An Operational Ontology for the Selection of Advanced Courses in Management Information Systems

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Abstract *- The issue of curriculum development is one of the most keys to human resource development. On the other side, the management information system curriculums have to be related to the technological and economic development of the organizations. In this context, we propose an original operational approach for helping teachers and decision-makers for curriculum development. Our approach starts by selecting a set of organizations and their categories. Then, the most important concepts could be observed based on selected criteria. After that, the correlations between concepts have to be calculated for generating the new curriculum ontology. Our approach is validated by testing its feasibility. 100 organizations, 173 categories have been used for generating new curriculum ontology. The new ontology shows a spectacular view of the most important concepts to consider for the development of a management information system curriculum. Also, the generated ontology shows the correlations between the selected concepts.*

Keywords — *Ontology; Management Information System, Selected Ontology*

I. INTRODUCTION

Universities are continually teaching students basic and advanced courses in different areas. Also, universities play a fundamental role in the social and economic development of countries in a competitive world [1]. According to [2], countries' productivity and success depend on their educational systems' ability to meet the challenges of the 21st century. In particular, the Saudi government has realized that the 21st century requires several skills to be integrated into the curriculum which in turn pouch universities to improve their teaching strategies [1]. Apart from that, the ontologies are very popular in education and in software technology [3,4].

In thousands of Universities are offering courses in the area of Management Information Systems (MIS). Basic courses of MIS may be unified given that they are fundamental and teach the theory and the basis of the different advanced courses. However, the advanced professional courses have to be dynamic for meeting the new needs of the organizations. Furthermore, these advanced professional courses maybe contextualized according to the regions to meet specific local needs. Several universities select advanced or professional courses based on benchmarking the courses of other universities teaching similar fields. This method allows to select courses quickly and allows the person responsible for the selection to have some argument to defend his/her choice. These arguments are based on the fact that other university teaching the selected course. This method will pouch the universities to offer similar courses without necessarily be aligned with the organizations' and industry's needs. Also, this method may deprive several universities of pedagogical innovation. Their chance to have new different courses will decrease. However, the correct benchmarking should be on the needs of industries. In this context, it is important to mention that curriculum design depends on several factors such as financial support, staff support, teacher engagement, teacher expertise in the area of the curriculum, and available educational [5]. Universities are teaching students many skills such as the scientific methods about operational decisions and leadership. From one side, these skills are very important for having qualified students. From the other side, do universities apply scientific methods for taking operational decisions concerning their curriculums and the list of advanced professional courses? What are the methods used by universities about these decisions? Are scientific methods? Are most universities applying leadership skills when they design curriculum and advanced professional courses? This paper presents an operational approach for curriculum design in the context of advanced and professional MIS. This new approach is based on the combination of two benchmarking: benchmarking of curriculum and benchmarking of organizations. The first benchmarking presents the existing related curriculums in different universities. The second one presents the needs of the organization and its potential for development. The results of the two benchmarks are represented in the form of ontology in order to see the concepts, their weight, and their relations. In this way, we have the spectacular view needed for having the operational curriculum design.

This paper is structured as follows: Section 2 presents the related work. Section 3 presents our approach for the operational curriculum design. Section 4 presents an experimental study and shows ontology for the design of the curriculum in MIS. Finally, section 5 discusses the results, concludes the paper, and gives potential future directions.

II. RELATED WORK

Curriculums are fundamental in higher education and the courses' contents, as well as the pedagogy of teaching, depend strongly on the curriculum design. Furthermore, the opportunities for students' careers are related to their curriculums. In addition, curriculums play an important role in the development of the economy and society. For these reasons, it is important to analyze the curriculum design method in general and in the area of information management systems.

