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Significant Factors as Low Hanging Fruits in Addressing the Employability Defect of Mechanical Engineering Graduates

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Abstract: ***Employability defect of engineering graduates is a major concern for the Industries under the current scenario of early to market, technological advancements, demanding customer needs, competitive environment and globalized manufacturing practices. Products of current day are addressed as systems, as they are an integration of many sub-systems and components of various domains of engineering, thus throwing the challenges on the Educational Industry to produce 100% employable engineering graduates as per the expectations of the Industry. As observed from literatures, employability of engineering graduates ranges 20% to 70% across the globe and hence a concern across nations. Defects with lower employability, percentage throw the light on the complex nature of the issue and hence various body, approach the solution through educational reforms at the national level. Employability of engineering graduates in India is around 20% (defect rate as high as 80%) as reported in literatures; hence the issue calls for a multi-pronged approach for the solutions, apart from national level Initiatives by the Government and professional bodies. This research paper is part of the on-going research of the first author, with specific focus on employability related to Mechanical Engineering Graduates. The research work identifies the significant factors which are like low hanging fruits that can be addressed easily at the institutional level, thus delivering a significant impact on the employability.***

Keywords: Employability, Mechanical Engineering Graduates, Six Sigma, Educational Quality, Higher Education

1. Introduction

Employability of engineering graduates from the educational institutions across the global poles is a concern for both developing and developed countries. Varying percentage of employable engineering graduates by the industries across the globe leaves a significant percentage of un-employable engineers as a defect of the process from the educational industry. Various nations across the globe have joined together in recognizing, bench marking, and developing accreditation standards and facilitate reforms in engineering educational institutions by sharing the best practices amongst the accreditation bodies across the nations, thus enhancing the quality of engineering profession. India is a signatory to one of the six accords known as Washington accord [1]. This explains the importance and impact of globalized scenario of product development by the Industries. Employable engineering graduates in India are around 20% as observed from the literature surveys related to this research [2, 3, 4, 5, 6, 7 and 8]. As found in the literatures, most of the research work focus was employability issue from the soft skills aspects of student, while few of the research work recognizes the hard or domain skills as the knowledge gap in employability. Research work [5] identified and quantified hard skills like measurements results in defects during the application of knowledge from theory to practice by the engineering students. Further, the literatures [6 and 7] also explained that the knowledge gap of applying theory into practice exists with practicing engineers and professionals whose experience is less than 5 years. This explains the knowledge gap of applying theory into practice is carried forward from the institution into the profession for a considerable amount of time after formal college education and results in defects. Many initiatives in India have been taken at the national, state and institutional level like TEQIP – Technical Education Quality Improvement Program, but as the issue is complex and defect rate on employability is very high, it is important to find significant factors that are easy to implement and shall have a high impact on employability, similar to the approach of plucking low hanging fruits, while reforms to the education curriculum, accreditations etc. shall deliver higher level of standards and excellence in education.

This research work focusses on identifying few such factors, as the Industry considers most important to them in addressing the employability issue and perceives can be addressed at the Institutional level with ease. The focus is further restricted to mechanical engineering graduates and with the employers who are likely to hire them in India. However, this approach can be adopted for other branches of engineering with suitable changes in the further construct.

Based on the identified factors from this explorative research, further constructs shall be made to find the granularity of identifying few parameters for implementing at institutional levels, which shall deliver a significant impact on employability

2. Quality and Its Impact

Defect in any form results in loss and if the defects can be eliminated, it can be turned into profit or gain. Industries over a period of time have evolved and embraced various quality models and approaches towards excellence, thus converted loss into gains by eliminating defects. One such popular quality model is six sigma, which is a structured approach with the usage of quality tools. Industrial leaders like Motorola and GE has demonstrated to the world by embracing six sigma quality model that they made a savings of $17billion and $8billion respectively [9]. Thus adoption of Six Sigma model at the institutional levels shall not only address employability issues of engineering graduates, but also enhancing the quality in educational institutions [9 and 10]. Varwandkar [11] citing Narayan Murthy, founder of Infosys, explained that even premier institutions of India are also not 100% employable engineering graduates.

3. Objective of this Research

The objective of this research, which is explorative in nature, is to find few significant factors which are like low hanging fruits as perceived by the employers and if not met, shall lead to the defects in employability of mechanical engineering graduates. These are the few Critical To Quality (CTQ), that are low in difficulty as an implementable solutions at the institutional level, but at the same time will benefit the employers with high impact on employability by reducing the knowledge gap [5, 6 and 7]. Such factors shall be used for further constructs of finer dimensions and thus identifying few significant factors that are easy to implement and deliver significant impact [Fig 1] on defect rate of employability.

