Evaluation Model for Course and Program Effectiveness in Higher Education

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***Abstract*--This paper presents a comprehensive assessment model for academic programs and courses in higher education institutes. Assessing and evaluating courses and programs of study are vital in today's academia in order to meet the challenges associated with the market demand and the stakeholders' expectations. Hence, it is crucial to implement a rigorous assessment and evaluation model for continuous quality improvement in order not only to meet national and international accreditation standards, but also to continue improving and delivering an effective level of learning. The model presented here uses internal and external evaluation instruments. Recommendations can then be made from analyzing the results for improvement of courses and degree programs. Course evaluation is carried out using marks obtained from the various assessment instruments used throughout the semester and from the students' achievement expectation of the course outcomes. The main effect of this evaluation model is, therefore, to improve and enhance the delivery of the degree programs, and subsequently the educational outcomes.**

***Index Terms*-Course Learning Outcomes, Program Outcomes, Assessment Tools, Rubrics, Quantitative and Qualitative tools.**

I. Introduction

Assessment of educational effectiveness plays an important role in the quality control and improvement of the institutions of higher education. It is also a source of information to the stakeholders, such as governmental and local regulatory entities, prospective students, parents, regional and international accrediting organizations [1 - 4]. Even though students' ratings of instruction is an important factor in assessing the educational effectiveness [5 - 8], relying on it alone is insufficient and frequently leads to confusion. Many institutions have tried innovative methods to measure instruction effectiveness; for example, San Diego State University attempted to improve its general education programs in two phases where twenty faculty from different disciplines were involved in pilot rubrics for three of the five areas of their GE program [one ref from 2015].

Therefore, selecting appropriate indicators of educational effectiveness of programs and institutions is an important and a difficult task [9 - 13]. Developing performance indicators for assessing students' learning should be part of any model of assessment [14, 15]. The workforce representatives, accrediting organizations, and governments expect higher education institutions to prepare students for the labor market by development of appropriate competencies and skills [16 - 18]. Attaining such outcomes must be documented throughout the process of assessment. This paper proposes an assessment and evaluation model of educational effectiveness, which aligns criteria for educational success with specific indicators of achievement of these criteria. The model assesses both the courses and their academic program by using many internal and external performance indicators, some of which are quantitative while others are qualitative [19 - 21]. The model does not use a new set of tools and new methods but rather it is a comprehensive collection of tools that, collectively, is missing from the literature as a complete model.

II. Course Evaluation Methods and Tools

Course outcomes can be evaluated using both quantitative tools such as the students' marks, students' expectation of course achievement, students' feedback on the course and faculty at the end of the semester, and qualitative tool such as faculty observations of students' performance during laboratories, assignments, projects, presentations, and so on. Faculty observations of students' performance can be recorded using rubrics. Hence, a comprehensive course assessment and collection of results are used for evaluating the achievement of course outcomes. The evaluation process is meant to ensure that the course outcomes are being monitored, measured, and improved. The results of the evaluation process should be applied to the improvement of the courses, the program, and the educational experience of the students.

A growing number of institutions require faculty members to submit course reports at the end of each semester, which contains evaluation of the student's achievement of each course outcome for every course they have taught and their analysis of the outcomes. Hence, the analysis should objectively indicate the level of the students' achievement of the course outcomes, which should lead to plan of action for improving each course at the next offering, if some of the outcomes where not achieved. Each semester course report is updated to indicate the changes and the improvements that have taken place over a number of semesters. Many institutions use specialized software, such as TaskStream, to maintain their course files.

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We will be evaluating a hypothetical course and its marks. The marks for any course is normally divided into a number of parts, for example three parts: course work (C), midterm (M) and final (F). We further assume that each part is divided into sub-marks. The sub-parts for C are, for example, C1, C2, C3, C4, C5, and C6, and the sub-parts for M are M1, M2, M3, M4, M5, and M6, and the sub-parts for F are F1, F2, F3, F4, F5, and F6. We also, assume that the course outcomes are CO1, CO2, CO3, CO4, CO5, and CO6. The sub-parts do not have to carry equal weight but for illustrative purposes, we will assume in this case that they do.

