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Competency Evaluation using Graduate Attributes – A comparative study

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***Abstract*— The reformation in the education system is inevitable with the growth and advancement in the society. Thus, towards the end of the 20th century, there is a pedagogical transformation from the output-based education system to the outcome-based education system. Outcome based education is a student centric learning approach in which learning is set around specified goals (outcomes). It gives importance to the knowledge and skills acquired by students than what or how something is taught. The role of the faculty is as facilitator to help students in achieving desired outcomes. In this method, the purpose of any program is clearly specified in terms of Course Outcomes, Program Outcomes, Program Specific Outcomes, and Program Educational Objectives. The attainment of these outcomes is a measure of effectiveness of the program and the assessment of the same is monitored by various accreditation agencies in different parts of the world. After a series of discussions among these agencies, a set of graduate attributes are set forth as parameters for the assessment of the quality of education. In India, the accreditation agency is known as the National Board of Accreditation and the graduate attributes are named as program outcomes. A student graduating from an accredited program is considered a competent graduate. In this study, the competency of Civil Engineering graduates of selected institutes in Kerala state is compared in terms of these graduate attributes. The opinion of academicians and industry professionals regarding the preparedness of the current undergraduate civil engineering curriculum to develop "industry-ready engineers" is also discussed in the study.**

***Keywords*—attainment; competency; civil engineering curriculum; graduate attributes**

***JEET Category*—Research.**

I. INTRODUCTION

TEChnological development and globalization paved the way for young engineers to work at the international level. For the acceptance of engineering graduates in the global economy, both technical knowledge and professional competency are essential. The quality of students graduating from various institutes is evaluated and ensured by accreditation agencies. The engineering education sector in India is accredited by two agencies National Assessment and Accreditation Council (NAAC) and the National Board of Accreditation (NBA). NAAC accredits institutes and universities whereas NBA accredits technical programs such as engineering and management. These agencies are supported by the International Network for Quality Assurance Agencies in Higher Education (INQAAHE). It is an international quality assurance body that works closely with national accreditation bodies to promote and advance excellence in higher education through the support of an active international community of quality assurance agencies. NBA is also supported by Washington Accord as India is a signatory of the Washington Accord since 2014. It is an international alliance among various countries that allows the mutual acceptance and recognition of engineering graduates among the signatory countries.

Lots of research were done to identify the competencies required for engineering graduates. Male (2009) identified 64 competencies required for Australian engineering graduates and later it was reduced to 49 items which were grouped into 11 items. These competencies were found consistent with that defined in the USA and Europe. Also, the competency group identified by Male in her study closely resembles the grouping of outcomes listed by Engineers Australia, the accreditation body in Australia, and ABET. Lunev (2013) compared the list of competencies of Russian and European Universities with each other and later both lists of competencies were compared with that of the CDIO list of competencies. The similarity of competencies between Russian and European universities indicated the possible convergence of competencies among other universities all over the world. This enabled collaboration and mobility of engineers among different universities of the world. Also, the academicians, employers, and alumni of Russia were asked to do the importance rating of these competencies and to measure the proficiency acquired by the students in the skill and abilities from their educational program. The responses showed that all three groups of respondents consider the same set of skills important. Passow (2012, 2017) conducted a survey to rate the importance of ABET competencies and found that problem solving, communication and teamwork were the competencies of high score. Jesiek et al., (2014) identified the contextual dimensions of engineering competencies and technical coordination,

engineering cultures, and ethics, are identified as important parameters. Jainudin et al., (2015) presented the perceived level of competency of students by the industrial and faculty supervisors during industrial training. Peng (2016) discussed the mismatch between the educational attainment of a graduate with a Master of Engineering (MEng) degree and the industry needs in China and identified that there is a mismatch between MEng educational attainment and the industry needs in China.

From all this literature it is clear that in addition to technical know-how, skills are very much essential for engineering graduates. The majority of the literature discussed the generalized competencies required for an engineering graduate and it matches with that of graduate attributes defined by Washington Accord (program outcomes in the Indian context). This study aimed to discuss the competencies developed in Civil Engineering graduates during his/her undergraduate engineering program. The competency is measured in terms of attainment of program outcomes defined by the National Board of Accreditation (NBA), the accreditation agency in India. The program outcomes of selected tier II institutions in different parts of Kerala are compared. Also, the viewpoint of academicians and industry professionals regarding the competency of Civil Engineering graduates is discussed in the study.

