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Industry Linked Curriculum Enrichment System Towards the Improvement of Employability

Sourish Haldar[1*], Amit Majumder[2], Shyam Sundar Santra[3], Bishwarup Neogi[4], Partha Sarkar[5]

[1,2,3,4,5]JIS College of Engineering, Kalyani 741235, West Bengal, India.
[1]sourish@gmail.com, [2]amit.majumder@jiscollege.ac.in, [3]shyamsundar.santra@jiscollege.ac.in, [4]biswarup.neogi@jiscollege.ac.in, [5]principal_jisce@jisgroup.org

Abstract: Enrichment of curriculum is most significant aspect for any academic program. It is essential to design curriculum on the basis of requirement towards particular aim of study. In this article the concept of curriculum enrichment targeted towards engineering study is elaborated. A computational systemic approach is designed which is capable of calculating the amount of curriculum/syllabus modification for any program. The amount of regulation wise curriculum/syllabus modification obtained in percentage manner. Mainly, the application study is depicted on engineering case applying the proposed methodology. In addition, this paper proposed one mathematical model approach for indication towards employability generation in our society. Considering engineering education this modeling approach is presented. Overall, curriculum enrichment system focusing on employability generation is specific contribution of this research.

Keywords: Engineering Education, Curriculum Enrichment, Modification Percentage Calculation, Curriculum Employability Mapping

Corresponding Author
*Department of Electronics & Communication Engineering, JIS College of Engineering, Block – A Phase – III, Kalyani. West Bengal. India. PIN – 741235.
* sourish@gmail.com

1. Introduction

Engineering education has undergone a shift in paradigm in the last two decades. The transformation has occurred due to several factors. High-speed internet has permeated into the every strata of society. Cheap high performance computation facility has been made accessible to every student. Smart mobile phones are the norm today, which was unavailable even few years back. This has enabled the mass population to access study materials from all over the world. Learning is no longer limited to class-room only.

In regard of skill-set required from an engineering graduate, it is expected that in addition to the knowledge of domain specific engineering subjects, one must be aware of environmental and social impacts of the job. Outcome based education has already been the norm from quite some time now. Aim of every course offered is clearly defined first and the syllabus is formulated accordingly. Artificial Intelligence, Machine Learning, Internet of Things, Nano-Technology, Automation, Big-Data and Bio-Technology have become applicable to all domains of Engineering.

The nature of employment has also shifted. Instead of large corporations offering life-long employment, start-ups are being created based on contemporary market demand. At the end of the demand, the companies are dissolved and new entities are created requiring new set of skills among the employees. In this ever-changing and fast-growing environment, the engineering curriculum must be inconformity with industry demands. Thus, regular revision of curriculum and syllabus has become essential for engineering education to remain relevant.

The Covid-19 pandemic has enforced remote learning in global scale. Imparting engineering knowledge in remote learning mode is a great challenge faced by faculties and students.

This article is proposing a structured methodology for formation and implementation of curriculum and syllabus revision. Sec-II is going to describe the system of

