

The Next Level in TC2K: Continuous Quality Improvement

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Abstract

Many educators in engineering technology are currently working on preparations for their next accreditation visit by the Technology Accreditation Commission (TAC) of the Accreditation Board of Engineering and Technology (ABET). With these visits come a need to understand new evaluation criteria, TC2K; criteria focused on improving the quality of student outcomes.

The TC2K evaluation criteria is a quality based standard that begins with basic quality concepts. This paper gives examples for an MET program of goals and measurable outcomes, along with assessment and evaluation techniques used to assure that constituents are receiving expected outcomes. Most institutions that are working on their TC2K preparation have begun to integrate these basic concepts into their way of operating. However, there is a next level that goes beyond the evaluation and assessment stage that, in many cases, needs further exploration – Continuous Quality Improvement (CQI). Purdue University Calumet (PUC) is one institution that has spent significant time working with its educators and involving them in the processes that have lead to an understanding and application of CQI in their educational environment.

This paper will focus on how this next level in quality improvement (CQI) is instilled into engineering technology programs that seek to satisfy ABET's TC2K criteria. It will begin by exploring what is meant by CQI. Examples will then be shared from the efforts currently underway at Purdue University Calumet. Examples will include unique processes that have been developed to support CQI whether through simple changes in faculty evaluations or a completely new process of course improvement and documentation. Also included will be various ongoing assessment techniques that have produced quality improvement results.

Introduction

As with any efforts to instill quality concepts into an otherwise existing culture comes the need for learning new language and new ways of doing things. Some of the terms that have been evolving in the educational quality culture are terms such as goals, objectives, outcomes and assessment. These terms are frequently used in the new TC2K accreditation criteria. In addition to learning new terms, new ways of doing things must be developed and documented as plans, processes and procedures. These plans, processes and procedures then aid an organization in developing their new quality

culture. Requirements such as this type of documentation are also a basis for the new TC2K criteria.

One problem with following criteria that is focused on creating a quality culture is that it is often difficult to define what needs to be done. This has been one criticism of institutions pursuing accreditation under the TC2K criteria. Over time it has become relatively apparent that an institution must at minimum train its educators in understanding basic quality concepts. Educators must understand who their constituents are and they must be able to document what they are trying to accomplish for those constituents at the various levels within the organization. This means they must be able to properly develop course learning objectives to support the program objectives that support overall departmental, school, and institutional goals and objectives. Further, educators must be educated in assessment methods that will help them ensure that they are meeting those outcomes successfully.

A second issue with the new criteria is that, unlike the old criteria which theoretically allowed educators to gain accreditation and then ignore any efforts towards satisfying constituents until the next accreditation cycle, the new criteria requires that all efforts be on-going. This on-going aspect of the new criteria is the next step in understanding what is expected from this criteria. This on-going nature is a basis in quality cultures that allows for improvements or changes to be made when it is realized that there is a change in constituent need or a change in the environment within which an organization is operating. Under the old TAC/ABET criteria, necessary changes may go unnoticed until the next accreditation cycle at which time the need for data to be collected and evaluated is initiated. In today's rapidly changing world, this delay in the assessment process could be detrimental to an educational program.

What is CQI?

Continuous Quality Improvement (CQI) or Continuous Improvement (CI) is just a label that refers to the mass involvement in making relatively small changes, which are directed towards organizational goals on an ongoing basis. This is not something an organization can be without one day and have the next. CI develops over time, from tentative first attempts and the self-conscious adoption of new ways of doing things, to the point where incremental improvements become an integral part of organizational life¹ thus creating a new organizational culture. This CQI culture has been incorporated into manufacturing organizations over the years under various labels such as Total Quality Management (TQM), Six Sigma, Performance Measurement (PM), Quality Assurance (QA), Lean Manufacturing, among others. No matter what it is labeled, the driver behind the efforts is relatively similar. An organization must start by focusing on their customer and understanding the customer needs, and then they must develop goals and objectives that will steer the organization toward a specific measurable outcome. Next, they must gather data and assess the results to see if the goals and objectives are being achieved and the desired outcomes are being realized. If not, appropriate improvements and adjustments must be made. Also, standardized processes and procedures should be

documented to aid in this effort which should be a continual on-going part of the organizational culture.

