ASEE's 123rd Annual • Conference & Exposition • New Orleans, LA • June 26-29, 2016

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Paper ID #16362

An Academic Program Assessment Methodology to Leverage the Integrated Higher Education Environment Created by the Complete College Tennessee Act (CCTA)

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Abstract:

During the analysis of a course revitalization initiative to improve course effectiveness (student success) and efficiency (per student cost of classes) in College of Engineering gateway classes at Tennessee Tech University, it became apparent that the higher education environment, which includes the institutional mission and resources to sustain the mission, has a major effect on instructional effectiveness and efficiency. The problem of assessment in this environment is exacerbated when distinguishable student partitions are not included in the analysis.

The analysis established a critical need for a platform to administer the integrated higher education environment created by the *Complete College Tennessee Act*. W. Edwards Deming's *System of Profound Knowledge* is proposed as the basis for that effort. In addition, the *System of Profound Knowledge* may be a platform for strategic planning and continuous improvement across colleges, departments, and academic degree programs.

Background

The Tennessee Public Agenda focus is on increasing statewide educational attainment by implementing *Tennessee's Complete College Tennessee Act* (*CCTA*), enacted in 2010. ("Complete College TN Act of 2010") *CCTA* also acknowledges limitations on state funding for higher education. The Agenda reflects the importance of the state's educational system for leveraging economic development. Specific *CCTA* provisions include establishing:

- Higher education funding, in part, based on outcomes that include degree production, research funding, student remediation, transfer and graduation rates, and job placements. Each institution has uniquely weighted outcomes that reinforce mission and Carnegie classification. The funding formula also rewards institutional efficiency, reduces program duplication, and leverages workforce development in Tennessee.
- Community colleges, as the educational system centerpiece, with expanded common programs for consistency and quality across these institutions. In addition, beginning in fiscal year 2012, remedial and developmental education will be administered only by community colleges.
- A transfer policy that enables anyone who earns a two-year community college degree to enroll as a junior in a four-year university. The 41 credit hours of general education core and 19 credit hours of pre-major courses for selected baccalaureate degree majors (history, agriculture, civil engineering, psychology, etc.) offered by the community college enable a student to transfer with 60 credit hours necessary for junior standing.

- Establish dual-admission/enrollment policies for *Tennessee Board of Regents (TBR*) and *University of Tennessee* (*UT*) institutions. To facilitate university transfer, the community college and university may concurrently admit students who meet admission requirements for both institutions. These students may simultaneously enroll in classes offered by either institution and receive advising and student services from both.

In effect, *CCTA* organized public higher education institutions into an integrated higher education system to enhance cooperation between *TBR* colleges and universities and *UT* institutions. As part of the *CCTA* implementation strategy, the *Tennessee Higher Education Commission* (*THEC*) approved institutional mission profiles that differentiate academic degree program specialties, degree levels, and mix of undergraduate and graduate programs used in Carnegie Classifications.

The recently initiated *Tennessee's Drive to 55 Alliance* engages private sector partners, leaders, and non-profits to support the state's initiative of 55 percent of Tennesseans with a college degree, associate degree, or certificate by year 2025. To support the initiative, *Tennessee Promise* funds college tuition and fees not covered by Pell Grants, *HOPE* Scholarship, or the Tennessee Student Assistance Award Program (*TSAA*). Of the state's 74,000 high school graduates in year 2015, 58,000 applied for *Tennessee Promise* support to attend one of the 13 community colleges or 27 colleges of applied technology. ("Haslam Postsecondary Education Initiatives Showing Success," 2015)

Higher Education System

Concepts of reinventing government as a customer driven service began in the 1990's. The common thread originates from the quality movement proposed by W. Edwards Deming. He proposed the management of integrated systems as the basis for quality in any production system. Deming formalized the approach into a *System of Profound Knowledge* (*SPK*). The success of Deming's approach is demonstrated in his work to assist with rebuilding Japan's post World War II economy. (The Deming Institute, 2015) An *SPK* to develop the *CCTA, Tennessee Promise,* and *Tennessee Reconnect* into an integrated higher education system may be characterized as:

- ***An appreciation of a system***: A systems approach enables higher education stakeholders to view the higher education environment as internal and external interrelated educational component subsystems.
- ***The theory of knowledge (TOK)***: Stakeholders must test opinions, theories, hypotheses, and beliefs on dynamics of the system against data to understand institutional and student relationships and determine changes necessary to achieve increases in the number of college degrees, associate degrees, and certifications awarded. These theories must be developed, applied, and tested to advance knowledge of higher education in a systematic fashion.
- ***A knowledge of variation***: In the analysis of higher education subsystems, the two sources of statistical variations are common and special cause. Common cause variations are usually predictable. Special cause variations represent unique events outside the system and therefore unpredictable. Methods for distinguishing sources and understanding causes of

variation in system performance data, as well as predicting behavior, are essential for testing knowledge of higher education.