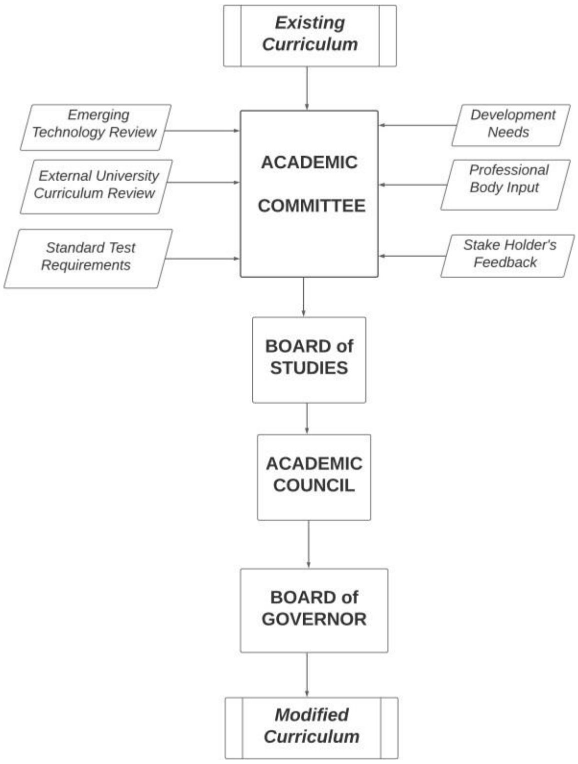

Fig.1. Entities of Curriculum Enrichment

curriculum and syllabus formation. Sec-III would present a novel algorithm for quantifying the change in successive revisions. Sec-IV would show the mapping of curriculum with employability, skill-development, and other aspects of engineering education out-come.

2. Aspects of Curriculum Enrichment for Global/ National/ Regional/ Local Developmental Needs

The major criteria of formation of engineering curriculum is that it should ensure that, at the end of studies, the graduate has developed (i) basic science knowledge required for all engineering courses, (ii) engineering science skills, (iii) knowledge in the specialized domain e.g. Mechanical Engg., (iv) advanced knowledge of contemporary technology, (v) skills pertaining to work environment like communication, leadership, problem solving attitude, cooperative group work, (vi) environmental, ethical and other social aspects. These requirements results in categorization of courses and credit distribution of engineering curriculum.

The courses are chosen to meet global, national, regional and local developmental needs. The guideline of curriculum is provided by the apex body of technical education like AICTE of India. The curriculum is further enriched bystake-holders' feed-back and advice of professional bodies. The academic body, responsible for curriculum and syllabus formation, has to be keenly aware of recent innovations and technology trends. Requirement of standardization examinations like Graduate Aptitude Test in Engineering (GATE), Graduate Record Examination (GRE) are also contributing factor.

Determining entities for revision of curriculum are

TABLE I
DEVELOPMENTAL NEEDS LITERATURE SURVEY

Issue	Global	National	Regional
Climate Change	Report of the Intergovernmental Panel on Climate Change [1]	India's Climate Change Policy [2]	State of Environment Report West Bengal 2016 [3]
Economic Inequality	World Inequality Report 2018 [4]	Indian income inequality, 1922-2015 [5]	West Bengal Poverty, Growth & Inequality [6]
Future Health	Research for universal health coverage: World health report 2013 [7]	Annual Report Of Department Of Health And Family Welfare 2017-18 [8]	Plan of Action 2011-2015 as approved by The Chief Minister, West Bengal [9]
Fourth Industrial Revolution	World Economic Forum: Fourth Industrial Revolution [10]	India's Readiness for Industry 4.0 [11]	
Employability	World Economic Forum Report, "The Human Capital Report 2015" [12]	Government of India: Ministry of Labour & Development: Annual Report 2015-16 [13]	
Water Crisis	Water: a shared responsibility; the United Nations world water development report [14]	Central Water Commission: Annual Report 2015-16 [15]	West Bengal Drinking Water Sector Improvement Project [16]
Global Warming	Global Climate in 2015-2019: Climate change accelerates [17]	India's Progress in Combating Climate Change [18]	State Action Plan On Climate Change [19]
Women's Security	The Global Gender Gap Report 2015 [20]	Report on the Status of Women in India [21]	Department of Women & Child Development and Social Welfare [22]

(i) review of emerging technologies and innovations, (ii) updated developmental needs (iii) stake-holder's feed-back (iv) advice of professional bodies (v) review of curriculum-syllabus of national and international universities (vi) standardized test requirements.

From the input of industry professionals and feed-back from alumni, a set of advanced courses are chosen so that the students can be trained for skills required in future jobs.