Creating a CQI culture at PUC

With the intent of this paper to provide examples for achieving TAC/ABET accreditation under the new TC2K criteria, it might be assumed that the focus of the examples should be on academic programs intending to pursue accreditation. However, fully satisfying TC2K criteria will rarely be possible, or at best very difficult, if the overall institution has not also begun to participate in the transformation to a CQI culture. At Purdue University Calumet (PUC), it is the academic departments that are lagging behind in this culture change. For PUC the initial quality culture change began in 1995. PUC is an autonomous campus however it is part of the larger Purdue University system. Top administration of Purdue University, who reside at the West Lafayette campus, partnered with Motorola, Inc. in 1995 to establish the Excellence 21² program to utilize the principles of continuous improvement and total-quality management at Purdue.

In 1997 PUC's Administrative Service personnel (who include essentially every staff member not in an academic department, including the registrar, admissions, placement, housekeeping, police, computer services, facilities, and maintenance) adopted the Malcolm Baldrige National Quality Award Criteria as its model and road map to developing a quality organization. Thirty administrators were initially trained in quality techniques and many of these have since achieved various levels of ASQ (American Society for Quality) certifications. Due largely to their understanding of quality methodology and techniques, when Indiana was hit with serious budget shortages starting in 2001-02, Administrative Services was able to absorb much of the impact on campus thus sparing academic programs.

The academic areas of the institution began to involve themselves in transforming to this CQI culture when both regional and program level accreditation requirements began to focus in this direction. In 2001 PUC was among the first to adopt the North Central Association of Schools and Colleges (NCA) Academic Quality Improvement Program (AQIP) rather than conventional regional accreditation criteria that was still available at that time. The AQIP model is also patterned after the Malcolm Baldrige National Quality Award criteria. The emphasis with AQIP is on "action projects" showing goals and measurable improvements. Two of the quality projects PUC initiated were to establish a Center for Professional Development and to establish a Student Success Center. Both of these projects heavily involved the campus community and have helped to foster a quality conscious environment across the institution.

CQI in TAC/ABET Accredited Programs: The First Steps

With a strong foundation and CQI culture established across the PUC campus, it would be thought that initiating processes and procedures to support the TC2K criteria in specific programs would be relatively easy. However, it still requires educating all who are involved. At PUC there are three departments which house TAC/ABET accredited

programs; The Department of Electrical and Computer Engineering Technology, the Department of Construction Management Technology, and the Department of Manufacturing Engineering Technologies and Supervision (METS). The focus of this paper will be on the efforts within the METS department. This department includes two non-accredited programs (Organizational Leadership and Supervision as well as Computer Graphics Technology) and two TAC/ABET accredited programs (MET-Mechanical Engineering Technology and IET- Industrial Engineering Technology).

The initial drivers for the METS department to support the change to a CQI culture existed for many reasons. One of the reasons included a change in upper management at PUC with the hiring of a new Chancellor in 2000. This was a significant turning point in the changing of the then established “old” culture prevailing over the campus. It was during this time frame that TC2K criteria (then called ET2K) was being developed and trialed by the TAC commission. This highlights another driver more directly linked to the METS department; the department head at this time was also a TAC/ABET commissioner who therefore understood the significance in the changes of this criteria. He was a driving force that advocated training and education.

One of the first steps in creating a CQI culture is to develop a strategic plan. This should start at the top of the organization and include a mission, vision, goals and objectives. However, because there are so many different levels within an organization it is often confusing as to what “level” those involved should be focusing on. Different goals must be developed for the various levels within an institution. The METS department first began to focus on this task in the fall 2000 semester. At this time, PUC was under the direction of a new chancellor who was in the process of developing a new strategic plan at the university level. Therefore, the effort at the various levels began in parallel making it somewhat difficult at first to clearly link the METS department goals with those at higher levels within the institution.

When performing strategic planning, most people quickly learn that the missions, objectives, and outcomes of all units must be mutually supportive for best success. Figure 1 shows the mission support structure as it exists today at PUC of the METS department programs and courses. Note that this is intended to be a generic figure, and not all units will have all five levels shown, and others may have more. For illustrative purposes you will note in this figure that course MET 461 is a course in the MET program which is a part of the METS department in the School of Technology at PUC.