II. Materials and Methods

During the 1990s there was a revolution in the engineering education system, as there is a paradigm shift from input output system of education to outcome-based education (OBE). Outcome based education is a student centric learning process, which gives importance to what the student could do after attending the course rather than what the teacher taught in the class. The outcomes are defined at various levels of a program like course outcomes, program outcomes, program specific outcomes and program educational objectives. For every program, for tier II institutes curriculum and syllabus of each course will be given by university. First of all, course outcomes are defined and are mapped with program outcomes and program specific outcomes. For each course, there will be four to six course outcomes and they are mapped in a scale of 1 to 3 with program outcomes and program specific outcomes. This mapping matrix of course outcomes with program outcomes and program specific outcomes is called program articulation matrix.

In order to compute attainment of each program outcome, the course outcome attainment is computed first. Then from the mapping strength of each course with program outcomes in program articulation matrix, program outcomes attainment associated with each course is computed. Both summative and formative assessment methods are used for computing course outcome attainment. In summative assessment every activity related to academics like internal exams, assignments, conduct of laboratory experiments, seminars, projects and university exams are considered. For formative assessment activities like course end feedbacks, one minute paper, clicker questions etc can be used. The institution has the freedom of for fixing the proportion of summative and formative assessments. Also, in the summative assessment, institutes decide the proportion of internal exam component and end semester exam component. Various institutes use proportion like 20:80, 30:70, 40:60, 33: 67, 50:50, 70:30, 80:20 etc., for internal and end semester exam.

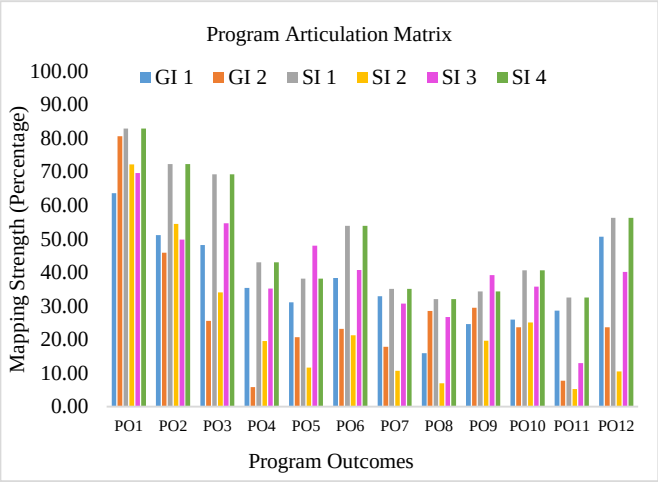
Now the expected proficiency and expected attainment is fixed based on the previous academic experience of the program. Attainment levels are fixed in a scale of 1 to 3 depending on the percentage of students crossing expected proficiency. From the predefined proportion of summative and formative assessment as well as the number of students crossing expected proficiency course outcome attainment values are computed. Averaging all the course outcome attainment values give the overall attainment value.

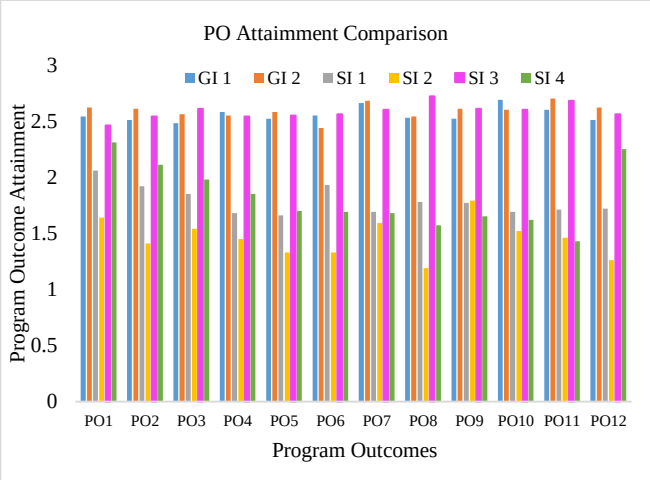
Once the course outcome attainment is computed program outcome attainment is computed from the direct and indirect method in the proportion 80:20 as stipulated in the National Board of Accreditation manual. Direct attainment values are taken from overall course outcome attainment value and mapping strength in the program articulation matrix. The indirect method involved the student feedback and employer feedback etc.