- ***A knowledge of psychology***: The principle of the organization is the understanding that people are motivated primarily by intrinsic needs, including pride in workmanship and working with others to achieve system outcomes. These values are reflected in *TBR* institutions.

CCTA created an integrated higher education system that leveraged the goal of *Tennessee Promise* to increase system enrollment in an environment with diverse academic student profiles. Because *TBR* administers all community colleges and Tennessee's 4-year universities (excluding those in the University of Tennessee System), *CCTA* was a logical step to create a seamless Tennessee higher education system. *TBR*'s role is to ensure efficient *Student Transition Paths* between all community colleges and 4-year institutions that affect an increase in the number of degrees and certificates awarded. Since enacting CCTA, community college and 4-year university faculty have developed pathway agreements to formalize transfer requirements.

State funded tuition for roughly half of the *CCTA* prescribed academic experience is a significant financial incentive for students to enter the system via a community college. Where students enter the system has a dramatic effect on subsystem resource allocation requirements. Embedded issues are capacity requirements for community colleges and universities to provide advising as well as academic programs for these students.

Tennessee's Governor recently proposed removing the 4-years universities from *TBR* jurisdiction and creating boards to govern each institution. Without additional information on administrative authority for CCTA, future success of an integrated higher education system becomes more uncertain. For now, *CCTA* and *Tennessee Promise* are the basis for a well-defined higher education system; however, as discussed in following sections, there are major implementation issues, especially in engineering disciplines.

The admission criteria for the College of Engineering (*COE*) at Tennessee Tech University (*TTU*) reflect the signature of graduating well prepared engineers for regional companies. Criteria for freshmen entering directly from high school are a 3.0 high school *GPA*, a 20 *ACT* composite, and a 22 *ACT* Math sub-score. *COMPASS* exam scores are used in lieu of the *ACT* requirements for freshmen 21 years of age or older. Admission criteria for international students are a high school diploma, demonstrated language proficiency, and an *ACT* Math sub-score (usually via the *ACT COMPASS*) of 19. Transfer student requirements are a 2.0 composite *GPA*, a 2.0 *GPA* in the last full-time semester, and a *C* or higher in a pre-calculus mathematics course.

Approximately 65% of *TTU* students are from the 14 surrounding counties and most transfer students are from four community colleges. Tennessee State in Nashville, the only other engineering college in the area, serves a different region. Therefore, from a *TTU* perspective, higher education may be viewed as a regional system with a scalable *SPK*.

The engineering accreditation body, *Accreditation Board for Engineering and Technology* (*ABET*) and university accreditation body, *Southern Association of Colleges and Schools Commission on Colleges* (*SACSCOC*) adopted the systems approach to accreditation with varying levels of success. In both instances, emphasis is on performance metrics for graduates and cursory consideration for entering students. A major concern of research-intensive universities with the initial draft of *ABET 2000* was a one size fits all accreditation strategy imposed excessive constraints on academic programs with a well-funded research agenda.

The roots of institutional research are to support accreditation efforts. Most institutional research activity is to produce descriptive metrics. Because *SPK* focuses on cause and effect, that approach for administering academic degree programs requires a paradigm shift in institutional research from descriptive statistics to include inferential statistical methods to assess predictor relationships for student success.

The S*hewhart Cycle*, developed by Walter Shewhart at Bell Laboratories during the 1930s, provides the basis for a statistical quality control approach to administering the higher education system. The objective is to ensure that students are able to, with minimal disruption, migrate between *TTU* and community colleges. For the bi-directional *Student Transition Paths* shown in Figure 1, agreements must eliminate academic program discontinuities by including well-defined community college course outcomes and related performance criteria that ensure academic success for transfer students. Similarly, to reflect a global higher education optimization strategy, *TTU-COE* academic advising must include recommending community college academic programs to students when those programs match their interests and needs.

