Integrated Assessment Model for Multiple Outcomes and Criteria

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A unique experience in coordination between educational institution and industrial partners to build new paradigm in education through an NSF sponsored program. Long experience in curriculum development. Extensive knowledge in academic programs, professional development programs and on the job training plans. Motivated, fluent in English with multi-lingual capability, internationally educated professional, with work experience in different countries and international organizations. Highly diversified, personable and outreaching communication skills. Winner of 2012 faculty of the year award at Lawrence Technological University. Nominated for Teaching Excellence and Using Technology in Classroom Awards.

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Jerry Cuper is a professor and advisor in the Department of Engineering Technology in the College of Engineering. His education includes graduate and undergraduate degrees, and completion of a technology apprenticeship program. Mr. Cuper's career has spanned a wealth of experience in the machine shop, on the drawing board, in construction, and many years in engineering design, testing and development, management, and planning. Most of his career was with the Ford Motor Company. Mr. Cuper's last assignment was managing the Ford Technology Review Center to help implement suppliers' new technologies. He developed and led the implementation of a new supplier process to dramatically change the way supplier technologies were integrated into Ford products. This supported Ford's vision to change from being a fast follower to being a leader in technology. Mr. Cuper developed the first-production automotive application of Graphite Fiber Reinforced Plastic; this bracket was given the Materials Engineering "Award of Merit". Cuper has taught courses in engineering and business at Lawrence Tech evening programs as an adjunct instructor since 1978. He has demonstrated the ability to work extremely well with students to focus their efforts on academic achievement and long-term career goals. Mr. Cuper's passion is muscle cars. He has owned 21 Mustangs over the years, starting with the 1965 Fastback 2+2, and now has a 2013 GT glass-roof coupe.

Prof. Kenneth Cook P.E., Lawrence Technological University

Ken Cook is the chair of the Department of Engineering Technology in the College of Engineering. Mr. Cook is a registered professional engineer, a certified clinical engineer, and holds some 28 patents of his own. He holds degrees from or attended DeVry Technical Institute, Lawrence Technological University, Wayne State University, and Oakland University. Cook has many years of experience in engineering design, management and sales. His was most recently executive vice president and chief engineer for Vultron/Trans Industries. His earlier positions included General Manager of R&D in machine tool controls and gauging at GTE-Valenite Corp., started and managed the clinical engineering department at William Beaumont Hospital, Royal Oak, and was a research associate in radiology, nuclear medicine, and biomechanics at Wayne State University. Ken has taught at Lawrence Tech evening programs as an adjunct instructor since 1965. His senior projects class, where students generate project ideas, research, design, manufacture, and assess the market for inventive products is the capstone course. Cook also has enjoyed a long side career in magic finding his hobby very useful in teaching. A highlight for his students each year is the two-hour magic performance he offers as a congratulatory send-off for them and their guests.

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1. Abstract

Assessment of Student Outcomes and Program Criteria are a vital part of accreditation process for ABET/ETAC.

ETAC requires that a program seeking accreditation must present evidence of systematic, detailed and meaningful assessment process of the Student Outcomes "**a** through **k**".

Furthermore, based on ETAC accreditation guide, "each program seeking accreditation from the Engineering Technology Accreditation Commission of ABET must demonstrate that it satisfies all Program Criteria implied by the program title".

The above quotation indicates that the accreditation-seeking program has to demonstrate additional assessment of these criteria besides assessing the ETAC **a** through **k** Student Outcomes.

Single title programs assessment might not be as rigorous as it is with programs implying more than one title.

It is common that many programs in the nation involve more than one title, such as Electrical and Electronics, Electrical and Computer, Mechanical and Manufacturing, to mention a few.

The assessment process for such dual title programs becomes sophisticated and might even be ambiguous when attempt to assess each title criteria and ETAC outcomes separately.

This paper will address this challenging situation for programs with dual titles seeking ETAC accreditation.

The paper will introduce a model that has proven to be sufficient to address this complicated, yet essential part of the accreditation process.