Course instructors are required to record all the sub-parts M1, …, F6 and use them to calculate the outcome achievements for each student. For example, assume that the student's marks obtained in a course for the three parts C, M, and F are X, Y, and Z respectively.

Assume farther that the mark X is the sum of the sub-parts X1, X2, X3, X4, X5, and X6 (all carry the same wright in this example). Similarly, the mark Y is the sum of the sub-parts Y1, Y2, Y3, Y4, Y5, and Y6. Finally, the mark Z is the sum of the sub-parts Z1, Z2, Z3, Z4, Z5, and Z6. The sub-parts of each student's marks are recorded for, say, n students into a table, and the course outcome achievements are then calculated for each student using the following formula:

$$O_i = 100 * (X_i / M_i + Y_i / C_i + Z_i / F_i), i=1,\ldots,6 \quad (1)$$

The values O1, O2, O3, O4, O5, and O6 are the contribution of each student to the achievements of the outcomes CO1, CO2, CO3, CO4, CO5, and CO6 for n students. Finally, the average outcome achievement of all students for every outcome is computed. Therefore, every outcome is precisely measured and every outcome is measured by more than one tool.

III. Case Study: Actual Course Results and Analysis

The above tool of evaluation is used to evaluate courses offered in the Department of Computer Engineering. As an example, we consider below the outcomes of the data structures course:

Table 1: Data Structures Course Outcomes

Code	Outcome
CO1	Use linked lists as a problem solving technique.
CO2	Use recursion as a problem solving technique.
CO3	Apply stacks and queues to a variety of problems.
CO4	Represent trees and graph, with their standard manipulation algorithms.
CO5	Use different techniques of searching and sorting.
CO6	Evaluate various alternatives and select appropriate ADTs.

The evaluation tools used to evaluate the student achievement are the midterm exam, the course work (quizzes and assignments), and the final exam. The marks used to evaluate each outcome are as shown in Table 2. Table 3 shows the course average achievement of each course outcome using the students' marks.

Table 2: Mark Distribution to the Course Outcomes

Tool	Mark	CO1	CO2	CO3	CO4	CO5	CO6
Midterm Exam	25	10	8	7			
Course Work	30	5	5	5	5	5	5
Final Exam	45	3	3	12	14	8	5
Percentage	100	18	16	24	19	13	10

Table 3: Mark Distribution to the Course Outcomes

	CO1	CO2	CO3	CO4	CO5	CO6
Average	54.6	70.0	58.0	64.0	75.4	68.6

The last row in Table 2 is a weighted measure of evaluating the course outcomes based on their importance. If an outcome is more important than another outcome then the important outcome should carry a higher weight. For example CO6 in Table 2 is less important than CO3, hence CO3 was weighted at 24% while CO6 was weighted at 10%. The average row in Table 3 is a measure whether a course outcome is achieved or not. Having different values of averages for the course outcomes indicates that the outcomes were not equally achieved. Low averages necessitate action of improvements in the next course offering.

One important assessment tool of course outcome achievement is the faculty observations of students' performance. This can be achieved using rubrics for the different course components such as laboratories, presentations, and assignments. A rubric is a table in which the first column lists the course outcomes and the remaining columns detail the level of understanding of the course materials (Outstanding, Adequate, Developing, and Ineffective) which reflect on the level of course outcome achievement. The course instructor can design a rubric to assess the outcomes of a programming course, for example and record his / her observations on the level of students understanding of the course materials during a lab section or in a discussion or when marking an assignment. These observations are recorded in one rubric for the whole section and not for each individual student. As the progress through the semester the course instructor can form an opinion on the level of course outcome achievement. If there are 12 labs to be covered during the semester in a programming course then let's say that labs 1, 2, 3, and 4 cover outcome CO1 and CO2, while labs 5, 6, 7, and 8 cover outcomes CO1, CO2, CO3, and CO4. Also labs 9, 10, 11, and 12 cover outcomes CO1, CO2, CO3, CO4, CO5, and CO6 then the instructor can monitor how the students understanding of the course materials is improving as the semester is approaching it end.

