CHAPTER 1

INTRODUCTION

1.1. Background

ABET (Accreditation Board for Engineering and Technology) accredits post-secondary degree granting programs. Accreditation is a guarantee that the study program is up to the mark and touches the baseline of quality that is expected from it by the relevant industry.

ABET demands that the CQI process is fabricated and entrenched in the engineering program, which is coupled with the Outcomes that the students have to achieve. Criterion 1 of ABET Engineering Criteria 2011-12 (http://www.abet.org/forms.shtml) dictates that student's progress must be monitored. While, Criterion 3 Criteria 3 not only sets targets or outcomes to be accomplished, but also the guarantee and evidence that these results are used to iteratively improve the engineering program.

NUST has chosen to undergo the rigors of improving the academic program through ABET accreditation and has chosen College of EME's Computer and Electrical Engineering department to prepare for meeting ABET standards. The Criteria listed by ABET is very broad and it has been left up-to the Engineering Program applying for accreditation to provide substantial evidence that not only the stipulated criterions have been met, but also that there are systems in place that would ensure continuous quality improvement of the engineering program over time.

1.2. Problem Statement

So far, none of the Universities in Pakistan have achieved ABET accreditation. In Computer Engineering, only one University in India is ABET accredited in contrast to 216 universities of the U.S. NUST being a pioneer and the leading university of Pakistan, has decided to acquire ABET accreditation. In the initial phase, two engineering programs of College of E&ME have been selected to prepare for ABET evaluators' visit. Accreditation is difficult to achieve with a manual system in place, as it would be very cumbersome to collect and present the data to the ABET's evaluators using a manual system. No 'Off the Shelf' free software tool is available, which can be readily used/configured for this purpose. Furthermore, the problem with ABET is that it does tell you "what" to do but not "how" to do it. Many academics have shared their experiences of implementing process for Continuous Quality Improvement (CQI) Aspect of ABET and the experiences of implementing Academic Program Assessment Process, in the research papers published in different journals/conferences. However, most of them are either at abstract level or non-relevant due wide differences between the educational systems/cultures. This necessitates that the various facets of

implementing ABET accreditation criteria 2011-12 within the limitations set in by our educational system and prevailing educational culture be researched. Based on this research and the options available for upgrading and improving the educational system, an automated framework must be designed that would facilitate all stake holders (students, faculty, industry advisors, and administration) to actively contribute towards the process of CQI. The Workflow Automation Framework will maintain Objective Evidence of Learning and will also assist the Engineering Program towards meeting Criterion 1 and 3 of ABET Accreditation Criteria by achieving Program Outcomes and Departments' Program Educational Objectives/Goals.

1.3. Research Aim and Objectives

With this in background, the overall aim of my work is to carry out a cross domain research where the concepts of software engineering domain will be used to simplify, streamline and facilitate the Workflow Automation Process in the education domain, thus developing an automated framework for Continuous Quality Improvement (CQI) as required under Criteria 4 of ABET EC-2000 (2011-12). It will help to accomplish Outcomes by the students and which are assessed and evaluated using assessment techniques, keeping within the ambit of those outcomes and within the limitations set in by our educational system and prevailing educational culture. To achieve this aim, I have set following objectives for my research:

a. To gain in-depth knowledge ABET Criteria EC-2000 (2011-12), Continuous Quality Improvement (CQI), Academic Program Assessment Process, Direct/Indirect assessment methods, and other relevant concepts.
b. To describe the existing (if any) Workflow Automation Framework / Process in our department highlighting its inadequacies, limitations, deficiencies and weaknesses.
c. To standardize the Workflow Automation Framework across all the departments/campuses of NUST.
d. To develop best (optimum) Workflow Automation Framework by:
    (1) Removing inconsistencies / redundancies from the our Academic Program
    (2) Simplifying the processes (remove burdensome manual process)
e. To establish Workflow Automation Framework / Process that can:
    (1) Align and map programs and courses to college and university mission
    (2) Manage course section and program outcomes.
    (3) Maintain objective evidence of fulfilling ABET's criteria

(4) Provide a process for analyzing stakeholder's feedback using feedback tools.

(5) Provide a facility to plan meetings and also trace their follow-up actions

(6) Establish a mechanism for Continuous Quality Improvement of the program

(5) Facilitate achieving ABET accreditation.

f. To identify the inadequacies/limitations of the existing approaches

g. To practically implement our solution in the software engineering domain

h. To identify future research areas.

1.4. Research Methodology

Our research methodology consists of several steps that are described as follows:

a. Firstly, a thorough and exhaustive knowledge about ABET Criteria EC-2000 (2011-12), Continuous Quality Improvement (CQI), Academic Program Assessment Process and other relevant concepts was gained. This step was conducted by reviewing existing literature in this area and analyzing various approaches for simplifying, streamlining and facilitating the Assessment Process with software or software engineering.

b. Second phase consisted of studying the requirements and expectations of the ABET evaluators which was a missing area in the literature. We had to acquire an assessment planning CD-ROM compiled by ABET's director of Professional Services, from USA. This was the critical stage in the research, where the structure of the CQI system that was intended to be put in place was chalked out broadly, based on what the evaluators are looking for.

c. We then concentrated on studying the present academic environment of the university within the constraints of the NUST rules. In addition to that, relevant minutes of the meeting were studied to know the expectations of Pakistan Engineering Council as well.

d. Next was the design phase in which the design of an optimum Workflow Automation Framework was finalized after extensive brainstorming, research and process re-engineering. This required a lot of deliberation and interaction with the advisor and committee members.

e. Finally, the development work was started which was extensively and regularly reviewed by the research advisor. Our proposed and designed system was implemented using .Net framework and is now available in the form of CASE tool.

f. It is highlighted that the system would mature only if the top management and the faculty buys-in the idea of ABET culture in education system and the culture is adapted across the

board. This would entail a total dedication and team work of the faculty and the improvement of the program, based on feedback received from the alumni and industry's Engineering Advisory Board.

1.5. Structure of Thesis

The structure of thesis is developed in a very logical pattern for an easy understanding of research case study. This thesis is structured into six chapters and document is organized as follows:

Chapter 1: It consists of general Introduction, Research Aim, Objectives of Study, Strategy, and Approach and Thesis Layout.

Chapter 2: This chapter provides literature review. Firstly, the relevant definitions/concepts and ABET's EC-2000 are discussed in this chapter, followed by the discussion on "Transition from the existing teaching methodology to EC-2000","the conduct of Campus Visit and expectations of the ABET's evaluators". Finally the experiences being shared by universities around the world that have acquired ABET accreditation are discussed

Chapter 3: In this chapter, the current educational culture prevalent in Pakistan will be discussed in general, with special focus on the methods currently employed in College of E&ME. Then the complete focus will be shifted towards the proposed structure, that would be in-line with the ABET's requirements. Finally, the Process Re-Engineering aspects to incorporate the Engineering Skills will be discussed.

Chapter 4: This chapter would discuss the modeling and design aspects of the Workflow Automation Framework.

Chapter 5: In this chapter, the quality improvement mechanism would be discussed.

Chapter 6: Conclusion and future work is the last chapter of the thesis in which we give overall summary of the thesis. We discuss certain limitation and benefits of our work and finally areas for future work have been identified and discussed.

1.6. Summary

No other university of Pakistan has ever applied or even prepared for ABET accreditation. This research signifies to identify and prepare the Computer Department for the ABET's evaluation visit, help in preparation of ABET's self-study report and most importantly, provide objective evidence of learning that would lead towards Continuous Quality Improvement of the Computer Engineering Program. Subsequently, the end product of this research work (WAF^{TM}) can later be marketed to other universities of Pakistan seeking ABET accreditation

CHAPTER – 2

LITERATURE REVIEW

The literature was reviewed to find answers to the following questions:

2.1 Why is accreditation important?

Accreditation of the engineering program is important because it helps:

a. Establish Quality of education in engineering

b. Worldwide recognition of knowledge and competency of graduating students

c. Ensure that students are properly equipped and trained to enter their practical careers

d. Impart valuable education to students so that they can cope up with varied educational careers / fields

e. provide information of quality programs to the prospective students and their parents

f. Gradual improvement of the program iteratively

2.2 What are the remunerations of seeking Program Accreditation?

Program accreditation helps the faculty transform the educational program to address following types of stakeholders:

a. The prospective students in deciding about the program

b. The parents of these prospective students who want to choose a high value program

c. The institution itself for identifying and improving upon its weaknesses

d. The employers who seek to employ the best graduating students

e. The industry who has to convey their concerns to the teaching grounds i.e. programs

f. The government, incase of a publically funded university that funds are being used for the benefit of the community

2.3 What is ABET Criteria EC2000 ?

The revised accreditation criteria was spelled out in 1997 by Accreditation Board of Engineering & Technology (renamed as ABET in 2005), commonly known as ABET Criteria EC-2000. It was a quantum shift from the traditional topics-based curriculum and what students were taught to what they actually learnt. Among the various challenges/standards an engineering program has to meet, there is a set of eleven outcomes which a student must possess, (commonly known as criteria a-k).

The criteria are based on assessing the student on a broad range of engineering outcomes. This entails a substitution of old teaching methods with new ones rather than just adding an additional outcomes assessment to the already piled-up teaching system. To get this new system in place

requires a considerable effort and time for the initial transition from the old teaching system to the new outcomes-based system. Before I elaborate the criteria, it is felt that the reader should have a common understanding of the terms related to the accreditation criteria.

2.3.1 Definitions.[1]

a. Program Educational Objectives: Program educational objectives are broad statements that describe what graduates are expected to attain within a few years of graduation. Program educational objectives are based on the needs of the program's constituencies.

b. Student Outcomes: Student outcomes describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire as they progress through the program.

c. Assessment: Assessment is one or more processes that identify, collect, and prepare data to evaluate the attainment of student outcomes and program educational objectives. Effective assessment uses relevant direct, indirect, quantitative and qualitative measures as appropriate to the objective or outcome being measured. Appropriate sampling methods may be used as part of an assessment process.

d. Evaluation: Evaluation is one or more processes for interpreting the data and evidence accumulated through assessment processes. Evaluation determines the extent to which student outcomes and program educational objectives are being attained. Evaluation results in decisions and actions regarding program improvement.

2.4 What are the Criterions of EC-2000

In order for any engineering program to apply for accreditation, following criteria must be met.

2.4.1 General Criterions of Baccalaureate Level Programs

2.4.1.1 Criterion 1- Students: Student performance must be evaluated. Student progress must be monitored to foster success in attaining student outcomes, thereby enabling graduates to attain program educational objectives. Students must be advised regarding curriculum and career matters.

The program must have and enforce policies for accepting both new and transfer students, awarding appropriate academic credit for courses taken at other institutions, and awarding appropriate academic credit for work in lieu of courses taken at the institution. The program must have and enforce procedures to ensure and document that students who graduate meet all graduation requirements.

2.4.1.2 Criterion 2 - Program Educational Objectives: The program must have published program educational objectives that are consistent with the mission of the institution, the needs of the program's various constituencies, and these criteria. There must be a documented and effective process, involving program constituencies, for the periodic review and revision of these program educational objectives.

2.4.1.3. Criterion 3 - Student Outcomes: The program must have documented student outcomes that prepare graduates to attain the program educational objectives. Student outcomes are outcomes (a) through (k) plus any additional outcomes that may be articulated by the program.

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 within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

d. An ability to function on multidisciplinary 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 broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, 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.

2.4.1.4. Criterion 4 - Continuous Improvement: The program must regularly use appropriate, documented processes for assessing and evaluating the extent to which both the program educational objectives and the student outcomes are being attained. The results of these evaluations must be systematically utilized as input for the continuous improvement of the program. Other available information may also be used to assist in the continuous improvement of the program.

2.4.1.5 Criterion 5 – Curriculum: The curriculum requirements specify subject areas appropriate to engineering but do not prescribe specific courses. The faculty must ensure that the program curriculum devotes adequate attention and time to each component, consistent with the outcomes and objectives of the program and institution. The professional component must include:

a. One year of a combination of college level mathematics and basic sciences (some with experimental experience) appropriate to the discipline. Basic sciences are defined as biological, chemical, and physical sciences.

b. One and one-half years of engineering topics, consisting of engineering sciences and engineering design appropriate to the student's field of study. The engineering sciences have their roots in mathematics and basic sciences but carry knowledge further toward creative application. These studies provide a bridge between mathematics and basic sciences on the one hand and engineering practice on the other. Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs.

c. A general education component that complements the technical content of the curriculum and is consistent with the program and institution objectives. Students must be prepared for engineering practice through a curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints.

d. One year is the lesser of 32 semester hours (or equivalent) or one-fourth of the total credits required for graduation.

2.4.1.6. Criterion 6 – Faculty: The faculty must be of sufficient number and must have the competencies to cover all of the curricular areas of the program. There must be sufficient faculty to accommodate adequate levels of student-faculty interaction, student advising and counseling, university service activities, professional development, and interactions with industrial and professional practitioners, as well as employers of students.

The program faculty must have appropriate qualifications and must have and demonstrate sufficient authority to ensure the proper guidance of the program and to develop and implement processes for the evaluation, assessment, and continuing improvement of the program, its educational objectives and outcomes. The overall competence of the faculty may be judged by such factors as education, diversity of backgrounds, engineering experience, teaching effectiveness and experience, ability to communicate, enthusiasm for developing more effective programs, level of scholarship, participation in professional societies, and licensure as Professional Engineers..

2.4.1.7. Criterion 7 – Facilities: Classrooms, offices, laboratories, and associated equipment must be adequate to support attainment of the student outcomes and to provide an atmosphere conducive to learning. Modern tools, equipment, computing resources, and laboratories appropriate to the program must be available, accessible, and systematically maintained and upgraded to enable students to attain the student outcomes and to support program needs. Students must be provided appropriate guidance regarding the use of the tools, equipment, computing resources, and laboratories available to the program. The library services and the computing and information infrastructure must be adequate to support the scholarly and professional activities of the students and faculty.

2.4.1.8. Criterion 8 - Institutional Support: Institutional support and leadership must be adequate to ensure the quality and continuity of the program. Resources including institutional services, financial support, and staff (both administrative and technical) provided to the program must be adequate to meet program needs. The resources available to the program must be sufficient to attract, retain, and provide for the continued professional development of a qualified faculty. The resources available to the program must be sufficient to acquire, maintain, and operate infrastructures, facilities, and equipment appropriate for the program, and to provide an environment in which student outcomes can be attained.

2.4.2 General Criteria for Master's Level Program

Masters level programs must develop, publish, and periodically review, educational objectives and student outcomes. The criteria for master's level programs are fulfillment of the baccalaureate level general criteria, fulfillment of program criteria appropriate to the masters level specialization area, and one academic year of study beyond the baccalaureate level. The program must demonstrate that graduates have an ability to apply master's level knowledge in a specialized area of engineering related to the program area.

2.5 Problems and Issues with Each Criterion [2]

2.5.1 Criterion 1: Students

a. Problems pertaining to the counseling of the students
b. In sufficient monitoring
c. Handling of transfer cases

2.5.2 Criterion 2: Program Educational objectives

a. PEOs not published
b. Stakeholder input is not sought
c. Evaluation process is haphazard
d. CQI evidence non-existant

2.5.3 Criterion 3: Program Outcomes

a. All outcomes not mapped in entirety
b. Proof of attainment of outcome is not sufficient / relevant
c. Assessment and evaluation process is not methodical

d. CQI proof is not available

2.5.4 **Criterion 4: Professional Components**

a. System is bypassed to show improvement, false grading

b. Choice of selective and elective subjects is not given

2.5.5 **Criterion 5: Faculty**

a. Not sufficient in number to meet the workload

b. Morale of faculty is declining with adverse effects on the program

2.5.6 **Criterion 6: Facilities**

a. Space constraints

b. Laboratory facilities are inadequate

c. Obsolete equipment

d. Insufficient funds

e. Up-gradation not a regular feature

2.5.7 **Criterion 7: Institutional Support & Financial Resources**

a. Top management not given sufficient tenure to implement their policies

b. Insufficient budget, which affects the salaries and purchase of equipment

c. Staff which has to provide support is non-existent or insufficient

The actual emphasis of ABET is not assessment rather continuous improvement of the program and processes, in order to satisfy the stakeholders.

2.6 What are the Steps of Transition to ABET's EC-2000

The initial transition system should address the following [3]:

a. Recognize and Understand the fact that ABET Engineering Criteria 2000 requires a major change in methodology by which we impart engineering education instead of being a mere addition to the existing system/status quo.

b. Recognition of the fact that this transition process would include assessment of existing system, designing the new system, assessing and evaluating the engineering program.

c. Recognize that the process of designing and implementation would involve vast groups of people (for example: faculty, administration and campus-wide committees, students, alumni and employers)

d. Development of both the institutional and program specific educational objectives and get the faculty and administrations consensus on these.

e. Compare these institutional and program specific educational objectives with the ABET Engineering Criteria EC2000 and identify the process and program mismatches.

f. Embed the program educational objectives (mapped with ABET criteria) into the engineering program's completion requirements.

g. Give the students a chance to prove and show that they have achieved and acquired the standards relating to the outcome, through which the assessment data is subsequently generated. The assessment would then be used for modification of specific aspects. These modifications when fitted-in would cause some old academic components to be removed, thereby, embedding the ABET based assessment criteria into the 4-year baccalaureate degree framework.

h. Identification and separation of individual measures (related to individual students/degree requirements) and group based measures (anonymous surveys)

i. Analysis on replacing/integrating the conventional academic grades (A-F) in-term of measures representing the meeting of educational objectives.