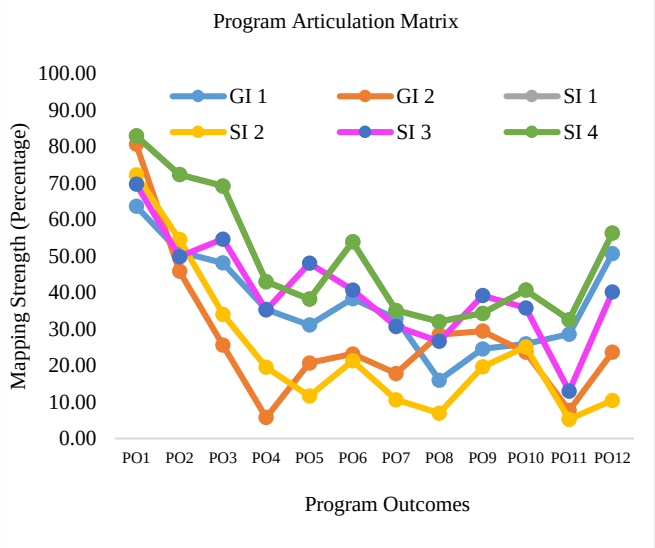
For the present study program outcome attainment values are compared among selected tier II institutes of Kerala state. All the institutes are affiliated to APJ Abdul Kalam Technological University. Altogether there are 123 institutes in Kerala state with Civil Engineering program. As per the statistics of July 2022, 28 civil engineering programs of Kerala state is accredited by National Board of Accreditation. From the accredited institutes data from six institutes; two government institutes and four self-financing institutes are compared and presented. Fig 1 presented the comparison of program articulation matrix and Fig 2 presented the comparison of program outcome attainment values of these institutes. The abbreviation GI represented the government institute and SI represented self-financing institute. Fig 3 presented the comparison between actual mapping strength and non-zero mapping strength of sample program outcomes of these institutes. PO1 and PO11 mapping strength of a particular institute is presented in the Fig 3.

Once the program outcome attainment is computed the preparedness of current undergraduate civil engineering curriculum to develop employability skill is considered in the next session. This is done by scrutinizing the opinion from academicians and industry professionals. Survey questionnaire is prepared and circulated to academicians and industry professionals as google forms. Eighty-seven academicians and forty-six industry professionals participated in the survey. They are asked to express their views in a scale of “0” to “7”, “0” being lower value and “7” being upper value. The respondents are also asked to comment on methods to enhance employability skills of fresh civil engineering graduates.

The comparison of opinion of the academician and industry professionals in statistically performed in SPSS software. The result of independent sample ‘t’ test is presented in the Table 1.







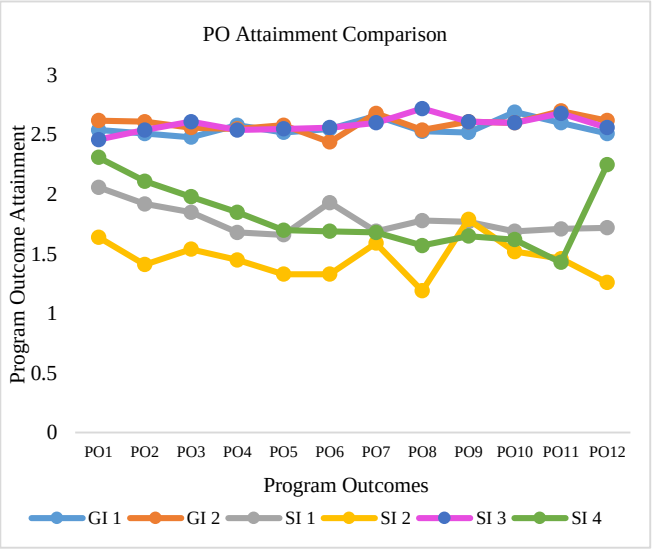
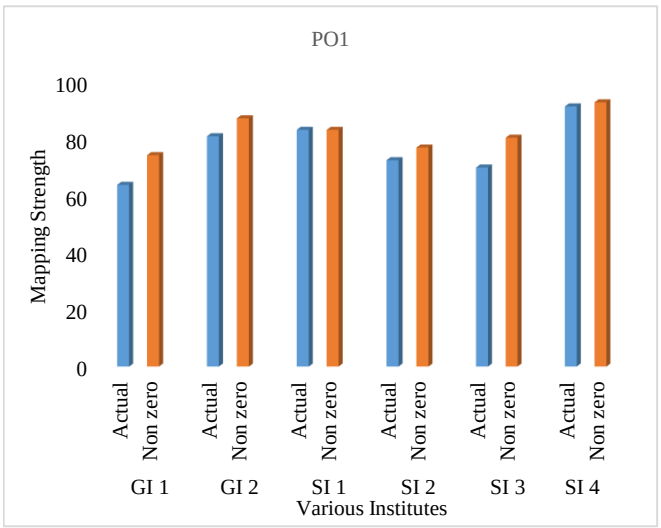


