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A Novel Fuzzy Based Assessment Method for Learning Outcomes

Binu Thomas

Outcome based education (OBE) is a recent development in student-centered teaching-learning model that emphases on measuring student performance through outcomes. Outcomes include knowledge, skills and attitudes suggested in Blooms taxonomy. The OBE approach encourages students to become active learners because it focusses on student attainment in comparison to teacher-centered learning approach. The level of the attainment of Course Outcomes (COs) is the indicator of the skill, knowledge and behavior that students acquired at the end of the course. In Outcome Based Education every activity performed in the class room is linked with the measurable course outcomes. In this paper, we present an effective fuzzy based approach to assess the attainment of outcomes by mapping every assessment activity performed in the class room with the Course Outcomes (CO) and eventually to Program Outcomes (PO). The attainments of outcomes by the students are also expressed as fuzzy memberships which can also be represented graphically. The entire work is based on the OBE implementation case study of Marian College Kuttikkanam, (MCK)

Keywords: fuzzy sets, course outcomes, programme outcomes, outcome assessment.

I. INTRODUCTION

Student Centered Innovative Teaching Learning is one of the key component in quality assurance and enhancement in the higher education envisioned by accreditation agencies like National Assessment and Accreditation Council (NAAC)[1].Outcome-Based Education" (OBE) framework is considered as a substantial leap forward to improve higher education in India and help Indian students contest with their global counterparts[2]. The student centered learning OBE method stimulates more student's involvement through responsible participation in teaching learning process [3, 4]. In OBE, skill or knowledge acquired by the students is more important than what is taught in the classroom by the teacher According to Heywood [5], "Education that is outcome-based is a learner-centered, results-oriented system founded on the belief that all individuals can learn". The key points in the Outcome Based Education (OBE) approach are [6, 7]:

- Student learning outcome are clearly mentioned.
- The student's progress is evaluated based on demonstrated achievement.
- Multiple instructional and assessment strategies need to be available to meet the needs of each student.
- Outcomes give a clear picture on the knowledge and the skill achieved.

In OBE, the classroom activities are always planned well in advance and facilitated based on the need and level of the learners [7]. The OBE approach along with Blooms Taxonomy give a clear picture on the knowledge and the skill achieved by the student at the end of the course [8]. It does not depend on what is taught by the course teacher the class but it depends on what knowledge and skill the learners acquired through the completion of the course. It focuses on the best way for individuals and organizations to get self-knowledge about where they are and what they want to be [9, 10].

The concept of Fuzzy Logic was conceived at the early beginning of the 70s by Lotfi A Zadeh, a professor at the University of California at Berkley. He presented it as a way of processing data by allowing partial set membership rather than crisp set membership or non-membership [11, 12]. In this approach to set theory, Zadeh reasoned that people do not require precise, numerical information input, and yet they are capable of highly adaptive control [13]. What Zadeh proposed is very much a paradigm shift and this concept first gained acceptance in the Far East.

This paper presents the concept of assessing the attainment of outcomes in OBE through the integration of fuzzy sets. The final attainment of CO, PSO and PO can be assessed through various assessment activities given to student like assignments, seminars, exams, group activities etc. In this paper Section I is the introduction and Section II gives the basic definitions. Section III deals with outcome assessment and Section IV gives a special reference to outcome assessment at MCK. Section V deals with assessment methodology, VI is discussions of results and finally Section VII concludes the paper.

II. DEFINITIONS

A. Outcomes

Outcome based education (OBE) is student-centered instruction model that focuses on measuring student performance through outcomes [14]. Outcomes include knowledge, skills and attitudes. Its focus remains on evaluation of outcomes of the program by stating the knowledge, skill and behavior a graduate is expected to attain upon completion of a program [10, 15]

There are three levels of outcome such as Course Outcome (CO), Program Outcome (PO), and Programme Specific Outcome (PSO) [16].

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* Correspondence Author
Dr. Binu Thomas*, Joint Director of Marian Institute for Innovate Teaching Learning and Evaluation (MIITLE).