All of the above inputs together with previous syllabus are presented to the Academic Committee of the College. The Academic Committee prepares the curriculum and suggestions for syllabus. With the help of these suggestions the Board of Studies of individual departments forms Syllabus Committee for the corresponding subjects of the curriculum. After the syllabi are formed the Board of Studies reviews the material and forwards it to the Academic Council. The complete set of curriculum and syllabus for the College is finally placed for approval from the Board of Governors. Approved new syllabus

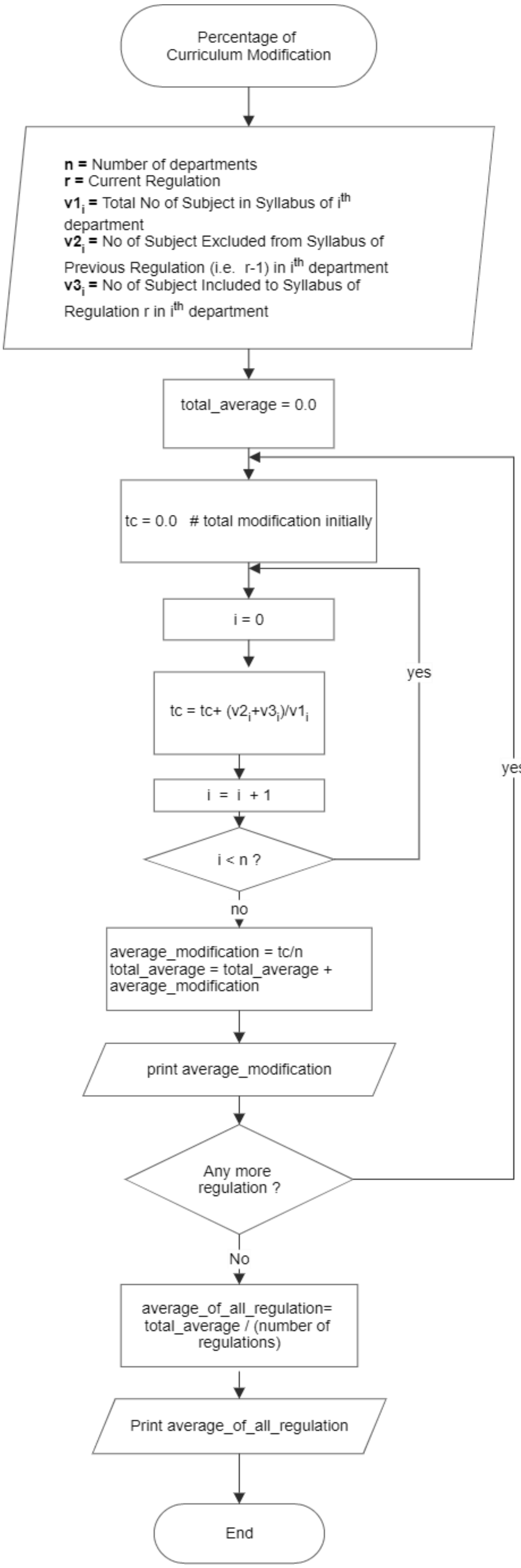

Figure 2: Percentage of Curriculum Modification

is usually implemented from the next academic year.

3. Quantitative Analysis Methodology Of Curriculum Enrichment

We are analyzing the Curriculum Enrichment in two ways,

(A) Percentage of Curriculum Modification, and

(B) Percentage of Syllabus Content Modification.

3.1. Computation aspect on Percentage of Curriculum Modification

Curriculum modification is the process by which changes can be made to existing modules or programmes at both undergraduate and postgraduate level of study. Curriculum of one regulation is changed from its previous regulation to increase the employability of the students. These changes occur in every department of an institute. Percentage of curriculum changes is calculated on the basis of changes in the curriculum made by each department in the current regulation. The whole process has been mentioned in Algorithm-1 and Figure-2.

Algorithm-1: Percentage of Curriculum Modification
Inputs (n,r,v1,v2,v3):
n=Number of departments
r=Current Regulation
v1i=Total No of Subject in Syllabus of ith department
v2i=No of Subject Excluded from Syllabus of Previous Regulation (i.e. r-1) in ith department
v3i=No of Subject Included to Syllabus of Regulation r in ith department
begin
total_average=0.0
for each regulation:
tc=0.0 # total modification initially
For ith department in all_departments:
tc=tc+ (v2i+v3i)/v1i
Next
average_modification=tc/n
print average_modification
total_average = total_average + average_modification
next
average_of_all_regulation= total_average / (number of regulations)
end

Example for Algorithm-1:
Table-2 shows one sample input-output of the algorithm. We have considered 11 departments. For each department we calculate curriculum changes and then we find out average percentage of Curriculum Modification for 2018 regulation.

