

FE Exam - Continuous Assessment and Continuous Improvement Tool

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Abstract

The Fundamentals of Engineering (FE) Exam is a nationally normalized measurement tool that can be used by the department to assess its graduating seniors. The Petroleum Engineering Department has developed a strategy to use the FE Exam as a tool for ABET assessment to compare petroleum engineering students in Texas and the nation. Comparison is also made between department students and engineering students at TTU, Texas, and the nation. The FE allows tracking (comparison and contrasting) of skill levels in the applied sciences of Chemistry, Computer Science, Mathematics, and Physics, all sciences critical to the successful petroleum engineer. The Geosciences, which are critical to petroleum engineering, are not measured by the FE exam; therefore a different assessment tool is used. The engineering subjects measured by this exam include: Dynamics, Electrical Circuits, Engineering Economics, Ethics, Fluid Mechanics, Material Science, Mechanics of Materials, Statics, and Thermo. Adjustments to the curriculum and individual courses over the last nine years and their cause/effect relationships on the FE are highlighted in the paper.

The College of Engineering also uses a Mock FE Exam as part of the assessment and preparation for the FE Exam. The College of Engineering typically has about 70 percent of graduates complete the FE Exam and usually 90 percent or better passage rate. The Mock FE Exam provides a performance score to accompany the passage rate on the FE. The College is currently developing web-based software tools to automate the assessment and reporting process.

The Petroleum Engineering Department at TTU, as a state-assisted institution, recognizes its responsibility to provide excellent education opportunities for its students. Since experience indicates that prospective students with poor academic records have little chance of successfully completing petroleum engineering degrees at TTU, class rank in high school and SAT-I and ACT scores are used to help predict potential academic performance. Other factors that could predict success in petroleum engineering at TTU are also considered.

Introduction

High quality of programs is one goal for the College of Engineering at Texas Tech University. In addition to having high quality in the areas of our education objectives, we also desire to have breadth in engineering knowledge and skills. While we acknowledge that we do not live in a perfect world, we desire that a high percentage of our students meet our quality standards. Quality goals imply assessment: measurement and comparison of quality indicators to standard or target values. We have elected to use the Fundamentals of Engineering (FE) Exam as one of our measurement tools. The FE Exam is not designed to measure complete knowledge and skills needed to be an engineer. For example, it does not measure the essential skills of oral and written communications. The FE does, however, measure basic knowledge and skills in math, chemistry, physics, and engineering. Because it is given nationally, it is a good index of how our students do in comparison to other students in our state and across the nation.

There are several advantages for using the FE Exam as an assessment tool. One, it has a historical base. Two, it is administered nationally. Three, a summary of performance in subject area is provided. Finally, there is no additional cost to a college or department—many students take the exam as part of the process to become a professional engineer. There is one disadvantage—the results are pass or fail instead of a numerical score. We use a Mock FE Exam administered locally in the college to obtain numerical values. We believe that both processes together provide a useful assessment tool.

Objective

The primary objective of this paper is to report how the College of Engineering uses the FE exam as a nationally normalized assessment tool. Special emphasis will be placed on petroleum engineering as an example program within the College of Engineering. True assessment is not complete or at least has little value unless results from the assessment are fed back into the system to maintain or improve quality. We, therefore, have included comments about how the Petroleum Engineering Department has or intends to use measured outcomes. Because quality of incoming students may affect the quality of the output measures, we have included SAT data as introductory background information. The ultimate goal was to determine if engineering students at Texas Tech University are performing at or above the average of other engineering students on a national scale.

Procedure

Our procedure is simple. The Dean's Office receives a report of who passed or failed and a summary of performance in the major topic areas on the exam. These results occur twice each year. Starting in fall of 1999, the College of Engineering also administers a one-half-day Mock FE Exam two weeks prior to the actual FE Exam. The format of both exams is similar. Students have an opportunity to self assess their probable performance on the FE with the Mock FE. If they detect a weak area of knowledge and skills, they can review in these areas. Students are now required to take the Mock FE as part of our assessment plan. While a performance level is not required at this time for graduation, the process seems to promote a professional engineering culture. We have a high percentage of our graduating class who take the FE Exam. Taking the Mock FE with feedback to the students has also encouraged students to take the FE Exam instead

of not showing up for the FE Exam. The results from the FE Exam have been analyzed as a function of time for this paper.

The College of Engineering typically has about 70 percent of graduates complete the FE Exam and usually 90 percent or better passage rate. The Mock FE Exam provides a performance score to accompany the passage rate on the FE. The College is currently developing web-based software tools to automate the assessment and reporting process.

Results

Comparisons are made between departments at TTU, College of Engineering, Texas, and the nation. The FE allows tracking (comparison and contrasting) of skill levels in the applied sciences of Chemistry, Computer Science, Mathematics, and Physics, all sciences critical to the successful petroleum engineer. The Geosciences, which are critical to petroleum engineering, are not measured by the FE exam; therefore a different assessment tool is used. The engineering subjects measured by this exam include: Dynamics, Electrical Circuits, Engineering Economics, Ethics, Fluid Mechanics, Material Science, Mechanics of Materials, Statics, and Thermo. Adjustments to the curriculum and individual courses over the last nine years and their cause/effect relationships on the FE are highlighted in this paper.

Background Results

The Petroleum Engineering Department at TTU, as a state-assisted institution, recognizes its responsibility to provide excellent education opportunities for its students. Since experience indicates that prospective students with poor academic records have little chance of successfully completing petroleum engineering degrees at TTU, class rank in high school and SAT-I and ACT scores are used to help predict potential academic performance. Other factors that could predict success in petroleum engineering at TTU are also considered.