B. Program Outcomes (PO)

POs are defined by Accreditation Agencies of the country (NBA and NAAC in India), which are the statements about the knowledge, skills, attitudes and graduate attributes of a formal educational program should have [17]. Program Outcomes could be viewed as the tangible skills developed by the students which establish the vision, purpose, and goals of a higher education institution through various programs offered by the institution [18].

C. CO and PSO

Course outcomes are statements that describe significant and essential learning that learners have achieved, and can reliably demonstrate at the end of a course [19]. Program Specific Outcomes (PSOs) are the statements that assert what the grandaunts of a specific program should do and what they can able to do [1].

D. Fuzzy Sets and Memberships

In fuzzy *logic* based systems, the collection of data are considered as *fuzzy sets*. Traditional crisp sets include or do not include an individual element; there is no other case than true or false. But in the case of fuzzy sets, it allows partial membership [13]. A fuzzy set has, potentially, an infinite range of truth values between one and zero [20]. Propositions in fuzzy logic have a degree of truth, and membership in fuzzy sets can be fully inclusive, fully exclusive, or some degree in between [11].The fuzzy set is distinct from a crisp set that it allows the elements to have a degree of membership. The core of a fuzzy set is its membership function: a function which defines the relationship between a value in the sets domain and its degree of membership in the fuzzy set [21]. The relationship is functional because it returns a single degree of membership for any value in the domain.

The fuzzy membership function is defined as:

$$\mu = f(s, x) \qquad (1)$$

Where,
μ : is the fuzzy membership value for the element
s : the universe of discourse
x : is the value from the underlying domain.

The central idea in fuzzy systems is the use of *linguistic terms* to represent the revealed regularities and exceptions. The linguistic representation of the variables in such systems makes it to be much natural for human users to understand. An age group can be represented with four overlapping linguistic terms as very young, young, old and very old. Rather than grouping the values to discrete intervals, the fuzzy approach groups the data set into certain linguistic terms and these groups have ill-defined boundaries that smear into the neighboring space often overlapping the limits of adjacent groups[22,23].

III. OUTCOME ASSESSMENT

The attainment of these outcomes are evaluated through the assessment of various learning activities given to the students throughout courses [3]. The activities are mapped with course outcome on a fuzzy scale. We use the fuzzy linguistic variable low, medium and high to (Figure: 1) associate each assessment activities with the course outcomes. The assessment activities can be assignments, seminars, exams, group activities etc., given to the students as part of the course. These activities are mapped with the course outcomes of the course so that by evaluating the assessment activities, the attainment level of course outcomes can be reached. The fuzzy mapping of marks obtained for different assessment activities to fuzzy linguistic variables is done as per the associations given in *table-1*. For calculation purpose fuzzy weights are assigned to linguistic variables these weights are also given in the table.

Table – 1: Mapping of marks to fuzzy linguistic variable

Fuzzy linguistic variable	Percentage of marks for assessment activities	Fuzzy weights for linguistic variables
Nil	0%	0
Low	1-50%	1
Moderate	51-70%	2
Significant	71-100%	3

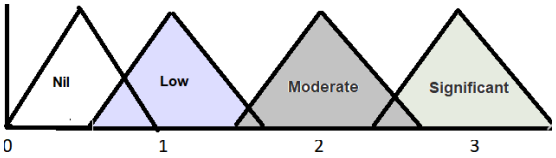

Figure 1. Fuzzy linguistic variables

IV. COURSE OUTCOMES AND PROGRAM OUTCOMES OF MCK

MCK Mission and vision helped to provide direction for creating program outcomes for the institution. Basically, those goals of the institution are translated into tangible, 'measurable' outcome statements.