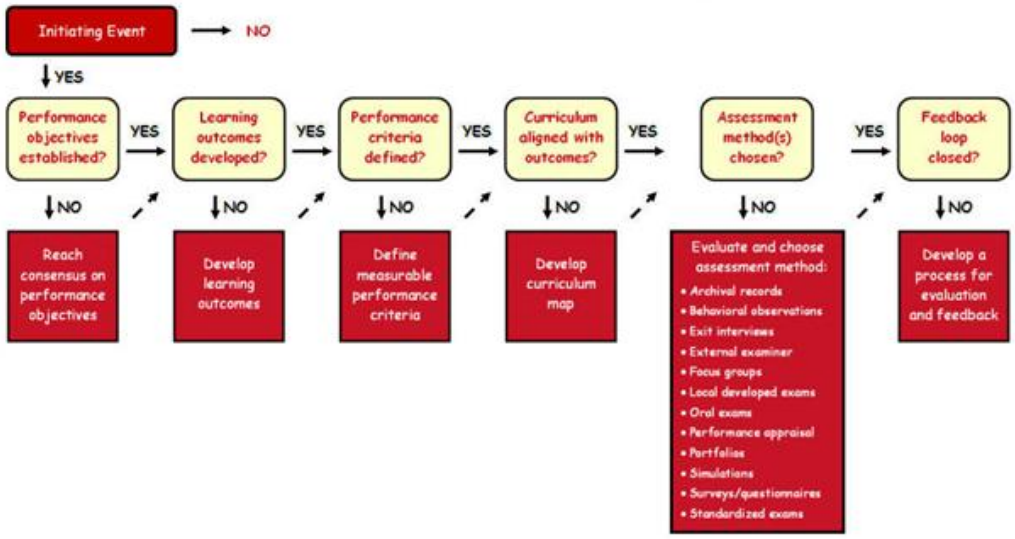
j. Also embed extra-curricular aspects (in line with ABET Criteria) and define/derive their assessment measures.

k. Plan for testing and validating the outcomes-based assessment.

l. Define and implement a time schedule for transition.

2.7 Continuous Improvement

The ABET Engineering Criteria is geared towards an enormous change in the approach towards program evaluation. The most significant change would be in faculty attitude towards the role of various courses in the overall educational process. Even after completion of the transition phase from the old academic system to the new one, the continuous improvement process would continue indefinitely. This could only be achieved by analysis throughout the educational program thereby removing the problematic areas and plugging them in with modifications/improvements in the courses, syllabi and teaching practices. In a nut-shell, change and continuous improvement is the main requirement/outcome of ABET based engineering program. Below is a flow diagram which guides towards a step by step implementation of the criteria [4]



2.8 What all aspects should be catered for ABET accreditation visit?

Before an accreditation visit is asked for, the university has to submit a self-study questionnaire. As per ABET, the preparation of the questionnaire report should take around one and a half year, because it has to show aspects like longitudinal development and continuous quality improvement. The evaluation team studies the report and then verifies the claims during campus visit. Let us take a candid look into what actions are required & expected by the program seeking accreditation.

2.8.1 Significant Aspects of the EC-2000

The significant aspects of EC 2000 are [5]:

a. The new criteria is less verifiable from audit point of view

b. There is no standard solution or template for the criteria; it is upto the degree program to tailor is as per its working environment

c. The evaluation of the program is done under a vast variety of subjects, some of which are:

(1) Faculty involvement

(2) Development of curricula

(3) Setting up of goals

(4) Extraction/assessment of outcomes achieved using a comprehensive assessment plan that gathers adequate data for evaluation and improvement of the program

d. All these aspects require a comprehensive structure to support all the functions and later a mechanism to evaluate the assessment data, thereby suggesting changes for improvement.

2.8.2 Common Difficulties in the Self-Study Report

Here we have to also cater for some common pitfalls in preparation for the self-study report [5]:

a. Difficulty #1:Self-Study report does not address the necessities of ABET evaluator : Programs seeking accreditation are inclined to gather all information which they can, thereby, trying to make the report heavy, either not touching or barely addressing the evaluation and CQI aspects. The evaluator tries to determine whether the report preparation is defective or the examination system , as the basic reason for program assessment is CQI, not only sustaining ABET's requirements. A good report must provide the relevant links between: Program Educational Outcomes, Objectives, Assessment Methods, and Improvements in the Curriculum.

b. Difficulty #2:The Self-Study report misses some criteria in entirety while addressing other criteria in detail: Instead of addressing a few aspects in great detail and missing other criteria altogether, the report should be prepared as to address all facets. The level of details may vary, but, no criteria should be skipped / left blank.

c. Difficulty #3:Poor Organization of the report. Often, the task of report preparation is split amongst various faculty members. The effort to combine the work of all members and prepare an integrated report is often overlooked. An evaluator who finds disjointedness in different parts of the report would not carry a good impression of the program.

d. Difficulty #4:Drafting the report from faculty's perspective instead of the evaluators'. In order to check and verify the quality of the self-study report, the report preparer has to try to put him/herself in the evaluator's shoes. What would he/she make out of this report and does the report address all items that are otherwise obvious to the faculty members / personnel who have prepared the report.

2.8.3 An Evaluator's Viewpoint on the ABET Criteria

During study of the Self Study report and conduct of the Campus Visit, the Evaluator anticipates [5]:

a. An organized and condensed Report that is linked to the criteria

d. Discrete criteria exist according to the program being offered (e.g., Computer Engineering, Electrical Engineering)

c. Curriculum is nourishing mix of mathematics, basic sciences and engineering topics

e. Processes exist to initially design, then put in place and iteratively improve the program

f. The planned assessment cycle is being implemented according to a well deliberated schedule and that assessment activities are focused towards attainment of outcomes

g. Adequate data is generated that can be later used to evaluate both the performance of individual students and the quality of the curriculum

h. Plans to improve the program are well documented and deep rooted

i. Institutional support is sufficient to sustain the program

j. The ABET criteria is well read and understood by the faculty

2.8.4 How the visit should be planned / organized.

In order for the best utilization of time during the conduct of the visit, it is very essential to involve the evaluator right from the planning stage, regarding how he/she plans to conduct the visit. In addition to that, the visit plan must have adequate flexibility to cater for the evaluators meetings with faculty, students, standing committees. The evaluator needs to gain a very close understanding about how the curriculum is developed, implemented, assessed and reviewed. Often, the committee member would require one-on-one meetings with faculty members. Use of purpose made movies showing campus activities can make the process speedy. In addition to that, ABET guidelines state that the evaluator should complete the visit report within the same duration, therefore timings for preparation of report draft and its review must also be catered for.

2.8.5 Incremental Growth

The implementation of ABET culture is a time consuming and demanding task, which requires dedication and commitment of the faculty. It is also worthy to note that the quality improvement of the program does not take place over-night. Even ABET advocates that the education cycle spans over 3-5 years. With each increment, the processes mature. Implementation of new teaching methods is scarce, as the initial structure to sustain the basic requirements of ABET are cumbersome to implement in the first place.

2.9: What does ABET 'a-k' Mean ?

The educational model of planning-implementing-evaluating-improving is a time consuming model in which each step take time and effort to be implemented. The program improvement is achieved in iterative cycles [6]. Universities around the world who have hurriedly implemented the this model have bypassed the actual spirit of this model, which is to know what is actually meant by these SLOs, so that the educational impetus is shifted accordingly and educational quality improvement is attained. Institutional culture does not change with revolution, rather with evolution. This infers that

the captivation of real knowledge and skills takes time, basing on the student's academic development. Resultantly, Student learning outcomes relates to two issues:

a. Extensiveness of the Paradigm. In order to implement a construct/concept, first its limits have to be defined. As a first step, constant terminology needs to be defined amongst all faculty members. A researcher, Nicholas [7], has defined this in his paper as, "…*proposed instructive (student) outcomes are explanations of what educational units (faculty) want students to recognise (cognitive), deliberate (attitudinal), or act (behavioural) upon completion of their engineering programs, in addition to broad knowledge or 'core' syllabi.*" The faculty faces a real dilemma in breaking down the above definition and its subsequent implementation:

   (1) Outcomes associated to Cognitive Domain. The dilemma is how to express them? Krotseng and Pike [8] have concluded that the cognitive education is mostly related to student learning including the learning of skills mentioned in core courses in addition to general education and the ability to communicate booth verbally and in writing. On a broader prospective or canvas, the cognitive skills are related only towards acquiring education. Focus is however shifted towards higher order skills with the increase in level or grade of education, such as creative writing of scenario building.

   (2) Outcomes Related to Attitudes. This implies the relation between student's attidues, values and his/her state of mind towards institutional goals or focus. Collection of data for this focus is acquired by conducting individual interviews, precisely designed survey questionnaires or through discussion in focus groups. The evaluation is later done at the broader or institutional level. EC 2011-12 does not include the construct of feelings, but, they nevertheless advocate the valuation aspect of engineering profession.

   (3) Outcomes Related to Behaviour. These are more related to the classroom environment. A simple definition would be to observe the reaction or conduct of the student to intrinsic or extrinsic impetuses. In terms of engineering growth, the behavioural aspects relate to what the students have learned all through their 4-year engineering educational progression. This in turn relates that not only the knowledge should be attained, but it should consequently be applied in harmony with the situation or problem posed.

Hence, a particular learning outcome can be defined by integrating these three elements (cognitive, attitudinal and behavioural).

b. The Level of Specificity. The broad terms in which the ABET criteria is defined may vary greatly. At one end, terms are generalistic such as, "Understanding", "Comprehending" and "Applying". In contrast, there also are relations that are too narrowly fixated, such as "Synthesizing", "Enumerating" and "Organizing". These wide-ranging statements help the institution in implementing the criteria in accordance with their prevalent educational culture. The ABET outcomes (a-k) must then be further broken down as per the need of the specific engineering programme. The lack of specific construct, however, does pose several problems:

(1) The need for a consensus on definitions, criteria and assessment process, both by the faculty and the students. By arriving at a consensus, it would be possible to map both the vertical and horizontal aspects of integration, which implies one specific to a program as opposed to the one that is spread across all engineering subjects. In case the faculty is able to make and inter-connect among these courses, only then he/she would be able to transfer knowledge, behaviour and attitude related education across the curriculum [9].

(2) Considerable time, expertise and resources are required in order to transform these outcomes into measurable explanations which would harvest apt assessment results.

2.10 What is Continuous Quality improvement (CQI) aspect of ABET?

ABET EC2000, Criterion 4: Continuous Improvement. "*The program must regularly use appropriate, documented processes for assessing and evaluating the extent to which both the program educational objectives and the student outcomes are being attained. The results of these evaluations must be systematically utilized as input for the continuous improvement of the program. Other available information may also be used to assist in the continuous improvement of the program*" [1].

The CQI process is based on evaluation of assessment data, identifying weak areas, suggesting program improvement and then archiving the data for further analysis and as evidence of CQI of the engineering program.

a. Identification of Weak Areas. ABET demands that systems be in place to identify and improve upon weak areas of the program. Faculty must continuously evaluate the assessment data for the following:

(1) Whether the students will be able to acquire SLOs by the time they are expected to graduate

(2) In turn, the faculty is able to acquire or achieve attainment of PEOs within the relevant engineering discipline

(3) Processes are in place to monitor and improve upon the classroom based teaching methodology

(4) Adequate time is allotted to counselling matter of the students and also to guide them regarding career matters, as required vide criteria 1 of ABET.

b. Evidence of CQI. For a successful campus visit of the ABET team, following data should be made available by the faculty to support evidence of a well-established CQI process. Also enumerated below are a few questions that the evaluator might ask [10]:

(1) *An uninterrupted time line for different assessment and evaluation undertakings*. The evaluator might ask "Over what period does the program collect and analyse the assessment data?"

(2) *Evidence of faculty agreement on the performance pointers for each outcome*. The evaluator might ask the faculty "How are the SLOs defined in a manner that the faculty can subsequently perform the assessment activities consistently?"

(3) *A well-structured data collection apparatus with emphasis on summative performance relating to each pointer*. The evaluator might ask: "How do you collect and summarize the assessment data, which shows horizontal learning?"

(4) *Process for focussing towards specific data concentration obtained from summative outcomes against specific performance indicators that pertain to individual students*. The evaluator might ask "Show me the data collection mechanism?"

(5) *Methods that have been employed to identify strengths and weaknesses in attaining an outcome by the students*. The evaluator might ask Show me how have you calculated and analysed the strengths and weaknesses of your students in attainment of individual SLO?"

(6) *The designing and implementation of the Evaluation process in order to identify and subsequently focus upon the weaknesses and the remedies employed later by the faculty*. The evaluator might ask "Show me how your proposed improvements as a result of evaluation data has helped in eradicating the identified weaknesses?"

2.11 What is Academic Program Assessment Process?

2.11.1 Definition of Assessment. It is a process aimed towards improvement or accountability (or both) in a system. Some of the formal definitions are as under:

a. "*A process of gathering and deliberating upon information collected over time and from different sources. It is used to get a deep insight into student learning process, knowledge of which is subsequently used to improve the quality of the engineering program through process improvement*". [11]

b. "*Wholesome and systematic processes for examining student's work against standards of judgment set-in by the faculty. This process helps in shaping the transformation between what the students were expected to learn and what they actually learned during their educational evolution. In addition to what the students learn in individual courses, their learning-over-time is also examined. The data collected from several sources and helps the faculty apprehend what the students really acquire from the educational system already in place*" [12]

c. "*It is not only a gathering of data. In order for it to be eloquent, the faculty must be unequivocally clear about the information being collected. The faculty must first focus upon the objectives set for learning and also ensure that these are effectively covered in the syllabus*" [13]

2.11.2 Sample set of Questions Describing Assessment: They are [14]

a. Valuation aspect of what the students are taught and what they learn?

b. Is the learning level of our graduates satisfactory?

c. How the engineering program and the institution contributing towards the growth of the students?

d. What measures can be put in place to improve upon student learning?

2.11.3. Properties of Good Assessment Techniques [15]

a. Binding: Are linked directly to the SLOs

b. Consistent: Any faculty member can grade and the results would not vary

c. Focused: The results gathered as a result help the faculty arrive at a consensus on the weaknesses

d. Effective and profitable: Talking in terms of the time and resources required

e. Encompassing all stakeholders: Will enable all of them to play they part

f. Stimulating all stakeholders: The outcomes generated as a result are binding upon the stakeholders responsible for program improvement

g. Triangulation: Same results are achieved through several assessment techniques

2.11.4. Faculty Experience. The faculty is generally experienced enough to have a fair idea of the strengths and weaknesses of the program. They know the shortfalls and bottlenecks in the conduct of the program and they also know the strong points of their program. Their knowledge and perceptions are based on some strong evidence, but, normally, that knowledge is not used by the faculty for the categorical purpose of program improvement. The process of gathering and compiling relevant data is the academic program assessment process, which is later used to evaluate the strengths and weaknesses of the program.

2.11.5 Assessment Methods.

2.11.5.1 The assessment process / evidence collection should be a mix of both direct and indirect assessment methods. The information so collected is aggregated / summarized for the entire program. But, in that context, it is quite necessary that the evidence be made anonymous. i.e., the removal of names of students, and more importantly, the data collected should not be used in any way to assess / evaluate / grade a faculty member. Next, we will take a look at what we mean by direct / indirect assessment methods.

a Direct Assessment / Evidence. Typically, it includes results and samples of student's coursework. It may also include results of professional or state level exams that the students are required to take. However, student's grades are not a true reflection of student learning, firstly, because, they are not typically assessed from the entire syllabus and local exams tend to stress on some parts of the subject instead of asking a wholesome set of questions.

b. Indirect Assessment / Evidence. The latest advancements in teaching and learning strategies which include various types of surveys, focus groups, job placement interviews, internships, foreign scholarships, undergraduate research activities can all form part of indirect evidence of student learning.

2.11.5.2 Tips for Data Collection. To avoid extra burden of processing cumbersome load of data, the data collection should focus on specific sets of data, instead of collecting each and every data item. In addition to that, the data collection system matures over time and its focus narrows down on data that is essentially required.

2.11.6 Assessment Cycles. Each program should have clear timelines for different assessment activities, based on the program curriculum. This is an iterative system which gets refined over time. Due emphasis needs to be given to the accreditation cycle which is typically spanned over a 3-5 year period. To determine the frequency of data collection from various assessment techniques, following question would serve as a guideline [16]:

a. Does the achievement of students drop in case of one particular objective?

b. Is the program strength associated with one particular objective being met ?

c. Does some essential / crucial program goal have a direct dependency on some particular objectives?

