Measurement of Program Outcomes Attainment for Engineering Graduates by using Neural Networks

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Abstract- This paper aims to provide an evaluation method for the attainment of Program Objectives for Engineering Graduates as defined by NBA (National Board of Accreditation). As NBA requires specific evaluation techniques and measurement methods for measuring the attainment of Course Outcomes, Program Outcomes and Program educational Outcomes, this paper provides a solution of the measurement techniques using neural networks. The performance of all the students of a batch can be displayed graphically using neural networks.

Keywords – Course Objectives, Program Objectives, Program Educational Outcomes, Rubrics, Multilayer perceptron, Classification

I. INTRODUCTION

The work on classification of student attainment of Program Objectives as defined by NBA for the students undergoing various courses in engineering is aimed at making the tabulation easier for the faculty engaging the students. The work begins with defining the rubrics for all the eleven program objectives defined by NBA [2][3]. The Course outcomes are measured based on the rubrics, the program outcomes are classified based on the score obtained in course outcomes. Further, the extent to which the Program Educational Objectives are achieved by the students undergoing the course are also classified. The classification is done using WEKA 3.7.4.

II.PARAMETERS TO BE CLASSIFIED

The parameters to be classified include the student attainment of Course Outcomes, Program Outcomes, Program Educational Objectives etc.

Program Educational Outcomes [PEO]
The Program Educational Objectives reflect the qualities that the student acquired in about 5 years after completing the course.

Program Outcomes [PO]
Program Objectives define the qualities attained by the students on completing the program. The program objectives defined by NBA are shown below[2].

- Engineering Knowledge
- Problem Analysis
- Conduct investigation of complex problems
- Modern Tool Usage
- The Engineer and Society
- Environment and Sustainability
- Ethics

- Individual and Team work
- Communication
- Project Management and Finance
- Life long Learning

Course Outcomes[CO]
Course Outcomes define the qualities attained by the students on completing the particular course on a subject. The extend of attainment of course outcomes are measured by rubrics.

Rubrics
Rubrics are the measurement tools for the attainment of the program objectives. The method of framing rubrics for the eleven PO's of the NBA is as shown below. The four logical levels of measurement are defined. An example of rubric written for measuring PO 1 is shown. Rubrics are written for all the eleven PO's to suit the requirements of the respective departments. Criterias (CR) are used to define the rubrics.

Table 1: Rubrics for measuring Engineering Knowledge [PO] (First Program Outcome)

Measurements→ Criteria[CR] ↓	**Needs Improvement**	**Developing**	**Satisfactory**	**Exceeds Expectation**
Relate the problem to an existing literature /mathematical models/engineering	Does not understand the connection between mathematical models and chemical, physical, and/or biological processes and systems in engineering	Chooses a mathematical model or scientific principle that applies to an engineering problem, but has trouble in model development	Relates mathematical and/or scientific principles to formulate models relevant to engineering	Combines mathematical and/or scientific principles to formulate models relevant to engineering Chooses a mathematical model or scientific principle that applies to an engineering problem
Analyze the problem mathematically	Does not understand the application of calculus and linear algebra in solving engineering problems	Tries to apply concepts of integral and differential calculus and/or linear algebra to solve engineering problems but not confident	Shows nearly complete understanding of applications of calculus and/or linear algebra in problem-solving	Applies concepts of integral and differential calculus and/or linear algebra to solve engineering problems
Engineering interpretation of mathematical and scientific terms	Does not appear to grasp the connection between theory and the problem	Partially interprets the mathematical terms	Most mathematical terms are interpreted correctly	Shows appropriate engineering interpretation of mathematical and scientific terms

III ASSESSMENT TOOLS

The various tools for assessing the students

- assignments
- mini-projects
- quizzes
- examinations
- presentations
- reports
- viva-voce
- lab performance (practical knowledge)
- industrial visits
- social service
- other co-curricular activities

are used for assessing the attainment of each CO.

IV FLOW OF MEASUREMENT

- Criteria are defined to measure CO's of each subject. (two or more CO's can define each subject)
- All the subjects in the program are grouped under the defined PO's.
- Numerical weight age is assigned to group the measured CO's of the subjects under each PO.
- Numerical weight age assigned to each PO gives a measure of the extent to which each PEO is satisfied.

V.MEASUREMENT AND SCORE OF CRITERIA CO

The table below shows the weight age assigned to each measurement criteria that are used to measure the course outcomes of each course. The basic score values are calculated based on the number of CO's and PO's that are used to calculate PO and PEO respectively.

Total Number of CO=n
Value of k^{th} CO=COk

Table II: Measurement of CO

Measurement	[1] Needs Improvement >45%	[2] Can Do Better 45%- 60%	[3] Satisfactory 60%-75%	[4] Exceeds Expectation <75%	Max Score for COk= sum of max score for criteria	CO Normalised
Basic Score For Criteria	0	1	2	3	X	
Score for CO	CO1+CO2+CO3+……COn				X1+X2…Xn= Y	
Classification score	>Y*.45	Y*.45-Y*.60	Y*.60-Y*.75	<Y*.75	-	(CO1+CO2…+COn) ---------- Y*n
Classification after Normalisation	>.45	.45-.60	.60-.75	<.75	-	-

VI. EXPERIMENTAL RESULTS

The evaluation was done on a group of 120 students in a batch and the results of evaluation are as shown below. The graphical representation of the classification values of each CO leading to the level of PO attainment can be easily seen.