The Model is based on a case of a program that has a Mechanical and Manufacturing Engineering Technology title. This program has to satisfy:

1. ETAC **a** through **k** student outcomes,

2. Society of Manufacturing Engineering (SME) **a** through **d** criteria,

3. American Society of Mechanical Engineering (ASME) **a** thorough **h** criteria.

Needless to say that the above reference Outcomes and Criteria (a, b….) of the three organizations do not necessarily line up.

Our model was built in response to the need of finding a common denominator Outcomes/Criteria and map the three different ones to it. We will demonstrate that the model will make the assessment process feasible, logical and meaningful.

The paper will show that the model could be used as a template for dual titles programs for assessment and accreditation purposes.

2. Assessment Requirements for Mechanical & Manufacturing Bachelor Degree Program

Most, if not all, Engineering programs and Engineering Technology Programs have adopted the ABET/ ETAC **a** through **k** Student Outcomes (These outcomes have been reduced recently though combining some of them and use numbers for the outcomes instead of letters).

Assessment plans for these programs are designed to provide evidence on how these outcomes are met. This is a common and well established process which most programs are already well acquainted with.

Programs of Bachelor of Science in Engineering Technology (BSET) assessment plans need to show that a through k student Outcomes are assessed. This is considered sufficient since the evaluators are from ABET/ETAC only. A program offering a degree in Mechanical Engineering Technology has to provide evidence that the program criteria as suggested by the American Society of Mechanical Engineering (ASME) are being assessed alongside the **a** through **k** Students outcomes. A program offering a degree in Manufacturing Engineering Technology has to include the program criteria suggested by Society of Manufacturing Engineering (SME) in the assessment plans.

A program offering a degree that include a "Double Title" like the Bachelor Degree in Mechanical and Manufacturing Engineering Technology must present a plan for assessing the **a** through **k** Students outcomes, **a** through **h** outcomes of ASME and **a** through **d** of SME. The letters of the three organizations are not compatible as we mentioned earlier.

Below are the descriptions of all three organizations outcomes/Criteria:

2-1 ETAC Student Outcomes

Student outcomes must include, but are not limited to, the following learned capabilities:

a. an ability to select and apply the knowledge, techniques, skills, and modern tools of the discipline to broadly-defined engineering technology activities;

b. an ability to select and apply a knowledge of mathematics, science, engineering, and technology to engineering technology problems that require the application of principles and applied procedures or methodologies;

c. an ability to conduct standard tests and measurements; to conduct, analyze, and interpret experiments; and to apply experimental results to improve processes;

d. an ability to design systems, components, or processes for broadly-defined engineering technology problems appropriate to program educational objectives;

e. an ability to function effectively as a member or leader on a technical team;

f. an ability to identify, analyze, and solve broadly-defined engineering technology problems;

g. an ability to apply written, oral, and graphical communication in both technical and non-technical environments; and an ability to identify and use appropriate technical literature;

h. an understanding of the need for and an ability to engage in self-directed continuing professional development;

i. an understanding of and a commitment to address professional and ethical responsibilities including a respect for diversity;

j. a knowledge of the impact of engineering technology solutions in a societal and global context; and

k. a commitment to quality, timeliness, and continuous improvement.

2-2 ASME Program Criteria for Bachelor Programs in Mechanical Engineering Technology

Associate degree program graduates must demonstrate knowledge and competency in the following topic areas:

a. geometric dimensioning and tolerancing; computer aided drafting and design; and a basic knowledge and familiarity with industry codes, specifications, and standards;

b. selection, set-up, and calibration of instrumentation and the preparation of laboratory reports and systems documentation associated with the development, installation, or maintenance of mechanical components and systems;

c. basic engineering mechanics.

An associate degree program must have an integrating or capstone experience which utilizes the skills acquired.

For baccalaureate programs, given the breadth of technical expertise involved with mechanical systems and the unique objectives of individual programs, programs may focus on preparing graduates with in-depth but narrow expertise, while other programs may choose to prepare graduates with expertise in a broad spectrum of the field. Therefore, the depth and breadth of expertise demonstrated by baccalaureate graduates must be appropriate to support the program's educational objectives.