- 1) The average composite SAT scores for incoming freshman from 1993 – 2001 is plotted in figure 1. The University, College of Engineering and Department of Petroleum Engineering raised the minimum admission standards from 1995 to 1996, which resulted in a 70 to 90 point increase. The SAT scores for petroleum engineering students (plotted in thick red with diamond markers) have improved over the last nine years from 975 to 1175. This is a 20% improvement. Over the same time frame the College of Engineering (thick light green) and the University (thick yellow) averages have improved 15% (1025 to 1180) and 25% (930 to 1180) respectively.
- 2) The average composite ACT scores for incoming freshman from 1993 – 2001 is plotted in figure 2. The State of Texas prefers to use SAT scores and converts ACT to SAT (composite SAT=44.4*composite ACT, math SAT=22.2* math ACT, English SAT=22.2* English ACT). Small changes in ACT are more difficult to detect from year to year as indicated by figure 2.
- 3) The average class rank in high school for incoming freshman from 1993 – 2001 is plotted in figure 3. The Petroleum Department Scholarship committee has used this and high school grade point average in conjunction with SAT and ACT to award scholarships to incoming freshman. The committee has raised its standards over the last three years.

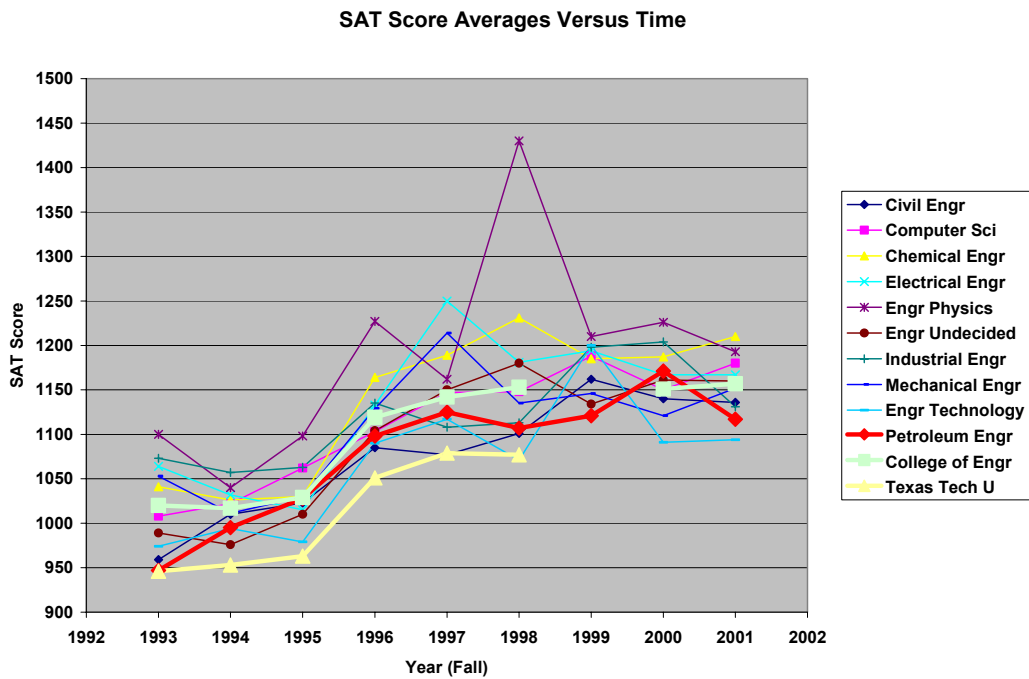


Figure 1 SAT Score Averages Versus Time

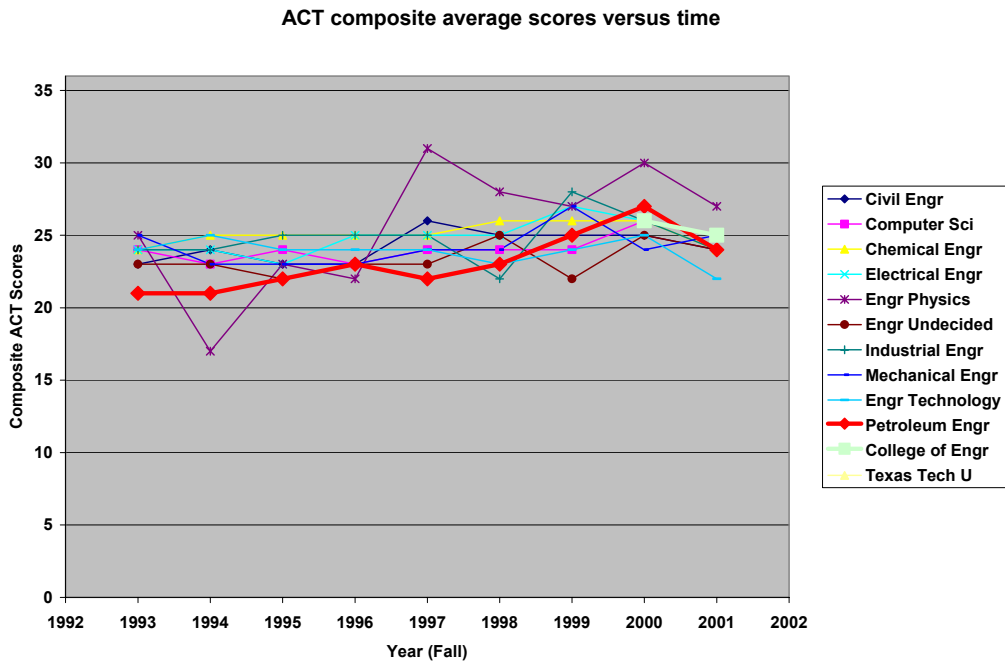


Figure 2 ACT composite average scores versus time

Results on FE

The FE exam subject distribution was changed between 1996 and 1997. Questions in the subject of computers were reported separately, additionally discipline specific afternoon sessions were introduced. Petroleum Engineers take the general afternoon session, as there is not petroleum engineering specific session.

