and Spring of each year.
Students will be able to perform back of the envelop calculations to estimate scale and scope and to determine reasonableness and feasibility	Assignments and exams will require students to (a) estimate proportions and rates based on incomplete data (b) predict outcomes of experiments.	70% of students score > 80% on the specified questions.	Data collection will occur in the Fall and Spring of each year.

## Evaluation Methodologies

In order to assess student learning outcomes and measure the success of the QEP, we will use methodology based on Design of Experiment (DoE) originally developed by R.A. Fisher. DoE is a structured, organized method that can be used to determine the relationship between the different factors (Xs) affecting a process and the output of that process (Y). DoE involves designing an experimental setting in which all relevant factors are varied systematically. Analysis of these experiments can identify optimal conditions, factors exerting the largest effects on the results, and those with little or no obvious effects. The DoE methodology also provides insight into the existence of interactions and synergies between factors.

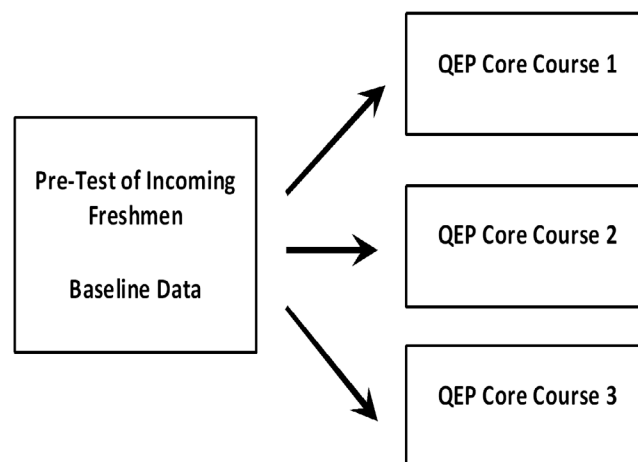
### *Effectiveness of an Individual Course*

In year 1, we will conduct a test of the quantitative abilities of students in specific courses that have been targeted for the QEP. This will provide benchmark data. Students in the redesigned course will be given the same test. The scores can be compared to assess any changes in student learning outcomes. To reduce the effect of confounding factors, the same instructor will be selected.



### *Effectiveness of a Course relative to Baseline Data:*

This would allow comparison of any redesigned course in the Core Curriculum to baseline data from incoming freshmen to assess changes in student learning outcomes.



## Literature Cited

- Baker, S. (2008) *The Numerati*, Houghton Mufflin Co, Boston.
- Burrows, W. (1998) *This New Ocean: A History of the First Space Age*. Random House. NY.
- Carevale, A. and D.M. Desrochers (2001) The Democratization of Mathematics. in *Mathematics and Democracy: The Case for Quantitative Literacy*, Lynn Arthur Steen, ed. (Princeton, NJ: National Council on Education and the Disciplines, 2001), 21–31.
- Cohen, P.C. (2003) Numeracy in Nineteenth-Century America, in: *A History of School Mathematics*, George M. A. Stanic and Jeremy Kilpatrick, eds. (Reston, VA: National Council of Teachers of Mathematics).
- Cohen, P.C. (2001) Democracy and the Numerate Citizen: Quantitative Literacy in Historical Perspective. in *Mathematics and Democracy: The Case for Quantitative Literacy*, Lynn Arthur Steen, ed. (Princeton, NJ: National Council on Education and the Disciplines, 2001), 7–20.
- Colburn, W. (1826) *First Lessons, Or, Intellectual Arithmetic on the Plan of Pestalozzi*, Riverside Press, Cambridge, Mass.
- Colburn, W. (1841) *An Introduction to Algebra upon the Inductive Method of Instruction*, Hilliard, Gray & Co. Boston.
- Colburn, W. (1853) *Arithmetic Upon the Inductive Method of Instruction*. Benjamin B. Mussey & Co. Boston.
- Edson, T. (1856). “Warren Colburn,” *American Journal of Education*, 2: 302.
- Hughes-Hallet, D. (2002) *Calculus, Single Variable*, 3rd Ed., Wiley.
- National Commission on Excellence in Education. (1983) *A Nation at Risk: The Imperative for Educational Reform*. Washington, DC: U.S. Government Printing Office.
- National Commission on Mathematics and Science Teaching for the 21st Century (2000) *Before It's too Late*. Washington, DC: U.S. Department of Education.
- Organization for Economic Cooperation and Development (OECD) Center for Educational Research and Evaluation. 2001. *Education Policy Analysis 2001*. Paris: Organization for Economic Cooperation and Development.
- Steen, L.A. (1988) The Science of Patterns. *Science* 240: 611–16.
- Steen, Lynn Arthur. (1990) Numeracy. *Daedalus* 119: 211– 31.
- Steen, Lynn Arthur. 1992. Does Everybody Need to Study Algebra? *Mathematics Teacher* 85: 258–60.
- Steen, L.A., and S. L. Forman (1995) Mathematics for Work and Life. in *Seventy-Five Years of Progress: Prospects for School Mathematics*, Iris Carl ed., 219–41. Reston, VA: National Council of Teachers of Mathematics.
- Steen, L.A. (1997) Why Numbers Count: Quantitative Literacy for Tomorrow's America. New York, NY: College Entrance Examination Board.
- Steen, Lynn Arthur. 1998. Numeracy: The New Literacy for a Data-Drenched Society. *Educational Leadership* 47: 8–13.
- Steen, Lynn Arthur. 1999. What's the Rush: Algebra for All in Eighth Grade” *Middle Matters* 8: 1–6, 7.
- Steen, L.A. (2000) Reading, Writing, and Numeracy. *Liberal Education* 86: 26–37.
- Talk of the Nation. Public Broadcasting Service (PBS). September 18, 2000. “World Fuel Crisis/ UK Fuel Tax: The Facts.” BBC News, BBC Web page. September 21, 2000.



Quantitative Scholarship: From Literacy to Mastery

# *A QEP for Student Success*