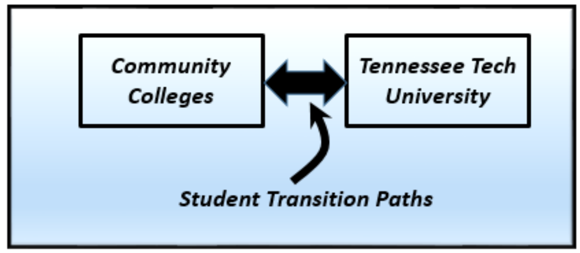


Figure 1: CCTA Systems View

The *Plan-Do-Study-Act* (*PDSA*) of the cycle in Figure 2 describes a systematic process of theory and application of knowledge necessary to administer an *SPK* for higher education performance. Cycle definitions are as follows:

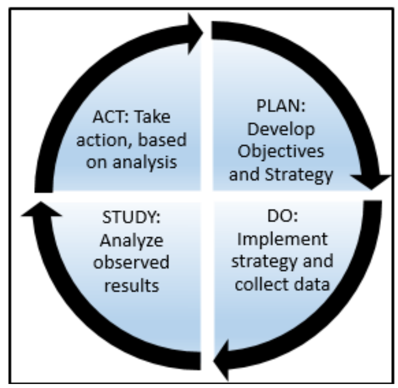


Figure 2: Shewhart PDSA Cycle

- ***Plan:** Configure subsystem changes based on the analysis of System Performance Metrics.*
- ***Do:** Implement subsystem reconfiguration activities to achieve desired performance metrics.*
- ***Study:** Analyze the effects on performance metrics by comparing observed and expected results.*
- ***Act:** Take action based on results of the analysis. If expected metrics were not achieved, initiate the cycle again with different activities. Use what was learned from the analysis to plan improvements.*

The remainder of this paper presents a case study of a *TBR* funded initiative to evaluate the effects of high enrollments classes with a hybrid content delivery method in the *TTU-COE*. The focus of the analysis was preliminary screening of data to determine overall trends in student performance. (Montgomery, Runger, and Huebele, 2011).

TBR Project Environment

CEE 2110 Statics and *CEE 3110 Mechanics of Materials* are engineering mechanics gateway courses for the civil engineering (*CE*) and mechanical engineering (*ME*) curricula in the *COE* at *TTU*. Similar curricular content can be found in every *ABET* accredited *CE* and *ME* program. The instructional model for administering these courses has been a conventional lecture format with extensive outside class assistance to supplement the lecture. This approach is inherently labor intensive and therefore difficult to scale for large sections. Economies of scale, similar to the Carnegie Mellon experience, ("Blended Learning to Boost Capacity of Computer Science Course," 2015) are the primary motivation for implementing the blended learning paradigm.

The project assessed *CEE 2110* and *3110* classes with large enrollments and a hybrid content delivery method that includes a traditional class lecture and interactive topical software. Textbooks for *CEE 2110* and *CEE 3110* are *Statics, 13th Edition* and *Mechanics of Materials 9th Edition,* respectively. The author of both texts is R. C. Hibbeler. The publisher, *Pearson Education*, provides *Mastering Engineering* (PME) as a companion online software system.

A successful implementation enables faculty to administer a more efficient (same level of resources for an increased number of students in the class) and effective course (improve student understanding and retention of the material). Because the minimum acceptable result is that class size does not adversely affect course effectiveness, the analysis focus was course effectiveness.

During spring of 2014, fall 2014, and spring 2015, three experienced faculty members taught five sections of mechanics courses in the PME environment. Two *CEE 2110* sections had combined enrollments of 158 students and two *CEE 3110* sections had combined enrollments of 121 students respectively. A third section of *CEE 3110* had 18 students. Course management for these sections was by a primary instructor as the focal point for student contact and grade assignment. However, these faculty collaborated on content, pace, and selection of assignments for both courses.

During calendar year 2014, 81 of 344 (24%) *CEE 2110* students and 78 of 214 (36%) *CEE 3110* students enrolled in a *PME* administered section. Spring 2015 data is not included in the analysis; however, during that period 77 of 155 (50%) *CEE 2110* students and 61 of 144 (42%) *CEE 3110* students enrolled in *PME* sections. Increases in class enrollments are indicative of improvements in course efficiency.