Fig. 1. Comparison of program articulation matrix of various institutes

Fig. 2. Comparison of program outcome attainment of various institutes



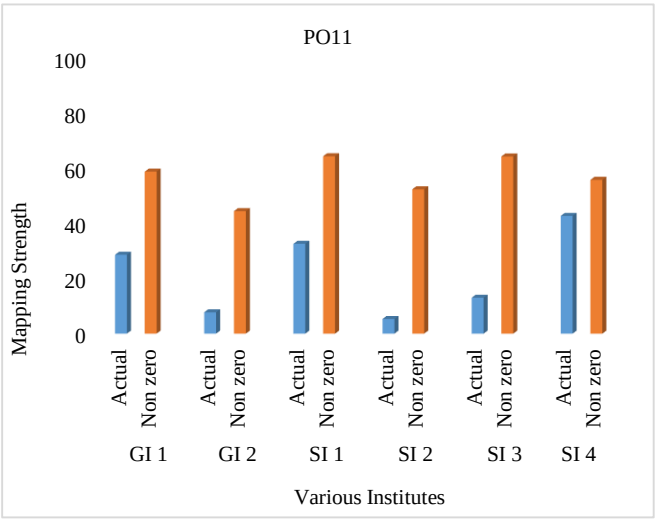


Fig. 3. Sample for the comparison of actual mapping strength Vs non zero mapping strength (PO1 and PO11)

TABLE I
RESULT OF INDEPENDENT 'T' TEST

PO	Category	N	Mean	S. D	S.E.M	t	df	p
PO1	A	87	4.90	1.49	0.16	4.22	131	0.000
	I.P	46	3.67	1.76	0.26			
PO2	A	87	3.95	1.58	0.17	3.18	131	0.002
	I.P	46	2.96	1.95	0.29			
PO3	A	87	4.11	1.60	0.17	4.32	131	0.000
	I.P	46	2.83	1.72	0.25			
PO4	A	87	3.74	1.57	0.17	3.02	131	0.003
	I.P	46	2.80	1.90	0.28			
PO5	A	87	4.00	1.56	0.17	1.28	131	0.203
	I.P	46	3.57	2.00	0.29			
PO6	A	87	3.76	1.70	0.18	1.91	131	0.058
	I.P	46	3.13	1.97	0.29			
PO7	A	87	3.75	1.77	0.19	1.77	131	0.080
	I.P	46	3.17	1.80	0.27			
PO8	A	87	3.82	1.78	0.19	0.44	131	0.664
	I.P	46	3.67	1.83	0.27			
PO9	A	87	4.41	1.64	0.18	1.49	131	0.138
	I.P	46	3.93	1.97	0.29			
PO10	A	87	3.85	1.67	0.18	2.93	131	0.004
	I.P	46	2.93	1.79	0.26			
PO11	A	87	4.09	1.66	0.18	2.82	131	0.006
	I.P	46	3.24	1.66	0.25			
PO12	A	87	4.08	1.71	0.18	2.68	131	0.008
	I.P	46	3.22	1.87	0.28			

