The following Program and Learning Outcomes and Assessment are guidelines for BS students of the Department of Chemical Engineering. These SACSCOC Outcomes and the Assessment process are aligned with the existing Departmental ABET process, however, it is important to note that the ABET and SACSCOC nomenclature differs and so equivalence is established here for clarity, see Table 1.

Table 1. Equivalence of ABET and SACSCOC nomenclature.

<table>
<thead>
<tr>
<th>ABET Nomenclature</th>
<th>SACSCOC Nomenclature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Educational Objectives</td>
<td>Program Outcomes</td>
</tr>
<tr>
<td>Program Outcomes</td>
<td>Learning Outcomes</td>
</tr>
</tbody>
</table>

**Program Outcomes:**

The TTU Chemical Engineering Curriculum is specifically designed to prepare students for either a professional career in the Southeastern US regional chemical process industries and/or simultaneously to prepare students who will choose to pursue graduate studies in engineering. Our overall Program Educational Objectives have been redesigned throughout academic 2007-2008. The redesign process involved use of faculty consensus management techniques at multiple faculty meetings and retreats dedicated to undergraduate curriculum. The feedback of our BOA and other constituencies was incorporated into this redesign process. The Program Educational Objectives are designed to guide curriculum development, to be measurable statements of purpose, and to advertise our curriculum intent to our constituencies.

Program Educational Objectives (2007 – present):

*Within roughly five to seven years after graduation, our graduates will:*

- **Be recognized as real-world problem solvers:** the graduates of our program will obtain positions such as plant process engineer, design engineer, group leader, production engineering, sales engineer.

- **Be recognized as critical thinkers:** the graduates of our program will demonstrate that they consistently make informed decisions through a process wherein they utilize critical thinking skills.

- **Continue their formal education:** the graduates of our program will demonstrate that they have continued their education beyond the BS through some form of professional development (not necessarily leading to another degree) or will have graduated from a professional school with an MS, PhD, MD, JD or similar degree.

- **Work at the frontiers in ChE:** the graduates of our program will utilize and apply technologies such as bio materials, nano- and micro-systems, multi-scale analysis, informatics, group dynamics and, multi-media.
Learning Outcomes:
Every student will demonstrate...

a- an ability to apply knowledge of mathematics, science and engineering,
b- an ability to design and conduct experiments, as well as to analyze and interpret data,
c- an ability to design a system, component, or process to meet desired needs,
d- an ability to function on multi-disciplinary teams,
e- an ability to identify, formulate, and solve engineering problems,
f- an understanding of professional and ethical responsibility,
g- an ability to communicate effectively,
h- the broader education necessary to understand the impact of engineering solutions in global and societal context,
i- a recognition of the need for, and an ability to engage in life-long learning,
j- a knowledge of contemporary issues,
k- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Assessment of Program and Learning Outcomes

Figure 1 is a flowchart of our current continuous improvement process.

Figure 1. Continuous improvement process diagram for the Department of Chemical Engineering (ABET nomenclature used here, see Table 1).

Our process begins with a mapping of the University Mission, College Mission and Departmental Mission. We have identified our constituencies as (1) our students, (2) our alumni, (3) the employers of
our students and (4) graduate schools that admit our students. This exercise clearly identifies our regional responsibility since the majority of our constituency resides in Tennessee and the near-south east with exception of graduate schools which are predominantly in the east, but not exclusively. Our Program Outcomes (PO) were developed with consideration of our constituency and their unique regional needs and the Mission of our Department, College, and University in mind. The ABET 2000 Criteria 3 and the AIChE Criteria were adopted as our Learning Outcomes (LO). Course outcomes are mapped to Learning Outcomes and assessment tools developed as “means of measuring” Program Outcomes and Learning Outcomes. We are currently using the following eight metrics as means of assessing our Program Outcomes:

1. FE Exam Results
2. Graduate School Placement
3. Capstone Design Outcomes
4. Senior Lab Outcomes
5. BOA Comments
6. Exit Interview Comments
7. Employer Survey (three-year cycle)
8. Alumni Survey (three-year cycle)