Best *ACT* composite score was used as a proxy for delineating student profiles. The rationale for composite score was to have a broad-based metric of a student's academic achievement and normalize for variability in high school instruction in mathematics. Indicative of a regional university, *ACT* scores for the *TTU COE* are within the spectrum of University of Tennessee-Knoxville and community colleges profiles.

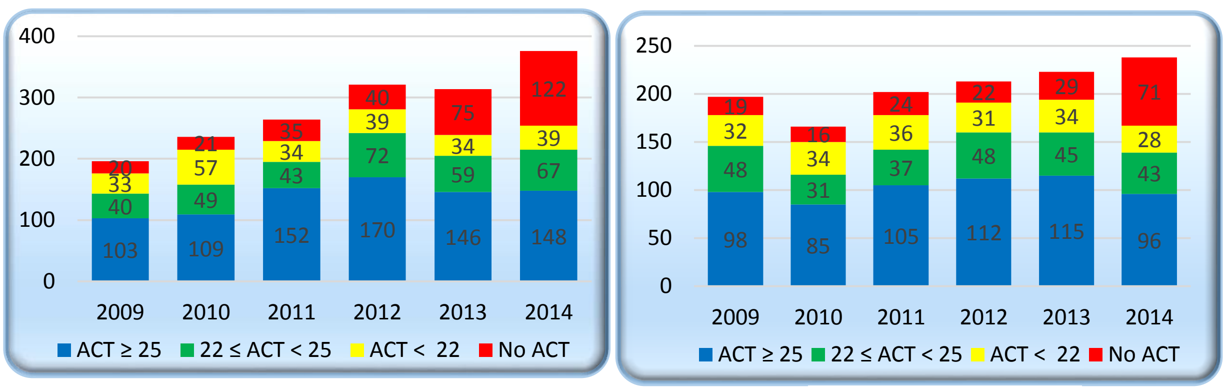
Student population was divided into four mutually exclusive categories based on *ACT* scores. *Category 1* students are *Core Students* with *ACT scores* ≥ 25. For most engineering colleges these students are adequately prepared to begin engineering degree coursework. State flagship institutions typically admit students with *ACT* scores of 25 and above because of their college of engineering mission.

Category 2 students with 22 ≤ *ACT < 25* scores are *TTU Regional Mission Specific* who, with mentoring, should be able to complete engineering degree requirements at *TTU*. *Category 3* students with *ACT < 22* scores are *At-Risk Students* who may have difficulty mastering an engineering curriculum.

Category 4, Unknown-Risk Students, are transfer students who are not required to submit *ACT* test scores and international students without *ACT* scores. Transfer credits are the basis for advising transfer students and placement tests are used for international students. Although the university has rubrics to estimate *ACT* scores for international students, these students were included in the category of students without an *ACT* score.

Project Analysis

To provide visualization of the analysis, data are color coded by category to indicate risk for student success. *Core*, *Regional Mission*, *At-Risk* and *Unknown-Risk* students are represented by Blue, green, yellow, and red respectively.