- Figure 4 is a plot of Fundamentals of Engineering (FE) pass rate from 1993 – 2001. The solid red, blue and yellow curves are Petroleum Engineering at respectively TTU, the State of Texas, and in the nation. The dashed red, blue and yellow curves are engineering at respectively TTU, the State of Texas and in the nation. (The same legend will be used to simplify discussion on most of the next curves) Over the last nine years the Department of Petroleum Engineering at TTU has been the top performer except during the 1996-1998 period. From 1993 to 1995.5 department students self selected taking the FE and their pass rate was almost perfect. In 1996 the faculty strongly encouraged students to take the test during their senior year. The pass rate slipped to 60%. Over the last five years, the department conducted progressively improved review classes and the pass rate has average 90% the last 2.5 years. Also of note over the last five years is that the scores in the fall exam are lower than the spring exam. A possible explanation maybe that there is an extra month to prepare for the exam in the spring over the fall.

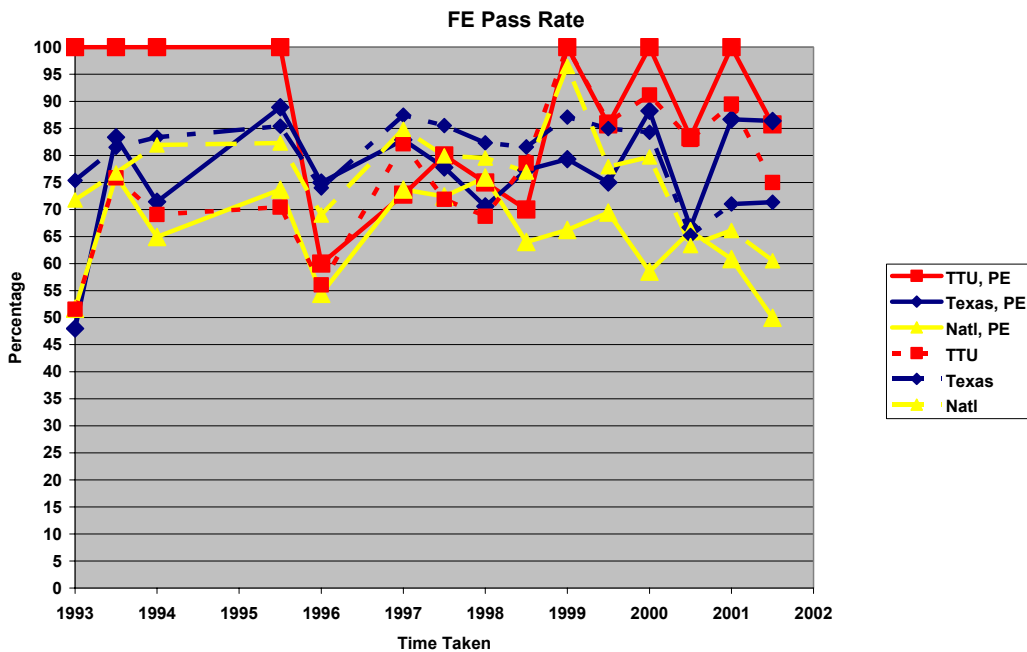


Figure 4 FE Pass Rate

- 2) Figure 5 shows in red the same FE pass rate for TTU Petroleum Engineering as in Figure 4. The blue curve (and dotted blue linear curve fit) indicate the number of TTU Petroleum Engineering Students passing the FE divided by the number of students graduating that half year. The effects of faculty encouragement to take and pass the FE and the review classes can be seen. The linear curve fit shows an improvement from 22% to 100% over nine years. The department target is to have 95% of its students graduating to pass the FE.