3.2. Computation aspect on Percentage of Syllabus Modification

The course syllabus documents the weekly learning topics and provides students with a path to identify when and how course content will be covered. The syllabus also sets students expectations for workload by outlining assessment items and due dates. Modification in syllabus content is necessary in new regulation to make students familiar with recent changes in different field of technology and to make them more employable. To find out percentage of changes in syllabus, we take help of Gensim. It is a Python library formodeling topics, indexing documents and finding similarity in large body of texts. To find out percentage of syllabus modification we identify subjects which are designed by concentrating on a particular field and consider one generic name for this set of subjects. For each generic subject we find out percentage of modification in syllabus content from previous Regulation to current regulation. We find out percentage of syllabus modification in last few years. The whole process in mentioned in Algorithm-2 and Fig.-3.

Table 2: Percentage of Curriculum Modification

Program Name	**Syllabus of Regulation 18**			
	Total No of Subject in Syllabus of Regulation 18	**No of Subject Excluded from Syllabus of Previous Regulation**	**No of Subject Included to Syllabus of Regulation 18**	**Percentage of Syllabus Change from R18**
B.Tech. in Electronics and Communication Engineering	107	12	36	44.85
B.Tech. in Electrical Engineering	110	25	35	54.54
B.Tech. in Civil Engineering	108	27	36	58.33
B.Tech. in Information Technology	115	10	41	44.34
B.Tech. in Bio-Medical Engineering	106	14	32	43.39
B.Tech. in Computer Science and Engineering	113	2	20	19.46
B.Tech. in Mechanical Engineering	105	18	35	50.47
M.Tech. in Electrical Devices and Power Systems	40	9	20	72.5
M.Tech. in Mechanical Engineering	38	5	14	50
M.Tech. in Mobile Communication and Network Technology	31	5	11	51.61
M.Tech. in Computer Science and Engineering	53	12	27	73.58
Average				**51.19**

3.3. Technology behind similarity measurement between two documents

Computation of similarity among text documents is a common task in Natural Language Processing (NLP). To compute text similarity between documents the input documents are transformed into real-valued presentation. Gensim provides neural network based approach to find real-valued vector representation of a text document. After the documents are structured into vectors, Cosine similarity function can be used to project one document into the other for degree of overlap. Cosine function in Python measures the angle between the two vectors. The return value is a real number between -1 to 1.Completely identical documents, when compared, would have a return value of 1. Absolutely dissimilar document would return the other extreme value of zero, implying the vectors of the concerned documents are orthogonal.

The most primitive algorithm for building a vector would be to count the total number of words in the documents. This is not always effective as a little difference in word count can make the algorithm effective. A better approach is to find frequency of different words.The TF-IDF (term frequency–inverse document frequency) values of the words in a document could be used to generate real-valued vector representation of a document. The TF-IDF value of a word is a statistically calculated value to indicate the importance of the value of a particular word in the set of documents. The following formulae are used to calculate TF-IDF value of a word or token t.

$$\mathrm{tf}(t)=\frac{\text{Number of times term t appears in a document Total}}{\text{number of terms in the document}}$$

$$\mathrm{idf}(t)=\log\left(\frac{\text{Total number of documents}}{\text{Number of documents with term } t \text{ in it}}\right)$$

$$\text{TF-IDF}(t)=\mathrm{tf}(t)*\mathrm{idf}(t)$$

We need to consider these TF-IDF values of all the words present in a document to get the real valued vector representation of the document.