<u>In addition to the outcomes expected of associate degree</u> program graduates, baccalaureate degree program graduates must demonstrate knowledge and competency in the following topic

areas unless the program's faculty and primary constituents approve the substitution of other specific mechanically-related technical subjects:

d. differential and integral calculus;

e. manufacturing processes; material science and selection; solid mechanics (such as statics, dynamics, strength of materials, etc.) and mechanical system design;

f. thermal sciences, such as thermodynamics, fluid mechanics, heat transfer, etc.;

g. electrical circuits (ac and dc), and electronic controls; and

h. application of industry codes, specifications, and standards; and using technical communications, oral and written, typical of those required to prepare and present proposals, reports, and specifications.

The capstone experience, ideally multidisciplinary in nature, must be project based and include formal design, implementation and test processes.

2-3 SME Outcomes for Graduates from a Bachelor Program in Manufacturing Engineering Technology

Graduates must demonstrate the ability to apply the following to the solution of manufacturing programs to achieve manufacturing competitiveness:

(a) Materials and manufacturing processes;

(b) Product design process, tooling, and assembly;

(c) Manufacturing systems, automation, and operations;

(d) Statistics, quality and continuous improvement, and industrial organization and management.

3.0 The Model

3.1 Assessment Challenges

Assessment plan for a Bachelor in Mechanical and Manufacturing Engineering Technology (BSMMET) Program has to include all the above Outcomes/Criteria beside any additional outcomes that the department considers relevant and important to have.

The challenge is to satisfy the prove of assessment of three organizations criteria in one process.

The plan should not only list these outcomes/criteria, but indicates the assessment methods, curriculum mapping, courses used in the assessments and metrics used in the assessment as main requirement for a meaningful assessment plan.

Assessing each of the above the above 24 Outcome/Criteria will have the following hindrances:
1. A long list of Outcomes to assess: The list will be long and more than double the set of any outcomes needed for any of the three organizations,

2. Duplication and redundancy: duplication will be obvious due to overlapping of some of the outcomes from the three sets and redundant assessment of same outcome more than once.

3.2 Inter-Mapping Outcomes

To respond to the challenges, it is logical to start studying the overlapping of these three organizations outcomes. Since **a** through **k** of ETAC are the outcomes of the accreditation organization, it would be practical to use them as the reference and attempt to map each of the ASME and SME outcomes to them to the ETAC Outcomes. This will address the problem partially and will not provide sufficient solution to the problem.

Since the direct mapping was insufficient, it is suggested that the best way to approach this task is to have indirect inter-mapping approach.

The inter-mapping approach requires the program (BSMMET), in this case, to develop criteria that will respond satisfactorily to the following needs:

1. Encompass all skills and capabilities of the program graduates
2. Conform to ETAC **a** through **k** Student Outcomes
3. Demonstrate the knowledge areas required by ASME
4. Achieve competitiveness required by SME to solve manufacturing problems

Based on that, the BSMMET Program designed the following eleven program criteria:

1. Geometric dimensioning and Tolerancing; computer aided drafting and design

2. Selection, set-up, and calibration of instrumentation

3. Engineering Mechanics, Statics and Dynamics

4. Differential and Integral Calculus

5. Materials Science, Selections and Strength of Materials

6. Manufacturing Processes and Systems

7. Thermal Sciences

8. Electrical Circuits and Control

9. Product Design, Tooling & Assembly

10. Statistics, Quality, Continuous Improvement, and Industrial Management

11. Technical Communications, Oral and Written

These program criteria were mapped directly to each on the 24 outcomes of ETAC, ASME and SME. Using the program criteria as reference point, ETAC **a** through **k**, ASME **a** through **h** and SME **a** through **d** were all mapped to each other.