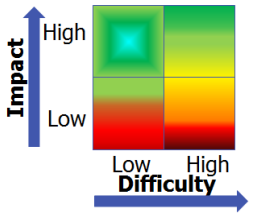


Figure 1: Four Blocker [2]

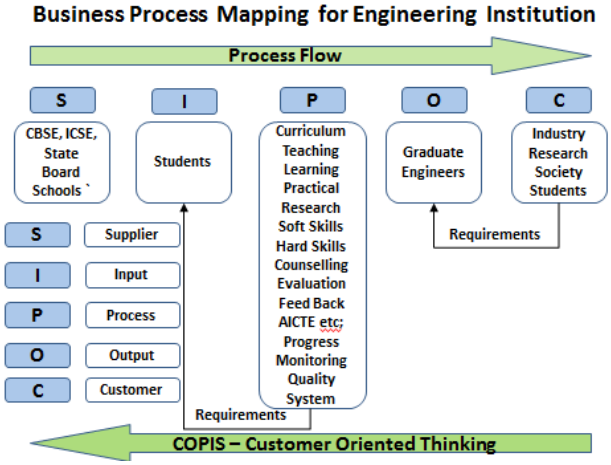


Figure 2: COPIS Model [7]

In a product development scenario of the industry, solutions with higher impact & higher difficulty quadrant [Fig. 1], will require innovative approaches, design changes etc., with long-term planning, budgets etc., after exhausting easy to implement with high impact solutions that would bring down the defect percentage to say less than 1%, after defect rate is brought to a considerably to a lower level, thus achieving for excellence. However, in the current research as defect is very high, low difficulty – high impact solutions are the focus.

Unlike the one explained in Fig 2 of COPIS model for engineering education, the product and process Industry can apply appropriate changes and define input controls, either through supplier requirement specifications or design specifications etc., to contain the variations in the inputs to the process. But in the education industry, the education process is controlled by the various bodies as brought-out in COPIS model, with less or no opportunity to control all the process parameters, by the engineering institutions where the process of converting student (input) into an engineer (output) takes place. Control on input factors are largely governed by governmental policies, regulatory body norms for admission etc., thus limiting the window of opportunity for controls in the input parameters to address the employability issue by the institutions. However, educational institutions have to address the defect rate of employability, hence identification of significant factors that are like low hanging fruits which can be plucked with ease, while implementation of solution with less difficulty at the institutional level shall be of immense help to them.

Related to this current research, the quadrant that is high impact with high difficulty for the educational industry, are the ones requiring implementable solutions by regulators like AICTE etc., initiatives like TEQIP, educational reforms, accreditations boards, governmental policies etc., which shall deliver excellence in long-term. These bodies have control in defining the specifications on both inputs and in the process.

4. Research Survey Methodology

4.1 Sampling Approach in VoC Collection

As observed from the literatures, most of the work except for [8], is limited to smaller geographical locations of India and largely focused with soft skills. This is largely due to time and budgetary constraints of the researchers. However, the research work by [8] was carried out at the national level, covering all the domains of the engineering graduates and the project was funded by World Bank in addressing the issue at the national level. Focus of [8] is not in identifying factors that are low hanging fruits and also not with specific domain like mechanical engineering.

While deciding on the target audience for the research survey, [8] contemplated on the survey respondent including immediate supervisors with whom the engineering graduates from the institutions will be working and have a direct knowledge on the skills needed and available for the work. However Andreas [8] dropped this idea, as the survey was covering all the branches of engineering graduates at the national level and left it to the organization to choose the respondent and was largely responded by HR professionals.

However, as this work is focused to mechanical engineering domain; hence persons who will be involved as touch points in the hiring process, either in accessing the employability of the engineering graduates during screening or selection time of the candidates and supervisors under whom the fresh recruits will be working in the organization are the target audience as respondents, thus ensuring direct technical knowledge on the most important skills required in execution of the job and are must-to-have skills from employer perspective.

It is also important to cover larger geographical sections and various Industry segments, as engineers are mobile for job needs and also hired by various industry segments.

4.2 Sample Size and Characteristics of Respondents

Multi stage sampling approach was adopted for this explorative research work, with interviews of the Industry expert to understand which skill they consider as an important need to be addressed by the Institutions and the perceived skills that would meet their need, based on their experience in recruitments and also with mentoring and guiding fresh mechanical engineering graduates in their jobs. These respondents were participants to advanced robust product and process design, measurement system analysis workshops, conducted across India at multiple locations by RAISE Consultancy services through professional bodies of the India like ACMA – Automotive component manufacturers associations, IMTMA – Indian machine tool manufacturers associations etc., are practicing professionals in mechanical engineering domain across functions and with experience ranging between 5 to 15 years from various geographical locations of India. As the invitation to every workshop is rolled out by the professional bodies on an all India basis, hence the respondents to this survey are random samples and not biased with any one segment of the industry or location of the country. These practicing professionals represent various industries who would hire mechanical engineering graduates. Industry segment and its projected need till 2022, [12] has also been consulted.