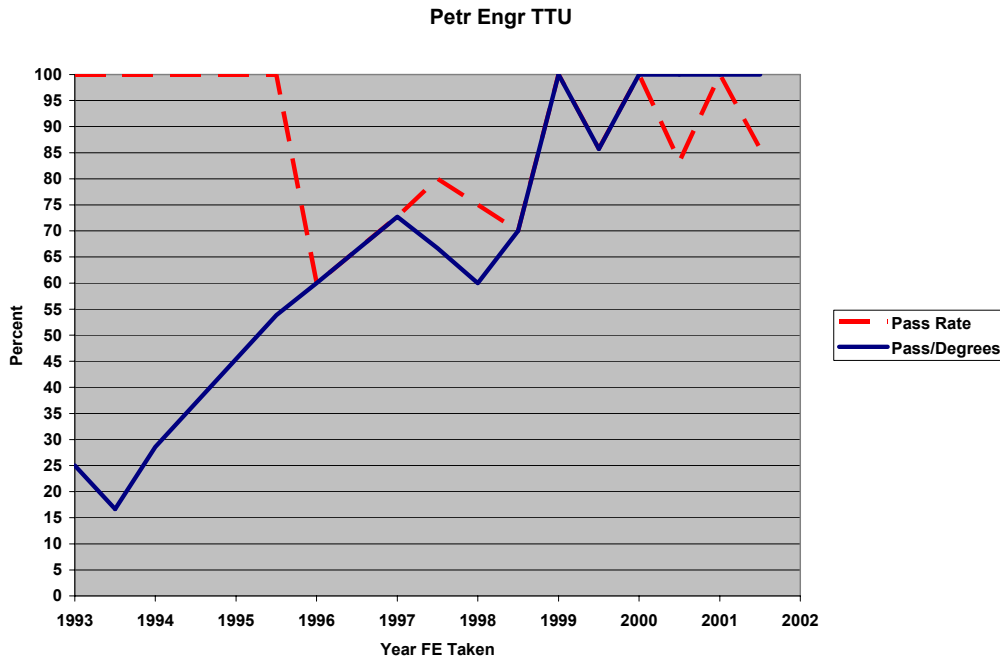


Figure 5 Petroleum Engineering FE Pass Rate

- 3) Figure 6 shows Chemistry scores have improved from 45% to 65% from 1993 to 2001. TTU petroleum engineers' performance in chemistry is slightly ahead of its competitors in Texas and the nation. During this time frame the college engineering, during freshman orientation, piloted a chemistry placement test. Dr. Heinze, the petroleum engineering undergraduate advisor, played a key role in both the chemistry and math assessment pilot tests. As a result students are more successful in freshman chemistry (C or better grade has improved from 35% to 77%). The chemistry department has made placement, as determined by the assessment test, mandatory for the entire university and agreed to administer the test removing the burden from the college of engineering. The department curriculum committee reported that at TTU's college of engineering only the departments of Civil, Chemical, Industrial and Petroleum engineering require more the first semester of Chemistry. Figure 6, a plot of all TTU FE exam participants Chemistry results, indicates improvement from 47% to 65% over the last nine years. The curriculum committee recommended dropping the second Chemistry, as only thermodynamics are needed from CHEM 1308, from future Petroleum Engineering requirements and adding Petroleum Thermo to PETR 2302 (Properties of Petroleum Fluids). Comparing FE exam Chemistry scores over the next few years will show the results of this action.

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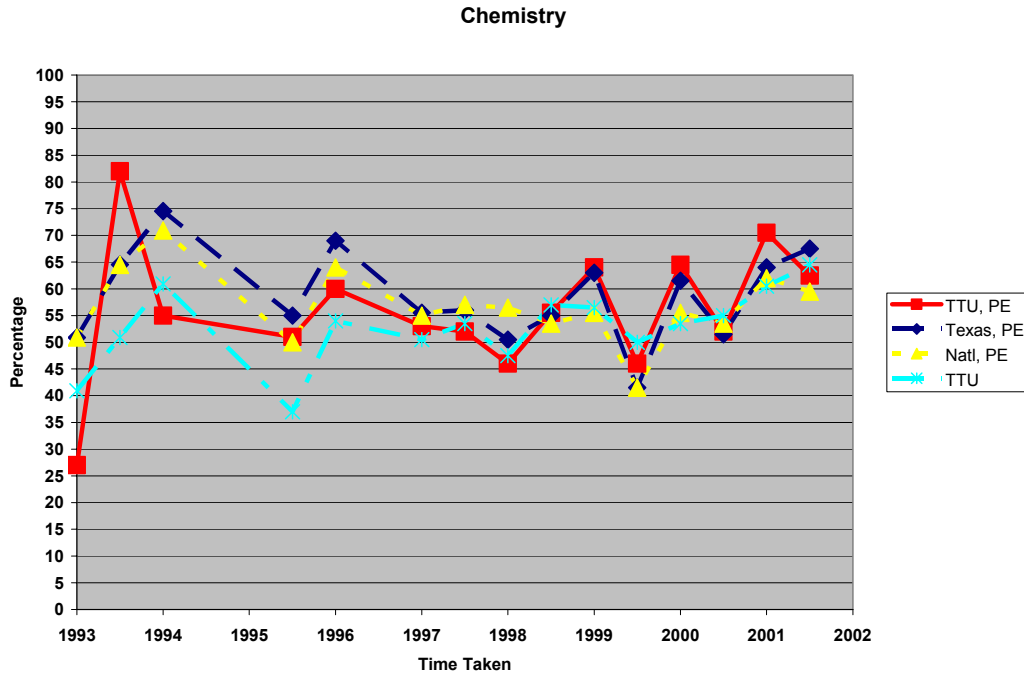


Figure 6 Chemistry Petroleum Engineering Students

- 4) Figure 7 shows Computer scores have dropped slightly from 60% to 58%. Computer scores have only been reported separately on the FE since 1997. It should be noted that the FE content of the computer session changed in Spring 2001. Less emphasis is now placed on programming languages and more emphasis on logic and software usage. This is the direction the petroleum engineering department moved in 1997. The departments Spring 2001 scores improved to 77%. A department goal of 65% on the computer questions is targeted.
- 5) Figure 8 plots Dynamics, which has dropped from 53% to 48% over the last twelve FE exams. The same trend is observed for PE's in Texas and nationally. The dynamics target is 50%.