IV. Program Assessment and Evaluation

As mentioned earlier, to meet the challenges associated with the rapid advancements in any field of study at a higher education institute, it is important to assess and review the program of study and its courses. The department of the offered program has to commit itself to implementing a rigorous program evaluation and continuous quality improvement. In this regard, the department should continuously evaluate and enhance its programs to ensure that they meet national and international accreditation standards.

Effective evaluation should be an essential part of the department's endeavor to improve its degree program. The evaluation measures are to be carried out using various forms and surveys to ensure the credibility of the evaluation. In this article we propose an evaluation model that can be used to evaluate academic programs. The model uses two simultaneous tracks: Internal Evaluation (IE) and external Evaluation (EE). Their combined results should thoroughly be analyzed and considered for implementation into the programs in such a way that they meet any accreditation standards. In addition, most academic institutions usually have a Quality Control Department (QCD), which also helps the academic departments in evaluating the achievement of their program outcomes and goals.

In Fig. 1, the program goals and outcomes are drawn from the institution mission statement. Each course has a set of goals and uses different tools and resources to measure its effectiveness. The evaluation tools are used to assess and evaluate the data. Conclusions and recommendations are then made as a result of evaluating the data for each course, which subsequently leads to improving the program. This cycle of development, assessing, evaluating, and improving the program goals and outcomes is the guarantee that the program remains a dynamic one that offers the students and program constituents a solid and up-to-date education.

The program administrators have to develop a set of goals and outcomes for the program, a set of goals and outcomes for each course, and finally the goals and outcomes of each course is mapped to the goals and outcomes of the program.

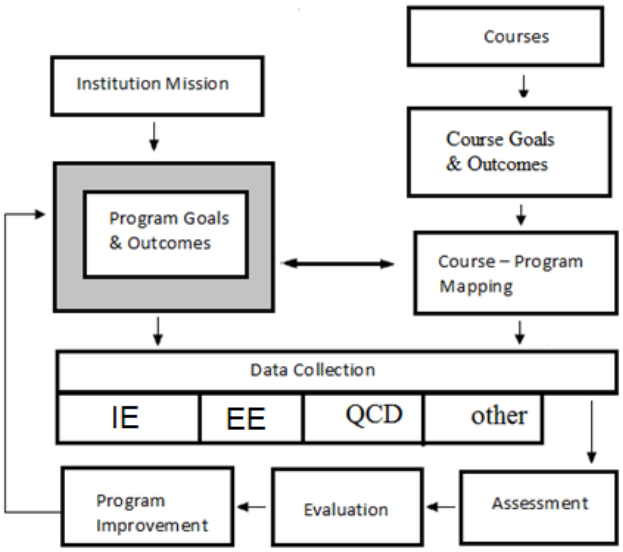

Fig. 1: Goals and Outcomes Development and Improvement Cycle

The following subsections describe the internal, external, and quality control department evaluations methods:

A. Internal Evaluation

Every academic department utilizes a number of internal evaluation tools to continuously evaluate the effectiveness of its programs. These tools include the following:

1) Student Evaluation

Institutions use an end-of-semester student survey to solicit student's opinion. Surveys are conducted confidentially and collect students input on course material, course organization, instruction and instructor's performance. Result are summarized by the University Quality Control Department and standardized against all other courses in the department, the college and the university. A summary of the results are tabulated and reported to both the college and the department, which evaluate the survey results and produce directive comments for improvements (if any). Student's comments on the forms are also delivered to the faculty. This student evaluation of the course and faculty has an important part in the process of program assessment because they are the main beneficiaries in the teaching process. If problems were reported then the department takes that seriously and takes steps for improvements.