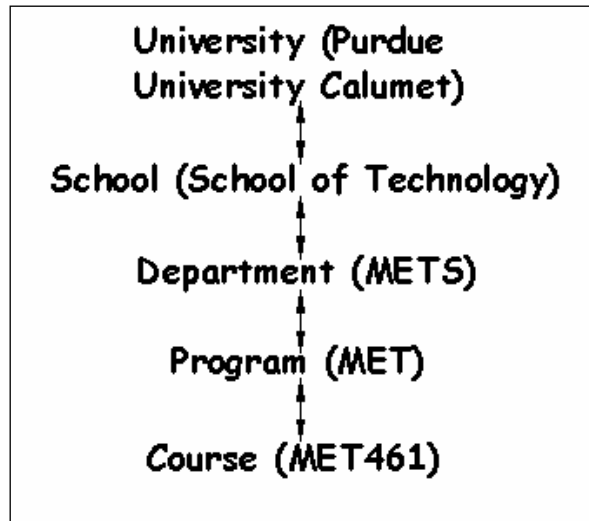


Figure 1 – Mission Support Structure

For programs seeking TAC/ABET accreditation, Criterion 1.a states “Each engineering technology program must have in place: published educational objectives that are consistent with the mission of the institution and applicable ABET criteria,” so the links shown in Figure 1 must be made. An example of this from PUC’s METS Department’s strategic plan is:

METS Department goals:

1. The METS department will maintain a student centered learning environment that helps students develop professionally into the sought after graduates of their respective fields in this region. This supports The School of Technology Goals I and III.
2. The METS department will create, expand, and continuously improve programs relating to the focus of the department. This supports The School of Technology Goal I.
3. The METS department will actively assist faculty growth, development and partnership. This supports the School of Technology Goals II and IV.

As each goal for the department strategic plan was written, it was noted which goal it supported at the school level. During the development of these goals if this link could not be made the goal was questioned, sometimes refocused, but if no link was evident, it was ultimately removed. Each step clearly supports the next level above it.

Once the department strategic plan was in place, each individual program within the METS department had to focus their attention at a more micro level and develop a plan for each individual program. For programs seeking TAC/ABET accreditation this involved gaining an understanding of the TC2K criteria and terminology so that the resulting plans could easily be linked to show how they satisfied the criteria. To accomplish this the METS programs developed missions with supporting objectives. Each objective was then linked to program outcomes (as defined by TC2K terminology) and supported by individual course learning objectives/outcomes. This linkage is shown in Figure 2.

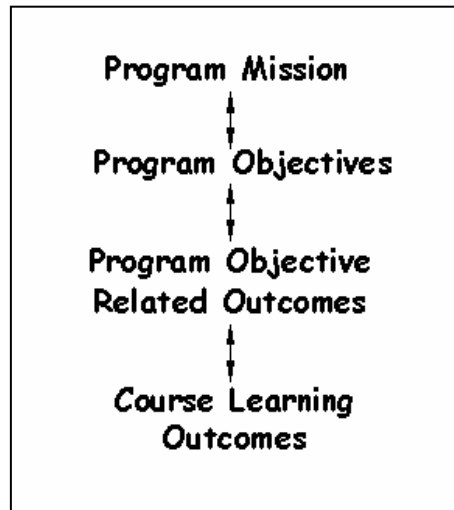


Figure 2 – TAC/ABET Program Support Structure

For the MET program (one of the two METS programs seeking re-accreditation), an example of the resulting three-fold mission is as follows:

The Mechanical Engineering Technology (MET) **program mission** is three-fold:

1. The program will provide a student-centered learning environment where students with mechanical interests and aptitudes learn the mathematical skills, scientific principals, and mechanical engineering technology topics needed to earn associate and bachelor degrees in preparation for a wide variety of careers in related fields.
2. The program will provide training at the individual topic, individual course, and certificate level for individuals interested in learning mechanical engineering technology topics regardless of a traditional degree goal.
3. The program will provide technical assistance in mechanical engineering technology related areas to local businesses.

Note that this mission supports METS Department goals 1 and 2 listed previously.

Moving further down the support structure, one of the MET program educational objectives with a specific linked outcome that supports the MET mission items 1 and 2 above is shown in Table 1 below.