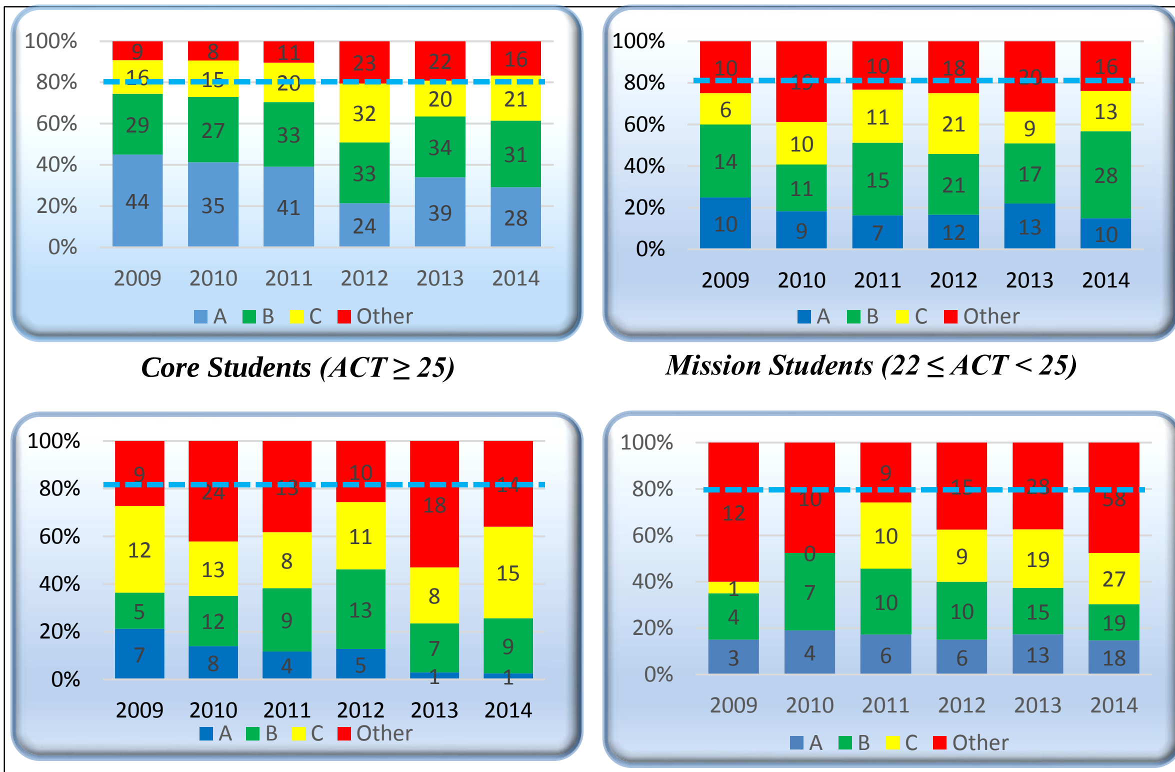
CEE 2110 ***CEE 3110***

Figure 3: Course Enrollment Data

Figure 3 presents total enrollment data for the *CEE 2110* and *CEE 3110.* A portion of the student population repeat a course therefore number of students enrolled includes duplicates within a calendar year. In addition to an increase in *CEE 2110* enrollment, a chi square analysis produced a *p* value of 6.7087E-18 for *ACT* classification categories that confirmed a significant increase in the *CEE 2110* Unknown-Risk category from ten percent to 30% of total enrollment in 2014.

Fewer students enroll in the *CEE 3110* course because of different degree requirements and passing *CEE 2110* is a prerequisite for enrolling in *CEE 3110. CEE 2110* and *CEE 3110* classes were included in the analysis; however, in the interest of brevity, only the *CEE 2110* analysis is presented because of similarities in *CEE 2110* and *CEE 3110* student profiles and grade distributions. The remainder of this section examines project effectiveness.

Charts presented in Figure 4 present *CEE 2110* grades by *ACT* categories. To provide visualization of the distributions, grades are color coded and shown as cumulative percent. Codes are *blue*, *green*, *yellow* and red *to represent A's, B's, C's, and All Other Grades* (primarily *W*, *D*, and *F*) respectively. Frequency counts are also included in each chart.



Core Students (ACT ≥ 25)

Mission Students (22 ≤ ACT < 25)

At-Risk Students (ACT < 22)

Unknown-Risk Students (No ACT)

Figure 4: Grade Distribution by Student Classification Category

Results of a pair-wise chi square analysis of grade distributions for student classifications in Table 1 indicate significant differences in spatial pairing of student categories.

Classification Comparisons	P Value
Core Students (*ACT* ≥ *25*) Mission Students (*22* <= *ACT*< *25*)	7.8005E-07
Mission Students (*22* <= *ACT*< *25*) At Risk Students (*ACT* < *22*)	0.001615887
At Risk Students (*ACT* < *22*) Unknown Risk Students (*No ACT*)	0.087750273

Table 1: Chi Square Pair-wise Classification Analysis

Grade distributions are statistically different for *Category 1* and *2* students. A visual contrast indicates confirms *Category 1* students are marginally more successful than *Category 2* students. Implications are after two years of preparatory math and science, disparity in entering student profiles for *Core* and *Region Mission Specific* students seems to be somewhat mitigated. Historically, the *TTU COE* signature has been producing mid-level engineering capability for regional companies and *Regional Mission Specific* are ideally suited for those positions.