The matrix below illustrates the links between all four sets of outcomes/criteria:

Table 3.1: Mapping of BSMMET Program Outcomes to ETAC, ASME and SME Outcomes

BSMMET Program Criteria	ABET Student's Outcomes											Mechanical Eng. Tech Outcomes								Manuf. Eng. Tech. Outcomes			
	a	b	c	d	e	f	g	h	i	j	k	a	b	c	d	e	f	g	h	a	b	c	d
1. Geometric dimensioning and Tolerancing; computer aided drafting and design	X	X										X											
2. Selection, set-up, and calibration of instrumentation	X	X											X										
3. Engineering Mechanics, Statics and Dynamics			X			X								X		X							
4. Differential and Integral Calculus	X	X													X								
5. Materials Science, Selections and Strength of Materials						X		X		X			X			X				X			
6.Manufacturing Processes and Systems			X	X				X	X	X						X			X	X	X	X	
7. Thermal Sciences			X			X											X						
8. Electrical Circuits and Control			X	X		X							X					X					
9. Product Design, Tooling & Assembly			X		X				X												X	X	
10. Statistics, Quality, Continuous Improvement, and Industrial Management	X	X					X	X		X	X												X
11. Technical Communications, Oral and Written					X		X												X				

This matrix could and will be used as the foundational instrument of the assessment plan.

The above table will facilitate direct assessment of all criteria, and since they are mapped to the other three outcomes, this will provide proof of assessment for the three sets of outcomes.

This table represents the general model of inter-mapping multiple Student Outcomes to each other. This table is considered the frame and could be extended to involve columns that a program finds essential for its assessment plan as we are going to note in the next table.

3.3 Identify Courses Used in Assessment

This phase is crucial not only for assessment plan, but also reevaluate the curriculum of the program. This tool creates a map that can be significantly used to validate the courses offered in the program from several angles such as: depth and breadth, coverage, sequences and pre-requisites. Also, it could serve for continuous improvement of the curriculum based on the changes of the three organizations outcomes/criteria.

The table below shows the suggested courses for each of the criteria and outcomes.

Table 3.2: Courses Used to Assess Program Criteria

BSMMET Program Criteria	Courses used in Assessment
1. Geometric dimensioning and Tolerancing; computer aided drafting and	TIE4193 GD&T, TME1023, TME4113
2. Selection, set-up, and calibration of instrumentation	TEE4224, TIE4115
3. Engineering Mechanics, Statics and Dynamics	TME31132 TME3223
4. Differential and Integral Calculus	MCS2313, MCS3324
5. Materials Science, Selections and Strength of Materials	TME4103,TIE4115
6.Manufacturing Processes and Systems	TIE3063, TME4413
7. Thermal Sciences	TME3204, TIE4115
8. Electrical Circuits and Control	TEE3103, TEE4214
9. Product Design, Tooling & Assembly	TIE4115, TME4113, TIE3063, TIE4913 Machining Processes
10. Statistics, Quality, Continuous Improvement, and Industrial Management	TME3333, TME4343, TIE3203
11. Technical Communications, Oral and Written	TIE3203,TIE 4115, COM3000 (WEP)

The Program Criteria in this model are in the format of knowledge areas. The reason is to involve faculty to develop their course learning objectives to satisfy that criteria since those objectives will be used as measurables of the assessment plan.

There are two points to consider:

1. Proposed courses used in assessment are, and should be, the main but not only tools that provides assessment data.

2. Since all organizations involved in the accreditation recognize the holistic impact of senior project on the outcomes, this course should be used to complement any shortcoming or emphasis needed in the assessment of certain criteria.

4.0 The Assessment Plan

After identifying the courses to be used based on the course description in the above phase, it is important to develop or review the course learning objectives. All objectives should be directly related to the course contents, measurable and could be linked to the criteria.

As mentioned earlier, the assessment plan should have the criteria/outcomes to be assessed, course used for assessment Metrics/ Performance indicators as a minimum or basics. The plan for the BSMMET program included as we can see in the table below Time lines, Loop-Closing and Level of Attainment based on Bloom's Taxonomy.

