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Use of Network Model for Analysis of Curriculum and its Mapping to Program Outcomes

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Abstract: Curriculum design is a very important academic process in engineering education. The curriculum should deal with needs of industry and keep pace with upcoming technologies at the same time create a sound fundamental base for a graduating engineer. It is always expected to attain graduate attributes to a larger extent. Hence it is very important to continuously monitor the gaps in the curriculum and update it.

Analysis of curriculum is always a matter of concern but a subjective task to be accomplished.

The purpose of this paper is to provide insight into model developed for understanding distribution of courses in various thrust areas, linkages in curriculum and mapping of curriculum to programme outcomes (PO). This model will help in identifying weakly mapped PO, contribution of a course in PO and defining Program Specific Outcomes (PSO).

The paper discusses a curriculum analysis of one programme in an autonomous self-financed college in University of Mumbai.

Keywords: program outcomes, network model, curriculum design, engineering education

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1. Introduction

The objective of the engineering curriculum is to adapt to upcoming technologies, implement application oriented learning and imbibe value system. In autonomous colleges, the focus is also to improvise curriculum by giving importance to modern tool usage, self-learning, continuous assessment and exposure to various fields of study by incorporating flexibility in curriculum.

Every graduate is supposed to acquire attributes in knowledge, skill and attitude domain through all curricular and co-curricular activities in span of four years. [4] Hence curriculum has major role to play for attainment of graduate attributes.

It is expected in the process of curriculum design and development that the gaps in the curriculum are identified and academic processes are revised accordingly.

Every educational institution has curriculum data typically represented in some kind of list or table form [1]. Curriculum for a particular program can be viewed as groups of relevant courses, projects and Interdisciplinary courses. The basic entity in a group is a course, which has information associated with it such as credits, prerequisite requirements, its mapping to PO etc. Current practice is to store this information as a table, where relationships are flattened to attributes in columns. This flattened format makes it difficult to visualise linkages within the courses and coverage of individual PO mapping.

The paper focusses on curriculum mapping model based on network concepts. Our curriculum mapping model formalizes the process of modelling curricular data in a structured model that explicitly models the connections among curricular entities. The analytics and visualization supports gap findings and improvement in academic processes.

2. Motivation

In our institute curriculum for four years of undergraduate program is designed and implemented from 2014-15 to 2017-18 under autonomous status. There are number of courses grouped as thrust areas of parent department, first year courses and interdisciplinary courses. The outcomes of each course are defined and mapped to program outcomes. The prerequisites for all courses are defined in the curriculum. However, at the completion of curriculum development following questions need to be answered for appropriate coverage and relevance of the curriculum.

RQ1: What is the distribution of courses pertaining to thrust areas and their relationship?

RQ2: What is the extent up to which the designed syllabus for a particular engineering program satisfy the Graduate attributes or program outcomes?

Visualization of this mapping and linkages in the curriculum is a challenge due to cumbersome tabular data.

In the process of searching tools for better visualization of curricular data, work done by faculty members at MIT was studied. [1][2][3]

It was felt that such interactive tool may be useful in answering above research questions.

3. Nature of the Model

From the basics of graph theory network model consists of vertices and edges representing entities and relationships between them. A vertex is assigned text or numerical value representing its properties. For a directed edge, the relationship exists in one direction and indicated by an arrow. An undirected edge shows bidirectional relationship.

Fig. 1 shows directed relationship between entity A and B whereas undirected relationship between A and

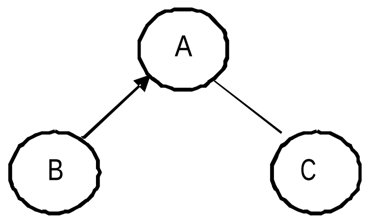

Fig 1. Basic Graph Theory Relationships

C. This paper uses all directed edges hence one directional relationships.

In Our curriculum model, the data for the curriculum mapping model is defined as types of entities: e.g. Institution, departments, thrust areas and courses. There is concept group defined as Program Outcomes. They are assigned attributes such as name, Unique identification, colour etc.

In this model two types of relationships are defined.

1. has parent of: This is a directional relationship that specifies organizational hierarchy. We created this relationships between Institute -Department - Thrust area and course in the group as shown in Figure 2

2. has prerequisite of: The courses in curriculum needs to be designed considering the prerequisite courses so that students can grasp the concepts in next course. A course can have more than one course as prerequisite or a course can be prerequisite for few courses. As shown in figure 2 course 1 has prerequisite of course 2.

The courses in the curriculum are mapping to program outcomes which are specific to engineering program. Figure 3 shows the relations of program outcome to courses.

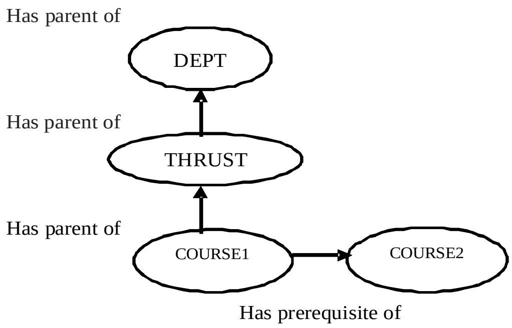

Fig. 2. Relationships of courses with thrust areas in curricular model

4. Methodology

Rhumbl is free online interactive visualization toolthat lets users create interactive network visualizations from spreadsheets. It was created by faculty members in MIT [1] in 2015.