Grade distributions are statistically different for *Category 2* and *3* students. A visual contrast indicates an increase in the percentage of *D/W/F*'s and corresponding reduction in *C* or above grades. *Category 3* and *4* are different for $\alpha = 0.1$ but not $\alpha = 0.05$. Almost half of the students in *At-Risk Students* and *Unknown-Risk* categories earned grades below *C*. In addition, the number of students in the *Category 4* increased from approximately 20 to 122 students between 2009 and 2014. For further analysis, *At-Risk* and *Unknown-Risk* students are considered as a broader category of *at risk* students because of the similar profiles.

The combination of the first two and last two categories appear to have bimodal metrics for course effectiveness. As expected by faculty teaching these classes, there seems to be no adverse effects from the hybrid course format for the first two categories. However, noise in effectiveness measurements seem to reflect systemic higher education issues that include institutional mission and resources to sustain the mission. These issues complicate a meaningful experimental design to assess the effects of academic profiles of students, instructor bias, high enrollment classes, and a hybrid content delivery method.

Systems Analysis

It is insightful to examine the environment in the context of the higher education system in Figure 1. A significant portion of transfer and international students are not making substantive progress toward a university degree. Data indicates that these students are enrolling in math and physics courses as well as *CEE 2110* and *CEE 3110* multiple times. Particularly problematic is that transfer students satisfied community college academic requirements and encounter academic difficulties at *TTU*.

The AY2000-AY2009 degree completion data from the *Education Advisory Board* (*EAB*) Student Success Collaborative indicates that 1,528 students enrolled in *CEE 2110* and 1,427 in *CEE 3110*. Of those students, 47% of the students who earned a (*D*, *W*, or *F*) in *CEE 2110* and 44% of the students enrolled in *CEE 3110* failed to complete engineering degree requirements within six years. Most of these students are in the broader category of *at risk* students.

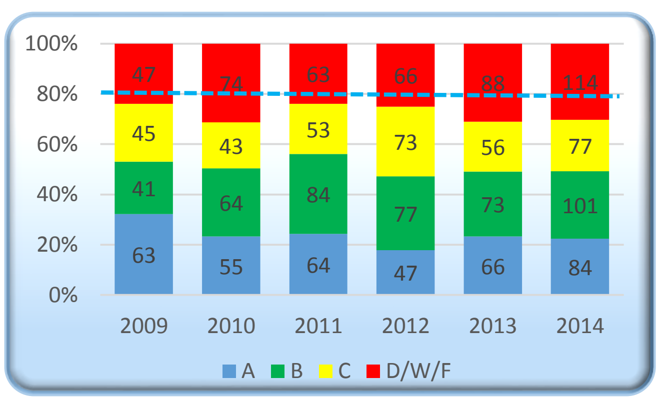


Figure 5: CEE 2110 – Grade Distribution by Year

The university strategy derived from the *CCTA* funding formula is retention of *at risk* students. Published *TTU* retention rate for freshmen cohorts fluctuate between 65 and 70 percent. However, an aggregate rate masks problems that are apparent in mutually exclusive subsets of the student population. As shown in Figure 5, success rates for all students enrolling in *CEE* 2110 are similar to the university's average retention rate. A visually preceived reduction in percentage of *A*'s and increase in *D/W/F*'s is confirmed by a *p* value of 0.01692 for the chi square test. In contrast, 30 - 50 percent of course grades for *Category* 3 and 4 students are a *D*, *W*, or *F*.

Anecdotally, these grade distributions are consistent with introductory courses in other academic programs within the college. The grade distribution profiles for *CEE 2110* are also consistent with the downstream course *CEE 3110* course. Unconfirmed implications are that these perturbations are downstream propagations in all *COE* academic programs.

The design of people intensive systems presents unique constraints. For example, functional requirements are that speed limits should be the speed that the majority of motorists naturally drive because changing the speed limit does not substantially influence average speed. Traffic engineers set speed limits based on the 85^{th} percentile of speed. The 85th percentile heuristic is based on principles that include the assumption that careful and competent actions of a reasonable person should be considered legal.

Justification is that a law cannot be effectively enforced without voluntary compliance of the majority. The 85^{th} percentile heuristic also has roots in the Pareto Principle ("Pareto Principle, 2015"), a common systems engineering metric. Symptoms of problems in an unstable traffic environment are motorist frustration and criticism of police traffic services.