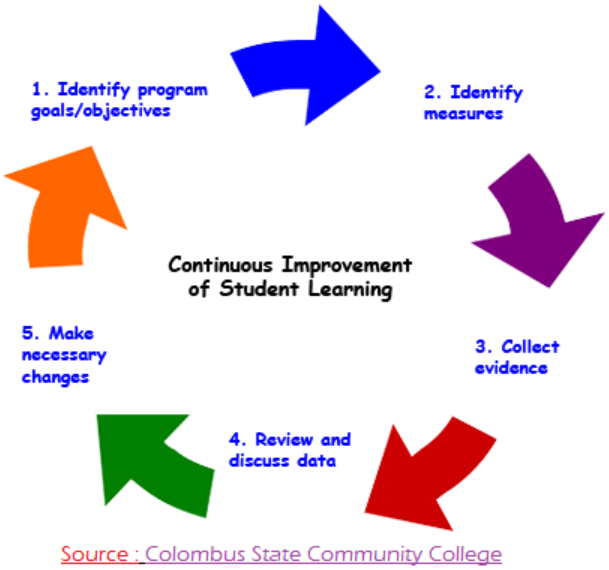
d. How many courses are linked to the fundamental objectives?

e. What are the core courses and are they linked to the fundamental objectives?

f. With what frequency are the courses run?

g. Are the goals being met by a set pattern of teaching methodology, or, are the methods being improved with advancement of educational standards?

h. What is the review frequency for the Program?



Source : Colombus State Community College

2.11.7 **Evaluation & using the results for Continual Improvement**. This is the most important phase of the CQI cycle. The important aspects to ponder upon with all stakeholders in this phase are:

a. Of all the assessment methods put in place, which ones are providing useful information

b. How much the decision-making process dependent upon the evaluation

c. With completion of the evaluation cycle, what changes to the program are agreed upon

d. What are the weaknesses of existing assessment system and what measures would ensure betterment in the system

2.12 ABET tells us what-is-to-be-done for ABET accreditation, but, does not tell us how-to-do-it!

2.13.1 Yes, that is exactly the case, ABET gives the institutions the liberty to select whatever teaching and assessment / evaluation methods necessary to meet the accreditation criteria. To illustrate this point, I would like to present the following material taken from ABET evaluation team training presentation:

a. Terminology. it has been left to the instituition to define the terminology that suits them. As an example: 'aim' can represent what the graduating students achieve within 4-5 years of entering their practical life (which is otherwise denoted by Program Educational Objectives)

b. Key Terms used by ABET team. Each criteria will be graded according to one of these four terms by the ABET team [1]:

(1) Compliance: The criteria is satisfied by the program

(2) Concern: Present results dictate that the criteria is being met, however conditions do exist for non-compliance

(3) Weakness: The Criteria is not being met adequately, which would in turn result in dilapidation of the engineering program

(4) Deficiency: The program does not meet or achieve the specified criteria

c. It should not be left onto the ABET evaluation team to identify the CQI process, rather the program itself should be conducted in such a manner that the CQI process is self-evident. For doing that, first of all there should be clear mapping between mission, goals and objectives. The evaluation team would only assess the program based on the assessment criteria and not on the program's general repute

d. ABET presumes that every graduate must have following traits:

(1) Able to have achieved the defined outcomes and all the other professional traits

(2) The achievement level may however vary in proportion to the importance or relevance of the outcome to the program needs.

2.12.2 From the above material reference [17], it is quite clear that the ABET team would compare the ground implementation and procedure with their broadly stated criterions as per EC2000. They allow any method / combination of methods to be used to achieve a criteria. But, they would definitely check and assess the quality of the program based on implementation and ground facts.

2.13 What Direct / Indirect assessment methods are available or being used? Universities and researchers from all across the globe are continually developing new educational techniques, linked to which are their specialized assessment methods. These techniques / methods lie in the ambit of either direct or indirect assessment, but, the results they yield are quite helpful in evaluating the assets and liabilities of the study program. The tables on the next pages enumerate the methods, highlighting both their strengths and weaknesses

2.13.1 Direct Assessment Techniques. Shown in tabular form on next page

Direct Assessment Techniques Assessing Academic Programs in higher education		
Technique	**Potential Strengths**	**Potential Limitations**
Published Tests	• Can provide direct evidence of student mastery of learning objectives • Generally, are carefully developed, highly reliable, professionally scored, and nationally normed • Frequently provide a number of norm groups, such as norms for community colleges, liberal arts colleges, and comprehensive universities • Online versions of tests are increasingly available, and some provide immediate scoring • Some publishers allow faculty to supplement tests with their own items, so tests can be adapted to better serve local needs	• If the test does not reflect the learning objectives that faculty value and the curricula that students experience, results are likely to be discounted and inconsequential • Most published tests rely heavily on multiple choice items that often focus on specific facts, but program learning objectives more often emphasize higher-level skills • Test scores may reflect criteria that are too broad for meaningful assessment • Students may not take the test seriously if test results have no impact on their lives • Tests can be expensive • The marginal gain from annual testing may be low • Faculty may object to standardized exam scores on general principles, leading them to ignore results
Locally Developed Tests	• Can provide direct evidence of student mastery of learning objectives • Appropriate mixes of items allow faculty to address various types of learning objectives • Can provide for authentic assessment of higher-level learning • Students generally are motivated to display the extent of their learning • If well-constructed, they are likely to have good validity • Because local faculty write the exam, they are likely to be interested in results and willing to use them • Can be integrated into routine faculty workloads • Campuses with similar missions could decide to develop their own norms, and they could assess student work together or provide independent assessment of each other's student work • Discussion of results focuses faculty on student learning and program support for it	• These exams are likely to be less reliable than published exams • Reliability and validity generally are unknown • Creating effective exams requires time and skill • Score exams takes time • Traditional testing methods may not provide authentic measurement • Norms generally are not available

Direct Assessment Techniques Assessing Academic Programs in higher education		
Technique	Potential Strengths	Potential Limitations
Embedded Assignments & Course Activity	• Can provide direct evidence of student mastery of learning objectives • Out-of-class assignments are not restricted to time constraints typical for exams • Students are generally motivated to demonstrate the extent of their learning • Can provide authentic assessment of learning objectives • Can involve ratings by fieldwork supervisors • Can provide a context for assessing communication and teamwork skills, as well as other types of learning • objectives • Can be used for grading as well as assessment • Faculty who develop the procedures are likely to be interested in results and willing to use them • Discussion of results focuses faculty on student learning and program support for it • Data collection is unobtrusive to students	• Requires time to develop and coordinate • Requires faculty trust that the program will be assessed, not individual teachers • Reliability and validity generally are unknown • Norms generally are not available
Competence Interviews	• Can provide direct evidence of student mastery of learning objectives • The interview format allows faculty to probe for the breadth and extent of student learning • Can be combined with other techniques that more effectively assess knowledge of facts and terms • Can involve authentic assessment, such as simulated interactions with clients • Can provide for direct assessment of some student skills, such as oral communication, critical thinking, and problem-solving skills	• Requires time to develop, coordinate, schedule, and implement • Interview protocols must be carefully developed • Subjective judgments must be guided by agreed-upon criteria • Interviewer training takes time • Interviewing using unstructured interviews requires expertise • Not an efficient way to assess knowledge of specific facts and terms • Some students may be intimidated by the process, reducing their ability to demonstrate their learning

Direct Assessment Techniques Assessing Academic Programs in higher education		
Techniques	Potential Strengths	Potential Limitations
Portfolios	• Can provide direct evidence of student mastery of learning objectives • Students are encouraged to take responsibility for and pride in their learning • Students may become more aware of their own academic growth • Can be used for developmental assessment and can be integrated into the advising process to individualize student planning • Can help faculty identify curriculum gaps • Students can use portfolios and the portfolio process to prepare for graduate school or career applications • Discussion of results focuses faculty on student learning and program support for it • Web-folios or CD-ROMs can be easily viewed, duplicated, and stored	• Requires faculty time to prepare the portfolio assignment and to assist students in preparing portfolios • Requires faculty analysis and, if graded, faculty time to assign grades • May be difficult to motivate students to take the task seriously • May be more difficult for transfer students to assemble the portfolio if they haven't saved relevant materials • Students may refrain from criticizing the program if their portfolio is graded or if their names will be associate with portfolios during the review • It may be difficult to protect student confidentiality and privacy
Collective Portfolios	• Can provide direct evidence of student mastery of learning objectives • Students generally are motivated to display the extent of their learning	• If assignments are not aligned with the objectives being examined, evidence may be problematic • If sampling is not done well, results may not generalize to the entire program

2.13.2. Indirect Assessment Techniques. Next we take a look at the indirect assessment techniques, enumerated in the table on the next page, along with their potential strengths and weaknesses.

Indirect Assessment Techniques Assessing Academic Programs in higher education		
Technique	**Potential Strengths**	**Potential Limitations**
Surveys	• Are flexible in format and can include questions about many issues • Can be administered to large groups of respondents • Can easily assess the views of various stakeholders • Usually have face validity — the questions generally have a clear relationship to the objectives being assessed • Tend to be inexpensive to administer • Can be conducted relatively quickly • Responses to closed-ended questions are easy to tabulate and to report in tables or graphs • Open-ended questions allow faculty to uncover unanticipated results • Can be used to track opinions across time to explore trends • Are amenable to different formats, such as paper-and pencil or online formats • Can be used to collect opinions from respondents at distant sites	• Provide indirect evidence about student learning • Their validity depends on the quality of the questions and response options • Conclusions can be inaccurate if biased samples are obtained • Results might not include the full array of opinions if the sample is small • What people say they do or know may be inconsistent with what they actually do or know • Open-ended responses can be difficult and time consuming to analyze
Interviews	• Are flexible in format and can include questions about many issues • Can assess the views of various stakeholders • Usually have face validity — the questions generally have a clear relationship to the objectives being assessed • Can provide insights into the reasons for the participants' beliefs, attitudes, and experiences • Interviewers can prompt respondents to provide more detailed responses • Interviewers can respond to questions and clarify misunderstandings • Telephone interviews can be used to reach distant respondents • Can provide a sense of immediacy and personal attention for respondents • Open-ended questions allow faculty to uncover unanticipated results	• Generally provide indirect evidence about student learning • Their validity depends on the quality of the questions • Poor interviewer skills can generate limited or useless information • Can be difficult to obtain a representative sample of respondents • What people say they do or know may be inconsistent with what they actually do or know • Can be relatively time-consuming and expensive to conduct, especially if interviewers and interviewees are paid or if the no-show rate for scheduled interviews is high • The process can intimidate some respondents, especially if asked about sensitive information and their identity is known to the interviewer • Results can be difficult and time-consuming to analyze • Transcriptions of interviews can be time-consuming and costly

Indirect Assessment Techniques Assessing Academic Programs in higher education		
Technique	**Potential Strengths**	**Potential Limitations**
Focus Groups	• Are flexible in format and can include questions about many issues • Can provide in-depth exploration of issues • Usually have face validity — the questions generally have a clear relationship to the objectives being assessed • Can be combined with other techniques, such as surveys • The process allows faculty to uncover unanticipated results • Can provide insights into the reasons for the participants' beliefs, attitudes, and experiences • Can be conducted within courses • Participants have the opportunity to react to each other's ideas, providing an opportunity to uncover the degree of consensus on ideas that emerge during the discussion	• Generally provide indirect evidence about student learning • Require a skilled, unbiased facilitator • Their validity depends on the quality of the questions • Results might not include the full array of opinions if only one focus group is conducted • What people say they do or know may be inconsistent with what they actually do or know • Recruiting and scheduling the groups can be difficult • Time-consuming to collect and analyze data
Reflective Essays	• Are flexible in format and can include questions about many issues • Can be administered to large groups of respondents • Usually have face validity — the writing assignment generally has a clear relationship to the objectives being assessed • Can be conducted relatively quickly • Allow faculty to uncover unanticipated results • Can provide insights into the reasons for the participants' beliefs, attitudes, and experiences • Can provide direct assessment of some learning objectives	• Generally provide indirect evidence about student learning • Their validity depends on the quality of the questions • Conclusions can be inaccurate if biased samples are obtained • Results might not include the full array of opinions if the sample is small • What people say they do or know may be inconsistent with what they actually do or know • Responses can be difficult and time-consuming to analyze

2.13.3. <u>ABET's view point on Direct and Indirect Assessment Techniques</u>. Very briefly, we take a glance at another table, which has been composed by ABET's Managing Director for Professional Services, who writes for an ABET Community Matters magazine, on Assessment Tips. The magazine that has now been discontinued, but these methods quote the ABET evaluator's viewpoint / expectations [19] :

Method	Direct	In-Direct
Locally Developed Exams	☑	
Standardized Exams	☑	
External Examiner	☑	
Oral Exams	☑	
Portfolios	☑	
Performance Appraisal	☑	
Simulations	☑	
Behavioral Observations	☑	
Focus Groups		☑
Archival Data		☑
Written Surveys, Questionnaires		☑
Exit and Other Interviews		☑

2.14 How inconsistencies in teaching styles and curriculum can be addressed?

a. Inconsistencies can be addressed by standardizing the assessment and evaluation procedures and processes in the university campuses / departments. This can be achieved by developing a software tool / platform which can be used by all the departments running different engineering programs / courses. Developing the software alone would not help, as, the faculty will use it only if they buy-in to the idea & the importance of using the software to record student's performance and to let the software analyze how the course was taught.

b. Based on the results, the feedback for improvement is delivered to the top management who can affect / take corrective measures towards the improvement of the system. In our case, the feedback is initially given to the Head of the Computer department and to the Training Officer of the department. HOD reviews the feedback report and does an initial examination/analysis of the problem to find out if the weakness was due to an over-sight in the instructional methodology by the faculty.

c. For the software implementation, it is a must that the faculty is given the confidence that this evaluation & feedback system will never be used for pointing out the faults/weaknesses of individual faculty members, but, rather for CQI of the Course and the Program.

d. After initial analysis, the HOD marks the feedback points for discussion in the next Department Board of Studies (DBS-CE)& later the university's Central FBS meeting (FBS-EME). In both these meetings, the problem is analyzed in great detail and the different options for its corrective measures are pondered upon. Then, mostly, with the consensus of the entire faculty, the corrective action is approved and the minutes of the meeting are recorded as executive orders for implementation.

e. Accordingly, the teaching/assessment technique is modified and the software upgraded to allow for standardization in the teaching / assessment methodologies.

2.15 Is there any standardized method for Academic Process Assessment?

a. Unfortunately, there is no standard method for the assessment process. Institutions worldwide have adopted different combination of techniques, relying on Direct Assessment (Qualitative & Quantitative) and In-Direct Assessment techniques, already discussed in preceding text. Institutions have to choose how to proceed with their assessment process basing on the region/academic culture and the available infrastructure & facilities. Though it is desirable to adapt the latest / emerging trends in imparting education, yet, engineering programs have to consider aspects such as student's background education and knowledge, faculty that is trained on these educational techniques as well as (more importantly) on their assessment methods. For example, one of leading trends is assessing the students through portfolios. Being an entirely new concept in Pakistan, magnanimous efforts would be required to educate the students on the importance n requirement of these portfolios. In addition to that, training of certain faculty members would be required to assess the portfolios. This training would have to co-ordinated with leading universities in e-portfolio techniques. After these two steps are done, then we have to allow the system to sync-in and mature iteratively, so that we can get the expected results / evaluation from the system. This requires patience, funding and most importantly, the resolve by the faculty and particularly, the top management to enforce the new technique and develop a portfolio culture for future students.

b. As part of improving the educational culture and taking a first step towards adapting ABET culture, our research team, under our supervisor has started work on assessment methodologies and how they can be incorporated in our environment.

2.16 How people have tried to simplify, streamline and facilitate the assessment process with software or software engineering ?Any critique / analysis on these approaches? Since the inception of the EC2000 criteria, universities around the world have developed many tools and methods to help collect the assessment data, document it and with the help of certain tools, even to evaluate it. However, with the exception of a very few universities, the details of these tools is never shared with the fellow community. Research papers and materials

broadly tell the outline of the preparation and conduct of the visit, intentionally skipping the details of the tools. The tools can broadly be divided into the following categories:

a. Rubrics: Before getting into the detail of rubrics, we first see the context for which they are required. Each program has different courses. Logically, each course must address one or more ABET criteria (a-k). On completion of the program, all criteria should have been met / addressed in various courses taught. For achieving these ABET criteria, each Course has to define the Course Outcomes. In order for assessing these outcomes, relevant Performance Criteria has to drafted. The performance criteria must be measurable (active verbs, focused around contents). An example of the above is shown in the table below:

Overarching Objective (ABET)	Outcomes (CE Program)	Performance criteria (CE Program)
Work effectively in teams	Make contributions	Researches and gathers information
	Take responsibility	Shares work equally
	Value others viewpoints	Listens to other team members

The most effective tool to establish performance criteria is rubrics. They usually contain grading on Likert's scales (1-4, unsatisfactory – excellent). The break-up of the criteria into grades helps assess the learning outcomes in an effective way. The example below shows how a rubric for an outcome pertaining to Life-Long Learning:

Performance Indicator	1 (Unsatisfactory)	2 (Partially Satisfactory)	3 (Satisfactory)	4 (Outstanding)
Ability to perform independent literature search	Unable to perform the search independently	Performs search with assistance	Performs search independently	Possesses and demonstrate outstanding capabilities
Development of a plan	No plan	Partial plan	Has developed a plan	Extensive & Flexible plan

b. Digital Portfolios

(1) It is a digital organization of document by its creator in such a manner to bring out the skills acquired over time and to show vertical growth of the student. They have the added advantage of proving e-access to the resume written skills of the student by the potential stakeholder, i.e., the faculty who grades the portfolio or the employer seeking a competent employee / intern. It provides the student a richer medium to express their skills and knowledge to potential employees.