2) Course Assessment Report

At the end of every semester, instructors submit reports evaluating the courses offered during that semester. These course reports should be discussed by the faculty and modifications to the course contents or course delivery are to be made accordingly. All material related to a course should be documented and saved in a course file. This peer assessment tool is an important one to ensure the level of course delivery and the quality of the materials.

3) Student Expectation Report

At the end of every semester, the course instructor calculates the percentage achievement of the course outcomes based on the student expectation of achievement. This is a

measure of the students' perception of their achievement from the course outcomes.

4) Course Outcomes Achievement Report

At the end of every semester, the course instructor computes the percentage achievement of the course outcomes based on the students' marks. This is a measure of how much the students achieved from the course outcomes based on the tools used.

5) Overall Course Results

At the end of every semester, department faculty discusses the overall results of all the courses offered in that semester. The faculty also discusses the learning outcomes and their contributions to the program learning outcomes. This tool is important in closing the cycle (Fig. 1) in which program outcomes and goals are measured. The internal evaluation tools, based on the result of the evaluation are used to improve and/or modify the course materials, outcomes, goals and improving and modifying the course teaching and delivery methods, if necessary.

B. External Evaluation

External assessments are usually present themselves in a number of forms, this includes the following:

1) Accreditation / Reaccreditation

The continuous accreditation / reaccreditation process conducted by the ministries of higher education in many countries generates a number of recommendations and suggestions for the department to discuss and implement in order to improve and raise the program level on continuous bases.

2) Surveys

The department should conduct a number of surveys on regular bases such as exit, alumni, and employer surveys to collect feedback about the degrees offered. Results of the surveys are, therefore, also used to assess and evaluate the program.

3) Program Advisory Committee

The Program Advisory Committee (PAC) is comprised of members of the department's faculty and leaders of industrial, business, and governmental entities associated with the relevant program who have a stake in the quality of education of the program graduates. The main function of this committee is to provide advice on program and curricula issues in light of the needs of the local industry. The PAC provides vital input to the department's management on current and future market trends.

C. Quality Control Department

The mission of the Quality Control Department (QCD) at any academic institution is to support planning, decision-making, assessment, and evaluation of the offered programs. The QCD is a service-oriented department that provides information for policy and management decisions for campus academic units, administrative units, and students and proposes alternative solutions to support the decision-making process.

The QCD collects evaluation data from the academic units through:

- Course evaluation forms
- Different surveys
- Annual reports of different units
- Statistical analyses of student performance

The QCD integrates data and analysis and produces reports and studies that includes:

- Yearly statistical book
- Annual report for the institution administration
- Student performance analyses
- Performance indicators

V. Qualitative and Quantitative Evaluation Tools

The program can be assessed by quantitative and qualitative tools. Qualitative tools such as the IE, EE, and QCD tools stated above. Some of the popularly used tools are the course marks, student expectation of how much they achieved from the course outcomes, exit survey, alumni survey, and employer's survey.

Qualitative tools such as facilities, faculty workload, and availability of sufficient funds for travel to conferences and meetings, have a major impact on the program development. Having a dedicated laboratory for the final year projects, for example, will help the students practice the team skill which is an outcome in every program. Similarly, if the faculty workload is discussed and the faculty assigned reasonable workload, they can spend more time achieving goals and outcomes.

VI. Assigning Weights to the Evaluation Tools

The weights assigned to some of the popularly used tools, both internal and external, vary depending on the outcome. Table 4 is an example for assigning weights to various tools, which can be used as a guideline:

Table 4: Percentage Weights of the Used Evaluation Tools

Core	Elective	Capstone	Student Expectations	Exit Survey	Alumni Survey	Employers Survey
30	15	15	10	10	10	10

VII. Measuring the Contribution of the Courses to a Program

Table 5 shows, as an example, three courses taught for Engineering students and their contribution to the program. The Table shows the course outcomes and their mapping to the program outcomes, assuming the program has eleven outcomes.