Table: 4.1 BSMMET program is the following:

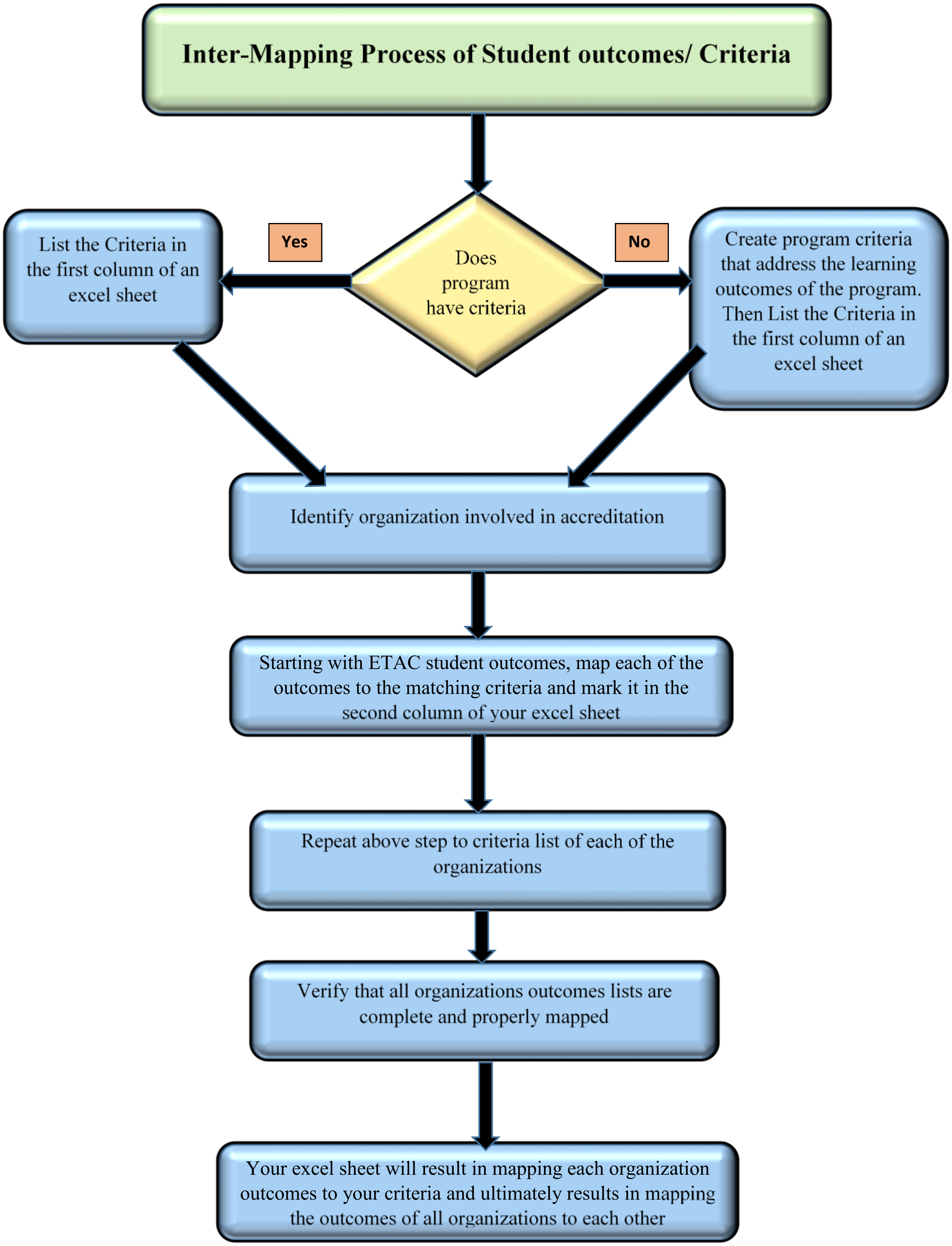
BSMMET Program Criteria	Courses to be used in Assessment	Metrics/ Indicators	Timeline	Loop-Closing	Level of Attainment
1. Geometric dimensioning and Tolerancing; computer aided drafting and design	TIE4193 GD&T TME1023 TME4113	1. At least 70% of students will score 75% on questions designed to directly address each of the course Learning Objectives 2. At least 75% of students will assign rank 4 or 5 to objectives in the indirect assessment	Once every two years	Two years	Level 3
2. Selection, set-up, and calibration of instrumentation	TEE4224	1. At least 70% of students will score 75% on questions designed to directly address each of the course Learning Objectives 2. At least 75% of students will assign rank 4 or 5 to objectives in the indirect assessment	Once every two years	Two years	Level 3