(2) Being a "*a focused composition of student's work which showcases his / her strengths and achievement. The student should be involved in selecting, organizing and presenting his learning achievement for those judging it, as a proof*." [20]

(3) Portfolio Design. There is no set solution for designing and organizing a portfolio. For the design to be finalized, the creator of the portfolio should first be crystal clear about what outcomes the portfolio would address and what type of assessment is envisioned to be achieved out of it. The intended usage of the portfolio will guide its design and focus. Portfolios are not themselves a proof, rather they are a purposeful collection and organization of proofs of achievement [21].

(4) Portfolio Types. There are two basic types of portfolios

(a) Showcase Portfolio: Collection of best work

(b) Developmental Portfolio: Collections showing evidence of growth

(5) In short, a portfolio is about "*collecting, selecting, reflecting and connecting*." [22]

(6) e-Portfolio Grading using Rubrics. The e-portfolio grading requires specialized training for faculty members, in addition to dedicating time for this laborious work. They are graded according to a grading rubric and the evaluation may therefore vary within faculty members. A sample grading rubric is attached below [23]:

e-Portfolio Evaluation				
	Incomplete	Partially Proficient	Proficient	Exemplary
	0 Points	1 Points	2 Points	3 Points
Reflections 3 pts	No reflections identify and describe professional growth goals for lifelong learning.	A few reflections identify and describe professional growth goals for lifelong learning and these are constructive in nature.	Most of the reflections identify and describe professional growth goals for lifelong learning and are constructive in nature.	All reflections clearly identify and describe professional growth goals for lifelong learning and are constructive in nature.
Selection 3 pts Selection of artifacts and written communication	Most artifacts and work samples are unrelated to the purpose of the e-portfolio.	Few artifacts and work samples are related to the purpose of the e-portfolio.	Most artifacts and work samples are related to the purpose of the e-portfolio.	All artifacts and work samples are clearly and directly related to the purpose of the e-portfolio.

e-Portfolio Evaluation				
	Incomplete	Partially Proficient	Proficient	Exemplary
	0 Points	1 Points	2 Points	3 Points
Use of Multimedia 2pts	The photographs, graphics, sounds, and/or videos are inappropriate. They are distracting and detract from the content.	A few of the multimedia enhance the purpose of the e-portfolio, create interest, and are sometimes appropriate.	Most of the multimedia enhance the purpose of the e-portfolio, create interest, and are generally appropriate.	All of the multimedia enhance the purpose of the e-portfolio, create interest, and are appropriate.
Captions 1 pts	None of the artifacts are accompanied by a caption that clearly explains the importance of that particular work including title, author, and date.	Some of the artifacts are accompanied by a caption that clearly explains the importance of that particular work including title, author, and date.	Most of the artifacts are accompanied by a caption that clearly explains the importance of that particular work including title, author, and date.	Each artifact is accompanied by a caption that clearly explains the importance of that particular work including title, author, and date.
Ease of Navigation 1 pts	There are significant problems with portfolio navigation links and many sections (standards, artifacts, and reflections) do not connect back to the Home page or preceding pages.	Some of the portfolio navigation links and some sections (standards, artifacts, and reflections) connect back to the Home page, but sometimes the links do not connect to preceding pages or to the original Home page.	Most of the portfolio navigation links and most sections (standards, artifacts, and reflections) connect back to the Home page.	All of the portfolio navigation links and all sections (standards, artifacts, and reflections) connect back to the Home page.
Layout and Text Elements 1 pts	The e-portfolio is difficult to read. Fonts, point size, bullets, italics, bold, and indentations for headings and sub-headings do not enhance the presentation	Background and colors are distracting in some places. They diminish somewhat the readability of the text.	The e-portfolio is generally easy to read. Fonts, point size, bullets, italics, bold, and indentations for headings and sub-headings enhance the presentation.	The e-portfolio is easy to read. Fonts, point size, bullets, italics, bold, and indentations for headings and sub-headings enhance the presentation.
Writing Mechanics 1 pts	The text has more than 6 errors in grammar, capitalization, punctuation, and spelling. It requires major editing and revision.	There are 4 or more errors in grammar, capitalization, punctuation, and spelling requiring editing and revision.	There are a few errors in grammar, capitalization, punctuation, and spelling. These require minor editing and revision.	There are no errors in grammar, capitalization, punctuation, and spelling.

c. Feedback Forms. Different types of feedback can be obtained in the form of feedback forms and survey questionnaires. Computerized forms have the advantage provide instant results, allowing the data to be summarized and analyzed for different kinds of trends / weaknesses and grey areas. They can be used in-house or through websites, catering for a large audience. The ease of online submission increases the chances of attracting more audiences. Some commonly used feedback types are:

(1) Alumni Feedback
(2) Employer Feedback
(3) Student Feedback
    (a) Post-Course Feedback
    (b) Exit / End-of-Program Feedback
(4) Faculty Feedback
    (a) Post-Course Feedback
    (c) End-of-Program Feedback

d. Assessment tools. These help in obtaining vital assessment information, which can subsequently be used to evaluate and analyze the weaknesses of the course, in addition to providing evidence of student learning. CQI can be achieved by iteratively running this process. There are several commercially available assessment tools, but, their cost effect is enormous for our university's funding / budget, however, their analysis will be done in detail by the other group member who is researching and developing the assessment resource kit for ABET. However, the broad categories of these tools are :

(1) PEO & PO Assessment
(2) Course Objectives Achievement Assessment
(3) Course Assessment based on Feedback, Interviews, TestResults
(4) Program Assessment: derived by aggregation of the course outcomes & assessment

e. Digital / Online tests. They help make the assessment process easier for both the faculty and the students. Grading can be done automatically for easy to mark question types such as true false and multiple choice. The basic concerns that guide development of such online tests are:

(1) Ease of use
(2) Reliability
(3) Security
(4) Scalability

2.17 How can software tool or business process reengineering or workflow automation help in achieving Optimum Academic Performance?

Any educational system that wants to take a quantum leap towards program improvement, requires to go through Business Process Re-engineering to eliminate redundant and burdensome processes, replacing them with automation.

2.17.1 Difference between Re-Engineering and Process Improvement. Following are the three generic categories of process improvement:

a. Rapid Successes. Small and localized changes / improvement that provide instant results (in a couple of months)

b. Iterative Development. Aimed at introducing incremental changes as stop-gap arrangement and resulting into improvements in business output

c. Re-engineering. Characterized by an altogether and a wholesome transformation from old methods into newer and efficient techniques of doing business, eliminating unproductive and time consuming activities and acquiring modern and efficient techniques

2.17.2 Factors affecting the change process. The initial phase of a BPR program is through a discussion with a large audience on what all has to be done. As a result, there is a long list of changes that have to be implemented, which itself becomes a challenging task [24]. The cases are appraised under the titles of:

a. Assignment Commencement. Generally, the case of undertaking a BPR program is originated or required by the top management. After initiation, this responsibility is then delegated to the low tier of management, which are then required to from inter-disciplinary teams. This is required for the following reasons:

   (1) Each team member overlooks and grasps their own particular area of speciality

   (2) This rich skilled team can later easily inte\ract with different group of people to identify the problems

b. Comprehensive Discussions. For implementing a BPR program at a university, the consultation is done with all levels of management and stakeholders. As a result the main processes are identified along with the roles played by stakeholders. After that step, the flow of information is studied, inter and intra department. Question could range from how a task is generated and who all are empowered to do so.

c. Senior Management Authorization. As a result of interaction and meetings, the agenda for change is identified and drafted. The project review team does make recommendations on how processes would be changed, but their implement-ability aspects are quite different. That is done through authorization given by senior management. This decision is not taken in isolation in most of the cases, rather a majority buy in is sought

d. Clutter Information Systems. The most difficult to handle is the flow of information, where mostly the information flow is following two different paths, one is university wide system, while the other are the ones drafted by specific department based on their requirements. This results into disintegration of process and information flow. Centrally designed systems are not used or are not suited in entirety to the requirements of departments. Each department maintains its own database according to its own necessities. To cater for these divergences, the centralized systems are sometime modified to cater these aspects, leaving them more cluttered.

e. Institutional Legislations & Embedded Beliefs. Case studies at Universities in UK bring out the fact that university's databases contain large amount of redundant and irrelevant data', accumulated over time, but now resulting into working practices that are cumbersome to maintain and use. As a result, there are some roles designed exclusively to add beaurocracy to the system. Simple administrative tasks have been developed into complex ones, with many roles just acting as a rubber stamp. The restructuring process aims to undo all that, but, unless it gets adequate backing, this surrendering of roles is a difficult proposition.

f. Educational Autonomy. Within a university, the role / task of imparting education is a driving force for processes. There is an emphasis on academic freedom. Therefore, to get a surrender on this type of freedom requires a cut across many senior approving roles. These management gurus have to be convinced that change is for the better, as otherwise they would treat it as an infringement drive by the center. Therefore, any attempt to modernize teaching processes by use of modern technology is viewed as a threat to their age old teaching and learning practices. For the BPR program to succeed, the core essence of the concept of teaching / learning should be taken into account.

g. Inaction and fortification. The change of mindset is a major milestone to be achieved in the BPR process. This mindset change is pulled back by the common question: 'why do we have to change a system that has been imparting knowledge successfully for such a long time?' This in turn hinders the elimination of redundant processes. The top management generally

does not take into account the vision drafted by the BPR program, which in turn fails to materialize as envisioned. For doing this, the age old power grabbing empires are fortified and defended. In such a scenario, the best foot forward is iterative development

h. BPI: A change process for the old-fashioned. The above factors produce a significant impact on how the project was initially conceived and designed and later how it would materialize, as opposed to its ideal implementation. For any BPR process to succeed, there is a need to adapt a modern culture, which dictates breaking the status-quo. Therefore this is always an uphill task to negotiate. Such a scenario dictates change through iterative process, in which existing education cycle is minimally disturbed. This can be termed more of process improvement, as opposed to process re-engineering.

i. Transformation through Information Technology. Whenever the automation results in decreasing the number of employees, it falls into a separate paradigm than that of BPR. BPR is a separate issue and not necessarily related to the institution's business interests. The revised BPR process aims at improving administrative process, making them more efficient, so as to cover the sluggishness of the education domain. Notwithstanding the institution wide pressures, change is carried iteratively.

j. Structural Revolution. Though the BPR aims at more efficient processes, through providing academic freedom and lesser checks and balances through centralized management, the agenda for BPR is a wholesome one that completely revolutionizes the way education is imparted. However, how this change will be implemented is a difficult question to answer.

2.17.3. Optimum Academic Performance. If the BPR process explained above is implemented whole-heartedly, it would help in achieving optimum performance. For this to happen there must be a transparency in the informational security and software's rights management, which should be auditable and accountable, in case of any breach. The Optimum academic performance can be achieved through:

a. Identifying redundant practices

b. Converting the manual record-keeping into an electronic one

c. Incorporating best practices, inspired from those implemented at leading universities

d. Using IT to help in decision making, based on evaluation of assessment data

e. Identifying trends through software tools, which otherwise are very cumbersome to arrive at, using manual calculations.

f. Identifying weak areas in educational systems through analysis and adapting remedial measures

g. Analyzing subsequent data to establish that the envisaged improvements have been accommodated and are effective

h. Create an Program portfolio as an evidence to program improvement, similar to the recently introduced concept of timelines by Facebook

2.18 What should be the design characteristics of such tools? The design characteristics of such tools should be as under:

a. The structure of the tools should be so designed, as to be in-line with the academic process.

b. The student related module should cater for the longitudinal view of student learning, i.e., to keep a record of his/her growth over time

c. The program related module should be able to show the latitudinal growth of the students, before and after the course

d. All program courses offered should have measurable and map able objectives to meet

e. The program course objectives should be a subset of the program objectives

f. The program objectives should be derived from the institutional vision

g. The program objectives should be so designed, as to lead towards the departmental Program Educational Objectives, i.e., the objectives that the students are expected to learn and practice within a few years of graduation.

h. The record should be kept in a central repository and should have adequate privacy restrictions

i. The analysis module should derive its input from the assessment module

j. A variety of reports should be generated according to the evaluation and analysis data, which should bring out the weaknesses in the educational modules

k. Each user should have appropriate rights to view only the relevant information needed/pertaining to him/her, which should be controlled through rights management system

l. The reports showing growth over time should be so designed as to implement the CQI aspect of learning, whereby personal growth as well as program and institutional growth can be shown to the evaluator

m. The system should be easy to use

n. Only the appropriate modules of the system should be accessible through internet, rest all information should be stored and accessible at college premises, due to individualism and uniqueness effort being put-in by college of E&ME in adapting ABET culture

2.19 Is there any requirement analysis or design analysis work available for such tools?

a. No, there is no requirement analysis or design analysis available for any of these tools, as they have been developed initially as R&D projects in leading universities of U.S., but later, seeing their potential and demand, these R&D units converted them into professional softwares and have marketed them. Obviously, they would never share the requirement or design analysis of these tools, otherwise, their sales would drop and competitors would creep in easily.

b. In such a scenario, one can just try to draw analogies and references from trail versions that are available for some of these tools, but, since they have been provided with limited functionality keeping the proprietorship in mind, therefore, only a few of their features are available.

c. Furthermore, in order to design and develop an automation system for our university, we have to start from a scratch and go through the requirements and then the design phase, followed by structure review and the prototyping approach would be used.

d. One thing is to be kept in mind here that the research work pertains to designing and developing a Workflow Automation Framework (WAF^{TM}) and not filling in all the data which requires contribution of the faculty and would grow and mature over time. In order for a successful ABET visit, this data should span over a period of 3-4 years, which would mean that the faculty and top management remains totally committed to the fact that they have to adapt and implement the ABET's academic culture.

e. This would entail a focus towards program improvement, instead of finding out weaknesses of the faculty members. For this to happen, the top management has to assure the faculty from day one of the implementation.

CHAPTER – 3

EXISTING ASSESSMENT SYSTEM OF NUST

3.1 The existing (if any) Academic Program Assessment Process in Computer Engineering Department.

The existing academic program assessment process being followed in College of E&ME in general and Department of Computer Engineering in particular, is based upon the NUST Academic Regulations (2005). Chapter IV of the regulations deal with Assessment and is reproduced below.[25]

3.2 CHAPTER IV : TESTS, EXAMINATIONS AND GRADING POLICY FOR ENGINEERING / INFORMATION TECHNOLOGY / MANAGEMENT SCIENCES.

a. The following may be scheduled during a semester of studies for the purpose of grading:

(1) Minor Tests (Quizzes): A number of quizzes conducted frequently in each course at irregular intervals (normally 2-3 per credit hour) throughout the semester, with/without intimation.

(2) Major Tests:

(a) Mid-Semester / One Hour Tests. A 2-3 hours test conducted at md semester or a number of one hour tests conducted (normally one per credit hour) in each course, at regular intervals, with due notice of at-least two days.

(b) End Semester Examination. The last comprehensive examination of approximately three hours duration is given in each course on its completion.

(3) Class Assignments: A Task relevant to a course of study assigned by concerned faculty to substantiate the course contents. The assignment may or may not be graded.

(4) Practical / Lab Tests: These tests include all such examinations / evaluations to ascertain the level of competency of practical application of knowledge acquired.

(5) Project: Project is a research work aimed at testing the ability of a student to translate the theoretical knowledge acquired during a course of study into practical use at Bachelor / Master level.