The nine programme outcomes of the college are listed in figure 2. All these program outcomes reflect the Mission and vision of MCK. The mission and vision of MCK is accomplished when the students attain these Program Outcomes. Similarly the course outcomes of Introduction to Computer Science (ITC,course code BCA101) offered at MCK is given below. These course outcomes reflect measurable skills and knowledge attained by the students after completing the course. The program outcomes of the college are achieved through the course outcomes of all such courses. The Program Specific Outcomes of individual's programmes of the institution can also be reached from course outcomes of all courses of the program. The course outcomes of ITC are;

- Explain how computing components may be combined to build computer systems
- describe the major components of applications software in the areas of word processing, spreadsheets, database management, presentation graphics, data communications, and Internet

- Apply efficiently general problem-solving strategies to the development of computer algorithms.
- Describe the role of an operating system in managing and interacting with computer system components including main and secondary memory in Windows environment
- Use Web browsers, search engines and e-mail in real time requirements with ethical concern

Figure 2. POs of MCK

V. ASSESSMENT METHODOLOGY

The assement activities given to students are maaped with course outcomes in the next step. One activity may be mapped with more than one outcome as represented in figure - 3. The activities are given marks as usual and the maximum marks for the activites are given in the given table. These activities are also mapped with one or more course outcomes and these course outcomes are assessed when the activites are evaluated.

Activity		Attainment
Seminar	4	CO1
Assignment	3.5	CO2
Video Presentation	4	CO1,CO2
Group Activity	3.5	CO2,CO4
Exam 1	5	CO1,CO2
Exam 2	7.5	CO3
Exam 3	7.5	CO4,CO5
Final Exam	60	CO1,CO2,CO3,CO4,CO5

Figure 3. Activity mapping with more than one outcome

After activity mapping, these assessment activities are given to students. Based on the performance of students in these activities, they are assessed and marks are given to these activities as usual. Since these activities are mapped with one or more course outcomes, the fuzzy attainment levels of linguistic variables (figure - 4) representing these activities are found. These calculations along with assessment marks and fuzzy attainment levels are represented in figure – 4.

Activity		Cos	% Marks Awarded	Attainment
Seminar	4	CO1	40	low
Assignment	3.5	CO2	85	Moderate
Video Presentation	4	CO3	70	Moderate
Group Activity	3.5	CO2,CO4	85	High
Exam 1	5	CO1,CO2	55	Moderate
Exam 2	7.5	CO3	75	High
Exam 3	7.5	CO4,CO5	40	Low

Figure 4. Fuzzy attainment levels of linguistic variables

A. Outcomes and Fuzzy Membership Values

The attainment level of course outcomes is calculated as a fuzzy membership and it is expressed using the linguistic variables. The fuzzy membership function used to calculate the attainment of course outcomes in given as *expr 1*.

$$\mu(CO_i) = \frac{\sum_{i=1}^{n}(AO)_i}{n_i} \qquad (1)$$

Where:
$\mu(CO_i)$ = Fuzzy membership for i^{th} Course Outcome
AO_i = i^{th} Activity Attainment
n_i = Number of activities to assess i^{th} Course Outcome

In the next step, the fuzzy mapping between the Course Outcomes and Programme Outcomes is done using a mapping table. The mapping table is developed based on the assessment methods and activities covered in assessing a course outcome. The mapping table entries indicate the fuzzy weight of relationship between the course outcomes and programme outcomes. A sample mapping table derived for the course Introduction to Computer Science (BCA101) is given in table - 2.

Once the mapping table is developed, the POs are calculated from course outcomes. Fuzzy membership values of linguistic variables are used (given in table - 1) for the calculations. The attainment levels POs are reached from the attainment levels of course outcomes. These calculations are made using the *expression 2*.

$$\mu(PO_i) = \frac{\sum_{i=1}^{n}(CO_i)*w_i}{\sum_{i=1}^{n}w_i} \qquad (2)$$

Where;

$\mu(PO_i)$ = Fuzzy membership for i^{th} Program Outcome

$\mu(CO_i)$ = Fuzzy membership for i^{th} Course Outcome

W_i = CO-PO Mapping weight from the mapping table.