Given two text documents in vector representation (say, $\mathcal{A}$ and $\mathcal{B}$) each of N-dimension, the cosine similarity between them can be defined using the following formula:

$$Cosine\_Sim(\mathcal{A},\mathcal{B}) = \frac{\mathcal{A}\cdot\mathcal{B}}{\|\mathcal{A}\|\times\|\mathcal{B}\|} = \frac{\sum_{i=1}^{N}\mathcal{A}_i\times\mathcal{B}_i}{\sqrt{\sum_{i=1}^{N}\mathcal{A}_i^2}\times\sqrt{\sum_{i=1}^{N}\mathcal{B}_i^2}}$$

To find the percentage of syllabus modification we need to consider syllabus of each subject as one document. If we consider one subject S_{cur} in current regulation and its corresponding subject S_{prev} in previous regulation, then, we can measure change in the syllabus content between

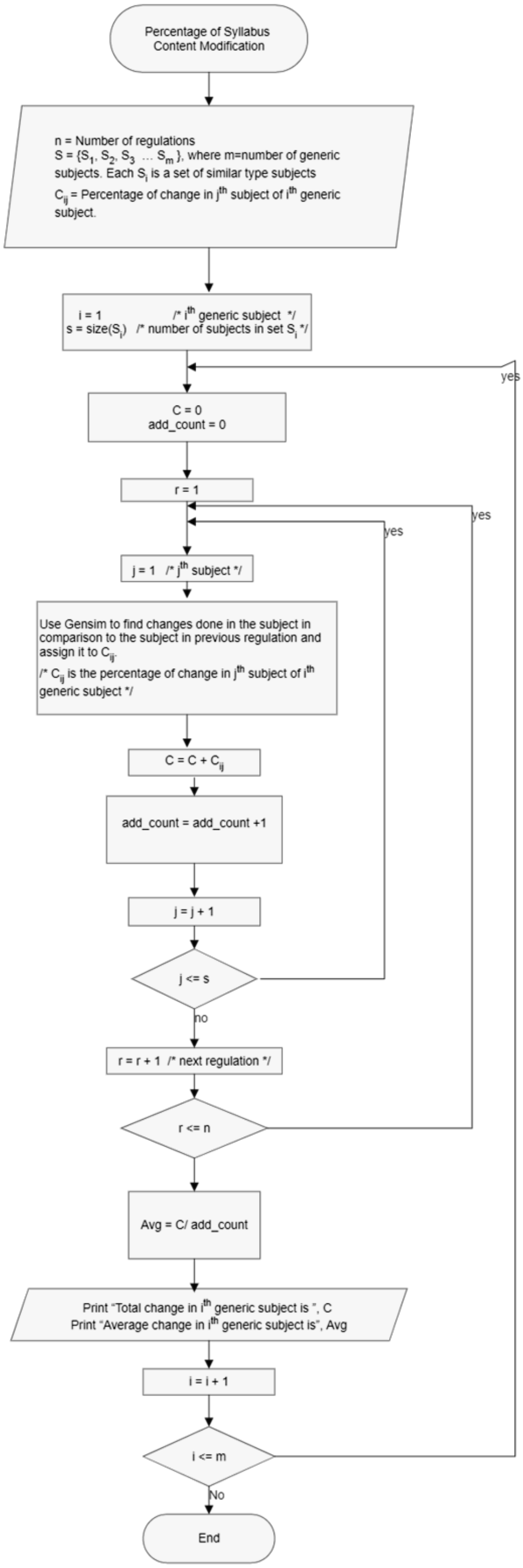

Fig 3: Percentage of Syllabus Content Modification

vector format and using the function of cosine similarity i.e. Cosine_Sim. Using this approach we can measure the change in the syllabus of all subjects.

Table 4: Percentage of Syllabus Content Modification as Example of 2 Subjects.

Generic Subject Name	Regulation 16 Subject Name	Regulation 16 Subject Code	% Syllabus Content Modified from Previous Regulation to 16 Regulation	Regulation 18 Subject Name	Regulation 18 Subject Code	% Syllabus Content Modified from Previous Regulation to 2018 Regulation	Total % of Syllabus Content Modified
Mathematics	Engineering Mathematics-I	M 101	10	Mathematics -I	M 101	20	30
Soft skill	Communicative English	HU 101	15	Professional Communication	HU 101	22	37

Algorithm-2: Percentage of Syllabus Content Modification

Inputs (n,S, CS):

n=Number of regulations

S={S_1, S_2, S_3 ... S_m }, where m=number of generic subjects. Each S_i is a set of similar type subjects

C_{ij}=Percentage of change in j^{th} subject of i^{th} generic subject.

begin

For each generic subject (say i):

C=0

add_count=0

For each regulation r (from n regulations):

For each subject (say j) in generic subject i:

i. Call Gensim to find changes done in the subject in comparison to the subject in previous regulation and assign it to C_{ij}.