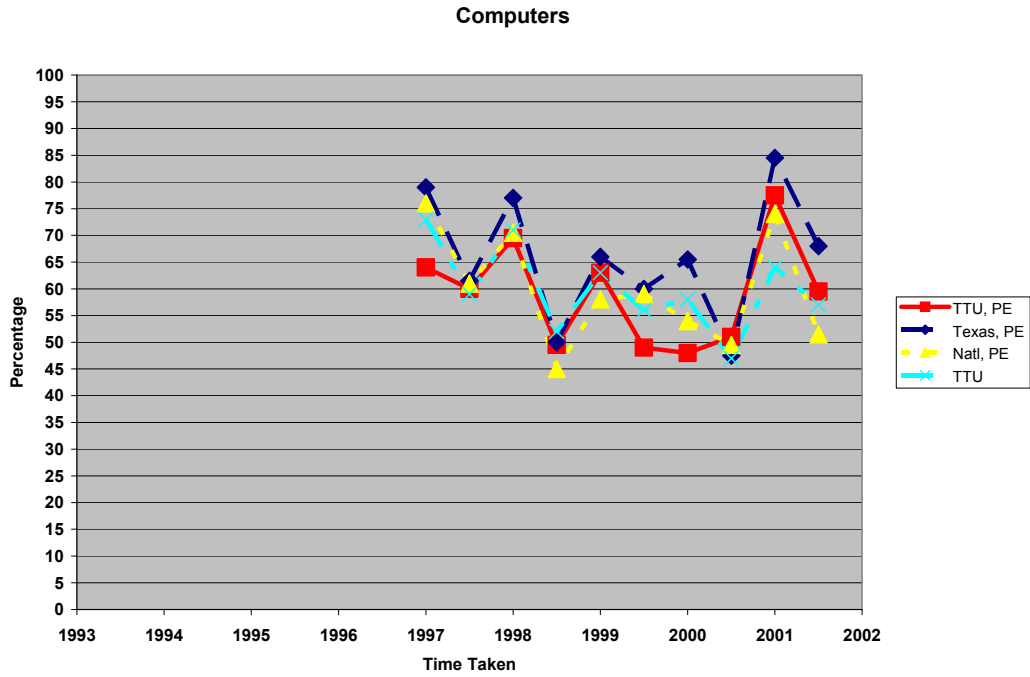


Figure 7 Computers

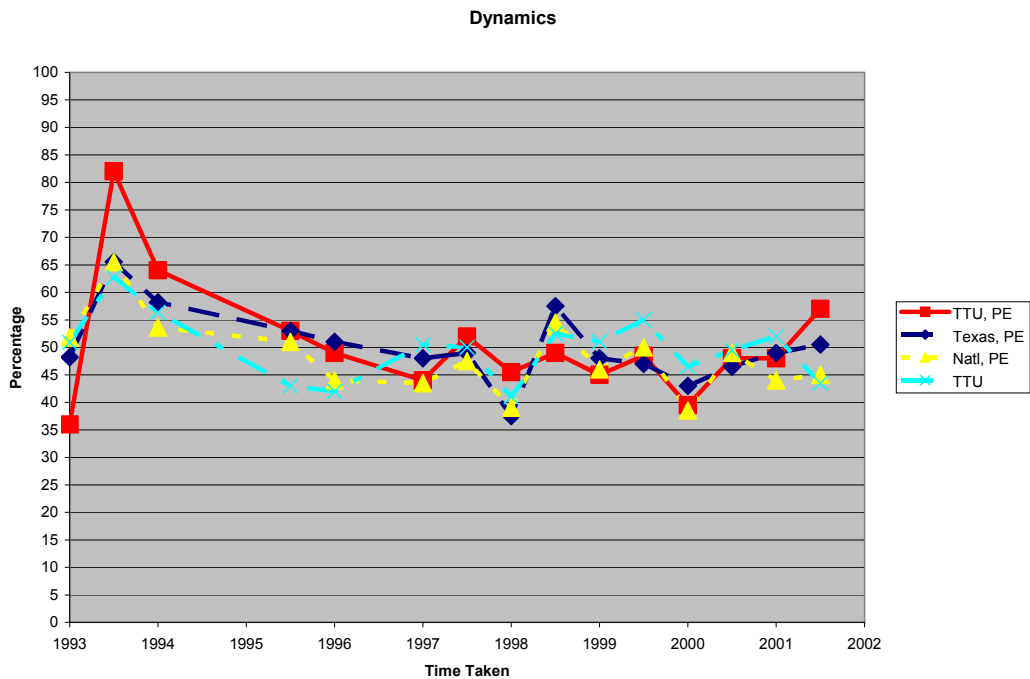


Figure 8 Dynamics

- 6) Figure 9 indicates Electric Circuits has improved from 37% to 48% in the last nine years. TTU PE's are doing better than Texas and national PE's. The curriculum committee has recommended dropping the EE 2304 course from the curriculum as only three weeks of the course content covers basic DC circuits. This material is also covered in Physics. Comparing FE exam Electric Circuits scores over the next few years will show the results of this action.

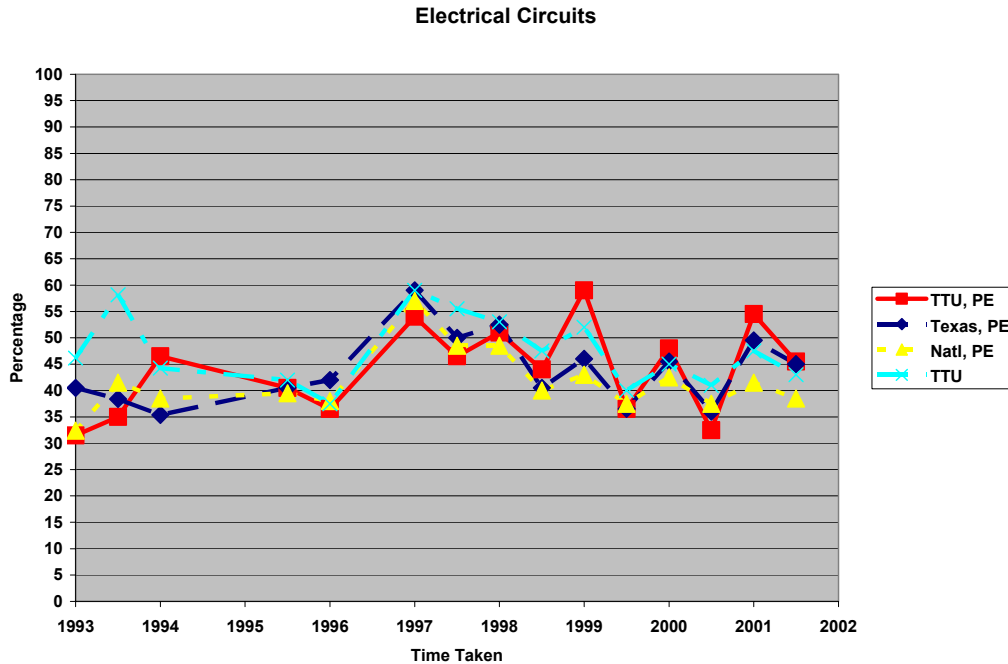


Figure 9 Electrical Circuits

- 7) Figure 10 plots Engineering Economics, which has improved slightly from 61 to 63% over the nine years. PE's in Texas and nationally are not doing as well in economic as TTU. Goal is 65%.