Table 5: Mapping Course Outcomes (Cos) to the Program Outcomes (POs)

Course #1		Course #2		Course #3	
POs	COs	POs	COs	POs	COs
PO1	1,2,3, 5,6	PO1	1,2,3	PO1	1,4
PO2	2,3,4,	PO2	1,2,3,4	PO2	6

	5, 6				
PO3	2,3,4, 5,6	PO3	1,2,3, 4	PO3	3,6
PO4		PO4	3,4	PO4	
PO5		PO5		PO5	2,5
PO6		PO6	3,4	PO6	2
PO7	4,5	PO7		PO7	5,7
PO8	3,5,6	PO8		PO8	8
PO9		PO9	1,3,4	PO9	1,3
PO10	1,2,5, 6	PO10	1,2,3, 4	PO10	1,3,4
PO11	2,3,4, 5,6	PO11	1,2,3, 4	PO11	

The Table shows that course outcomes CO1, CO2, CO3, CO5, and CO6 (written as 1, 2, 3, 5, and 6) of course #1 all contribute to the program outcome PO1. Hence, Table 5 shows clearly the relationships between the courses' outcomes and their contributions to the programs outcomes. The same applies for all the courses in the program. Table 6 summarizes each of the above courses and its contribution to the program outcomes.

Table 6: Number of Course Outcomes Contribution to the Program Outcomes

	Course#1	Course#2	Course#3	Total	Percent
PO1	5	3	2	10	14.1
PO2	5	4	1	10	14.1
PO3	5	4	2	11	15.5
PO4	0	2	0	2	2.8
PO5	0	0	2	1	2.8
PO6	0	2	1	3	4.2
PO7	2	0	2	4	5.6
PO8	3	0	1	4	5.6
PO9	0	3	2	5	7.0
PO10	4	4	3	11	15.5
PO11	5	4	0	9	12.7
Total	29	26	16	71	
Percent	40.8	36.6	22.5		

The percentages 40.8%, 36.6%, and 22.5% in Table 6 are the contribution of each course to the program outcomes. Further, the percentage 14.1%, for example, at the bottom of column PO1 is the three courses contribution to the program outcome PO1. These percentages can be used as a checking mechanism of the accuracy of the mapping of the courses outcomes to the program outcomes. Once all the courses are included in a table similar to Table 6, all percentages must add up to 100%.

An Example

Next, let us take a hypothetical set of data and apply it to the three courses mentioned earlier. Table 7 assumes that the outcomes of the three courses at the end of a semester were achieved by the shown averages.

Table 7: Percentage of Course Outcomes Achievements

	CO1	CO2	CO3	CO4	CO5	CO6	CO7
Cr #1	86.0	91.0	84.0	60.0	62.0	87.0	
Cr #2	77.4	73.2	76.5	74.6			
Cr #3	71.8	69.2	85.3	60.1	68.4	63.5	70.6

To calculate the averages of course #1 contribution to the program outcome PO1, the sum of percentages of CO1, CO2, CO3, CO5, and CO6 of Table 7 will be computed and divided by intersection cell of row one and column one of Table 6. The value of CO4 is not used because CO4 do not contribute to PO1 as in Table 5.

(86.0 + 91.0 + 84.0 + 62.0 + 87.0) / 5 = 82.0

In similar fashion, it is possible to calculate the contribution of the three courses to all program outcomes, as shown in Table 8.