/* C_{ij} is the percentage of change in j^{th} subject of i^{th} generic subject */

ii. C=C+C_{ij}

iii. add_count= add_count +1

Next

Next

Avg=C/ add_count

Print "Total change in i^{th} generic subject is ", C

Print "Average change in i^{th} generic subject is", Avg

Next

End

Example for Algorithm-2:

Table-4 shows a sample input-output for the algorithm-2. There are 2 generic subject names: one is Mathematics and the other is Soft skill.

4. Curriculum Employability Mapping

Investigation of relation between curriculum and employability mapping has been performed on the Regulation-2018 syllabus of Electronics & Communication Engineering Department of JIS College of Engineering, Kalyani. This case study producing one complete aspect on employability generation form curriculum design. The curriculum is the main structure of education framework which reflects student's inclination to the industry. The curriculum designed by several ingredient of subject knowledge. In case of engineering curriculum different types of subjects are included. All types of subjects are necessary for students in his/her professional life. Such as basic science subject is needed for employability generation but domain knowledge related subjects are most important for entry level in industry. Skill development type subject is very important for students towards specific skill up gradation. In this age of Industry 4.0, advanced elective is essential for future professionalism of students. In addition, practical laboratory performance in all the subjects will reflects performance of the students in industry. In this research, the subject classification has been performed on considering employability generation. The industry specific employability generation for the engineering stream depends on the course curriculum (in particular, basic science courses, inter departmental courses, skill development courses, domain specific courses, practical applications courses and advance elective courses). Therefore, to make a relation between the numbers of courses i.e., number of basic science courses, inter departmental courses, skill development courses, domain specific courses, practical applications courses and advance elective courses, first we are defining the following relations between the course and employability by assuming total course is equivalent with employability:

i. $B_s \approx c_1 \times E$;
ii. $I_d \approx c_2 \times E$;
iii. $S_d \approx c_3 \times E$;
iv. $D_s \approx c_4 \times E$;
v. $P_a \approx c_5 \times E$;
vi. $A_e \approx c_6 \times E$.

E is representing the employability factor in these model equations. The meaning of the other notations of above relations (i.) to (vi.) is given in Table 5.

Table 5: Meaning of the notations of our relation (i.) to (vi.)

No	Notations	Meaning	Notations	Meaning
i	B_s	Number of basic science courses	c_1	The ratio of the percentage of Basic Science courses and 100
ii	I_d	Number of inter departmental courses	c_2	The ratio of the percentage of inter departmental courses and 100
iii	S_d	Number of skill development courses	c_3	The ratio of the percentage of skill development courses and 100
iv	D_s	Number of domain specific courses	c_4	The ratio of the percentage of domain specific courses and 100
v	P_a	Number of practical application courses	c_5	The ratio of the percentage of practical applications courses and 100
vi	A_e	Number of	c_6	The percentage of

Table 6: Values used in our simulations on the basis of ECE-JISCE 2016 Curriculum Structure

SEM	B_s	I_d	S_d	D_s	P_a	A_e	Total Course
1ST	4	3	3	0	0	0	10
2ND	3	3	2	2	0	0	10
3RD	1	4	1	3	0	0	9
4TH	2	0	1	7	0	0	10
5TH	0	0	2	7	1	0	10
6TH	0	1	1	7	1	0	10
7TH	0	0	2	4	1	3	10
8TH	0	0	2	2	1	2	7
Total Course	10	11	14	32	4	5	76

If we solve the relations (i.) to (vi.), considering the Table 9, then we find the relation between the employability and the number of courses in the curriculum which is

$$\frac{D_s B_s\,(0.047059P_a - 0.023529A_e)}{S_d I_d\,(P_a - A_e)} = c_4.$$

where 〖c〗_1=c_3, c_5=c_2-0.023529 and c_6=c_2-0.047059. The values used in our simulations are given in Table 8 and the calculated values are presented in Table 9.