BSMMET Program Criteria	Courses to be used in Assessment	Metrics/ Indicators	Timelin e	Loop-Closing	Level of Attainment
3. Engineering Mechanics, Statics and Dynamics	TME3113	1. At least 70% of students will score 75% on questions designed to directly address each of the course Learning Objectives 2. At least 75% of students will assign rank 4 or 5 to objectives in the indirect assessment	Once every two years	Two years	Level 4
4. Differential and Integral Calculus	MCS2313 and MCS3324	1. 1. At least 70% of students will score 75% on questions designed to directly address each of the course Learning Objectives 2. At least 75% of students will assign rank 4 or 5 to objectives in the indirect assessment	Once every two years	two years	Level 4
5. Materials Science, Selections and Strength of Materials	TIE4115, TME4103	1. At least 70% of students will score 75% on questions designed to directly address each of the course Learning Objectives 2. At least 75% of students will assign rank 4 or 5 to objectives in the indirect assessment	Once every two years	two years	Level 4
6. Manufacturing Processes and Systems	TME4413, TIE3063	1. At least 70% of students will score 75% on questions designed to directly address each of the course Learning Objectives 2. At least 75% of students will assign rank 4 or 5 to objectives in the indirect assessment	Once every two years	two years	LEVEL 4
7. Thermal- Fluid Sciences	TME3204	1. At least 70% of students will score 75% on questions designed to directly address each of the course Learning Objectives 2. At least 75% of students will assign rank 4 or 5 to objectives in the indirect assessment	Once every two years	two years	Level 4

BSMMET Program Criteria	Courses to be used in Assessment	Metrics/ Indicators	Timeline	Loop-Closing	Level of Attainment
8.Electrical Circuits and Control	TEE3103, TEE 4214	1. At least 70% of students will score 75% on questions designed to directly address each of the course Learning Objectives 2. At least 75% of students will assign rank 4 or 5 to objectives in the indirect assessment	Once every two years	two years	Level 4
9. Product Design, Tooling & Assembly	TIE4913 (Machining Processes) TIE4115 TME4113	1. At least 70% of students will score 75% on questions designed to directly address each of the course Learning Objectives 2. At least 75% of students will assign rank 4 or 5 to objectives in the indirect assessment	Once every two years	Two Years	Level 3
10. Statistics, Quality, Continuous Improvement, and Industrial Management	TME3333, TME4343, TIE3203	1. At least 70% of students will score 75% on questions designed to directly address each of the course Learning Objectives 2. At least 75% of students will assign rank 4 or 5 to objectives in the indirect assessment	Once every two years	Two Years	Level 4
11. Technical Communications, Oral and Written	TIE3203, TIE4115, COM3000 (WPE),	1. At least 70% of students will score 75% on questions designed to directly address each of the course Learning Objectives 2. At least 75% of students will assign rank 4 or 5 to objectives in the indirect assessment	Once every two years	Two Years	Level 4

Each course has approved Learning Objective that are used to measure satisfaction of the achievement of the program criteria as mentioned in the plan above.

The modeling process is presented in Chart 4-1 below:


Inter-Mapping Process of Student outcomes/ Criteria
Does program have criteria
Yes
List the Criteria in the first column of an excel sheet
No
Create program criteria that address the learning outcomes of the program. Then List the Criteria in the first column of an excel sheet
Identify organization involved in accreditation
Starting with ETAC student outcomes, map each of the outcomes to the matching criteria and mark it in the second column of your excel sheet
Repeat above step to criteria list of each of the organizations
Verify that all organizations outcomes lists are complete and properly mapped
Your excel sheet will result in mapping each organization outcomes to your criteria and ultimately results in mapping the outcomes of all organizations to each other

5.0 Conclusion and Lessons Learned

The tradition of using **a** through **k** or any other ABET Outcomes is easier to adopt for assessment purposes, yet it might create a problem if there is a need to include other organization outcomes or modify those outcomes. Problem becomes more sophisticated when the program has to satisfy multiple professional organizations outcomes/criteria.

Each time the assessment plan is changed, data collection problems and mistakes most likely will start occur. The presented model allows the programs to make the changes on the inter-mapping of outcomes without the need for radical changes in the assessment plan.