MET Program Educational Objective 1 The Mechanical Engineering Technology program will produce graduates that are prepared for successful careers in the areas associated with the design, installation, manufacturing, testing, evaluation, technical sales, or maintenance of mechanical systems.		
Educational Objective 1 Program Outcomes	ABET Criterion 2: Students and Graduates (a-k)	Assessment Methods
1.1. Students will demonstrate proficiency in mechanical design, materials, manufacturing processes, mechanics, fluids, and heat and power.	a, b, c, d, f	1. Course Embedded 2. CMfgT exam results 3. Senior Projects

Table 1

Note that this outcome not only supports MET Program Educational Objective 1 but it also is linked to five TAC/ABET (a-k) outcomes (a,b,c,d,f) from Criterion 2 Program Outcomes of the 2003 revised TC2K criteria. One step beyond this at the course level, course objectives were created which support the program educational objectives. These objectives can then be assessed by using both subjective input from students as well as objective input obtained through traditional tests, assignments, projects, etc. A specific example of the documented assessment results for course MET461, Computer Integrated Design & Manufacturing is shown in Table 2. This table is the standard format that the METS department instructors have adopted in order to standardize their documentation method for displaying their student learning assessment. Standardization such as this is a necessity for continuous improvement. This is part of a larger course assessment program³.

Programs seeking TAC/ABET accreditation should be prepared to demonstrate links from the lowest course level to the highest university level mission. Obviously this process and linkage cannot be developed “overnight” and must be carefully thought out in order to create a system with repeatable steps that can be used easily by all faculty in an on-going effort. The methods presented here show how the METS Department programs at PUC intend to show compliance between courses, programs, and institutional missions and goals. All of this development and documentation of missions/ goals/ objectives/ outcomes etc. is simply a first step when pursuing accreditation using TC2K criteria. If developed correctly (involving constituents as well as faculty in the process), this documentation will need to be periodically reviewed for update; however the initial time consuming exercise of its development should be a one-time exercise.

Once this first step of developing and documenting the strategic plan is complete, the second step in pursuing accreditation using TC2K criteria can begin. This is the collection, evaluation and assessment of data that relates to measurable results. This is

done at various levels just as the strategic plan development. The bulk of TAC/ABET accreditation criteria focus on assessment at the program and course level. However, there are also requirements for assessment at the department level and some minimal requirements at the institutional level. Assessment techniques are another area that faculty should be trained in so as to develop methods that are sound and useful. The METS department has sent several faculty members to various workshops on assessment and these faculty members have likewise developed mini-training sessions where they have shared their new found knowledge with their colleagues. Over the course of several years various METS faculty have developed and refined the Course Learning Outcomes Assessment document that is shown in Table 2. This has become the media by which all METS faculty document their assessment results at a course level during each academic semester.

Table 2 – Course Learning Outcomes (Objectives) Assessment

MET461 Computer Integrated Design & Manufacturing – Instructor and Student Course Objective Assessment													
Semester: Fall 2002				Instructor: Higley									
Course Objective	Supported Related Outcome and Criterion	Course Embedded Assessment of Student Performance						Student Evaluation (%)					
		Assessment Tool 1	Score (%)	Assessment Tool 2	Score (%)	Assessment Tool 3	Score (%)	E	G	A	P	NA	Composite
1. Explain the use and applications of parametric design.	1.1 Technical Proficiency a,b,c,d,f	Midterm Part 1	82					38	62	0	0	0	4.4
2. Explain the use and applications of finite element analysis (FEA).	1.1 Technical Proficiency a,b,c,d,f	Final Part 1 Questions 1-4	57					38	50	12	0	0	4.3
3. Explain the use and applications of computer aided manufacturing (CAM) systems.	1.1 Technical Proficiency a,b,c,d,f	Final Part 1 Question 5	100					38	50	12	0	0	4.3
4. Explain the integration of all aspects of a product's life cycle.	1.1 Technical Proficiency a,b,c,d,f	Midterm Part 1 Question 5	78					25	62	12	0	0	4.1
	3.1 Personal Responsibility i,j,k												
	3.2 Human Differences i,j												
5. Use parametric design, FEA, and CAM systems to design, analyze, and manufacture mechanical components.	1.3 Computer Applications a,d,g	Midterm Practical	90.5	Final Practical	80.5	Group Project	93	38	50	12	0	0	4.3
	1.4 Open-ended Problems a,b,c,d,f												
	2.5 Self-Learning h,k												
Instructor Comments for needed changes: Objective 5 needs to be split into multiple objectives. Objective 2, FEA terminology needs to be covered more in class.								Number of responses:				8	

CQI in TAC/ABET Accredited Programs: The Next Level

The steps discussed so far in this paper are the basic beginnings for satisfying TC2K criteria. All institutions must have documented goals and objectives linked from the lowest level of the organization (course level) to the highest (institutional) level. They must also have documented processes and procedures that allow for the collection, evaluation and assessment of data to link achievement of those goals. These steps in meeting the new criteria have been explored, discussed and information disseminated at workshops in recent years as the TC2K criteria has been developed. The overall intent of the new criteria however goes beyond these “trainable” steps to another level; the level at which a new quality culture is instituted into the organization. This is what accredited institutions should be striving to achieve; a CQI culture.