Table 1 presents nine examples of strategies for curriculum development. Each strategy includes the source of knowledge and the potential tools for knowledge representation. According to [6], in a discipline characterized by continuous advances such as computer science, the curriculum 2020 committee found little to change since curriculum 2010. Furthermore, most of the changes are in the advanced courses, which are related to the engineering discipline. Machanick [6] summarized the direction of the 2020 curriculum review based on his experience and the related work. Okudan et al [7] conducted an on-line search for understanding the current practice in universities that offer entrepreneurial leadership courses. They have used the keywords entrepreneurial leadership course(s). Their search has returned several courses from many universities. Okudan et al. [7] summarized these courses in a list. Peeters and Lievens [8] collected knowledge from literature, qualitative interviews, and quantitative questionnaires in order to define the curriculum design. They defined some recommendations such as it is more efficient to plan few courses simultaneously during short time periods than planning several parallel courses. it is important to reduce contact hours and enhance the self-study for improving efficiency learning. Jadhav and Patankar [9] focused on the role of teachers in curriculum development. Teachers know the needs of all stakeholders and they understand the psychology of the learner. Also, teachers know the teaching methods and strategies. So, the teacher can plan, design, manage, program, and implement the curriculum [9]. Similarly, for [10], the most important person in the curriculum implementation process is the teacher. With their knowledge, experiences, and competencies, teachers play an important role in any curriculum development effort. Teachers are responsible for introducing the curriculum in the classroom. So, teachers need training and workshops to contribute to curriculum development [10]. Oliver and Osterreich [11] mentioned that students could be the source of questions that orient the curriculum of teachers' training. In fact, knowledge transfer for teaching and learning plays an important role in the curriculum of teachers' pre-service [11]. Hidayati, [12] combined the opinions of the students, teachers, and principals for the development of a new curriculum template. A new generation is the owner of a social media account. Their interest in conventional book reading is declining since they chose smartphones. Their competency in Information technology becomes necessary. For these reasons, a new curriculum should be aligned with current technology development [12]. Jonker et al [13] interested in the flexibility of curriculum for two reasons: (1) students have different learning needs. (2) Society has different needs from education. Jonker et al, (2020) collected data based on interviews with the teacher for the curriculum design. For, Yazçayır and Selvi [14] curriculum design have to start with the analysis of the draft curriculum. Experts in the curriculum development should analyse the existing curriculums their objectives, content, and teaching methods [14].

Table 1. Examples of strategies for curriculum development.

Curriculum Development	**Source of Knowledge**	**Tools for knowledge representation in structured or semi-structured ways**
Machanick, 2000 [6]	Related work Teachers' knowledge	No tools are developed
Okudan et al, 2005 [7]	Benchmarking on university delivering the same courses	List of similar courses
Peeters and Lievens, 2012 [8]	Related work Opinion of students Opinion of lectures	No tools are developed
Jadhav and Patankar, 2013 [9]	Teacher knowledge	No tools are developed
Oliver and Osterreich 2013 [11]	Student-inquiry	No tools are developed
Alsubaie, 2016 [10]	Teachers' knowledge	No tools are developed
Hidayati, 2019 [12]	Opinions of students, Opinion of teachers, Opinion of principals	No tools are developed
Jonker et al, 2020 [13]	Opinion of teachers	No tools are developed
Yazçayır and Selvi, 2020 [14]	Opinion of experts Comparative analysis of the draft curriculum with the previous one	No tools are developed

From table 1, we observe that there are different sources of knowledge used for developing curriculums. Among these sources, we cite the related work combined with the teacher's knowledge [6] used for developing a curriculum in computer science. Benchmarking on university delivering the same courses [7] is used for developing an entrepreneurial leadership curriculum. Related work combined with the opinion of students and lecturers is used for curriculum design from a pedagogical perspective [8]. Teacher knowledge [9] is used for planning, designing, managing, programming, and implementing the curriculum. This focus on the teachers' knowledge is also the direction of [10] and [13]. However, others work such as [11,12,14] consider also the intervention and the opinion of students as a source of knowledge for the curriculum design.

Three sources of knowledge are used in the literature: the teacher, the student and the university. Teachers knowledge is used in different ways: (1) directly, when teachers participate in the design of curriculum. (2) Indirectly when collecting the knowledge of others teachers through the related work. Also, students' knowledge is used in two ways. (1) Through their opinions. (2) Through their inquiries. University knowledge is used in the benchmarking about similar curriculums. This shows that the curriculum development process needs more openness on the industries and enterprises. They are important stakeholders and the curriculum must be aligned to satisfy their needs. Concerning the tools of knowledge representation for curriculum design, most related works do not present any tool specialized in knowledge representation in structured or semi-structured ways. Just, as a result of benchmarking on university delivering similar courses [7], the results are structured in the form of a list of courses. So, advanced information technology tools have to be developed for supporting curriculum designers. We need to have a shared knowledge representation of the companies and the industry's needs.