Using the limit on voluntary compliance as C for an acceptable course grade and anything less is noncompliant, a course is unstable when 15 percent of grades are *D, W,* or *F*. As indicated in Figure 5, noncompliance for the most recent years is approximately 30%. The implication is large class sizes coupled with a significant number of low *ACT* scores has created an *at-risk* class environment.

The cumulative effect is *at risk* students engaging in *at risk* behavior in an *at risk* environment. Symptoms of an unstable course are an increased rate of academic dishonesty, poor class attendance, and faculty evaluations indicating students are frustrated by their lack of success.

Faculty are pressured to administer large sections of courses with a disproportionate number of students not academically prepared for the course. To exacerbate the systemic problem, many of these unprepared students move on to upper level courses. This environment may also adversely affect course content and thereby the academic preparation of *Category 1* and *2* students that may not be discernable in high variability grade distributions.

Because a significant portion of the *TTU* revenue stream is state funding and student tuition and fees, ("Wright, D.L. and Deaton, R. 2012") aggressive student recruiting is a common strategy for growing revenue streams. When recruiting causes a shift in student profiles, the shift implicitly redefines the institutional mission (mission drift). In a business context, there are communications problems between marketing and production. A contention of Deming's *Principles of Management* is most barriers to continuous improvement are the result of short-term thinking (the opposite of constancy of purpose). Mission drift is an adjustment to purpose and implicitly dominates continuous improvement. The *ABET* and *SACSCOC* emphasis on an analysis of program graduates is unable to detect subtle shifts in constancy of purpose that may have significant ripple effects.

Systems Design

Based on the above analysis, the conclusion is a critical need for a platform to administer the integrated higher education environment and proposed W. Edwards Deming's *SPK* as the basis for that effort. In addition, the *SPK* may be used as a platform for strategic planning and continuous process improvement across academic degree programs, departments, colleges. From a COE perspective the focus is systemic approach to continuous improvements in ABET accredited curricula that meets academic needs of students from a diverse and time variant student profile.

Without well-defined measurement criteria for course outcomes, developing an effective process improvement strategy for course metrics is problematic. Elizandro, et al. (2011) developed a method for monitoring course stability based on the Pareto Distribution and Bloom's Taxonomy for formulating course outcomes. Heuristics were that the course was stable when 80 % of student grades were *C* or above and the average grade for course outcomes and course grade was *B* for students who made *C* or above on each metric. Rationale for the *B* average was student eligibility for the Hope Scholarship.

Exam grades of (*D, W,* or *F*) were considered nonperforming students. As such, they received individual academic counseling but their performance was not included in the analysis of content and pace of the course. Such an approach provides clarity of expectations to students, enables faculty to communicate course content and grading criteria, and provides a well-defined platform for assessment and program improvements. The approach was critically acclaimed by the *ABET* evaluator in the 2008 exit interview and recommended for other academic programs.

It is critical that the directional *Transition Path* between the university and community colleges in Figure 1 have well-defined processes for efficiently guiding students between institutions and academic programs that match their interests and needs. *TTU-COE* academic advising should reflect a global optimization strategy for higher education. Because *TTU* has a limited number of technology programs, advising may include recommending academic programs at other institutions or community colleges. Processes must also minimize academic program discontinuities between community colleges and *TTU* for transfer students. Although *TBR Pathways Initiatives* ensures students may transfer with the 60 credit hours necessary for junior standing for selected degree programs, absent from the agreement are well defined community college course outcomes and related performance criteria that ensure academic success for transfer students.

Similar to most institutions, the advising strategy for *at risk* students at *TTU* is intervention after the student encounters academic difficulty. The percentage of *at risk* students in the *CEE* 2110 and 3110 satisfies the definition of an epidemic, which is the occurrence of more cases of a disease than would be expected in a community or region during a given time period. In that environment Booy, A.R., et al, suggest vaccination is an early intervention strategy ("Booy, A.R., et al") to reduce the incidence of an epidemic.

An analogous approach is to require *at risk* students to contract with program faculty upon admission, rather than waiting until academic problems occur. The contract outlines a strategy for student success. The implication is that faculty are able to articulate requirements that improve the student's likelihood for success. Monitoring student adherence to the contract enables advisors to recommend academic options that match the student's capability and interests.

Because of the *SPK* focus on causal relationships, process improvement strategies require a paradigm shift in institutional research from descriptive to inferential quality control statistical techniques. Data systems must be available to assess effectiveness of these processes.