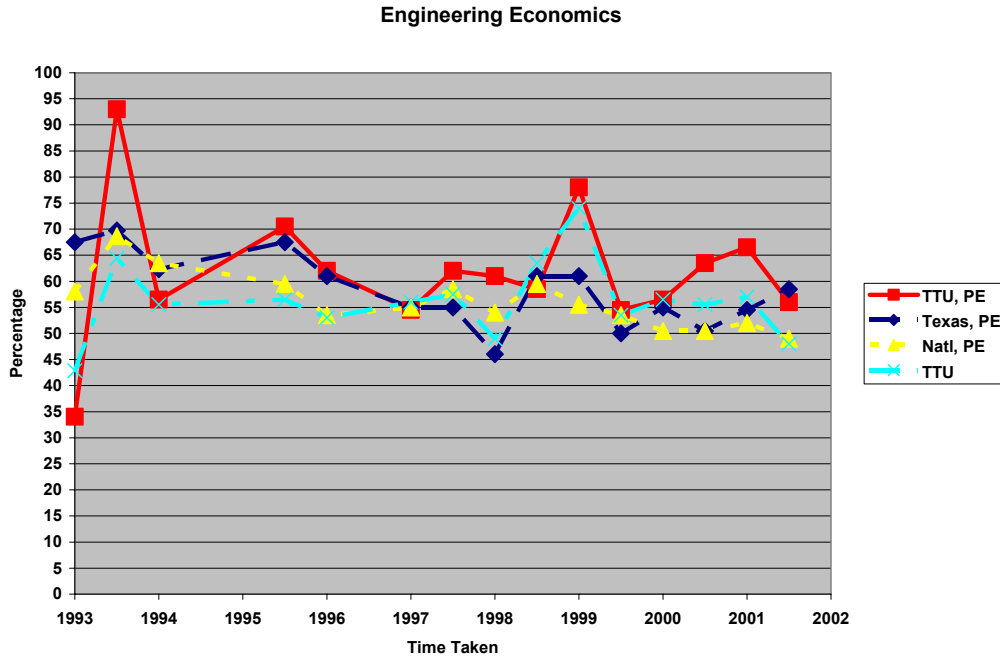


Figure 10 Engineering Economics

8) Figure 11 shows Engineering Ethics. TTU has improved from 69 to 83%. Ethics was first report separately on the FE in 1997. This last year TTU has been better than the other PE's. Target is 75%.

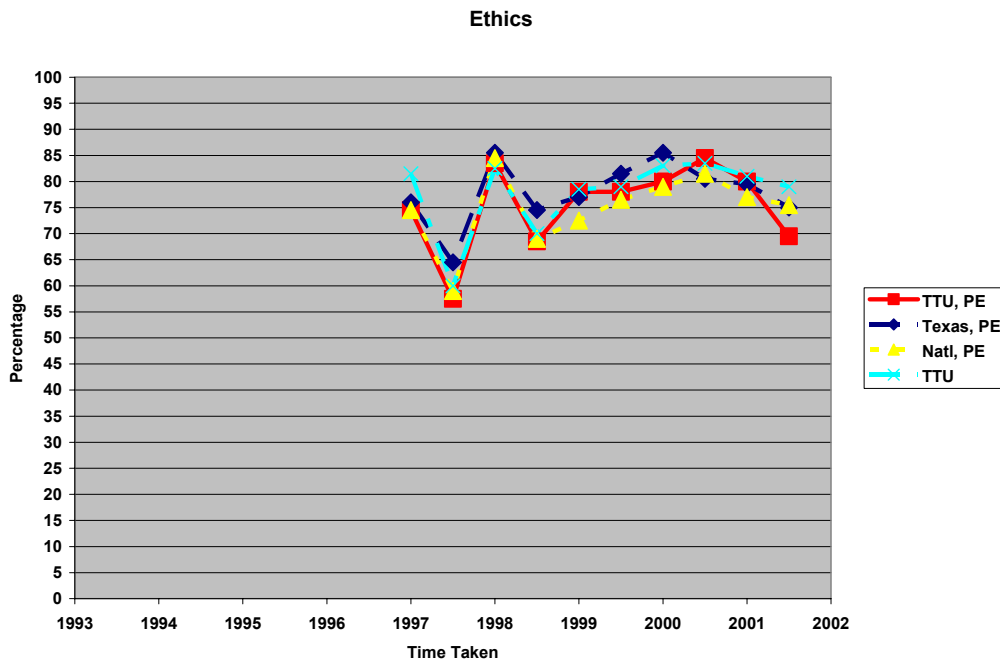


Figure 11 Ethics

- 9) Figure 12, Fluid Mechanics, TTU has been consistently scoring 57% and consistently above the other PE's. Target is to improve to 60%.