To support the designers of curriculum, it is important to offer them the knowledge about the organization's needs. From one side, this will allow them to be aligned with the current needs of the companies. From the other side, this will facilitate the curriculum design by documenting and sharing the knowledge. This will allow having the right decision. In this context, ontologies are powerful tools for knowledge representation and may be used for representing educational knowledge. According to [15], ontologies could be used for sharing learning content, reuse of learning objects, the conceptualization of knowledge, personalization of learning, and improvement of its efficiency. Ontologies are a technology that has several advantages for organizing information. Also, the mappings between ontologies could be done automatically and allow presenting relevant knowledge to humans [16]. Katis et al [17] observed that curriculum development could be improved by using ontologies.

III. CURRICULUM ONTOLOGY GENERATION

This paper presents an operational approach that allows generating an ontology of concepts that allows supporting teachers during the design of a curriculum aligned with the needs of the organizations.

Figure 1 presents our process of generating curriculum ontology. The four steps of the process are: defining the list of organizations, classifying the selected organizations according to their specific categories, generating the matrices of concepts, and generating the curriculum ontology. The first two steps may be done based on search in the Web and benchmarking. The last two steps could be done through an implemented algorithm. The next sub-session presents these steps in detail.

A. Preliminary Steps

The preliminary steps aim to define a set of categories based on benchmarking on a list of organizations. These earlier steps are fundamental for having a curriculum aligned with the needs of regional or international organizations. To collect the list of organization and their categories, it is possible to research the Web. Most organizations publish significant information about their domain of work and their added values. It is possible also to find this step done by organizations specialized in statistics.

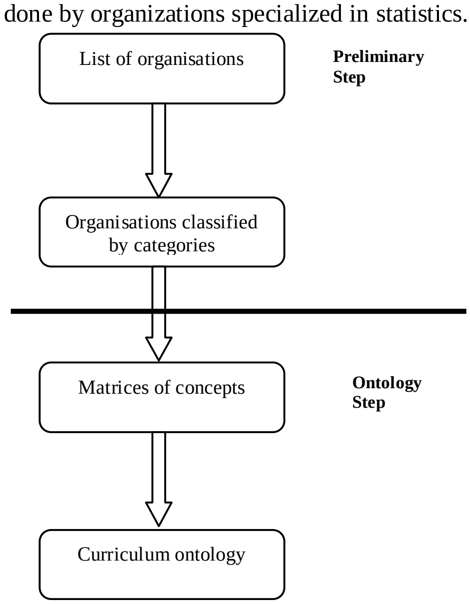

Figure 1. Our process of generating the curriculum ontology.

The objective of the preliminary steps is to have a list of categories and the set of organizations working in that category. The list of categories and the associated organization may be represented in the form of a table similar to Table 2. The first column includes different categories. Then, for each category, the Table 2 presents the list of related organizations as well as their number.

Table 2. Example of an organization classified according to their categories

	Organizations				Number of organizations
Category 1	Organization 1.1	Organization 1.2	….	Organization 1.m1	m1
Category 2	Organization 2.1	Organization 2.2	….		m2
…					
Category n	Organization 1.1	Organization 1.2	….		mn

B. *Ontology Steps*

(In this step, our aim is to find the weight of the relations between concepts. To do that, we search the number of appearing of two concepts simultaneously as categories of the same organization. We generate matrices like table 3. It is composed of the selected concepts in lines and columns. In each cell, we have the number of appearing of the concept in line with the concept in the column. This number means the weight of the relation between the two selected concepts.

Table 3. Example of metrics of concepts

	concept 1	….	concept x
concept 1	k1.1		k1.x
…..			
concept x	kx.1		kx.x

After completing the matrices of concepts, it is possible to construct the ontology of concepts. This ontology could be represented in a way like figure 1. Each concept will represent a node in the graph represented in figure 2. If two concepts appear simultaneously according to the matrices of concept, they will be related to the ontology. Besides each concept, its weight will be represented based in its total number of appearing (derived from the matric classifying the organization by categories). For each relation, there is weight will be displayed which represents the number of simultaneous apparitions of the related concepts.