The above equations were devised to draw a relation among Employability Factor and different components of the Curriculum. In further study to generalize the relation the equation may be modified. Statistical methods may be applied.

Table 7: Calculated Values on the basis of of ECE-JISCE 2016 Curriculum Structure

Percentage of B_s w.r.t total course	13.16	c_1	0.1316
Percentage of I_d w.r.t. total course	14.47	c_2	0.1447
Percentage of S_d w.r.t. total course	18.42	c_3	0.1842
Percentage of D_s w.r.t. total course	42.11	c_4	0.4211
Percentage of P_a w.r.t. total course	5.26	c_5	0.0526
Percentage of A_e w.r.t. total course	6.58	c_6	0.0658

Table 8: Values used in our simulations on the basis of ECE-JISCE 2018 Curriculum Structure

SEM	B_s	I_d	S_d	D_s	P_a	A_e	Total Course
1ST	3	3	2	0	2	0	10
2ND	3	6	2	0	2	0	13
3RD	1	5	1	3	2	0	12
4TH	2	1	0	7	2	0	12
5TH	0	1	1	6	2	1	11
6TH	0	0	1	6	2	4	13
7TH	0	1	1	0	2	4	8
8TH	0	0	1	0	1	4	6
Total Course	9	17	9	22	15	13	85

This case study is based on ECE Dept. JISCE. As per the Table 7 for 2016 curriculum c2, c3, and c4 values are comparatively higher than other parameters. It implies that students are inclined towards inter-departmental course, skill development and domain specific courses. The placement of 2020 batch of graduates was higher than the 2019 batch by about 11%. This improvement of placement may be attributed to the higher numbers of domain specific and skill development courses. Based on this experience, the 2018 curriculum was prepared to include relatively more number of interdepartmental and industry specific practical application courses. As depicted in Tables 8 and 9, the numbers of Inter-departmental (c2) open electives and Practical application courses (c5) are increased.

Table 9: Calculated Values on the basis of ECE-JISCE 2018 Curriculum Structure

Percentage of B_s w.r.t total course	10.58824	c_1	0.105882
Percentage of I_d w.r.t. total course	20	c_2	0.2
Percentage of S_d w.r.t. total course	10.58824	c_3	0.105882
Percentage of D_s w.r.t. total course	25.88235	c_4	0.258824
Percentage of P_a w.r.t. total course	17.64706	c_5	0.176471
Percentage of A_e w.r.t. total course	15.29412	c_6	0.152941

Increment in c2 would let the students chose their area of specialization for the upcoming job market. Hence courses like (i) Artificial Intelligence, (ii) Database Management System (DBMS), (iii) Python, (iv) JAVA, (v) Robotics, (vi) Machine Learning etc. are included as inter-departmental courses. Practical application courses(c5) include project based learning and innovative activities from the very beginning of program. This has been implemented so that the students are ready to contribute in industry after graduation. Based on these changes it is expected that placement of 2022 batch of graduates will increase.

5. Conclusion

Algorithm of percentage calculation for curriculum enrichment presented here for consecutive regulation of any institution. Amount of modification calculation of syllabus is additional contribution of this research. The parameter for both the case is percentage which is quantitatively defined for all curriculum/syllabus of JIS College of Engineering as an example. Industry linked employability generation related investigation is performed considering example of curriculum/syllabus for ECE Dept. JIS College of Engineering which improved the student placement results. This proposed methodology will be convenient for any other program curriculum/ syllabus modification processes. The software approach for percentage of curriculum/syllabus reform calculator will be conducted. Association with inclination of program/ institution for specific employability generation will be investigated. The mathematical equation regarding employability relation from curriculum input will be applied for other program study. The measurement of employability focus under curriculum is essential for the development of our society. This research contributed some original approach on curriculum/syllabus improvement measuring processes towards employability generation in our society.

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