Once all of the initial steps have been put in place, meaning that plans are complete and processes and procedures are standardized, then the real work can begin. This is the work of continually improving so that institutions and individual programs can satisfy and eventually delight constituents.

CQI Results at PUC

Because of the efforts that have taken place in the METS department so far and the processes and procedures that have been put in place, improvements at various levels have already been achieved. In addition, there are several keys that exist to help structure the department so that goals are continually reviewed, data is continually collected, evaluated and assessed, and input from constituents and improvement actions are continually reviewed and documented. Generally these keys take the form of established regular meetings and/or reports.

There is also one additional committee that has been formed within the department in the past two years that is directly related to the METS CQI efforts. This committee is called the METS Assessment Committee. This committee is charged with writing the annual department assessment report, a requirement of the University. Prior to the establishment of this committee, it was the department head's responsibility to write this report which was submitted at the end of each academic year. In light of this, no faculty member ever saw or reviewed the contents of this report. The assessment committee has been instrumental in developing what they call the “ten tools of assessment⁴.” These were developed with all applicable accrediting agencies in mind with the intention of developing a report that would contain all pertinent content. With this being the basis for the report it can be easily altered to fit any agency's required format since all accrediting bodies applicable to the METS department now focus on a CQI model.

In addition to this committee, several regularly scheduled meetings take place within the department that aid in supporting the CQI culture. These include:

1. Industrial Advisory Board Meetings These meetings are considered capstone meetings of the CQI culture and are held at least once a semester usually toward the end of the semester. These meetings include our constituents and are structured so as to routinely review pertinent information, gather important input, and document all program improvements.

2. Departmental Retreats A retreat is generally held at least once a semester generally toward the beginning of the semester. The retreats are structured so as to be educational and allow for any mini-training that may be pertinent to keep all faculty abreast of new developments and requirements within the department, especially related to CQI initiatives. Also, it is during the fall retreat that the faculty members review the department assessment report.

Also, processes and procedures now require several regular documents to be completed by our department faculty members in efforts to help foster a continuous improvement culture.

1. Annual Reports In March, each faculty member in the department constructs an annual report, which is used for determining raises. This report is done in a continuous improvement format, which starts with an individual mission statement. Next comes overall direction followed by general goals/objectives in support, then tactics/strategy. Finally at the most detailed level the report lists the faculty member's activities, accomplishments, honors, publications, presentations, course improvements, student evaluation scores or other evidence of improvement under the appropriate goal, objective, tactic, or strategy. The continuous improvement focus of the annual report tends to remove personal issues such as collegiality from consideration. The same general format is used in promotion and tenure documents.
2. Course Assessment Forms After each semester, every faculty member turns in a course update form that shows any course improvements made such as new text books, rewritten syllabi with student objectives or assessment measures, laboratory improvements or advances, grants or other evidence of continuous improvement. If no form is turned in, it is assumed the faculty member has coasted in that course that semester. The course assessment forms produced by an individual are also attached to his or her annual report.
3. Outcomes Assessment Each faculty member also does a Course Learning Outcomes assessment for each of their courses at the end of each semester that shows program educational objectives, student learning objectives in support, assessment measures to evaluate student outcomes and analysis/further actions. Student survey data on the course is also correlated on the form. These are also attached to his or her annual report. See Table 2 titled "Course Learning Outcomes (Objectives) Assessment" for an example for course MET 461.
4. Teaching Evaluations are turned in and also attached to annual reports since the latest revision of the TC2K criteria require evidence of teaching effectiveness.

It is important to note that more than half of the METS department's faculty are from programs that are not TAC/ABET accredited (Computer Graphics Technology and Organizational Leadership and Supervision). These colleagues do the same course assessments as the MET and IET faculty. They also have assignments to collect the data for the ten tools the department uses to produce the annual department assessment report. Every faculty and staff member contributes

to the assessment effort regardless of their program. The CQI culture is an institutional culture, not an ABET initiated exercise.