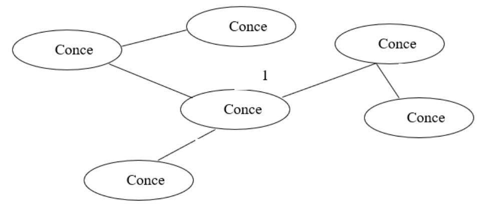

Figure 2. Example of curriculum ontology

IV. EXPERIMENTATION

Our operational experimental study uses data available in Crunchbase about the companies that raised the most money in 2019 in the USA. Figure 3 presents our search in the Crunchbase. We have selected the first 100 organizations. They include 173 different categories. An organization may belong to more than one category. Subsection 4.1 and 4.2 present the classification of concepts and the design of the curriculum ontology.

A. *Preliminary Steps*

From the 173 categories, we have to select the most pertinent according to some criteria. For example, if we consider the criteria: the most used categories, we will find first the "Software" which is the most used category to classify the 100 organizations that raised the most money in 2019 in the USA which appears 43 times. After the "Software", the "FinTech" appears as the second category. We have selected the first 10 categories which are "Software", "FinTech", "E-Commerce", "Mobile", "Information Technology", "Enterprise Software", "SaaS", "Artificial Intelligence", "Health Care" and "Financial Services". These selected categories will be considered as concepts in the rest of the paper. Table 4 presents the ten most appeared concepts and the number of organizations for each concept.

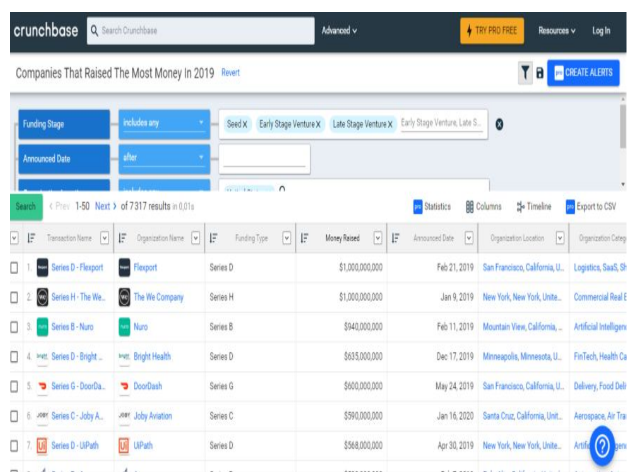

Figure 3. Companies that raised the most money in 2019 according to Crunchbase

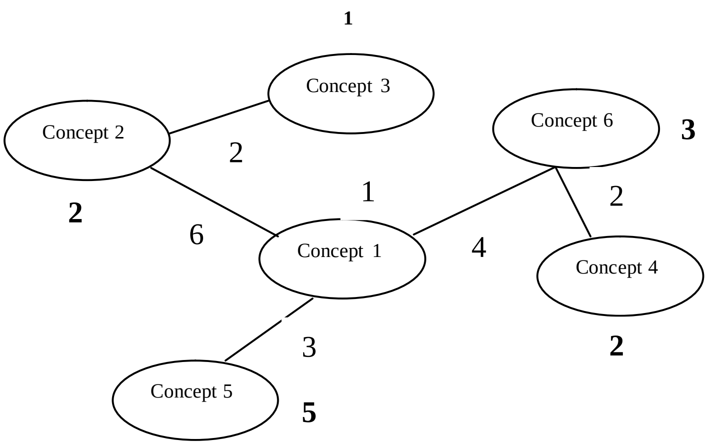

Table 4. Ten most appeared concepts

Category	**Number of organizations**
Software	36
FinTech	13
E-Commerce	11
Mobile	11
Information Technology	11
Enterprise Software	11
SaaS	11
Artificial Intelligence	11
Health Care	10
Financial Services	10

B. Ontology Steps

To study the relations between the concepts, we observed their correlations. These correlations are represented by the numbers appearing in the cells of table 5. For example, the concept of "Software" and the concept of "Information Technology" are considered as simultaneous categories in 9 companies. This shows the high correlation between the two concepts "Software" and "Information Technology". In fact, the maximal simultaneous appearance which appears in table 5 is 9. As another example, the concept "Mobile" and the concept "Software" are considered as simultaneous categories in 4 companies.