Table 8: Percentages of Course Outcomes Contribution to the Program Outcomes

Course	Course #1	Course #2	Course #3	Averages
Credit	4	3	3	
PO1	82.0	75.7	66.0	75.3
PO2	76.8	75.4	63.5	72.4
PO3	76.8	75.4	74.4	75.7
PO4	0.0	75.6	0.0	75.6
PO5	0.0	0.0	68.8	68.8
PO6	0.0	75.6	69.2	72.4
PO7	61.0	0.0	69.5	64.6
PO8	77.7	0.0	70.6	74.7
PO9	0.0	76.2	78.6	77.4
PO10	81.5	75.4	72.4	77.0
PO11	76.8	75.4	0.0	76.2

The averages in the last row of Table 8 are the weighted averages based on the credit hours of each course. These averages represent the extent to which the three courses have contributed to the achievement of the program outcomes. Finally, we present in Table 9 a rubric for the outcomes of a programming course and in Table 10 the instructor observations during 12 lab sessions.

Table 9 – part 1: Rubric to Record the Faculty Observations of the Course Outcomes

Outcome	**4 = Outstanding**
Identify different phases of problem solving and algorithm design	Analyze the problem. Identify the requirements. Write an algorithm. Declare the variables. Solve the problem. Write the code. Get correct result.
Develop, test, and debug computer programs	
Use the concepts of variables, data types, input, output,	Identify the data type. Understand what an

expressions, and assignment	expression is. Perform simple calculations.
Apply selection and repetition statements	Knows when to use selection. Knows when to use repetition. Knows how to use selection. Knows how to use repetition.
Implement modular programming	Knows what a function is. Use value parameters. Use reference parameters. Implement functions.
Use the concept of string and arrays	Knows when to use arrays. Knows how to implement arrays. Knows the difference between a string and a character array. Knows how to use strings.

Table 9 – part 2: Rubric to Record the Faculty Observations of the Course Outcomes

3 = Adequate	2 = Developing
Analyze the problem. Identify the requirements. Cannot write an algorithm. Declare the variables. Solve the problem. Write the code. Cannot get correct result.	Analyze the problem. Cannot identify the requirements. Cannot write an algorithm. Declare the variables. Solve the problem. Cannot write the code. Cannot get correct result.
Identify the data type. Understand what an expression is. Cannot perform simple calculations.	Identify the data type. Do not understand what an expression is. Cannot perform simple calculations.
Knows when to use selection. Knows when to use repetition. Knows how to use selection. Does not know how to use repetition.	Knows when to use selection. Knows when to use repetition. Does not know how to use selection. Does not know how to use repetition.
Knows what a function is. Use value parameters. Use reference parameters. Cannot implement functions.	Knows what a function is. Use value parameters. Cannot use reference parameters. Cannot implement functions.
Knows when to use arrays. Knows how to implement arrays. Knows the difference between a string and a character array. Does not know how to use strings.	Knows when to use arrays. Knows how to implement arrays. Does not know the difference between a string and a character array. Does not know how to use strings.

Table 9 – part 3: Rubric to Record the Faculty Observations of the Course Outcomes

1 = Ineffective	Points
Cannot analyze the problem. Cannot identify the requirements. Cannot write an algorithm. Declare the variables. Cannot solve the problem. Cannot write the code. Cannot get correct result.	
Cannot identify the data type. Do not understand what an expression is. Cannot perform simple calculations.	
Knows when to use selection. Does not know when to use repetition. Does not know how to use selection. Does not know how to use repetition.	
Knows what a function is. Cannot use value parameters. Cannot use reference parameters. Cannot implement functions.	
Knows when to use arrays. Does not know how to implement arrays. Does not know the difference between a string and a character array. Does not know how to use strings.	

