Estmating the Teaching Contact Hours based on Fuzzy Maps: New Approach

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***Abstract*— Current paper presents an innovative approach for developing a course specification taking in consideration the impact of the covered topics in a course on the whole program learning outcomes. It presents a practical methodology allowing instructors to design an efficient course specification based on the national academic accreditation and assessment standards.**

Keywords—Course Specification; NCAAA; Fuzzy Set; Estimation.

I. INTRODUCTION

On the core of the National Academic Accreditation and Assessment Standard stated by NCAAA lies process of matching the learning Outcomes (LOs) of a course with the whole program learning outcomes (PLOs) [1]. Since the standard does not show how to cover and match the topics that will be taught with the program learning Outcomes, the purpose of this work is to present an approach that aims to facilitate, on one hand, the matching process of LOs to PLOs. On the other hand, to show how should instructor to distribute the course topics over the semester. The proposed approach suggests to use the fuzzy set theory [2] as a way to describe imprecision that is characteristic of much of human reasoning. It suggests also to use Two-Phases process in which experts' opinions are elicited and matched with PLOs and LOs, then transform them into so-called topic-program learning outcomes (T-PLOs) Table.

II. THE PROPOSED APPROACH

A. Phase I: Elicitation process

Step1: In order to get coherent matrix, a set of domain experts are invited to set the relationship, from her/his own point of view, among the LOs and PLOs. Since it is difficult to avoid imprecision in the matching process, the experts are invited to set their opinion using a list of linguistics variables (very strong, strong, week, very week).

Step 2: Aggregating all the (linguistic) weight of the LOs-PLOs relation using the well-known fuzzy logic method of SUM. The result of this step is an aggregated (linguistic) weight. In case of linguistic weight, the defuzzification method of center of gravity (COG) is applied and a numerical weight for the relationship is calculated. The output of this phase is two matrices: One for presenting the LOs-PLOs relation and the other is for presenting the topics-LOs table.

The before mentioned methodology is applied using the following algorithm:

Step 1: For all the *M* experts, set credibility weight b_k = 1

Step 2: For all the ordered pair((LO_i and PLO_i) / (T_i and LO_i)) each k[th] of the M experts is asked to set the relation using the linguistic variables.

Step 3:

IF for one relation more than $2M/3$ different linguistic weights are suggested **THEN**

- ask experts to reassign weights for this particular relation and go to step 2

ELSE

IF the k[th] expert has proposed for a relation a linguistic weight that does not belong to the neighborhood of weights[1] **THEN**

- disregard this particular linguistic weight and penalize the expert who chose the “distant” weight and set him a new credibility weight $b_k = r.b_k$

Step 4:

- Aggregate all the linguistic weights proposed for each relation using the *SUM* method where the membership function μ suggested by k[th] expert is multiplied by the corresponding credibility weight b_k .

- Use the *COG* defuzzification method to calculate the numerical weight w_{ij} for each relation.

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[1] A linguistic weight does not belong to a neighborhood when it is not partially overlapping with at least another linguistic weight proposed by another expert.

Step 5: IF there is an ordered (LOs-PLOs/ Topic-LOs) pair not examined go to step 2

ELSE

- Construct the LOs-PLOs/ Topic-LOs table whose are the defuzzified weights w_{ij}.

END.

B. *Phase II: Transformation process*

After generating the LOs-PLOs and Topics-LOs tables, a Max-Min composition method is used to transfer them into the T-PLOs [3]. To illustrate the Max-Min composition, let:

$$R1 = \{(x, y) \mid (x, y) \in X \times Y\}$$
$$R2 = \{(y, z) \mid (y, z) \in Y \times Z\} \quad (1)$$

and the Max-Min composition will be:

$$R1 \circ R2 = \{(x, z) \mid (x, z) = Max\{Min\{\mu R1(x, y), \mu R2(y, z)\}\}\}$$
$$\text{for } x \in X, y \in Y \text{ and } z \in Z \quad (2)$$

III. Benefits of the Proposed Approach

As we mentioned before, the main goal of the proposed approach is to illustrate how to match the topics that will taught in a particular course with the whole program leaning Outcomes. However, we can extend this approach to estimate the required contact hours and topics distribution per weeks.

Let the generated T-PLOs Table, from the previous step, is presented as follows:

$$W = \begin{matrix} & PLO_1 & PLO_2 & \cdots & PLO_n \\ t_1 & w_{11} & w_{12} & \cdots & w_{1n} \\ t_2 & w_{21} & w_{22} & \cdots & w_{2n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ t_m & w_{m1} & w_{m1} & \cdots & w_{mn} \end{matrix}$$

where,

$w_{ij} \in [0,1]$, $w_{ij} = 1$ denotes the program learning outcome PLO_j is covered in the topic t_i, whilst $w_{ij} = 0$ is vice versa, $0 \le i \le m$ and $0 \le j \le n$, m is number of topics in a course and n is number of program learning outcomes.

Let also, R_{ij} denotes impact of a topic t_i on the program learning outcome PLO_j and is calculated as follows:

$$R_i = \frac{\sum_{j=1}^{n} w_{ij}}{Max(\sum_{j=1}^{n} w_{ij})} \quad (3)$$

Then, topics distribution per weeks is calculated as follows:

$$D(t_i) = \frac{h(C_i).R_i}{\sum_{i=1}^{n} R_i} \quad (4)$$

where,

$h(C_i)$ denotes the total credit hours for the course C_i.