(6) Thesis / Dissertation: Thesis / Dissertation is a report comprising the original research work of a student which is counted towards the partial fulfillment of his/her Master / PhD degree

b. End Semester Examinations of the university, shall be held at constituent / affiliated colleges / institutes / centres, on dates and according to the schedule prepared by the college / institute / center, unless otherwise approved by the Rector, and duly forwarded to HQ NUST as per regulation 18.

c. Thesis / Dissertations: Shall be examined and evaluated by a guidance and Examination Committee (GEC) constituted for this purpose.

d. Question Papers. All question papers are set by respective faculty and duly scrutinized, approved and conducted in accordance with the university policy. As per the spirit of semester system, there shall be no choice in attempting the questions. It shall also be ensured that the Question Papers are balanced with respect to the examination policy and have been prepared to cover the essentials of the whole syllabus completed by the faculty

e. Use of Reference Materials during tests / examinations. Prior to class test / Mid / End Semester examinations, the concerned faculty / invigilator shall announce such books, notes or other material which can be referred to by the students during the tests / examinations. Examinee shall not be in possession of any other books, notes, papers or material. Etc

f. Destruction of Question Papers / Answer Books / Result Sheets: The following policy of destruction of question papers / answer books / result sheets of all types of university exam shall be adapted, namely:

(1) Question Paper, if not part of the answer book, shall be disposed off after the conduct of the examination

(2) Answer books along with a sample question paper shall be retained till one year after the graduation of the class

(3) Hard Copy of results shall be retained forever

(4) Soft Copies shall be retained forever, as duplicate record, at a different and secure place

3.3 Critique/analysis on the existing processes. The existing process, though in-line with the national academic culture and being implemented in true spirit, is ages old. Following points can be highlighted in this regard:

a. As per the Direct and In-Direct methods highlighted in 2.12.5.1 above, only the following are being followed:

(1) **Direct Methods**

(a) Locally Developed Tests, to include major and minor tests

(b) Simulations in certain courses

(c) Behavioral Observations, These observations do not carry any weightage as per grading, yet in certain cases, grades are directly linked to behavioral observations and response of students in the class

(2) **Indirect Methods**

(a) Written Surveys / Questionnaires. Though, not a requirement of NUST academic regulations, yet this is being done in a partly automated way. i.e., the surveys are being administered using computers, but, the results are compiled manually.

(b) Archival Data. Partly a NUST academic regulation requirement, the data is kept to a certain extent. A sample question paper of locally developed tests along with three types of answer sheets (best, worst, average) are collected in course folder for that year. These manual data folders are meant to be shown to the visiting team of accreditation, or, as a record in case of any conflict / complaint against teaching of the course

(c) Focus groups. Though, not implemented as per the classical definition, these are tailored to own interpretation. A group of students is assigned to each faculty member and the faculty member is made responsible to call the students periodically, monitor their academics and address their concerns

b. The structure for analysis of teaching anomalies is present. Data extracted through surveys and exam results is analyzed in Departmental Board of Studies (DBOS) and Faculty Board of Studies (FBOS) meetings and minutes generated, but, in order to show the CQI

implementation, the follow-up action (which is missing in many a cases) is spread across piles of correspondence in different files / hard copies, which is cumbersome to link and produce

c. Engineering Advisory Board

(1) As of now, two meetings of the engineering advisory board have been conducted, but except one odd point, the follow-up on the points brought-up / agreed upon is non-existent or not traceable. In most of the cases, the last response is that the '*HOD agreed to the proposal*'. Mere agreeing to a proposal does not mean that CQI has taken place.

(2) In addition to that, there is no recognition / incentive for the Engineering Advisory Board to assemble, because they have to spare their precious time and resources to attend the meeting, with no follow-up or recognition of their valuable advice / services and no recognition is done at any level which could compel them to attend the next meeting.

3.4 Requirement analysis and defining design characteristics for a Best (Optimum) Academic Program Assessment Process. The requirement analysis process was carried out in detail. All the existing assessment methodologies were studied in detail and being a student of both baccalaureates level and masters level programs at College of E&ME spanning a duration of 20 years, I had a fair idea of how the assessment process was structured, documented and then implemented over the last two decades. However, not merely relying on this, I had collected material on the existing methods from various faculty members and from the co-advisor on ABET [Brig (R) Rafiuddin] who was also a GEC member of my dissertation.

3.5 System Requirements Specification: Following are the key components of the proposed SRS for an optimum Academic Program Assessment System.

a. Introduction

(1) Purpose. This document is basically the understanding of a College of E&ME's Computer Department's Workflow Automation Framework's requirement analysis and gathering prior to design and implementation. The SRS enlists the intended functions and capabilities o0f the system and also the proposed constraints. This SRS pertains only to the sub-system of ABET that would cover the automation aspects of ABET's implementation. i.e., Criteria 4 of ABET's EC-2000.

(2) Intended Audience. The administration, faculty and students of College of E&ME, who, together, have to make the implementation of EC2000 educational standards possible

(3) Product Scope. The product that would be developed at the end of my research work is intended to provide an automation framework, that is in-line with the criterion 1 & 3 of ABET's EC-2000, which would subsequently lead towards achieving Criteria 4 (CQI)

(4) References. All references are added at the end of the thesis report

b. Overall Description

(1) Product Perspective. The automation framework is a 3-tier web-based application, with database residing on SQL server 2008 and front end developed in ASP.NET with additional controls developed using Visual C# and AJAX.

(2) Product Features. The main features of the product would be:

(a) Mapping of Program outcomes to University's vision and DCE's PEOs

(b) Mapping of curricula to program courses

(c) Providing evidence of learning, both longitudinally and laterally

(d) Provide a central repository to gather data

(e) Gather data from external sources in the form of e-surveys

(f) Mapping of Program outcomes to sub-outcomes and performance criteria, making them measurable

(g) Record minutes of meeting and track follow-up actions, which ultimately can be shown as evidence to the CQI process

(h) Provide uniformity in the implementation of ABET's EC-2000 criteria

(i) Provide rights management according to user roles

(j) Provide an opportunity for all stakeholders to contribute towards program Improvement and see the results of their contribution

(k) Allow top management to address the problem being faced in implementation of teaching methodologies

(l) Allow adaption of the modern assessment and academic culture that is in-line with ABET's accreditation requirements

(3) User Classes and Characteristics

(a) Administrators

(b) Faculty

(c) Students

(d) DBA

(e) Employers

(4) Operating Environment

(a) The workstation on which this application would run must have a SQL Server 2008 already installed and running.

(b) The Server should be on a dedicated machine in the Server Room and should have internet connectivity

(c) The workstation must have Flash or ActiveX Controls installed for loading of Graphical User Interface.

(d) The workstations should have Microsoft's Dot Net Framework, version 4 installed

(5) Design and Implementation Constraints. Initially the software would be a standalone application, but, later in future work, will be integrated into the ERP of the college.

(6) User Documentation. A user manual will be included.

(7) Assumptions and Dependencies. Since the software uses components common to the college ERP, therefore, till integration into the ERP, duplication of data would exist

c. System Features

The system would have following features:

(1) User Accounts

(a) Description and Priority. As there is a difference in the amount of data access according to roles of the users. i.e., faculty or student and further

specific roles amongst the faculty members, therefore, the rights management will be controlled through user accounts

(b) Stimulus/Response Sequences. At the registration page, the stakeholder will get him/herself registered. The registration process will be verified with 12 hours and the users will be assigned to their specific account control. After that, the user can directly log-on from the logic screen interface

(c) Functional Requirements

i. Login Process:

aa. Functional Requirement

Ref. No	Functional Requirement	Category
1	Enter User Name	Evident
2	Enter Password	Evident

bb. Non Functional Requirement:

Ref. No	Non Functional Requirements	Category
1	Length of Max user name will be 7 characters	Evident
2	System will display a default icon image	Evident
3	If the User name and/or password field is left empty than System will display a message to the user to fill the required fields.	Evident

ii Sign Up:

aa. Functional Requirements:

Ref. No	Functional Requirement	Category
1	As soon as the user opens the application, he/she is being asked for registration.	Evident
2	Saves user name and password given by the user into the database.	Evident

bb. Non Functional Requirement:

Ref. No	Non Functional Requirements	Category
1	Length of Max user name will be 7 characters	Evident
2	System shows success message after completion of registration.	Evident
3	If the User name and/or password field is left empty than System will display a message to the user to fill the required fields.	Evident

iii Sign In:

aa. Functional Requirements:

Ref. No	Functional Requirement	Category
1	The user once registered by the admin logs into the application	Evident
2	Application maintains the session of the user	Hidden

bb. Non Functional Requirement:

Ref. No	Non Functional Requirements	Category
1	Length of Max user name will be 7 characters	Evident
2	If the User name and/or password field is left empty than System will display a message to the user to fill the required fields.	Evident

iv Log Out:

aa. Functional Requirements:

Ref. No	Functional Requirement	Category
1	If the user logs out, he will no more be able to interact with the application..	Evident
2	The session of the user will be ended and he would not be able to refer to any page of the application without logging in.	Hidden

d. External Interface Requirements

(1) User Interfaces. These are as under:

(a) Login Screen Interface

(b) ABET Basic Workflow Interface (to include several interfaces)

(c) Bloom Taxonomy Interface

(d) Feedback Interface (to include Surveys and Open Group interfaces)

(e) CQI Interface (to include meetings interface)

(2) Software Interfaces. No interface at present. All data is being fed in manually. However, in first phase, for the other part of the research on ABET to function, the ABET Workflow will provide appropriate outputs, which would serve as inputs to

Assessment Resource Kit (ARK™) and in return, receiving evaluation data output, which would serve as input for the meetings scheduler and CQI interface

(3) Communications Interfaces. Requires internet connectivity for web-based modules

e. Other Nonfunctional Requirements

(1) Performance Requirements. The system should have a response time of 10 milliseconds and system availability of 24 hours a day. All results have to be displayed in real time

(2) Safety Requirements. Since all the data is placed on a central repository and due to its value, it will be backed on weekly basis on a back-up disk / removable media

(3) Security Requirements. Will strictly confirm to user accounts access control, less the open group forum

(4) Software Quality Attributes.

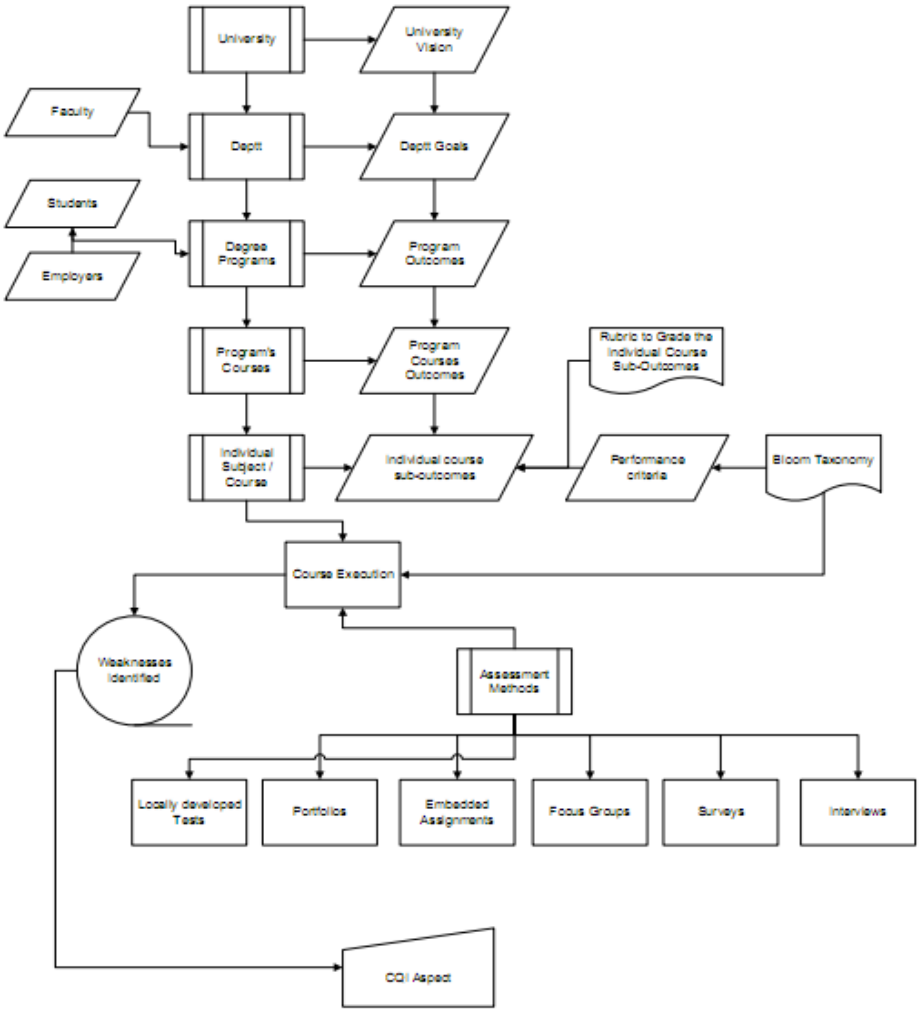
i. Availability: 24 hours a day, especially during office hours
ii. Correctness: Assessment related module should have 100% correctness
iii. Maintainability: Easy to maintain by a DBA
iv. Reliability: Has to be reliable, to ensure faculty buy-in
v Robustness: should be robust enough to sustain erroneous operation by novice users
vi. Testability: All modules should be testable and should provide consistent results
vii Usability. Should be user friendly and can be learned by a novice user after 1 hour training lecture

Appendix A: Glossary

ABET:	Accreditation Board of Engineering & Technology
Assessment Artifact:	Documentary proof of assessment
Bloom Taxonomy:	Categorization of higher order thinking skills and objectives
CQI:	Continuous Quality improvement
Direct Assessment Methods:	Direct measures of assessment require students to represent, produce or demonstrate their learning
Indirect Assessment Methods:	Indirect measures capture information about students' perceptions about their learning experiences and attitudes towards the learning process

Rubrics:	A scoring guide that seeks to evaluate a student's performance based on the sum of a full range of criteria rather than a single numerical score

Appendix B: Examination Model



Appendix C: List of Issues

Will be populated as the development work progresses

3.6 Designing of Best (Optimum) Workflow Automation Framework. Through research and analysis of the best educational practices being followed by universities around the world and also by carrying out an in-depth study into the educational culture prevalent in Pakistan in general and College of E&ME in particular, I am now ready to design the optimum Workflow Automation Framework that is likely to be implementable as a test case in Department of Computer Engineering at College of E&ME.

3.6.1 Requirement of Process Re-Engineering. After studying the existing educational culture prevalent at College of E&ME, I feel that the assessment and evaluation methods do not focus on

the total set of SLOs, listed in Criteria-3 of EC-2000. We can broadly divide student learning skills into two categories. Cognitive Skills and Professional Skills, enumerated as under:

a. Cognitive Skills

(1) An ability to apply knowledge of mathematics, science, and engineering

(2) An ability to design and conduct experiments, as well as to analyze and interpret data

(3) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, safety, manufacturability, and sustainability

(4) An ability to identify, formulate and solve engineering problems

(5) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

b. Professional Skills

(1) An ability to design a system, component, or process to meet desired needs within realistic constraints such as social, political, ethical and health

(2) An ability to function on multidisciplinary teams

(3) An understanding of professional and ethical responsibility

(4) An ability to communicate effectively

(5) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

(6) A recognition of the need for, and an ability to engage in life-long learning

(7) A knowledge of contemporary issues

c. Analysis. While, the Cognitive skills can be induced, assessed and evaluated using Cognitive Learning methods, the professional skills cannot be directly assessed and evaluated in the conventional terms. To provide evidence of this type of learning in a great challenge and is a major expectation of the ABET evaluator. The Professional skills may be conveniently assessed at the top 100 universities of the world, this focus, however, might not be addressed in other universities and is neither prevalent in our educational culture. For the existing criteria being practiced and also required by NUST, only the grades (Cognitive Learning) is what matters at the end of the day, with minimal focus on developing professional skills. In such a situation, adapting / accepting status-quo would mean that there is a magnanimous chance that the ABET evaluator would not be impressed by the tying up of a course with some outcomes or sub-outcomes and showing the achievement of the objective by merely showing the results of a class survey to support it.

d. The Engineering Skills can be addressed by identifying the student's learning process first, which is briefly explained below:

(1) Development phases in Student's Cognitive Learning. Perry[26] in his study has divided the student's development in three distinct phases:

(a) Dualistic rational Phase. Things Are either correct or incorrect, with no state in between

(b) Diversity Phase. More than two options emerge, but the path to reach them is still unclear

(c) Development Phase. The correct answer is related to the context in which it is seen, and it is up to the student to reach a conclusion through his / her knowledge

(2) Characteristics of a Mature Student. In the context of the above model, following points characterize a settled student, which are also in-line with ABET:

(1) Has acquired knowledge and is trained in his relevant field
(2) Decisions are based on awareness and judgment
(3) Regards his knowledge as his proficiency
(4) Becomes aware and responsible and stands by his judgments
(5) Acquires the ability to deliberate logically and in context
(6) Nourishes on aspects of evaluation and valuation
(7) Show responsible behavior and is society conscious

(3) Intellectual Development. Our educational culture is more of being-taught, than have-learnt. Students have little interest in exploring avenues of what they are being taught, rather they consider the teacher as an authority on the subject. In continuation to that, in most cases, designing something new poses severe challenge both to the student and in most cases to the faculty member as well. This design phase later becomes the ladder which leads to personal intellectual development

(4) Emotional Intelligence. The challenges posed in the design phase in turn are the basis for emotional growth, where the student sees it as an opportunity to do something new and different if proper guidance is available. The emotional dimension of a student's character is defined by Goleman [27] the research of the human brain on the relation between reasoning and feelings. The model of EQ that

was suggested by him is put in use by employers to judge their employees. His model has five proportions:

(a) Self-awareness (knowledge of one's own state)

(b) Self-regulation (having control upon one's own behaviour)

(c) Motivation (knowing when to give reward and when to hold it back)

(d) Empathy (respecting the emotional state of others)

(e) Social Skills (building affiliations)

The EQ level is given preference over the IQ level when a person is being considered to be promoted. Moreover, EQ keeps on developing for the lifetime. Goleman has compared the top emotional condition with "flow", which is a state in which all energies and focus is diverted on accomplishing an assignment. His research proves the once the students are completing a challenging assignment, they are in about 40% of flow. As an average, students are in a flow for about 15% of their timespan, normally near exams.