Table 10 – part 1: Faculty Observations of the Course Outcomes during the Laboratories

Outcome	Lab1
Identify different phases of problem solving and algorithm design	
Develop, test, and debug computer programs	
Use the concepts of variables, data types, input, output, expressions, and assignment	
Apply selection and repetition statements	
Implement modular programming	
Use the concept of string and arrays	

Table 10 – part 2: Faculty Observations of the Course Outcomes during the Laboratories

Lab2	Lab3	Lab 4	Lab 5	Lab 6	Lab 7	Lab 8
2	3	3	3	4	4	4
2	2	2	3	3	3	4
2	2	3	3	3	4	4
		2	2	3	3	3
					2	3

Table 10 – part 3: Faculty Observations of the Course Outcomes during the Laboratories

Lab 9	Lab1 0	Lab1 1	Lab1 2	average
4	4	4	4	3.42
4	4	4	4	3.18
4	4	4	4	3.36
4	4	4	4	2.89
3	4	4	4	3.33
3	3	4	4	3.50

VIII. CLOSING THE CYCLE

The program outcome assessment and evaluation tools stated above will result in the achievements and actions of the following points:

- Enhanced Delivery and Educational Environment
  - Revised Course Outcomes

- Revised delivery method
- Training and workshops
- Flexible and innovative program

- Enhanced Curriculum
  - Maintain up-to-date course file
  - Better assessment techniques
  - Ensure assessment quality
  - Enhanced exam levels
- Up-to-date Facilities and Equipment
  - Maintain and up-grade facilities
  - Enhanced working environment
- Measurement of Success and University Reputation
  - Curriculum revision
  - Course delivery revision
  - Better faculty production
- Quality Control
  - Quality control of the program
  - Public confidence and trust

All the above methods, tools, and results are summarized in Fig. 2.

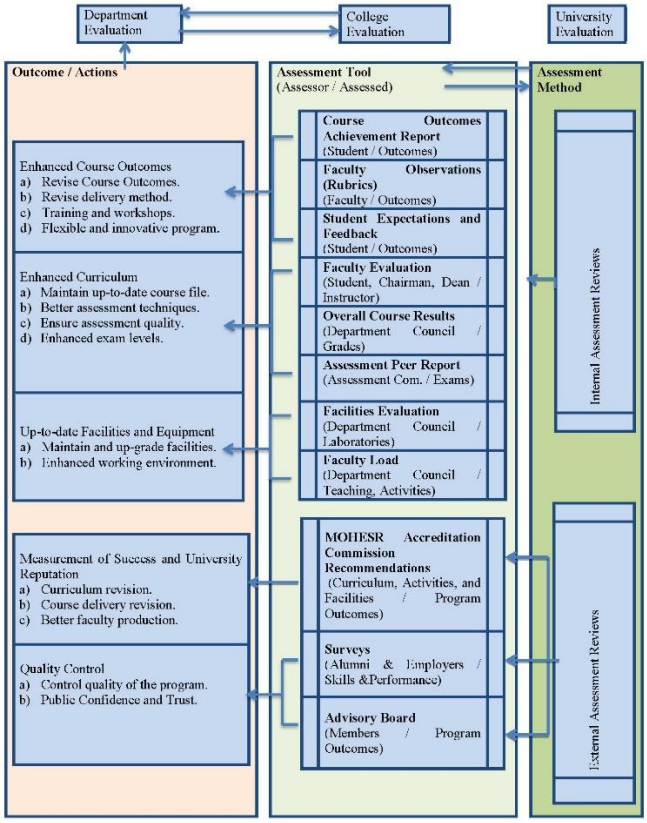

Fig. 2: Program Assessment Flow Chart

IX. Conclusion

In this article, we have presented a model for the assessment and evaluation of course outcomes and the program outcomes. The course evaluation part involves the students' marks and the student expectation of course outcomes achievement. The program part involves internal evaluation, external evaluation, and the quality control evaluation of the institution. The model starts by driving the program goals and outcomes from the institution mission's point of view, each course goals and outcomes are derived to support the program goals and outcomes. The evaluation tools are used to collect data, which is then assessed, and evaluated. This leads to the courses and program improvement, which closes the cycle of assessment and improvements.

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