Table - 2: A sample mapping table derived for the course Introduction to Computer Science (BCA101)

CO	PS01	PS02	PS03	PS04	PS05
CO101.1	Nil	Low	Nil	Nil	Nil
CO101.2	Nil	Nil	Nil	Low	Low
CO101.3	Moderate	Low	Moderate	Nil	Nil
CO101.4	Nil	Low	Moderate	Nil	Nil
CO101.5	Nil	Moderate	Low	Moderate	Low

B. Final Attainment of POs

Finally, the POs are calculated and the final attainment levels are converted into corresponding fuzzy linguistic variables. These PO attainment levels are calculated at the end of every semester and finally the PO attainment level of a student after the completion of a programme is calculated by finding the average of PO attainments for all the semesters. The fuzzy weighted average method [Table - 3] is used for calculating the final attainment of Programme Outcomes.

Table - 3: The fuzzy weighted average method used for calculating the final attainment of Programme Outcomes

Contributing COs	CO Attainment level	Level of correlation to PO1	Attainment Level (PO1) (Weighted Value)
CO101.1	Low	High	Moderate
CO101.2	Moderate	Nil	
CO101.3	High	Moderate	
CO101.4	Moderate	High	
CO101.5	High	Low	
Calculation Method	Low = 1 Moderate = 2 High = 3	PO1 =(1*3+2*0+3*2+3*1)/(3+0+2+3+1) PO1=2	2=Moderate

VI. RESULTS AND DISCUSSIONS

The concepts on Outcome based education and attainment of COs and POs are implemented on a software platform developed in PHP. The attainment levels of CO, PO and PSO are assessed using the systems. The attainment levels of individual students, batches and PO attainment level for the entire institution are evaluated. This will finally help to assess the success of the institution in achieving the mission vision and the purpose of its existence. The sample attainment of COs and POs by student is demonstrated in figure - 5 and figure - 6.

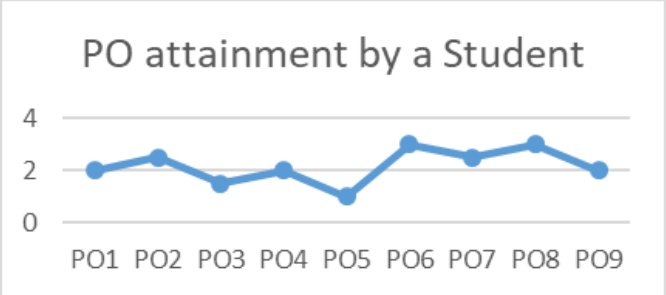

Figure 5. Attainment of PO by a student

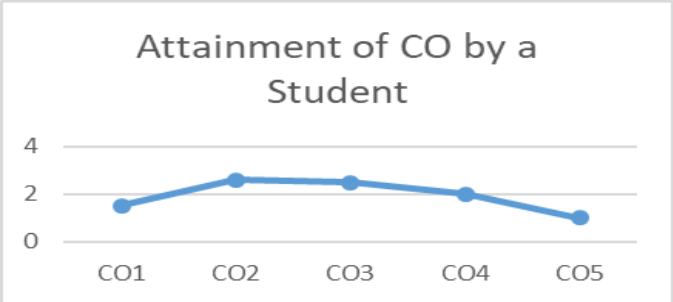

Figure 6. Attainment of CO by a student

VII. CONCLUSION

The concept of OBE is about developing the curricular structure based on what the learners are expected to achieve at the end of the education programme [6]. The direction towards OBE implementation has been supported by the accreditation agencies in India. Various education models have been highlighted in support towards OBE implementation by different agencies [11]. A fuzzy based model for outcome assessment was proposed in this paper. Development of COs, POs and their assessments from different learning activities were introduced and finally the attainment of these outcomes were demonstrated with an example.

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AUTHORS PROFILE

Dr. Binu Thomas has his PhD in fuzzy data mining. Presently he serves as the Joint Director of Marian Institute for Innovate Teaching Learning and Evaluation (MIITLE). He specializes in Learning technologies, Outcome Based Education(OBE), Augmented Reality based learning etc. He has conducted workshops in Moodle, ICT enabled teaching learning systems and OBE all across India. Now he is associating with Hong Kong Baptists University and Chinese University of Hong Kong to develop student centric ICT enabled teaching learning platforms.

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