(5) Student's Motivation for Growth. Following factors contribute towards student's growth:

(a) Motivational altitudes: A strong urge for change must exist for achieving growth beyond acquiring bare minimum knowledge. A first year student will show preference towards his position in society and attaining monetary strength, this may be attributable to the fact that the typical school that has developed their personality has prepared them for mugging-up to fetch good grades in exams and not for the research oriented culture that is supposed to prevail in the university's environment. So, in the university's scenario, this short-coming has to be made up for, by designing courses and assignments that engage the students in research. Galbraith [28] has enumerated the following levels pertaining to motivation:

i. Coercion (similar to forced labor)

ii. Remuneration (carrot policy, giving reward for extra work)

iii. Identification (need to be identified or acknowledged)

iv. Adaptation (expand the prevailing system)

The academic grades can be termed or associated with the remuneration level. The first three levels comprise extrinsic stimuli while the fourth level is

intrinsic. The true or deep learning can only occur once a student is in a flow, which is opposed to the one practiced at our schools of instruction namely surface, which may suffice for passing in exams, but, no learning aspect is involved in it. While the student is faced with a challenge and is in a state of flow, true learning can occur and create a marker event.

(b) Marker Events. They are the [29] one that *"… has a prominent impression on a one's life. …It changes the situation in one's life and one must learn to handle them*." Research shows that most people have marker events in their academic career. [30] *The event may be anything, a teacher, an assignment or a subject*. The individualities of Educational pointers are:

i. Are embedded in the memory
ii. Change the context in which things are seen
iii. Can be constructive or destructive
iv. Help foster development
v. Can be automated but cannot be enforced
vi. Add to knowledge and thought progression

While designing courses that have marker potential, the possibility of intellectual and positive growth is envisaged.

(c) Contest levels: The absorption level of a student is when he / she is working in pleasure-zone, that is a stage between monotony and anxiety. if the challenge posed is affordable, then it might lead to flow. It is unlikely that the student may retain positive learning outside this zone. Enhanced levels of learning can be achieved only if previous levels have been attained (bloom levels). Out of context information cannot become a building block for new levels of learning.

(d) Preferred Learning Style: Every student tends to learn more when he is taught in the method that suits his preferred method of learning. The options to learn can be expanded by help a student identify his / her preferred method or mode of learning.

3.7 How to Re-Engineer to Accommodate Engineering Skills. Based on the above discussion, I propose to introduce some unconventional (in our context) educational methods, which are as under:

a. Camaraderie Projects. Inspired from universities in the U.S. and the working of the United Nations., these would be a bit similar to community service, but different in the context that these would be undertaken in collaboration with U.N. or NGOs to provide value addition to some deprived society around the globe (or if that cannot materialize, then, within Pakistan). Feasibility work can be undertaken by establishing a new project management office, which would be responsible to liaise with the army to acquire such projects in African/under-developed countries, where basic educational or health facilities are missing. This would enhance the development of following skills in the students:

(1) Understanding of social responsibilities
(2) Ability to function on multi-disciplinary teams
(3) Acquiring broad knowledge to understand the impact of engineering solutions in a societal and global context

b. Scenario Building. Those students who have an ability to learn from real life situations are the one's who are likely to experience deep learning. "*Deep methodologies of acquiring knowledge originate amongst students actively immersed in probing own connotation and empathy (the practical world's awareness they possess), envisioning the wider canvas and not only the secluded structures or intangible glitches; representation of individual knowledge to create intellect for emerging ideas and skills which relate proofs to deductions"* [31]. Taking clue from this, I intend to introduce assessment through Scenario Building problems, where students, individually and as a team, are required to plan according to a scenario and constraints posed to them. The plan can be submitted individually and later discussed / presented in an interactive environment, like the concept of Model Discussions in the army. This method is likely to help develop the following traits in the students:

(1) An ability to understand realistic constraints
(2) Recognition for the need, and, an ability to engage in Life Long Learning
(3) An ability to communicate effectively, through written plans of work and group discussions

c. Distance Learning. As part of a course or even an especially designed course altogether, by using Information Communication Technologies (ICT), I propose to engage the students in a continual / life-long learning experience. This can be in the form of Webinars, Distance Learning modules, e-blackboards and virtual labs. When the students use emerging technologies to bridge distances, their creative and learning abilities explore new methods to acquire information. This method is likely to develop following traits in the students:

(1) A recognition of the need for, and an ability to engage in Life Long Learning
(2) An ability to communicate differently and effectively
(3) An ability to function on multi-disciplinary teams
(4) A knowledge of contemporary issues
(5) Broad education necessary to bridge distances and understanding of the global context of engineering problems and solutions
(6) In the context of learning, be at par with world's best universities through the use of ICT

d. Case Studies on Ethics. While we have already incorporated a separate course on ethics in the computer engineering program, yet, merely a subject in which students mug-up the entire contents of the book for some semester hours is not likely to inculcate in them the basics of engineering ethics and environment consciousness. In my opinion, Ethics and Environment related case studies (pertaining to specific engineering courses) be acquired from the industry and internet and integrated as a part of knowledge transfer in that course. This method is likely to build upon the already taken first step, (i.e. the first semester Engineering Ethics course), resulting into a graduating student who is environmental and ethically aware of the powers of engineering education and its misuse. This method is likely to develop the following traits in the students:

(1) An ability to design a system component, keeping in mind its environmental and ethical effects
(2) An ability to engage in Life Long Learning, by keeping abreast with the implications of good and bad design

e. Digital Portfolios. Using digital portfolios, the students can showcase their best work and can also witness their own longitudinal development over time. Portfolio assessment by self and peers also enhances the thought process and in turn, inculcating the traits of logical thinking and Life Long Learning. Through portfolios, students are expected to:

(1) Understanding the meaning of being responsible
(2) An ability and need to engage in Life Long Learning
(3) Teamwork and social context, through showcasing and peer review

CHAPTER – 4

MODELLING & DESIGN OF

WORKFLOW AUTOMATION FRAMEWORK FOR ABET

4.1 **Segments of the proposed Workflow Automation Framework**. To start with, I will explain the different sections of the basic workflow, one by one:

a. Vision. Assessment planning begins with the institutional mission statement which describes the communities that are served and the institutional purposes and other characteristics that define the institution.

b. Department PEOs. Program Educational Objectives are broad statements that describe what graduates are expected to attain within a few years of graduation. Program Educational Objectives are based on the needs of the Program's Constituencies.

c. Program Mission. The program mission is a broad statement of what the program is, what it does, and for whom it does it. It should provide a clear description of the purpose of the program and the learning environment. For a given program, the mission statement should, in specific terms, reflect how the program contributes to the education and careers of students graduating from the program. Mission statements for academic programs should reflect how the teaching and research efforts of the department are used to enhance student learning. The mission should be aligned with the Department, College, and University missions. In addition, the mission should be distinct for each program.

d. Program Outcomes. Program or Student Outcomes describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire as they progress through the program. These are commonly known as Outcomes a-k, and have already been described in 2.4.1.3 above.

e. Program Course Outcomes. These are a sub-set of the program outcomes. As a general rule, each Program (or Student Outcome a-k, as per ABET terminology) should be mapped to one or more of the Program Courses.

f. Sub-Outcomes. Taking lead from an American University [32] that has actually implemented the system in depth, I have broken down each Program Outcome into sub-outcomes, as an example. An outcome "an ability to design and conduct experiments, as well as to analyze and interpret data" can be catered as a whole (as done by most universities), or can be broken down into four sub-outcomes

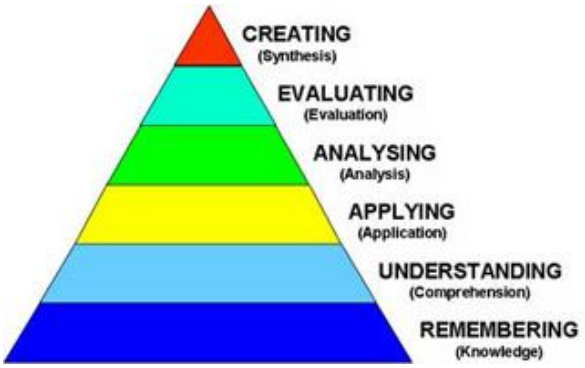
(1) An ability to design experiments
(2) An ability to conduct experiments
(3) An ability to analyze data
(4) An ability to interpret data

g. Performance Criteria. As the Outcomes specified in EC-2000 are broad and non-measurable and it has been left up to the Program and the Department to provide evidence regarding the educational methods used by them to reach this outcome. Therefore, turning the Outcome, or even the Sub-Outcome, into measurable terms, requires that a measurable set of criteria, known as Performance Criteria be set for each Sub-Outcome.

h. Bloom's Taxonomy. There is more than one type of learning. A committee of colleges, led by Benjamin Bloom (1956), identified three domains of educational activities:

(1) Cognitive: Mental Skills (Knowledge)
(2) Affective: Growth in Feelings or Emotional Areas (Attitude)
(3) Psychomotor: Manual or Physical Skills (Skills)

In our study, we confine ourselves to the Cognitive domain. This domain deals with acquisition of knowledge and practical skills involving observational patterns, recalling of facts and re-visiting the facts. The learning levels are shown in the figure below, lower level indicates basic skills. Each step ahead is growth. as a general rules, a next level can be acquired on attaining the previous one.



Cognitive Domain				
Level	Category or 'level'	Behaviour descriptions	Examples of activity to be trained, or demonstration and evidence to be measured	'key words' (verbs which describe the activity to be trained or measured at each level)
1	Knowledge	recall or recognise information	multiple-choice test, recount facts or statistics, recall a process, rules, definitions; quote law or procedure	arrange, define, describe, label, list, memorise, recognise, relate, reproduce, select, state
2	Comprehension	understand meaning, re-state data in one's own words, interpret, extrapolate, translate	explain or interpret meaning from a given scenario or statement, suggest treatment, reaction or solution to given problem, create examples or metaphors	explain, reiterate, reword, critique, classify, summarise, illustrate, translate, review, report, discuss, re-write, estimate, interpret, theorise, paraphrase, reference, example
3	Application	use or apply knowledge, put theory into practice, use knowledge in response to real circumstances	put a theory into practical effect, demonstrate, solve a problem, manage an activity	use, apply, discover, manage, execute, solve, produce, implement, construct, change, prepare, conduct, perform, react, respond, role-play
4	Analysis	interpret elements, organizational principles, structure, construction, internal relationships; quality, reliability of individual components	identify constituent parts and functions of a process or concept, or de-construct a methodology or process, making qualitative assessment of elements, relationships, values and effects; measure requirements or needs	analyse, break down, catalogue, compare, quantify, measure, test, examine, experiment, relate, graph, diagram, plot, extrapolate, value, divide
5	Synthesis (create/build)	develop new unique structures, systems, models, approaches, ideas; creative thinking, operations	develop plans or procedures, design solutions, integrate methods, resources, ideas, parts; create teams or new approaches, write protocols or contingencies	develop, plan, build, create, design, organise, revise, formulate, propose, establish, assemble, integrate, re-arrange, modify
6	Evaluation	assess effectiveness of whole concepts, in relation to values, outputs, efficacy, viability; critical thinking, strategic comparison and review; judgement relating to external criteria	review strategic options or plans in terms of efficacy, return on investment or cost-effectiveness, practicability; assess sustainability; perform a SWOT analysis in relation to alternatives; produce a financial justification for a proposition or venture, calculate the effects of a plan or strategy; perform a detailed and costed risk analysis with recommendations and justifications	review, justify, assess, present a case for, defend, report on, investigate, direct, appraise, argue, project-manage

In my implementation, I have further broken down all the sub-outcomes into performance criteria. There is a minimum of one or more performance criteria against one sub-outcome.

i. Rubrics. The concept of rubrics is being used for assessing and providing uniformity across grading and also amongst multiple assessors.

j. Faculty. This module is self-explanatory and pertains to the faculty members, being one of the most important stakeholders

k. Faculty Roles. This directly pertains to the roles assigned and powers vested in the individual faculty members according to their appointment and seniority.

l. Research Papers. This module is also being designed to provide uptodate data on the research aspects and improvements over time, by showing the increase in quality papers being published

m. Students. Another important stakeholder, which has been linked to Degrees, employer and status

n. Status. Pertains to the particular student, being a perspective, current of alumni student

o. Employer. This data is being kept both for obtaining feedback as employer of alumni student and also to select and shortlist members for Engineering Advisory Board

p. Departments. These house the engineering program and the infrastructure necessary to run and sustain the program

q. Room Types. Rooms could be further divided into classrooms, presentation halls, laboratories, conference rooms etc

r. Training Aids. Data regarding training aids and facilities is required to be presented in Criteria 7 of ABET

s. Minutes of Meeting. Different types of meetings are organized during the execution of a program. All information is recorded in the form of minutes for tracking the progress

t. Meeting Agenda Points. Each meeting that is conducted has to have a certain agenda to start with / focus upon. Points for the meeting may come directly from results / surveys or the Chair of the meeting may have his/her own points

u. DBOS Meeting. Carried out at the departmental level. This is the first forum to address smaller problems and helps in immediate corrective action

v. FBOS Meeting. This is conducted at the end of each semester in which the result of all the courses taught in that semester is presented at the Engineering College level

w. Curriculum Review Meeting. Conducted at even higher level, to incorporate additional syllabi in the courses being taught, or to introduce a new course

x. EAB Meeting. Conducted on a yearly basis, this meeting invites selected employers, representing different sub-disciplines of the concerned engineering department

y. MOM Follow-up. This takes care of all the routine decisions, of minor nature, to know who they have been marked to, and what is the latest on their status

z. Surveys. There are different types of surveys that are administered to get a first hand knowledge / feedback on the quality of information being imparted. The subtypes are

(1) Student - End of Course Survey
(2) Faculty – End of Course Survey
(3) Student - Exit Survey
(4) Alumni Survey
(5) Employer Survey

aa. Survey to Sub-outcomes Relation. Each question of the survey is so designed, as to be directly linked to one of the sub-outcomes. If the result of a question of a survey (using survey result and survey weighting criteria relations) from among the top three levels is below 70%, that sub-outcome is considered not to be met.

bb. Continuous Quality Improvement (CQI). This is the core of the Workflow automation module and is the culmination of all the results and weaknesses extracted as a result of evaluation of data received from the Assessment Resource Kit (ARK^{TM}), being researched and developed separately by another student. It is in this module that the CQI body records its decisions which lead towards the improvement of the Engineering Program

4.2 Modeling the Automation Framework

4.2.1 ERDs. The ERDs are under refinement/ continuous quality enhancement process till the thesis defense takes place. The initial prototype was changed after analysis and advice by the thesis advisor. The second and third versions were again upgraded. Presently the fourth version is also under review. Here I am posting the ERDs of the fourth version