Table 5. Relational interpretation between the concepts

	Software	FinTech	E-Commerce	Mobile	Information Technology
Software		1	3	4	9
FinTech	1		3	1	1
E-Commerce	3	3		2	0
Mobile	4	1	2		0
Information Technology	9	1	0	0	
Enterprise Software	6	2	3	0	5
SaaS	6	2	0	2	2
Artificial Intelligence	5	0	2	0	5
Health Care	3	1	1	0	3
Financial Services	1	5	1	1	0

Part 1 of Table 5: Relational interpretation between the ten concepts and the concepts "Software", "FinTech", "E-Commerce", "Mobile" and "Information Technology"

	Enterprise Software	SaaS	Artificial Intelligence	Health Care	Financial Services
Software	6	6	5	3	1
FinTech	2	2	0	1	5
E-Commerce	3	0	2	1	1
Mobile	0	2	0	0	1
Information Technology	5	2	5	3	0
Enterprise Software		3	4	0	3
SaaS	3		0	1	2
Artificial Intelligence	4	0		1	1
Health Care	0	1	1		0
Financial Services	3	2	1	0	

Part 2 of Table 5: Relational interpretation between the ten concepts and the concepts "Enterprise Software", "SaaS", "Artificial Intelligence", "Health Care" and "Financial Services"

In order to have more visibility of the significant correlations between concepts, we have to select the most important correlations. Assume for example, that a correlation between two concepts is considered as significant when their number of simultaneous appearances is equal or high than 4. This is explained by the fact that the number 4 is about half of the number 9 which is the maximal correlation number in table 5. This approach will allow us to have the graphic representation of the new correlations as depicted in figure 3.

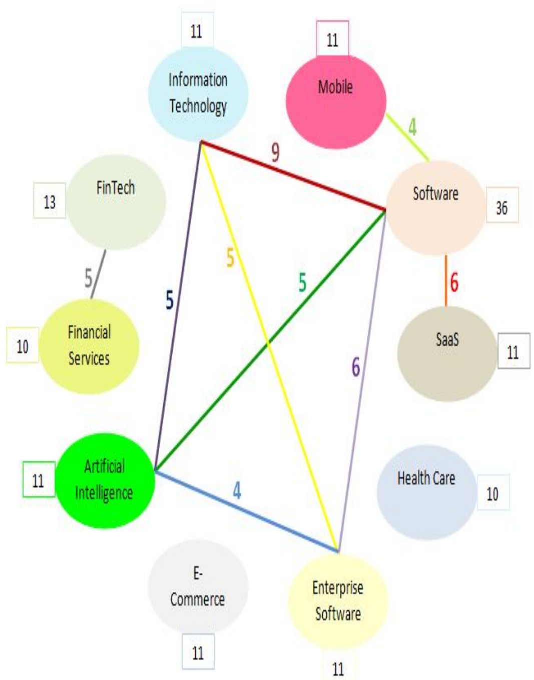

Figure 3. Extract from the curriculum ontology for the advanced courses in Management Information Systems

Figure 3 allows as to observe that there are four correlated concepts which are "Software", "Enterprise Software", "Information Technology" and "Artificial Intelligence". They form a square and each one is related to the three other concepts forming the square. The concept "Software" has two additional links with the two concepts "SaaS" and "Mobile". The concepts "FinTech" and "Financial Services" are related together but they don't have links with the rest of the ontology. The concepts "Health Care" and "E-commerce" are not connected with the rest of the ontology.

The observed ontology is a source of knowledge for the teachers who will prepare a new curriculum. In fact, they can see the most important concepts for companies. Also, they can observe the relations between the important concepts.

V. CONCLUSIONS AND PERSPECTIVES

In this paper, we have presented an operational ontological approach for helping teachers and decision-makers in preparing new curriculums. Our approach considers the real and updated needs of the organizations. The generated ontology gives a spectacular view of the concepts that have a significant link with the industries and the companies' developments. Also, the generated ontology shows the links between the concepts. This is important for teachers for designing the modules which include the subsets of courses.

To test the feasibility of our proposed approach, 100 organizations that raised the most money in the USA are selected. They are classified according to their categories. As a result, we obtained 173 categories. These categories could be the subject of different studies from a different point of view. In our study, we have calculated the ranks of the categories according to their numbers of appearance in the companies. The ten most important categories are selected and considered as concepts. Then, the ontology is generated based on the selected significant concepts and their correlations.

Researchers and curriculum developers could continue in this direction by considering the following challenges:

1. Enlarge the experimentations for generating more extended curriculum ontologies.
2. Develop the algorithm which allows generating the curriculum ontology
3. Develop the tools for the automatic generation of the curriculum ontology.

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