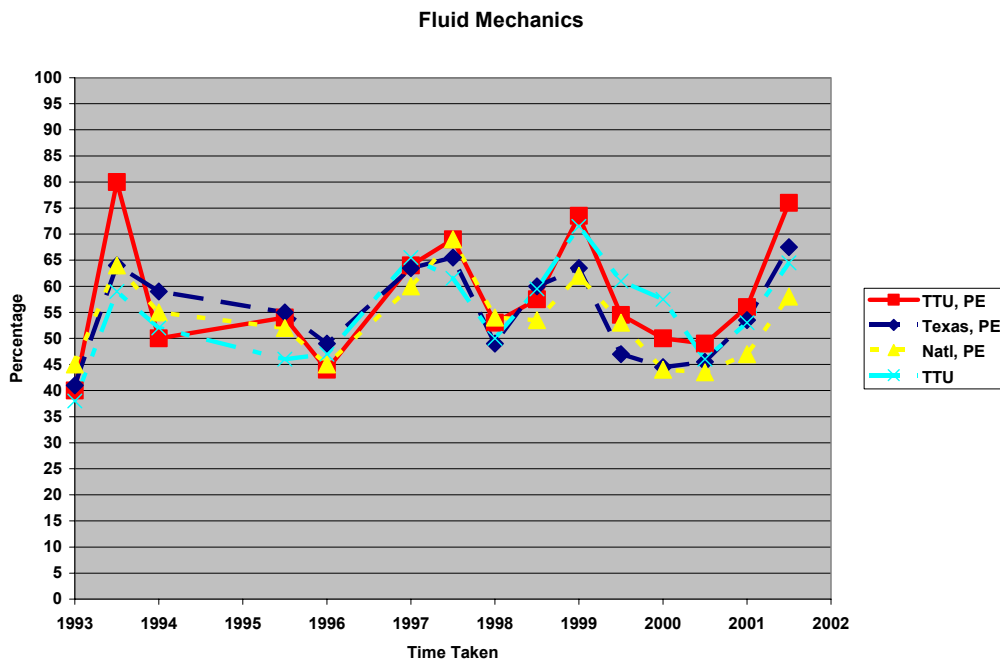


Figure 12 Fluid Mechanics

- 10) Figure 13, Material Science / Strength of Materials, TTU has improved from 37 to 60% in the last nine years. Goal is to maintain 60%.

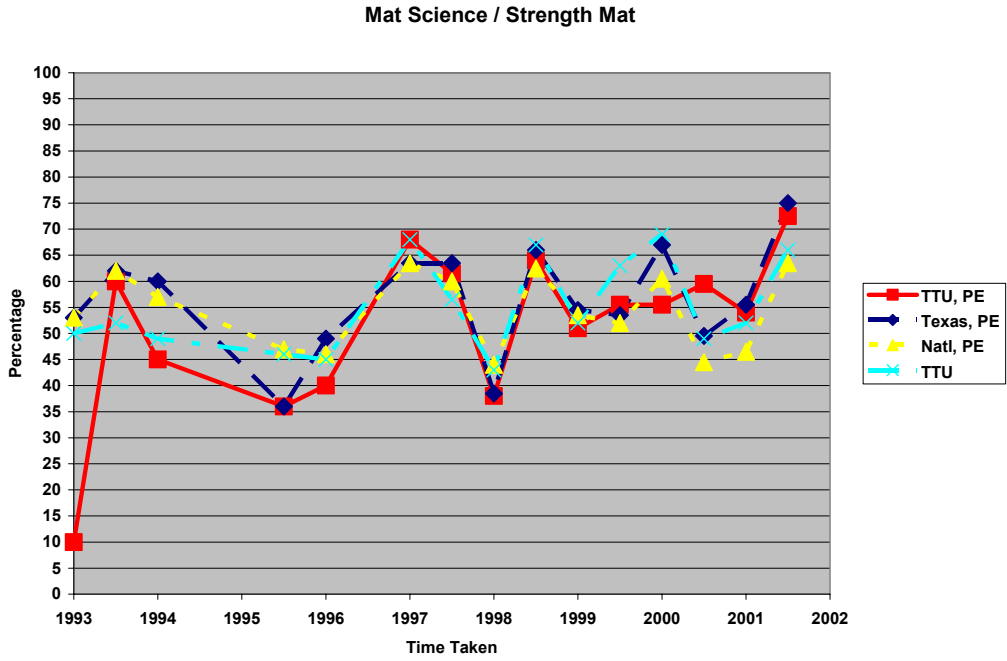


Figure 13 Material Science

11) Figure 14, Math, TTU has improved from 50 to 60 % over the last twelve tests. Target is to maintain 60%.

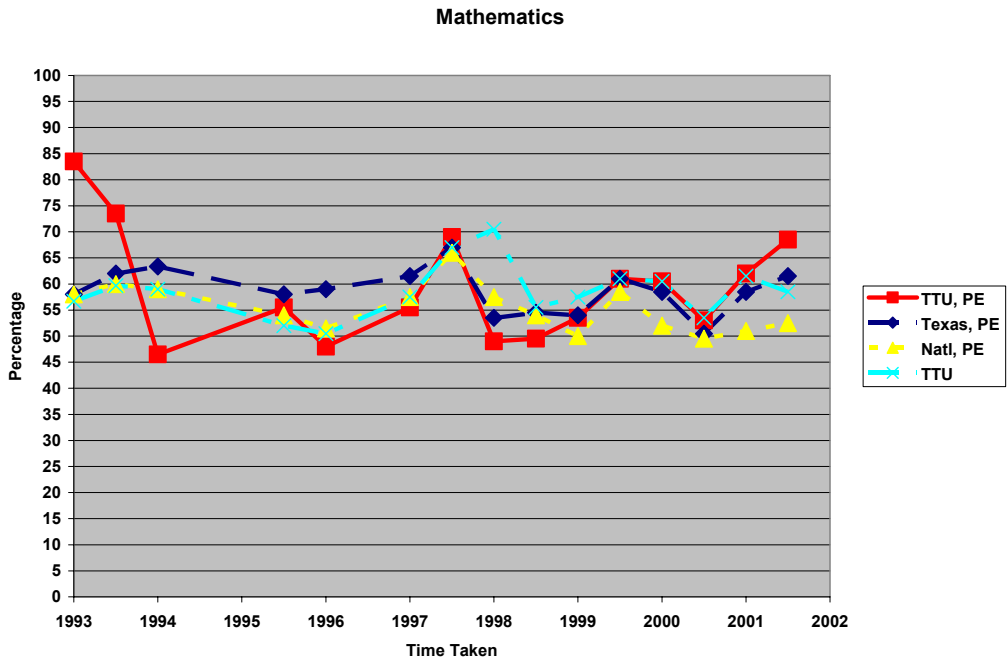


Figure 14 Mathematics

- 12) Figure 15, Mechanics of Material, TTU has improved from 32 to 38 over the last 5.5 years. On the Spring 2001 test department students achieved 50%. Target is to maintain 60%.