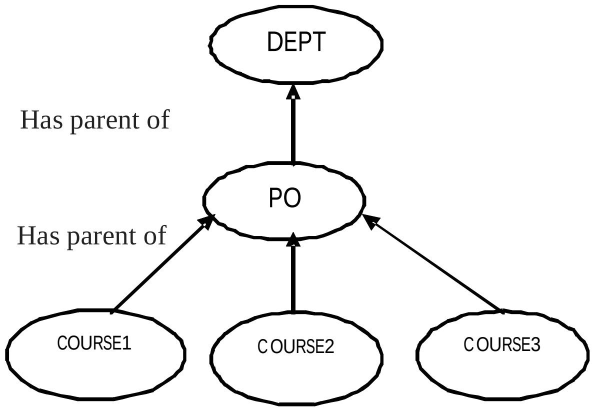

Fig 3. Relationships of courses with PO in curricular model

It requires spreadsheets to be created in certain template for creating network models. The relationships are established from the template of the spreadsheet.

5. Case Study

Sample mapping of curriculum of Electronics Engineering Program:

Based on template available for curriculum in Rhumble spreadsheet is created for sample model of "B. Tech Electronics Engineering" in an autonomous college in University of Mumbai.

Thrust areas identified in this program under department of Electronics Engineering are as:

- Circuits
- Digital Design
- Control and Instrumentation
- Signal Processing
- Communication Engineering

Apart from this additional three groups of courses are identified as

- First Year courses under department of sciences and Humanities
- Projects
- Interdisciplinary and audit courses.

Twelve program outcomes (PO)are defined based on Graduate Attributes suggested by National Board of Accreditation (NBA) as

- PO1: Engineering knowledge:
- PO2: Problem analysis
- PO3: Design/development of solutions
- PO4: Conduct investigations of complex problems
- PO5: Modern tool usage
- PO6: The engineer and society
- PO7: Environment and sustainability
- PO8: Ethics
- PO9: Individual and team work
- PO10: Communication
- PO11: Project management and finance
- PO12: Life-long learning

Our model has 1 institute, 2 departments, 8 thrust groups, 67 classes, 12 outcomes defined as nodes.

The relations between these lead to 91 "has parent of" relations for courses, thrust areas and program outcomes.

It also leads to 76 "has prerequisite of" relations which specify course linkages and 261 linkages which indicate Course to PO relations.

Hence the network model has overall 90 entities and 428 relations.

6. Outcomes of the model

This network model provides a basis on which analysis of the program can be conducted. and its mapping to program outcomes. For each program outcome, we can analyse its coverage in the curriculum of a program.

Fig.4 below shows snapshot of visualization of distribution of courses in various thrust areas for the program. The template for curriculum spreadsheet allows to choose different colour for group hence one can very easily see the courses in each group. The group of twelve program outcomes is distinctly seen as the nodes are bigger and greenin colour. The First-Year courses group in dark pink colour shows many courses but not very much linked to each other as they are all fundamental courses taught in first year. Remaining thrust areas in the department have linked courses as seen from the visualization.

Fig 5 shows how course of Signals and Systems is based on mathematical courses and linked to almost all courses in thrust area of Signal Processing. There are three electives in this group and they are mapping to almost ten program outcomes. Hence it can be seen that this is a strength of this program. Fig 6 shows weakly mapped program outcome (PO7) related to environment and sustainability. It is mapped through only ten courses. Whereas Fig 7 shows a highly mapped program outcome PO3 which relates to almost 50 courses. Since the outcome is related to

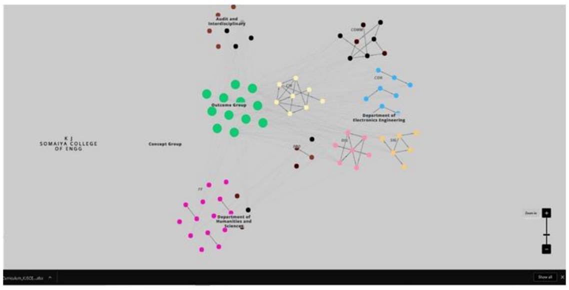

Fig 4 Visualization of Electronics Engineering Program Curriculum

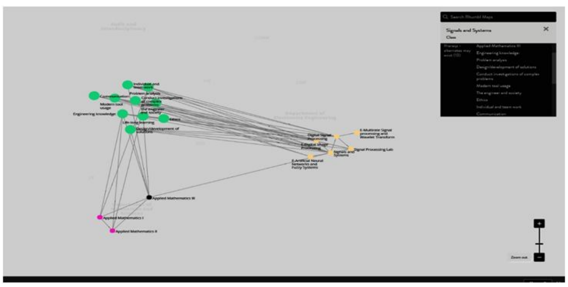

Fig 5. Mouse over on one course in interactive visualization tool.

ability of design and development it is very significant to have mapping to almost all courses in engineering curriculum.