The entire process is overseen by the Departmental Continuous Improvement Committee (CIC) which consists of the entire faculty since the faculty is relatively small, five regular, one Center-Faculty and two adjuncts. The CIC interacts with the constituency via surveys, teleconferences, newsletters, individual phone communications, focus sessions, campus meetings, and other modes of communication. To close the assessment loops for POs and LOs we must have a way to feed assessment results back into the curriculum. To do this at the course level, we have developed a course-level assessment policy. Each course will be formally assessed after each semester and prior to the next schedule semester in which it will be taught. The assessment process consists of:

1. Instructors must complete and submit to the department Continuous Improvement Committee (CIC) a Course-Level Assessment and Continuous Improvement Report (CLACIR) for each course taught.
2. The assessment results will be presented by the faculty responsible to the CIC.
3. The committee will decide on the level of action to be taken, i.e. department level only, BOA level, College Curriculum Committee level, etc.
4. Actions that modify the curriculum or course content will be implemented during the next semester in which the course is taught.

This policy provides for the ability for the feedback of PO and LO assessment results to the curriculum. Our feedback loop is formalized by three report formats that make up the backbone of our continuous improvement process.

1. Course-level Assessment and Continuous Improvement Report (CLACIR)
2. Program Outcomes Assessment and Continuous Improvement Report (POACIR)
3. Learning Outcomes Assessment and Continuous Improvement Report (LOACIR)

This trio of forms is the basis our documentation policy for making, tracking and documenting continuous improvement through the closure of the assessment loop. The CLACIR is the front line document. This document is now completed subsequent to each semester in which a course is taught. The form has
thirteen elements for which we have prepared an instruction sheet. The 13 elements are broken into three
groups: 1. syllabus information, 2. assessment information and 3. continuous improvement plan. The
syllabus section of this report defines the course objectives, outcomes and requirements, and their
relationship to our stated PO.

The assessment section includes information based on student outcomes. Finally, the continuous
improvement section includes feedback from our PO and LO assessment process and a plan of action for
course-level continuous improvement. This part of our documentation process will ensure that action is
taken at the course-level based not only on course-level outcomes, but PO and LO assessment feedback.
At the end of each semester there will be one CLACIR for each course taught in that term. Each CLACIR
will be reviewed by the CIC and an action plan agreed upon where course-level changes are needed.

 Significant changes in curricular content or pedagogy will be reviewed by the faculty with input from the
BOA at a subsequent meeting. Substantive changes may also need to be approved at the College and
University level.

The POACIR and the LOACIR are filed on a one to three year cycle subsequent to the collection,
collation and analysis of assessment metrics. These reports provide a written record of the assessment
process findings and are now the basis for tracking and documenting continuous improvement at the PO
and LO level.

**Assessment of Program Outcomes:**

Program Outcomes (PO) are assessed using eight metrics, see Table 2. These metrics are addressed on a
three-year cycle at which time a complete analysis is made and recorded in our Program Outcomes
Continuous Improvement Report (POACIR).

<table>
<thead>
<tr>
<th>Metric</th>
<th>Professional Preparedness</th>
<th>Communication</th>
<th>Individual Study</th>
<th>Teams</th>
<th>Ethics</th>
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<tr>
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<tr>
<td>Graduate School Placement</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>BOA Comments</td>
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<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capstone Design Outcomes</td>
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<td>X</td>
<td>X</td>
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<td>Exit Interviews Comments</td>
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<tr>
<td>1 – Year Cycle</td>
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<thead>
<tr>
<th>Metric</th>
<th>Professional Preparedness</th>
<th>Communication</th>
<th>Individual Study</th>
<th>Teams</th>
<th>Ethics</th>
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<tr>
<td>Overall FE Exam Results</td>
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<td>Graduate School Placement</td>
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<td>BOA Comments</td>
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<tr>
<td>Capstone Design Outcomes</td>
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<td>3-Year Cycle</td>
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</tbody>
</table>

**Assessment of Learning Outcomes:**

The content of each CHE course is mapped to our Learning Outcomes (LO), see Table 3 below. From this
mapping, we know which course focuses on which outcome. At the end of each semester a Course-Level
Assessment and Continuous Improvement Report (CLACIR) is filed for each Departmental required
course. These courses and the associated assessment forms provide evidence of student proficiency
against a subset of the LO’s. Collectively, assessments across the curriculum of required courses account
for demonstration of student proficiency against the entire set of LO’s.
Table 3. Analysis of course content for Program Learning Objectives. [Currently being used].