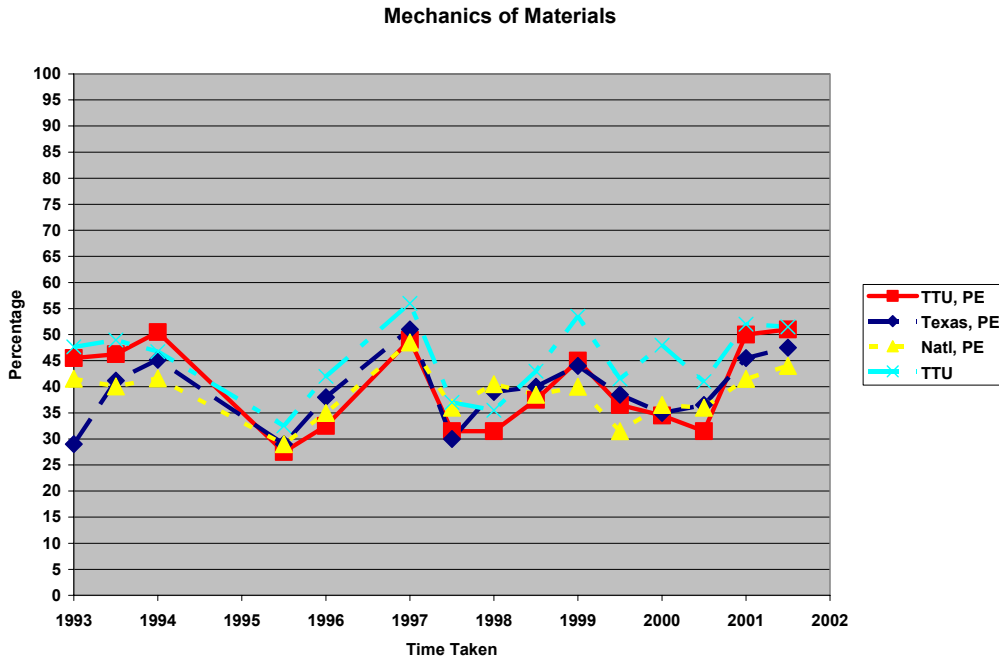


Figure 15 Mechanics of Materials

- 13) Figure 16, Statics, is disappointing. TTU has dropped over the last nine years from 63 to 44%. Statics is taken during the third semester and is the first engineering science course. This course has been changed to include a homework discussion session with the three lectures hours per week. FE results over the next two years should indicate this change in course presentation has improved the department student's scores. The curriculum committee is closely monitoring this issue and has investigated moving from Civil Engineering 2301 to Mechanical Engineering 24xx. It is also noted that PE's in Texas and nationally have experienced this reduced performance. Target is to bring back up to 60%.

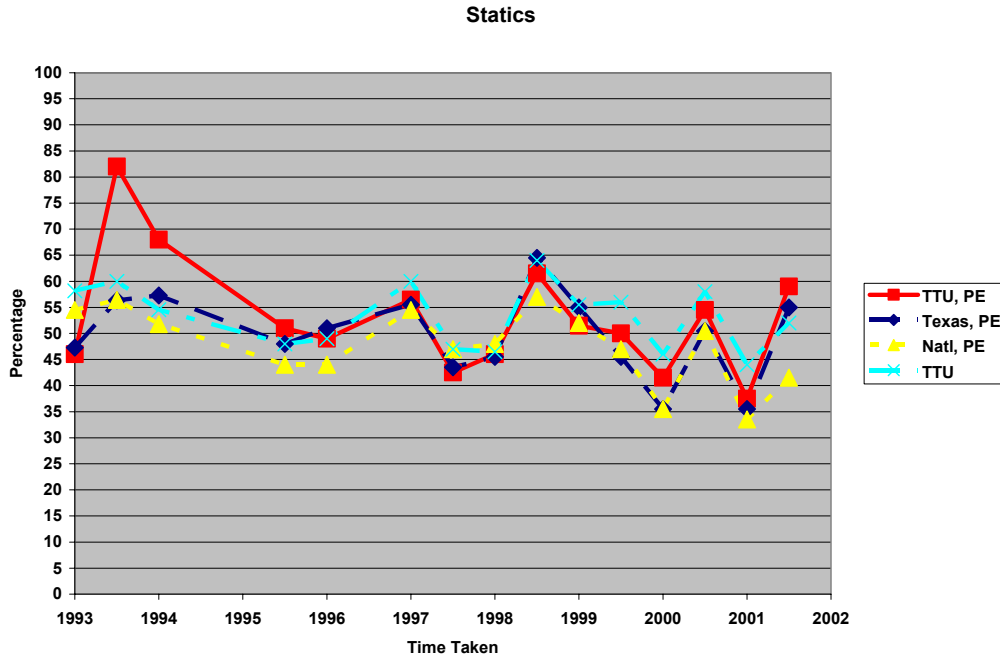


Figure 16 Statics

Conclusions

At least four conclusions can be made at this time from these results. First, student performance on the FE exam appears to be a reasonable and useful measure of engineering knowledge and skills. Second, we conclude that Texas Tech students have above average performance and that our engineering education system is sound. Third, we noticed that the trends for our students tend to follow the trends of the nation, which probably reflects variations of tests questions each year. Finally, we have observed increases in input quality of students as measured by SAT and ACT scores and we have seen an increase in our performance on the FE exam over time. The shape of these trend lines is not necessarily related.

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