182 industry experts, representing 130 Industrial organizations, representing 24 different Industrial segments are the respondents to this voice of customer data collection in identifying few of the important factors as perceived by them which can be addressed at the Institutional level, during the period June 2013 to Sep 2015. The respondents are from 26 geographical locations representing 11 different states, which employ large portion of mechanical engineering graduates.

This random sample of 182 considered in this research work is higher than 157 considered in the national level research by [8], hence considered adequate. However, more sample size with inclusion of other states which are not been included, like Chhattisgarh, West Bengal etc., would have been better, but could not be considered due to time and budgetary constraints.

Fig. 3 explains the respondents and their representation of various industry segments. As could be observed from the figure, large proportions of the VoC, to the tune of 42%, comes from automotive, machine tool and other allied segments, which employ large chunk of mechanical engineering graduates in India. The survey respondents also accounts by 7% from faculty of academic institutions and 10% from professional associations, thus bringing coherence, confidence and authenticity to the data collected, for extrapolating the research outputs to the other states of India. The factors identified from this work and consequent recommendations from this on-going research at a later stage for implementation at institutional level shall make a high impact and shall cater to all the segments of the employers of mechanical engineering graduates.

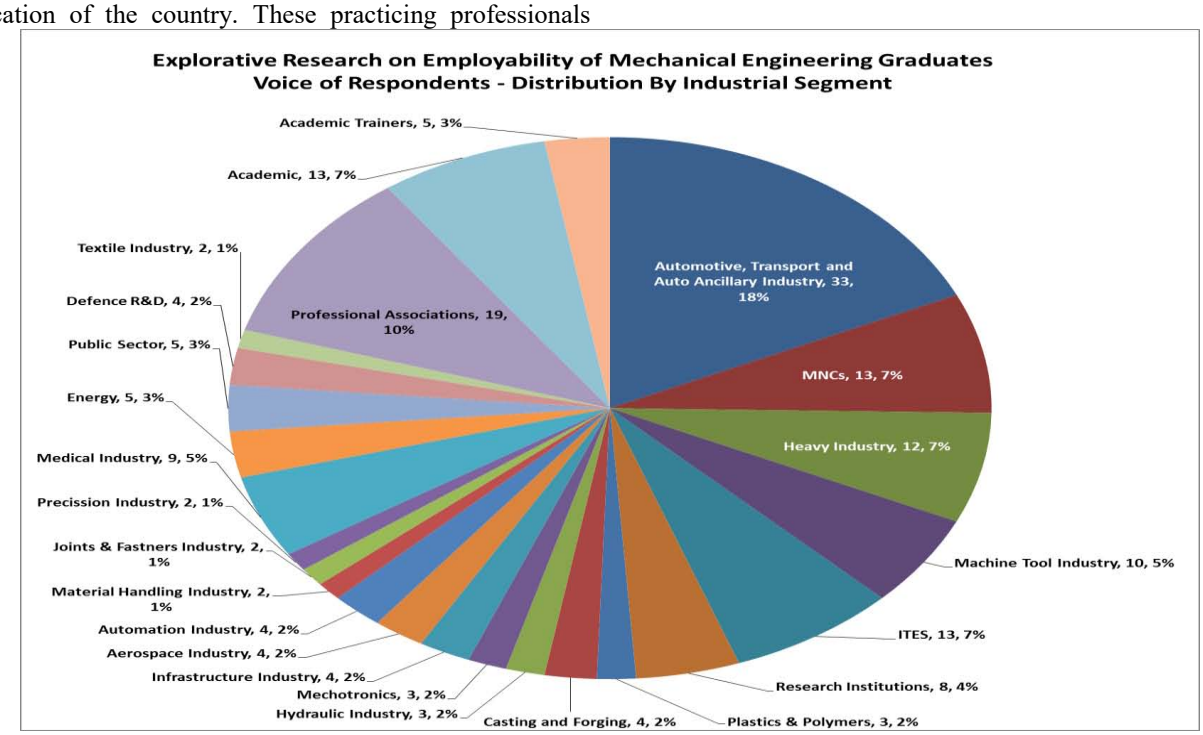


Figure 3: Respondents by Industry Segment to the VoC

4.3 Survey Design

An appropriate design and structured approach is required in collection of the voice of customer (employer) for identifying the few easy to implement significant factors that might have a significant impact on employability of mechanical engineering graduates.