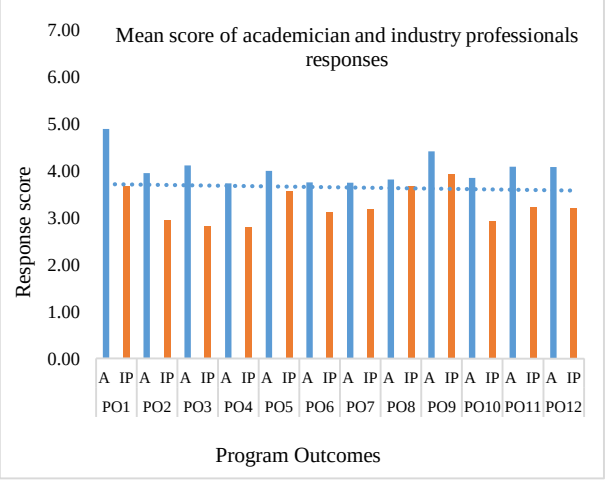


Fig. 4. Mean score of academician and industry professionals' responses

30% of academicians participated in the survey are male and remaining are female. From the industry professionals 65% are male and remaining female. 34% of academicians and 37% of industry professionals have more than 10 years of experience in appropriate field. Also, more than 50% of academicians have a little experience in the industry. The abbreviation A and IP in Table 1 represents academicians and industry professionals respectively. The mean score of academician and industry professionals' responses is presented in Fig 4.

III. Results and Discussions

In this study competency assessment of Civil Engineering graduates of Kerala state is discussed based on the program outcome attainment values. Data from six different institutes is compared. All these institutes are affiliated to APJ Abdul Kalam Technological University and falls under tier II category of NBA manual. From the data presented in Fig1, it is seen that the program articulation matrix showed a similar trend line. Except PO1 and PO2 all other program outcomes have mapping strength less 40%. It is also seen that there is drastic difference in mapping strength of program outcomes across various institutes with a least difference of 17% in PO10 to 45% difference in PO12. Since all the institutes considered in the study is affiliated to same university, following same syllabus, this change in mapping strength is debatable. Even though the courses are same, the course outcome statement and its mapping strength values are influenced by the experience of faculty and well as their familiarization with Outcome based education.

From the values presented in Fig 2, it is seen that irrespective of the difference in mapping strength of program outcomes, attainment values are more or less same. The program outcome attainment values are not influenced by the mapping strength. Also, there is no variation of program attainment value within an institute. The program outcome attainment vales are not influenced by the type of institute as it is seen that the attainment of government and self-financing institutes are seen overlaying. Fig 3 presented the difference between actual mapping strength and non zero mapping strength of each program outcome. For PO1 around 80 % of courses are mapped with it. So, the actual mapping strength and non zero mapping strength values lies in an appreciable range. But for PO11, the actual and non-zero mapping strength has comparable variation as the number of courses actually mapped to PO11 is less in the curriculum. This showed that the non-zero average values of mapping strength mislead the actual mapping strength especially when the number of courses mapped to program outcomes are less. Thereby a particular program outcome is being addressed by a single course with high mapping value gets more mapping strength than a program outcome with moderate mapping value covered by more courses. The usage of non-zero mapping strength in the computation of program outcome attainment gives non-realistic value of the same.

From the Fig 2 it is clear that the program outcome attainment values lie in the moderate range for all institutes. Also, the scale used in the attainment computation has three values namely; low, moderate and high. This small range of scale also affected the attainment value. At this stage the competency assessment deploying graduate attributes is arguable. So, the study is proceeded by the opinion of academician and industry professional to express their views regarding preparedness of current undergraduate civil

engineering curriculum to develop employability skill. Table 1 and Fig 4 showcased their views on preparedness of current curriculum. Both academician and industry professional have a moderate level of views on the curricular content. For PO1, PO2, PO3, PO4, PO6, PO10, PO11 and PO12 there is a significant difference in the opinion between academicians and industry professionals with academicians favouring the preparedness of curriculum. The academician and industry professionals have similar views about PO5, PO7, PO8 and PO9 and are doubtful in the curricular content to achieve these program outcomes. According to their views the following activities can enhance employability skills of fresh civil engineering graduate

- revise syllabus by considering industrial needs
- include compulsory internship and industry exposure in syllabus
- include guest faculty from industry in institutes.
- modify examination pattern by including evaluation based on their industrial knowledge also
- provide industry training to faculty
- inculcate self-learning attitude in students

III. CONCLUSIONS

The present study discussed the competency evaluation of Civil Engineering students using graduate attributes. From the comparison of program articulation matrix and program outcome attainment values it is seen that the procedure for attainment computation is to be modified for getting a realistic value. Then the opinion of academician and industry professionals on the preparedness of current undergraduate civil engineering curriculum to develop employability skill is discussed. According to them practices for modern tool usage, consideration of environmental and sustainable aspects, ethics and personal skills are difficult to attain from current curriculum. Their suggestion to enhance employability skills of fresh civil engineering graduate is also discussed in the study.

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