IV. Illustrative Example

At IS department, five domain experts are invite to fill the course specification of the " IS- 448 Semi-structured Data" course that is taught at the second semester of the fourth year of the curriculum plan [4,5]. According to the PLOs of the curriculum (Table 1), the experts should to match them with the course LOs (Table 2) which also should to be covered by the course topics (Table 3).

Table 1: Program Learning Outcomes

#PLOs	Description
PLO_1	Attain an ability to apply knowledge of computing and mathematics appropriate to the program's student outcomes and to the discipline. **[ABET-Criterion 3a]**
PLO_2	Attain an ability to analyze a problem, and identify and define the computing requirements appropriate to its solution. **[ABET-Criterion 3b]**
PLO_3	Attain an understanding of professional, ethical, legal, security and social issues and responsibilities. **[ABET-Criterion 3e]**
PLO_4	Attain an ability to communicate effectively with a range of audiences. **[ABET-Criterion 3f]**
PLO_5	Attain an ability to analyze the local and global impact of computing on individuals, organizations, and society.**[ABET--Criterion 3g]**
PLO_6	Attain an understanding of and an ability to support the use, delivery, and management of information systems within an Information Systems environment. **[ABET- IS Criterion 3j]**
PLO_7	Attain an ability to analyze the local and global impact of computing on individuals, organizations, and society. **[ABET-Criterion 3g]**
PLO_8	Attain recognition of the need for and an ability to engage in continuing professional development. **[ABET-Criterion 3h]**
PLO_9	Attain an ability to use current techniques, skills, and tools necessary for computing practice. **[ABET-Criterion 3i]**
PLO_{10}	Attain an understanding of and an ability to support the use, delivery, and management of information systems within an Information Systems environment. **[ABET-IS Criterion 3j]**
PLO_{11}	Attain and demonstrate programming skills in at least one high-level programming language.
PLO_{12}	Attain an ability to effectively utilize relational databases to store, retrieve, and manipulate data.
PLO_{13}	Attain an ability to use web languages and web services to create and interact with web pages.

Table 2: Course Learning Outcomes

LOs#	Description
LO_1	Explore semi-structured data settings.
LO_2	Design query mechanisms for semi-structured data
LO_3	Apply the skills of design and modeling data structure
LO_4	Examine the basic concepts of semi-structured data
LO_5	Design semi-structured data solutions

Table 3: Course Topics

Topic#	Description
t_1	Introduction: Semi-structured data, XML core concepts and namespace
t_2	DTDs, a simple schema language for XML documents
t_3	XPath, a navigation language for XML documents, XML Schema, a more expressive schema language for XML documents

t_4	XQuery, a query language for XML documents
t_5	Validation of HTML 5, RDF and Linked Data
t_6	CSS and the DOM
t_7	Web Data vs. Web Documents vs. Web Applications

At the end of discussion session, the experts fill the LOs-PLOs as presented in Table 4.

Table 4: Map course LOs with the program LOs

Course LOs #	Program Learning Outcomes			
	PLO_3	PLO_8	PLO_9	PLO_{12}
LO_1		0.7	0.3	
LO_2	0.2			0.8
LO_3			1	
LO_4		1		
LO_5	0.5		0.5	

Table 5: Map course topics with the program LOs

Course Topic#	Course Learning Outcomes				
	LO_1	LO_2	LO_3	LO_4	LO_5
t_1	0.6			0.4	
t_2	0.2			0.5	0.3
t_3		0.3	0.3		0.4
t_4		0.5			0.5
t_5			0.5		0.5
t_6			0.5		0.5
t_7		0.2	0.3		0.5

Based on formula in Equation (2), the result of transferring the LOs-PLOs and Topics-LOs tables into the T-PLOs.

Table 6: Transorming Result

Course Topic#	Course Learning Outcomes				
	PLO_3	PLO_8	PLO_9	PLO_{12}	R_{ij}
t_1	0	0.6	0.3	0	0.6
t_2	0.3	0.5	0.3	0	0.73
t_3	0.4	0	0.4	0.3	0.73
t_4	0.5	0	0.5	0.5	1
t_5	0.5	0	0.5	0	0.67
t_6	0.5	0	0.5	0	0.67
t_7	0.4	0	0.5	0.2	0.73

Let we are planning to arrange 45 meetings per a semester with 3 hours per week, then to estimate distribution per weeks we use the formula in Equation (4).

Table 7: Distribution Topics per weeks

Course Topic#	**No. of Weeks**	**Contact hours**
t_1	≈2	6.652174
t_2	≈1.5	4.304348
t_3	≈1.5	5.478261
t_4	≈2	5.869565
t_5	≈3.5	10.56522
t_6	≈3.5	7.826087
t_7	≈1.5	4.304348
Total	≈15	45h

V. Conclusions

This study proposed an innovative approach based on the Academic Accreditation and Assessment Standard stated by NCAAA, on one hand, to match the program learning outcomes with the topics that will be covered on a course. On the other hand, to estimate topics distribution per weeks. The proposed approach presents a practical methodology allowing instructors to design an efficient course specification and keep the required quality with acceptable level since it shows how the instructor can cover topics over the week.

References

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