Fig. 8 shows how fundamental course in a program (Basic Electricity and Electronics is considered here for Electronics Engineering Program) acts as prerequisite for many courses in variety of thrust areas and maps to program outcomes related to knowledge.

Fig 9 shows Course of Applied Mathematics III, its prerequisites AMI and AMII, the courses to which it acts as prerequisites. As can be seen from figure it acts as prerequisites to total 17 courses from almost four thrust areas and 5 courses are electives. It also shows mapping of program outcomes through the same course.

These are samples of how analysis can be done easily in the interactive visualization tool.

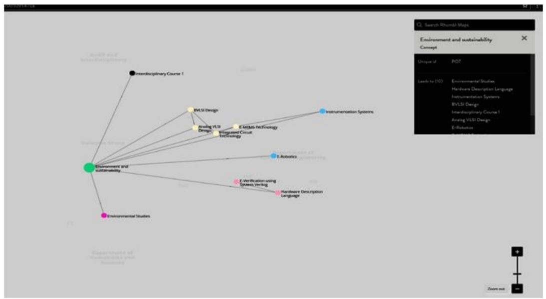

Fig 6Mouse over on Program outcome PO7

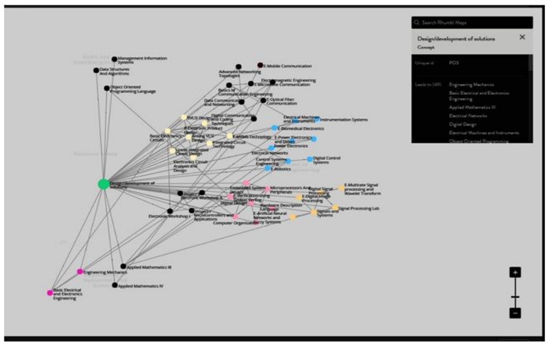

Fig 7Highly mapped program outcome (PO3)

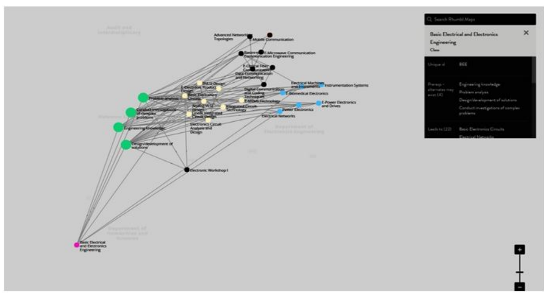

Fig 8Link of fundamental course of first year (BEE) to many thrust areas and basic program outcomes (PO1, PO2, PO3, PO4)

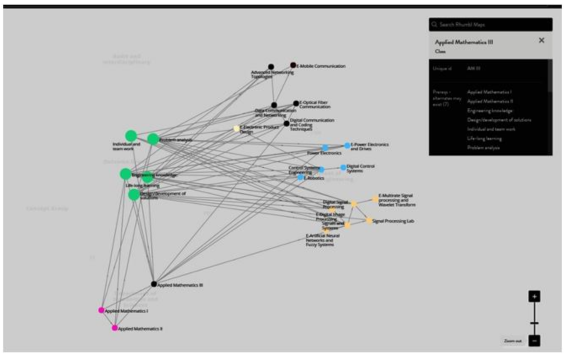

Fig 9. Analysis of curriculum Sample

7. Discussions and Conclusion

The paper presents a scalable network model used for curricular relationships visualization.

With reference to RQ1, it is observed that all thrust areas are having even distribution of courses and electives offered. The linkages within thrust areas show clear understanding of flow of curriculum.

Hence use of Rhumbl helped us in visualizing the distribution in thrust areas.

With reference to RQ2, from the results obtained it shows that PO1 to PO4 are maximally satisfied, PO5, PO6, PO8, PO10 and PO12 are moderately satisfied whereas PO7, PO9, PO11 are weakly satisfied through curriculum. This visualization and analysis was easier using interactive tool of Rhumbl.

In general, this kind of analysis will reveal areas of strength and potential gaps of coverage in a curriculum. Areas of strength can be considered for defining programme specific outcomes (PSO).

For the gaps identified, corrective actions can be planned. For example, in the case studied, since it is found that PO7, PO9 and PO11 is weakly mapped, activities need to be planned for attaining these program outcomes pertaining to teamwork, project management and sustainable development. e.g. More projects related to environment can be given to interdisciplinary groups on a large scale.

Any discrepancy or mistake in mapping the curriculum can easily be found out by the program coordinator using such visualization tool.

The curriculum can also be analysed on the basis of credits assigned to a course which can be used as weight to connecting edge.

Further the analysis can be based on type of courses e.g. core, electives, humanities, open electives etc with appropriate weight.

This kind of holistic analysis of the curriculum will provide guidelines for curricular revision.

Currently the study is presented based on data gathered from faculty members of one program. The course to PO mapping is based on activities conducted by the faculty members and judgement of the faculty members. Further probing and devising different model will also help in refining the mapping process.

Acknowledgement

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