Figure 6 presents a template for a systemic approach to improving processes embedded in Figure 2. Recursively, fishbone diagrams formulate improvements in performance measures of resources causing problems. For example, the fishbone diagram is a template for administering the *Shewhart Cycle* to satisfy functional course requirements by coupling course content with course outcomes and outcome metrics based on course exams and laboratory assignments. Closing the loop occurs when results are shared with institutional partners to reduce academic program discontinuities.

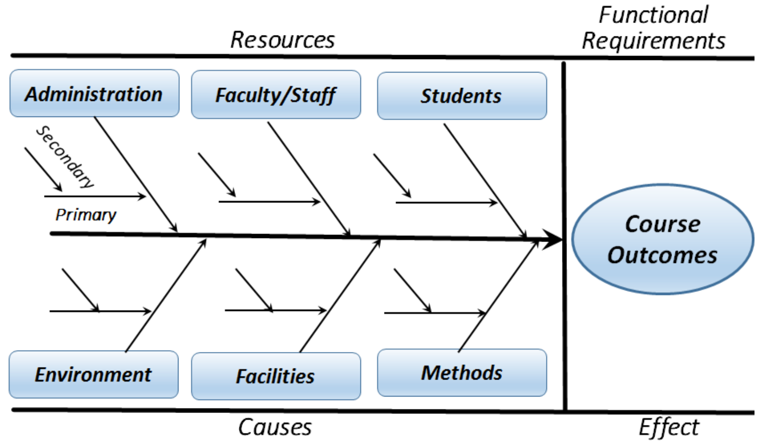


Figure 6: Fishbone Diagram for Administering Process Improvement

When mapping a course environment to the fishbone diagram, faculty, staff, and facilities are production resources. Methods are conversion processes and students are production units. The environment includes all academic support services. *Primary* and *Secondary* problems are impediments to process improvements.

The fishbone diagram may also be the basis for assessing effects of university and *COE* initiatives. In the context of strategic planning as well as continuous process improvement, the issues are resources to achieve well-defined initiatives (functional requirements) and the effects on other systems caused by reallocation of resources.

Conclusions and Recommendations

The analysis to assess effectiveness of the hybrid course delivery system for *CEE 2110* and *CEE 3110* courses indicates no apparent adverse effects on success for *Core* and *Regional Mission Students*. However, identified issues that exceeded the scope of the original project confirmed that almost 50 percent of *At-Risk Students* and *Unknown-Risk students* have significant difficulty in these courses.

Classes for these courses are characterized by *at risk* students engaging in *at risk* behavior in an *at-risk* environment. Symptoms are increased rates of academic dishonesty; poor class attendance, and faculty evaluations that indicate students are frustrated by their lack of success. Faculty are also under pressure to administer large enrollment sections with many students not academically prepared for the course.

At-Risk Students and *Unknown-Risk* students also have difficulty in these classes because of systemic impediments. The *CCTA* structural platform for processing transfer students has been in place for several years but there are persistent implementation issues.

Systems analysis and design for this project focused on administering *TBR Transition Paths*. Critical components of the bi-directional *Transition Path* must be well-developed processes for career path advising; a methodology to minimize academic program discontinuities between institutions; and processes that guide students to academic degree programs and institutions that match their interests and needs.

Retention rates are now an important component of the formula funding. However, retention rates based on the entire student population masks problems that are apparent in subsets of the population. There is also the potential for institutions to focus on a local optimization strategy at the expense of the *CCTA* higher education strategy.

Effects of the proposed dissolution of *TBR* on implementation of *CCTA*'s integrated higher education system is uncertain. However, an *SPK* implementation can be the platform for administering *TBR* defined partnerships. The *SPK* focus is causal relationships between processes requires a paradigm shift in institutional research from descriptive statistics to inferential quality control statistical techniques with data systems to assess effectiveness of processes.

Finally, to address problems caused by institutional mission drift, Deming's *SPK* is a strategy that can be recursively applied to strategic planning and process improvement for the university, college, department, degree programs, and course management.

Acknowledgements
The project was sponsored in part by the Tennessee Board of Regents *Fall 2014 Course Revitalization Initiative*. The authors express gratitude to Brent Cross, Systems Support Specialist with Tennessee Tech University's Enrollment Management, for providing student and course data as the foundation of this report.

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