You will recall that the definition used for CQI in this paper refers to the mass involvement in making relatively small changes, which are directed, towards organizational goals on an ongoing basis. Whereas it takes time to document major results from any efforts, changes and improvements have been made at various levels by the METS department faculty. Several that have been documented at the course level (as a result of the first trial course assessment system that was initiated in fall 2002) are:

CGT 116, Geometric Modeling for Visualization and Communication – a change from traditional lecture to cooperative learning for portions of the course have resulted in improved test scores. The course assessment system also noted that several course objectives were out of date and these were revised. These obsolete objectives were recognized because little data was available from the coursework to evaluate the objectives. When this was noted, the instructors realized that the lack of data was due to the material not being covered, and that was due to the obsolete nature of the material.

MFET 275, Computer Numerical Control Applications – one course objective was not being covered at all, so it was removed, and a new objective concerning computer aided manufacturing systems (CAM) instituted. The new objective was evaluated with a student project, and initial indications are the new objective/project combination works very well.

MET 325, Applied Thermodynamics – the course assessment system indicated a problem with the order the material was presented. A simple change in order resulted in improved student learning for a test semester. This course is being taught again in the Spring, 2004 semester, and the new presentation order will be tested again. Since the class size is larger, more meaningful data will be available.

MET 461, Computer Integrated Design & Manufacturing – a specific objective of this course was to introduce the concept of lifelong learning. This concept was explained to the students early in the semester, and it was incorporated by slowly reducing the instructor's role from that of instructor to that of advisor. Data from the course assessment system indicate that the students understood the concept and that the objective had been met.

Without the new assessment system and documentation requirements the areas for improvement that became evident with use of the system would, most likely, have been overlooked.

In addition to the course level improvements, overall improvements at a program level have also recently been made. Both MET and IET students are required to take the Society of Manufacturing Engineers (SME) Fundamental of Manufacturing examination⁵. This is a three hour exam with 130 nationally normed multiple choice questions. Passing the exam carries the CMfgT (certified manufacturing technologist) credential. Becoming certified, registered, or getting an advanced degree is evidence for an appreciation of continuing education as well as a

verification of knowledge learned while in the MET or IET program. Nationally more than half the students taking the exam pass it. Since all of our students take the exam rather than just the best, our pass rates were lower than half. The CQI process led the MET and IET faculty to work on raising students' success rate on the exam. We first offered review sessions taught by 5 of our 6 engineering technology faculty on two Saturdays each semester. The pass rate was not up to what it was before we started requiring all of our students to take the exam to graduate. In eleven administrations 39% of our students passed the exam. Then the local SME senior chapter was asked to donate copies of the main SME reference book for students to use in the review. The most recent pass rate increased to 60%. In hopes of continuing the improvement or at least maintaining it, the faculty has scheduled regular class time during the week for the review as part of the senior project survey class for the upcoming semester. We will also use some of the time to cover and assess other required TC2K outcomes not well covered elsewhere.

At a department level, the CQI initiatives and results are tied more directly to the institutional efforts. The AQIP project discussed earlier in this paper to improve student success has increased freshman retention for the university by 10% since its initial implementation. The METS department is now supporting this effort by developing a freshman seminar course for initial implementation in fall 2004 to continue to improve retention and student success within the department.

Conclusion

Continuous Quality Improvement is an integral part in closing the loop on development of a quality education program. CQI is difficult to define and is not one particular program or procedure. Rather, it is part of the culture that should be redefining the way educators operate. It may seem complicated and time consuming to initially develop goals and outcomes for our programs and collect, evaluate, and assess data that show we are meeting the goals we set, but if an institution can find ways to integrate these activities into day to day operations on an ongoing basis, a quality culture can seem quite manageable. This is what the METS department at PUC has done, created a structure within which simple, routine processes can be followed by all faculty members in order to allow them to continually focus on improving the quality of their students' learning.

Those preparing for TC2K accreditation visits should also keep in mind that evaluators are looking for evidence that a program's continuous improvement plan is producing improvements. Without improvements resulting from a department's assessment efforts, we are back to the same result that we obtained collecting notebooks of graded homework and tests for program evaluators to peruse under the old TAC criteria. This result was at best, a period during which we could say our program met the minimum requirements for accreditation.

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Biography

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