<table>
<thead>
<tr>
<th>Course No.</th>
<th>Description</th>
<th>Required/Elective (R/E)</th>
<th>a Know.</th>
<th>b Exp.</th>
<th>c Design</th>
<th>d Teams</th>
<th>e Formulate</th>
<th>f Ethics</th>
<th>g Comm.</th>
<th>h Global</th>
<th>i1 LL</th>
<th>j2 Cont.</th>
<th>k Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHE 2011</td>
<td>Chem and Biol Eng. Anal (JJB)</td>
<td>R</td>
<td>m</td>
<td>M</td>
<td>m</td>
<td>M</td>
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<tr>
<td>CHE 3010</td>
<td>Thermo of Chem. Proc. (HS)</td>
<td>R</td>
<td>m</td>
<td>M</td>
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<tr>
<td>CHE 3111</td>
<td>Cond., Rad., Diff. (RS)</td>
<td>R</td>
<td>m</td>
<td>M</td>
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<td>M</td>
<td>m</td>
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<td>Fluid Dynamics (PEA)</td>
<td>R</td>
<td>m</td>
<td>M</td>
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<td>M</td>
<td>m</td>
<td>m</td>
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<td>Kinetics (CR-Y)</td>
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<td>M</td>
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<td>M</td>
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<td>CHE 4240</td>
<td>Capstone Lab (HS)</td>
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<td>CHE 4410</td>
<td>Capstone Design I (JJB)</td>
<td>R</td>
<td>m</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>m</td>
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<td>CHE 4910</td>
<td>Senior Seminar (RS)</td>
<td>R</td>
<td></td>
<td>M</td>
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<td>M</td>
<td>m</td>
<td>m</td>
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</tr>
</tbody>
</table>

1 Life-long-learning
2 Contemporary issues

A complete set of CLACIR are available in hardcopy in the CHE Departmental office.

**Assessment Results and Implementation for Program Outcomes:**

Program Outcomes (PO) are assessed using the following matrix of indicators. For each indicator, a rubric or target performance level has been established. These indicators are gathered on a one to three year cycle and a complete analysis is performed and summarized in a Program Outcomes Continuous Improvement Report (POCIR). We are currently at the end of a three year cycle and are gathering results at this time.

**Assessment Results and Implementation for Learning Outcomes:**

At the end of each assessment period, one to three years, the results of all CLACIR are analyzed and summarized in the form of Learning Outcomes Continuous Improvement Report (LOCIR). The Chemical Engineering BS Program received full accreditation during the 2008 ABET visit which shows compliance of all the program outcomes and learning objects as outlined in this document.
The previous guidelines and QEP efforts has helped the Department of Chemical Engineering in a number of ways to increase the excellence of the programs. The examples below are few illustrative cases:

1. **The New Biomolecular Engineering Concentration**: Chemical Engineering initiated a new concentration (within the BS- Chemical Engineering Degree) in 2007 with one student. Currently the concentration enrolled 80 students being the fastest growing concentration within the College of Engineering and the only one of this type within the State of Tennessee. All program Outcomes and Learning Objectives are the same as described for the BS- Chemical Engineering and the students received the transcript with the name “Concentration in Biomolecular Engineering”.

2. **The New Transport Phenomena Sequence**: As part of the continuous improving efforts in the Chemical Engineering program, a new and more pedagogically coordinated sequence for the transport phenomena courses is being tested. This provides a very “student learning-center” platform and preliminary feedback from the students seems to be quite welcomed by them.

3. **The High-Performance Learning Environments (Hi-Pe-Le)**: The Dept. of Chemical Engineering focuses on three pillars for the education of the future chemical engineers, i.e. hands-on, team-based learning and critical thinking approaches. The anchoring pedagogical model for this approach is the Hi-PeLE that was highlighted by the National Science Foundation during one of the ERC-NSF Annual Meeting (2009) as one of the best practices in place to achieve engineers along the lines of the NAE 2020 Model.

4. **The New Computer Platform for Collaborative Learning (MoLE-SI)**: Chemical Engineering piloted in 2009 a new mobile computer learning platform, the “Mobile Learning Environment System Infrastructure” (MoLE-SI) in order to bring the “computer to the students” by using their mobile devices, smart phones, tablets, etc. Currently, a MoLE-SI III pilot is being implemented within the College of Engineering, College of Education and Colleges of Business. Initial assessment indicates that MoLE-SI helps to increase considerably the critical thinking of the students.