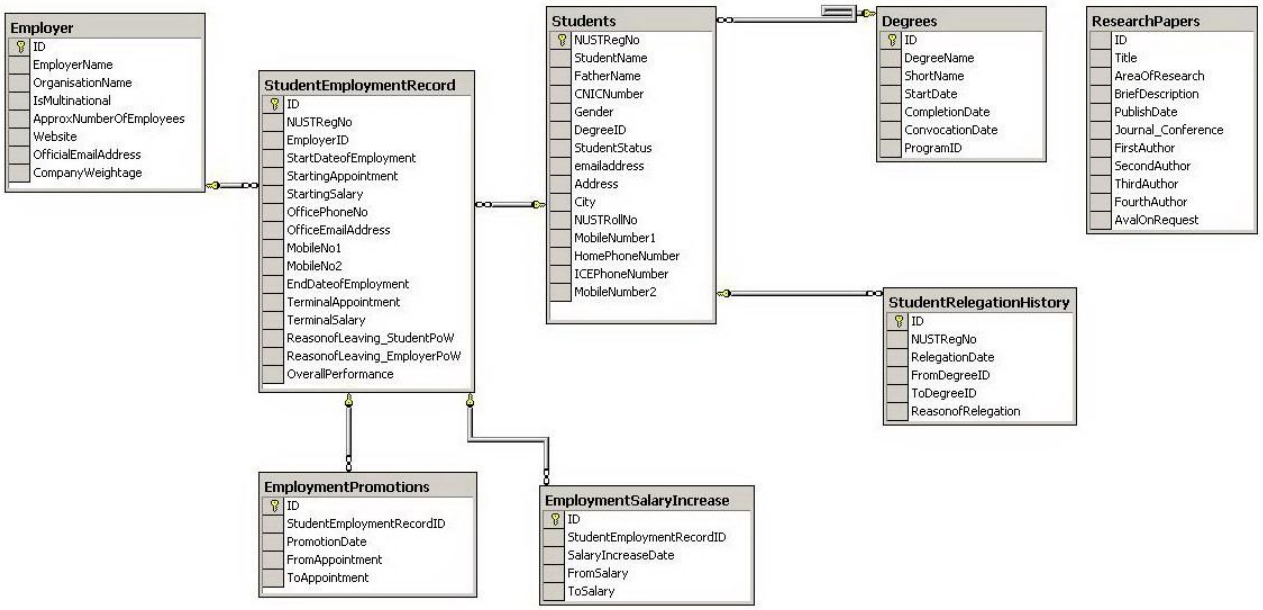


Figure 4.2.1.1 STUDENTS MODULE

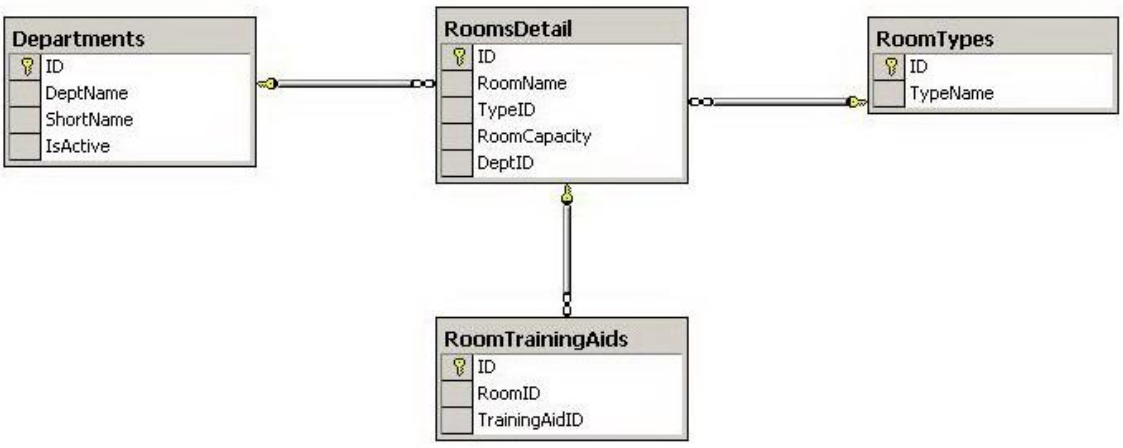


FIGURE 4.2.1.2 EDUCATIONAL FACILITIES

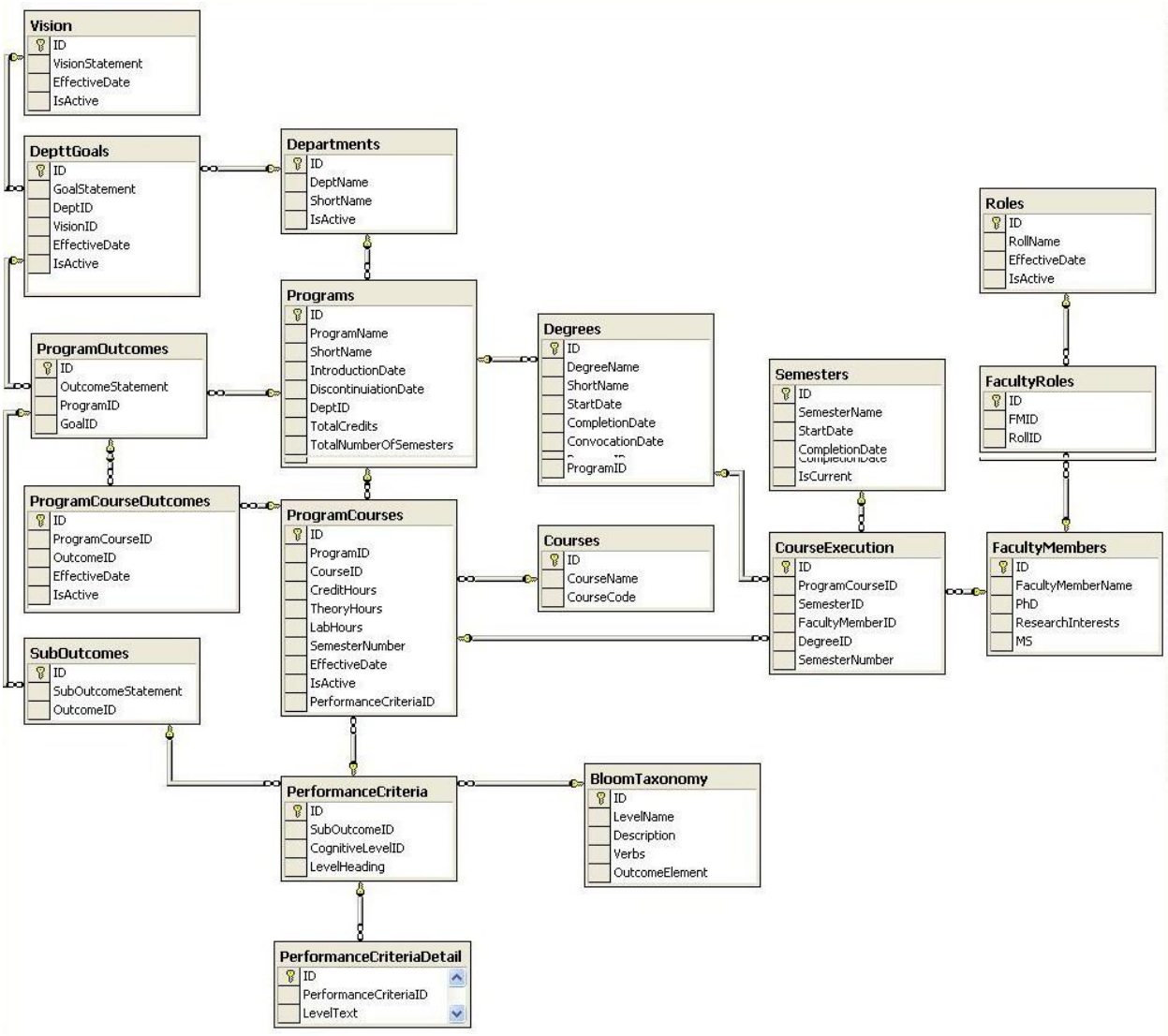


FIGURE 4.2.1.3 BASIC WORKFLOW OF THE AUTOMATION TOOL

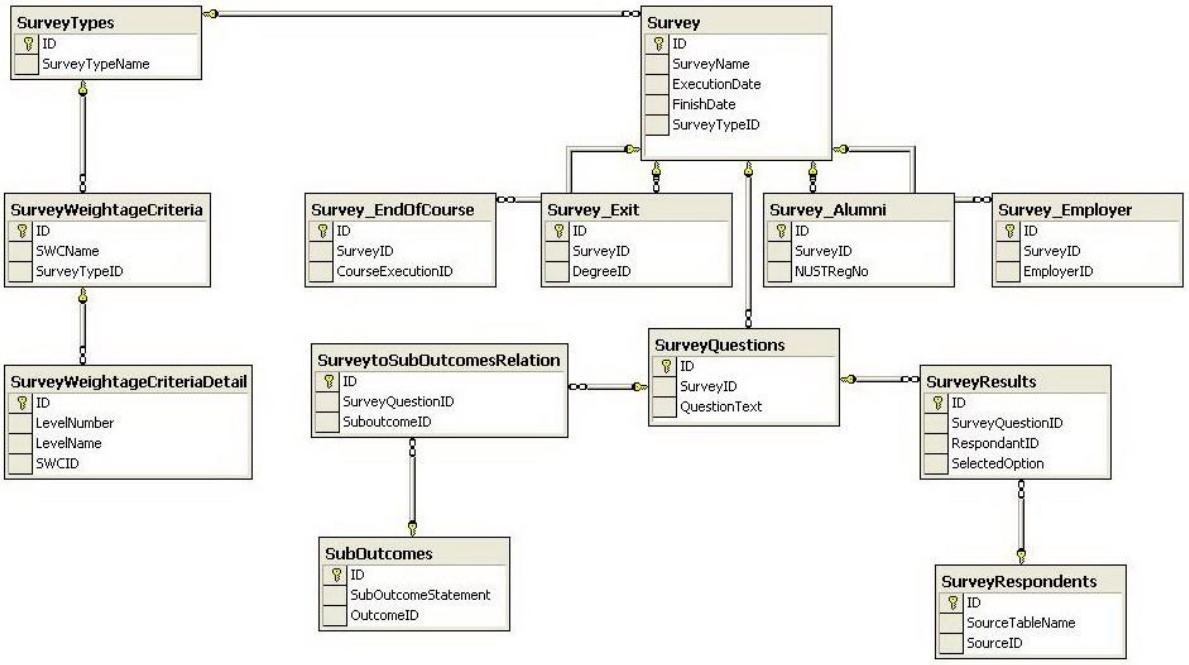


FIGURE 4.2.1.3 SURVEY MODULE

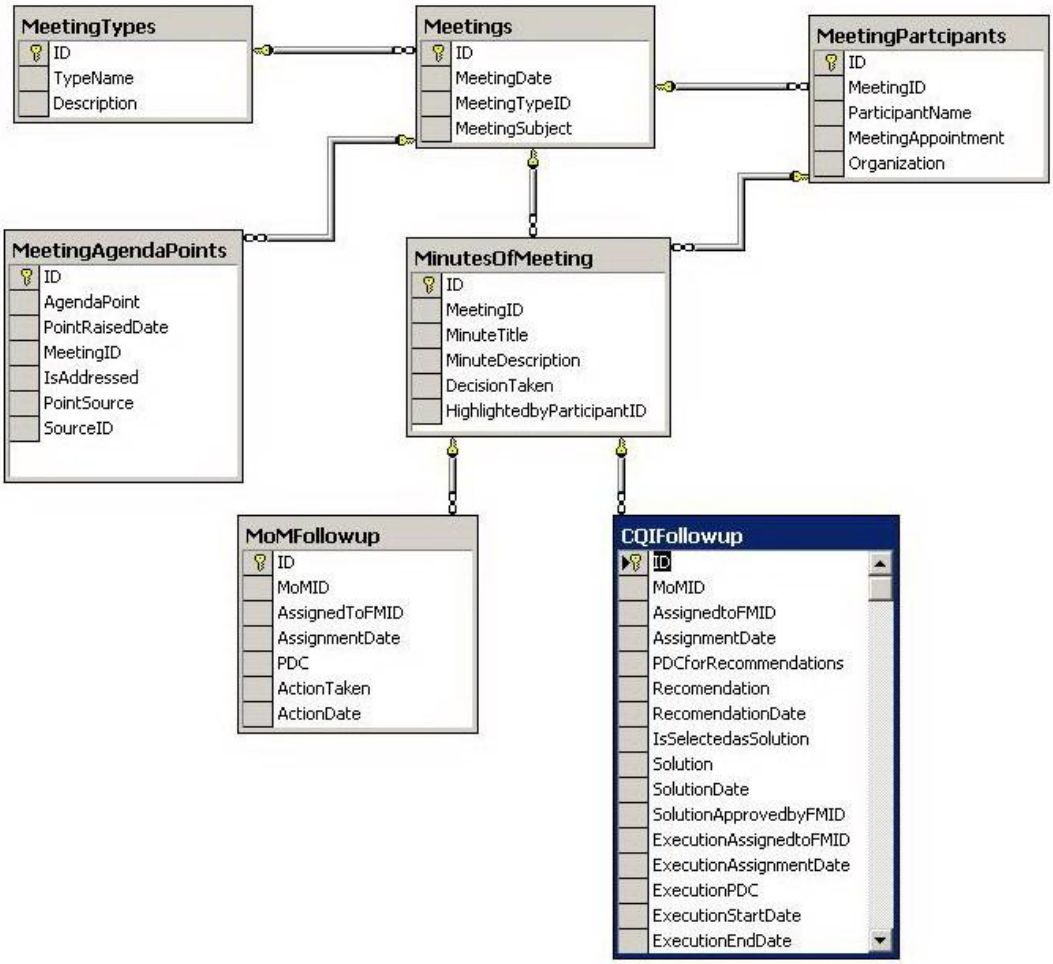


FIGURE 4.2.1.4 CQI MODULE

4.3 Describing how the workflow automation framework will be integrated into the existing system

. The workflow automation framework is presently a stand-alone system, but, subsequently, it would be linked to the College's ERP. Some of the common relations are:

a. Students

b. Faculty

c. Courses

d. Departments

e. Degree Programs

f. Courses

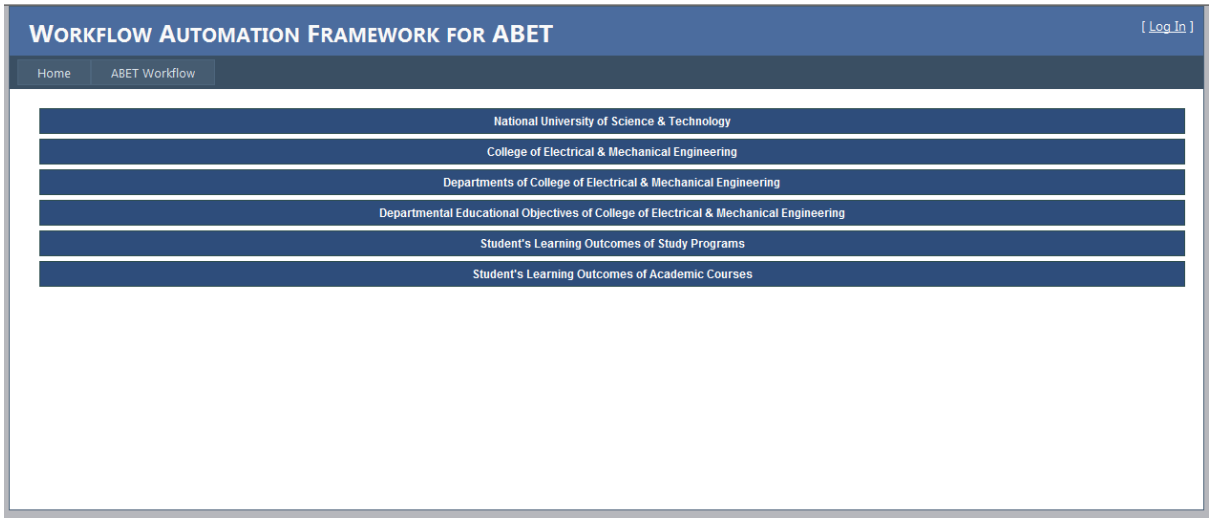
g. Student Result

h. Vision

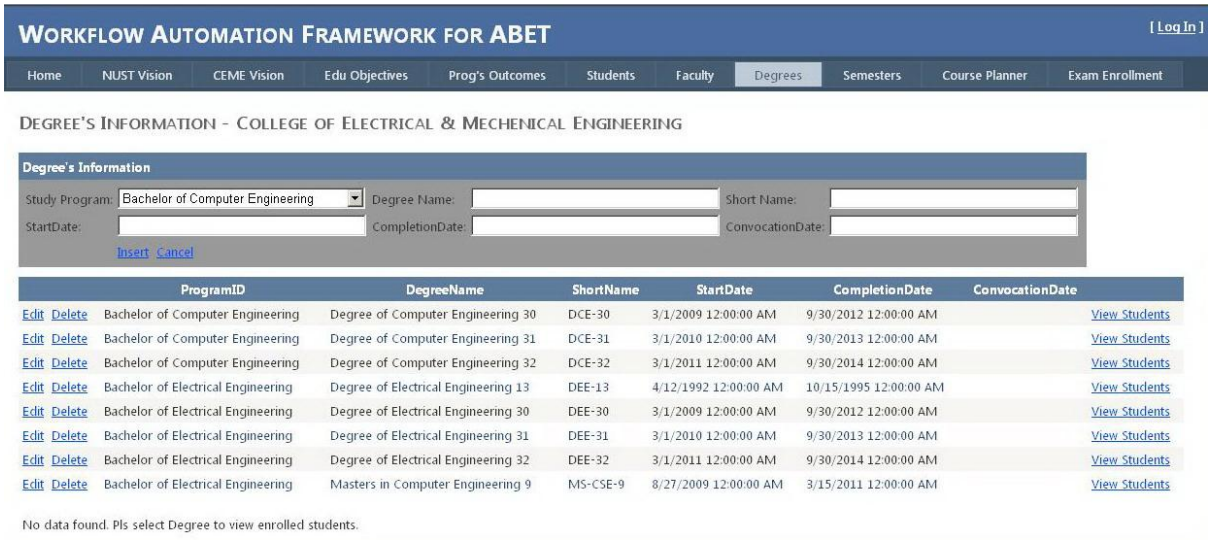
i. Program Objectives

j. Semesters

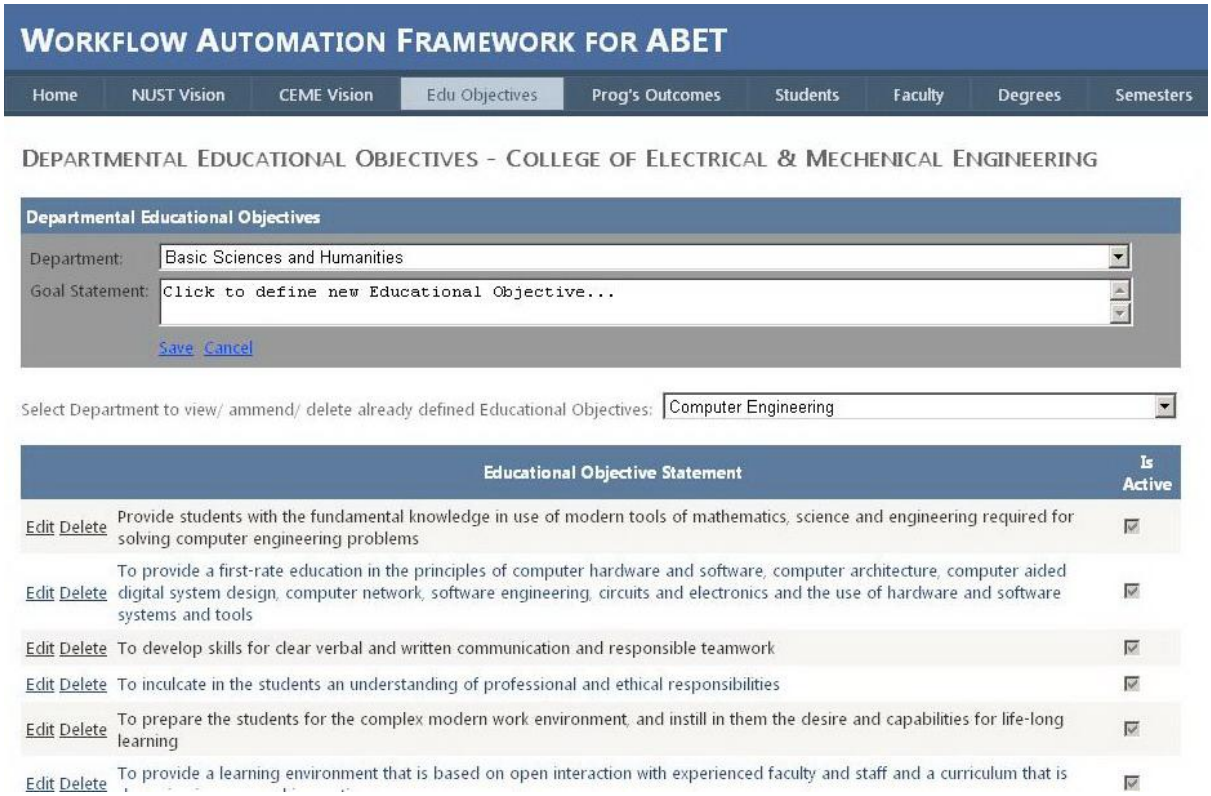
4.4 Screenshots of the front end software



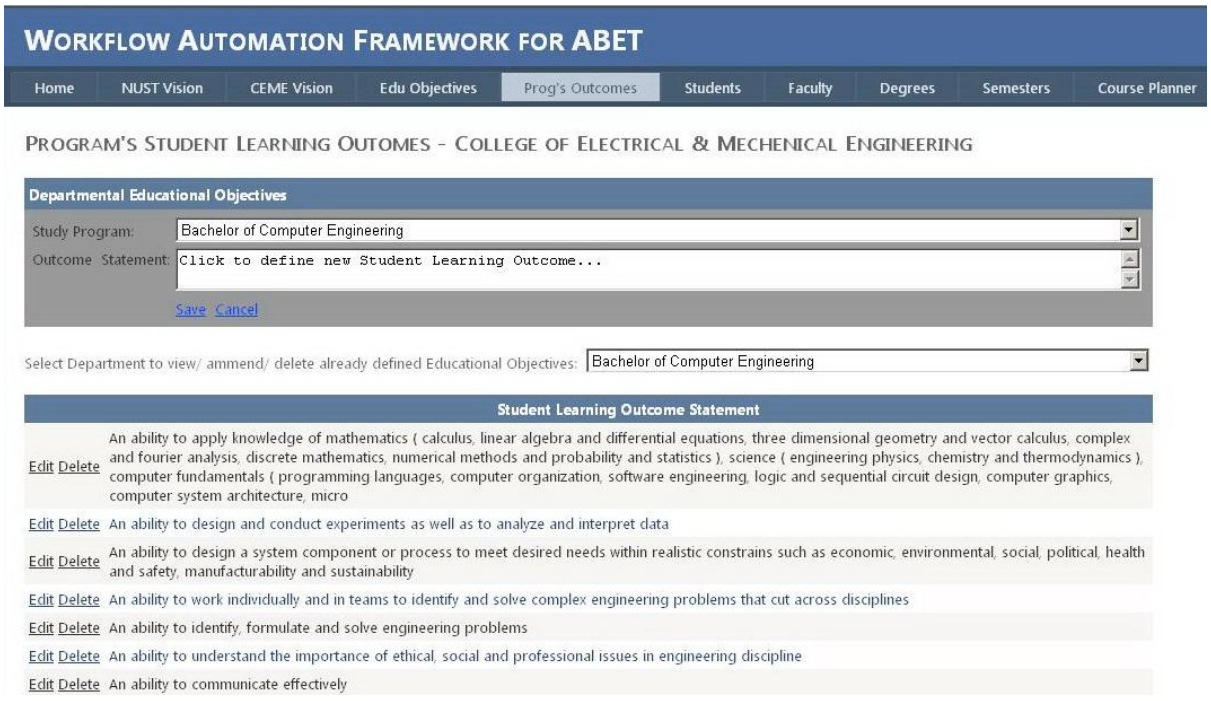
4.4.1.1 Basic Workflow



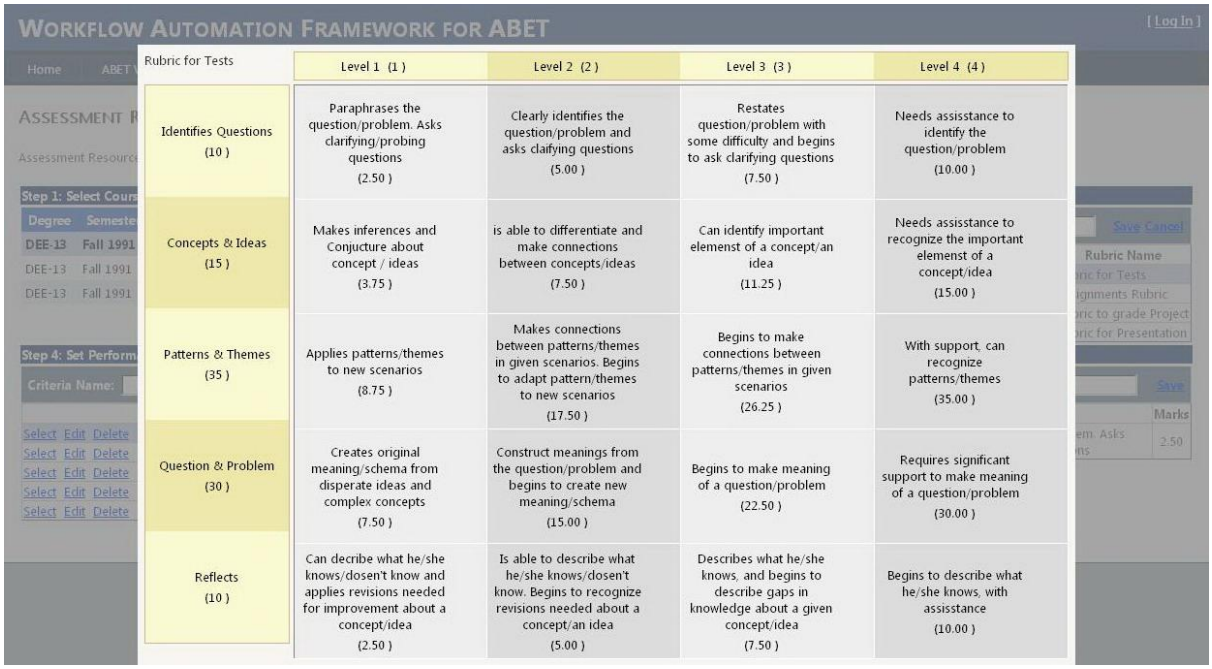
4.4.1.2 Degree Planner



4.4.1.3 DEO of Computer Deptt



4.4.1.4 Program Outcomes

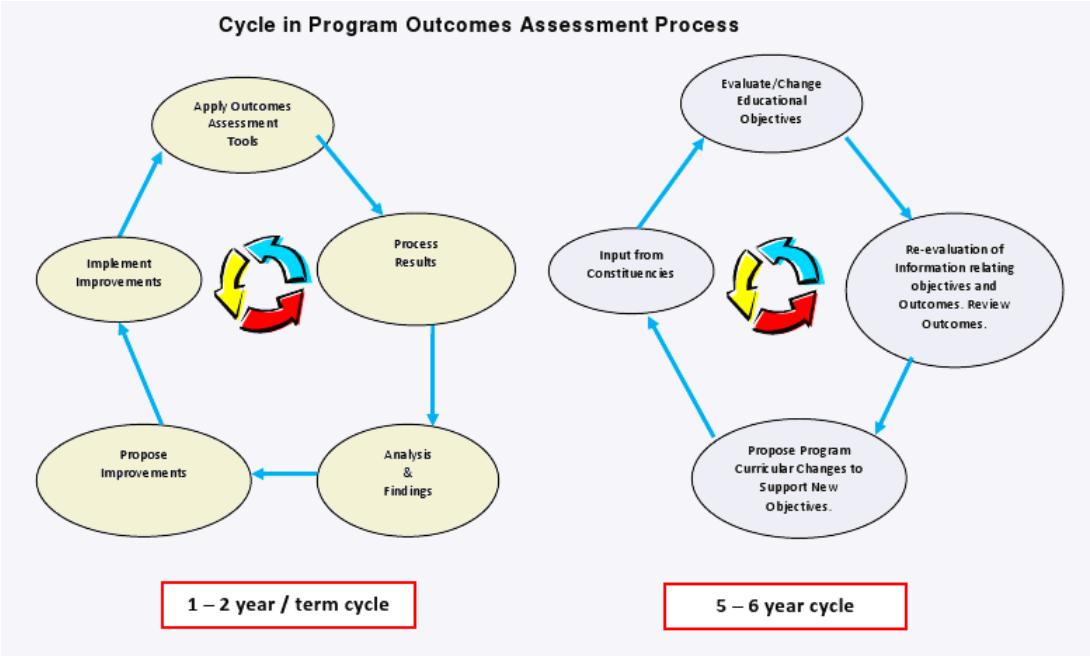


4.4.1.5 Rubric for marking

CHAPTER – 5

THE QUALITY IMPROVEMENT MECHANISM

5.1 **Closing the Loop**. The essential part of any quality improvement cycle or process is through feedback, often referred to as closing the loop. In the context of engineering program, the feedback can be divided into two main types, short term and long term.



a. The short term feedback refers to immediate feedback in form of examination results, surveys and portfolios. This feedback is then applied to the program for reviewing program course learning outcomes and syllabus and usually spans over a 1-2 year period.

b. The long term feedback is similar to the short term feedback, but is populated through feedback measures inhabited and matured over time, such as alumni surveys and industry board meetings. Based on this type of feedback and also through evaluation of results of short term quality improvement measures over 3-4 years period, the Program Educational Objectives and the curriculum is revised.

5.2 **The Short Term Feedback Measures in WAF™**. They are as under:

a. End of Course Survey

b. Locally Developed Tests, Embedded Assignments and Projects

c. Portfolios

d. Research Paper

e. Capstone Project

f. Open Group

5.3 **The Long Term Feedback Measures in WAF™**. They are as under:

a. Alumni Survey

b. Exit Survey

c. Employer Survey

d. EAB Meeting

e. Internships

f. Placement Interviews

5.4 **Continuous Quality Improvement**. Quality Improvement is an iterative process, which employs evaluation and feedback data to affect short term (outcomes realignment, syllabus improvement, change in teaching methods) or long term (curriculum review, revision of PEO) improvement. But, the process of quality improvement takes time and continuous effort. It can only succeed if the system is implemented across the board; through adaption of ABET culture in the paradigm of Program Improvement.

CHAPTER – 6

CONCLUSION AND FUTURE WORK

In this chapter, we present our contribution to developing an automated framework for Continuous Quality Improvement (CQI) as required under Criteria 4 of ABET EC-2000 (2011-12) to yield a usable web based software product. The overall concluding remarks are presented followed by limitations and benefits of our work. Finally areas for future work are identified and discussed.

6.1 **Conclusion:**

The Continuous Quality Improvement (CQI) aspects of ABET bring on a slew of complexities and complication in the Academic Program Assessment Process. It has been repeatedly shown in the literature that to build an optimum Academic Program Assessment Process for ABET accreditation in an educational institution; we must ensure that we maintain objective evidences of fulfilling ABET's criteria, provide a process for analyzing stakeholder's feedback using feedback tools and establish a mechanism for Continuous Quality Improvement of the program.

Review of existing literature revealed to us that the Engineering Criteria 2000 has intentionally been left open ended by ABET, focused on enquiring evidence of what students have learned rather than what they are taught. At its core is the call for a continuous improvement process informed by the specific mission and goals of individual institutions and programs. It enables program innovation rather than stifling it, encouraging new assessment processes and subsequent program improvement.

My research work was an effort to understand the criteria, its implementation facets in universities around the globe vis-à-vis their educational culture, Process Reengineering in the existing educational culture of NUST, with an attempt to sync our existing processes in-line with the identified expectations of the ABET evaluation team's requirements, introduction of new assessment methodologies and automation of our existing processes. Continuous Quality Improvement is achieved by closing the feedback loop, identifying the weak areas, plugging gaps in the system and aiming at quality improvement through innovation and up gradation of our teaching methodologies.

Accreditation planning and preparation calls for deliberation and concerted efforts by all stake holders by becoming a useful members of the process, playing their part in the proposed automation framework, feedback and academic quality improvement.

Evidence of program improvement would be collected over time, as the system is implemented and matures in three to four years. All CQI related data will be collected in the CQI relation, from which

necessary reports and graphs will be generated, that can be presented to the ABET's visiting team, to show the Continuous Quality Improvement of the Program, using the concept of timelines, recently introduced by Facebook.

6.2 **Limitations of the Research**

Leading Universities around the world have separate and dedicated academic quality improvement departments that are adequately funded and are in place for over one to two decades. Whereas, this being the first dedicated effort is aimed at achieving success in the limited time frame available, the research work has the following limitations

a. The system requires a maturity period of three to five years, which would encompass collecting data over time (longitudinal development), which has to be presented to the evaluation team to justify and prove continuous quality improvement of the Program

b. The system can only function if the ABET culture is implemented across the board, starting from the top management buying-in the idea and the all the faculty members playing their role towards improvement of the program, rather than finding out loopholes to bypass the transparency of the system.

c. The Top management has to understand and also absorb the fact that the system is intended to identify weaknesses of the program and not the individual faculty members. Only this assurance would help convince the faculty to implement the system in the true spirit.

6.3 **Benefits of Research Work**. The core reason for research and development of the Workflow Automation Framework (WAF^{TM}) was to provide an automated framework that would help establish a process for faculty members to manage Course Section and Program Outcomes, students' performance on Assessment Instruments (AIs), and targeted competencies of student performance. The benefits of automation envisaged through implementation of WAF^{TM} are:

a. Aligning University's mission, Department / Program's Educational Objectives, Program Student Learning Outcomes and Performance Criteria

b. Maintain Objective Evidence of Learning, resulting into meeting of Criterion 1 and 3

c. Removing inconsistencies

d. Introduction of additional assessment artifacts for mapping the engineering skills

e. Introduction of the concept of portfolios, both as a showcase and an assessment method, showing the skills acquired by the student over time. i.e., evidence of longitudinal development

f. Creation of Course Portfolios as evidence of improvement

g. Creation of Faculty Profile Pages, as per ABET's guidelines

h. Faculty Workload Management

i. Generating feedback through use of surveys

j. Introducing the concept of generating feedback through use of Open-Group (moderated) concept, where any stakeholder can post his/her views, without the need to identify himself/herself

k. Automated generation of agenda points for meeting, based on ARK™

l. Planning Meetings and recording their Minutes

m. Ease of Follow-up on Minutes of Meetings

n. Free availability of Workflow Automation Framework, which otherwise would cost approximately 50$ / student / year

o. Continuous Quality Improvement through introduction of CQI committee, which would have a vast data available for analysis and decision making

6.4 **Future Work**. Program improvement is an iterative process; calling for change through process re-engineering would be difficult to get approval of administration as it is likely to cut across roles and powers. Such a scenario calls for incremental change or business process improvement. In this backdrop, following future work is envisioned:

a. Generating an automated self-study report (a very ambitious task)

b. Defining sub-outcomes and performance criteria for non-ABET outcomes (academic work, not related to software domain)

c. In ABET workflow, drilling down deep up to question/assignment/project statement to show linkage to the outcome (a-k) via performance criteria

d. Showing evidence of improvement (structure already in place, but requires 3-5 years iterative cycle for relevant data generation

e. Developing a customizeable version for marketing to other universities via internet

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