Number of criteria selected- k=1to 3
Number of Course Outcomes for the subject-n=1 to 3
Max score for COk=9
Max score for course outcome= 27

Table III: Measurement of CO

Measurement	[1] Needs Improvement >45%	[2] Can Do Better 45%- 60%	[3] Satisfactory 60%-75%	[4] Exceeds Expectation <75%	Max Score for COk= sum of max score for criteria	CO Normalised
Basic Score For Criteria(CR)	0	1	2	3	CR1+CR2+CR3=9	
Score for CO	CO1+CO2+CO3				27	
Classification score for CO =PO11	12	12-16	16-20	<20	-	(CO1+CO2+CO3)/3 ---------- 27
Classification after Normalisation	>.45	.45-.60	.60-.75	<.75	-	-

Program Outcome 1= PO11+PO12+PO13…..PO1m

Where PO1m corresponds to the CO score of the m^{th} subject under PO1.

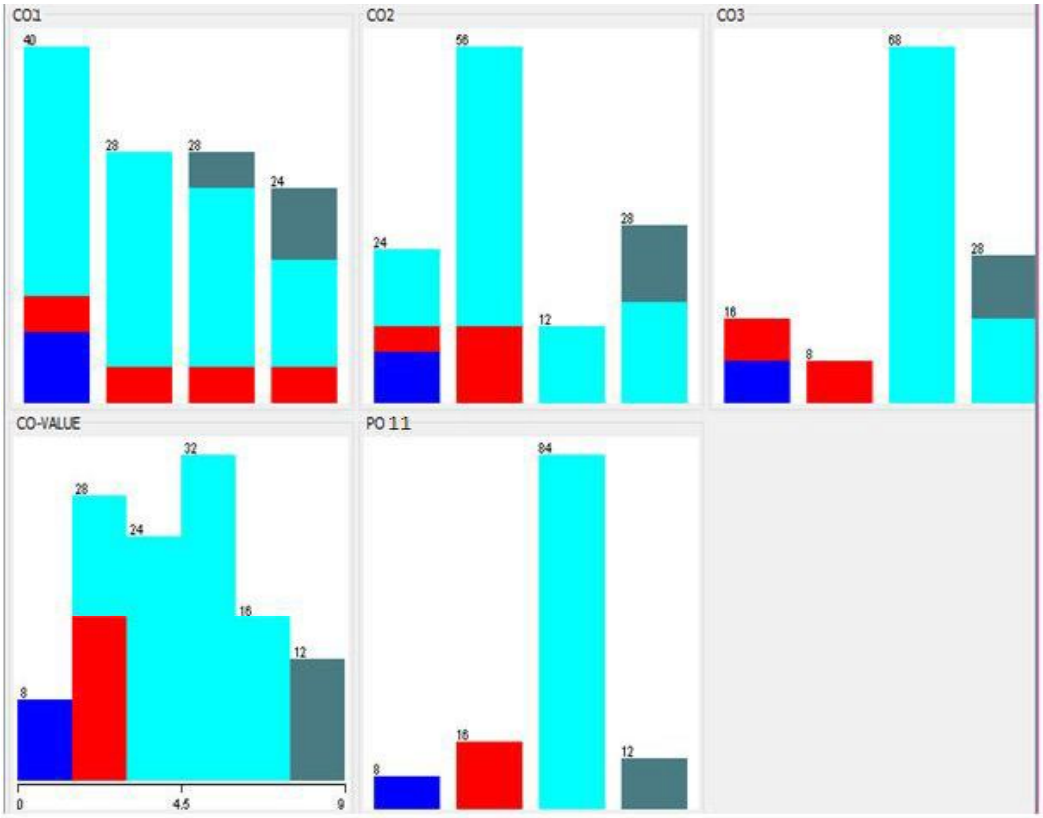

Figure 1: Graphical Representation of CO, PO11 Classification

The blue colour represents the number of students who needs improvement in satisfying PO, red colour represents the number of students who can do better in achieving PO, green colour represents number of students who have satisfactorily attained PO and gray colour represents the students who have exceeded the expectation in attaining PO.

The above figure shows the extend to which the students of a particular batch has satisfied the Program objective corresponding to a subject that they have studied. Based on the results of the Program objectives of all the subjects under the given PO, the extent to which the corresponding PEO is attained can be easily verified. (This has to be verified after a period of 3 or more years)

The statistical results obtained as a result of classification is shown below. 120 instances have been correctly classified. The classifier used is multilayer perceptron.

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=== Stratified cross-validation ===
=== Summary ===

Correctly Classified Instances         120               100      %
Incorrectly Classified Instances         0                 0      %
Kappa statistic                          1
Mean absolute error                      0.0072
Root mean squared error                  0.013
Relative absolute error                  2.954  %
Root relative squared error              3.7423 %
Coverage of cases (0.95 level)         100      %
Mean rel. region size (0.95 level)      25.8333 %
Total Number of Instances              120

=== Detailed Accuracy By Class ===

               TP Rate   FP Rate   Precision   Recall  F-Measure   ROC Area  Class
                 1         0          1         1         1          1        NEEDS-IMPROVEMENT
                 1         0          1         1         1          1        CAN-DO-BETTER
                 1         0          1         1         1          1        SATISFACTORY
                 1         0          1         1         1          1        EXCEEDS-EXPECTATION
Weighted Avg.    1         0          1         1         1          1

=== Confusion Matrix ===

  a  b  c  d   <-- classified as
  8  0  0  0 |  a = NEEDS-IMPROVEMENT
  0 16  0  0 |  b = CAN-DO-BETTER
  0  0 84  0 |  c = SATISFACTORY
  0  0  0 12 |  d = EXCEEDS-EXPECTATION
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Figure 2: Statistical results of classification

VII. CONCLUSION

The above paper makes the work of measurement of attainment of Program Objectives much easier for the faculty of technical education particularly in self-financing colleges in India. The same method can be done to classify PEO on the data provided by alumni database.

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