A structured approach of guided interview was conducted to with the respondents to understand their perception on the important factor. The interview was followed by simple questionnaire to collect the data in measurable form.

For this purpose of the study, lack of application of theoretical knowledge into practice, which affects the employability of mechanical engineering graduates have been considered as dependent variable as shown in Table 1.

Table 1: Independent and Dependent Variables

Independent Variable	*Dependent Variable*
Soft skills	Lack of application knowledge of theory into practise (knowledge gap) affects students employability
Analytical knowledge	
Knowledge on quality & cost	
Domain knowledge	
Faculty"s knowledge on practical applications	

4.4 Survey Instrument

The survey instrument consists of two components 1) Structured interview 2) Short Questionnaire. In the structured interview, the opinions of the technical professionals on the lower employability rate of mechanical engineering graduates is heard and followed by the short questionnaire to collect the data with their ranking for the independent variables. The short questionnaire of this explorative research shall be used for detailed constructs in further research. Table 2 shows the questionnaire design. The respondents have been asked to give their views in the order of their acceptance to strongly agree (SA), agree (A), neither agree nor disagree (NAND), disagree (D) and strongly disagree (SD).

Table 2: Short Questionnaire for this exploratory Research

Q_0	Employable mechanical engineering graduates issue, is it across Institutions? Yes / No					
	Question	*SA*	*A*	*NAND*	*D*	*SD*
Q_1	Application of theory to practice affects employability					
Q_{1-1}	Lack of Soft skills like communication, listening etc affects application of theory to practice					
Q_{1-2}	Lack of analytical and problem solving skills, affects application of theory to practice					
Q_{1-3}	Lack of knowledge on quality aspects and tools affects application of theory to practice					
Q_{1-4}	Lack of application of knowledge to practice from theory of mechanical engineering domain and latest technology tools like CAD etc.,					
Q_{1-5}	Absence of institutions close interaction with industry and consequent support in guiding the students, for applying theory to practice in products or process					

4.5 Research Hypothesis

Following null hypothesis has been developed for the research questions for inferential statistics.

H_{1-1} - Soft Skills do not have a significant impact on application of theory to practice
H_{1-2} - Analytical knowledge do not have a significant impact on application of theory to practice
H_{1-3} - Quality knowledge do not have a significant impact on application of theory to practice
H_{1-4} - Domain knowledge do not have significant impact on application of theory to practice
H_{1-5} - Absence of close interaction of institutions with Industry do not affect in guiding student for applying theory to practice.

5. Research Findings

Data collected from the respondents have been analyzed analyzed for the finding of statistical significance of variables using Minitab 17 [13], the multipurpose statistical analysis algorithm. The following are the findings from the research.

5.1 Gap in application knowledge of theory to practice is across Institutions

63% of the respondents agreed that, the gap in application knowledge from theory to practice is not restricted to one segment of institution, but it is across institutions as found from the study and quantifies the observation made by [11].

5.2 Reliability and Internal Consistency of Variables:

To understand the internal consistency, reliability and the correlation between dependent and independent variables, correlation analysis has been performed using Minitab 17, the results are as captured in Fig. 4

Correlation Matrix

	Q1	Q1-1	Q1-2	Q1-3	Q1-4
Q1-1	0.738				
Q1-2	0.861	0.726			
Q1-3	0.835	0.779	0.888		
Q1-4	0.881	0.769	0.895	0.947	
Q1-5	0.877	0.815	0.886	0.956	0.955

Cell Contents: Pearson correlation

Item and Total Statistics

Variable	Total Count	Mean	StDev
Q1	182	4.742	0.551
Q1-1	182	4.225	0.742
Q1-2	182	4.692	0.519
Q1-3	182	4.571	0.684
Q1-4	182	4.549	0.818
Q1-5	182	4.456	0.944
Total	182	27.236	4.003

Cronbach's alpha = 0.9641

Omitted Item Statistics

Omitted Variable	Adj. Total Mean	Adj. Total StDev	Item-Adj. Total Corr	Squared Multiple Corr	Cronbach's Alpha
Q1	22.495	3.507	0.8879	0.8225	0.9606
Q1-1	23.011	3.383	0.8018	0.6693	0.9662
Q1-2	22.544	3.528	0.9034	0.8398	0.9607
Q1-3	22.665	3.349	0.9480	0.9336	0.9511
Q1-4	22.687	3.215	0.9546	0.9369	0.9500
Q1-5	22.780	3.084	0.9669	0.9487	0.9530

Figure 4: Correlation Matrix and Cronbach Alpha

As observed from correlation analysis (Fig.4), overall Cronbach alpha is 0.9641, indicating high correlation in the model. Individual Cronbach alpha is above 0.95 for the dependent and the independent variables indicative none of the independent variables need to be dropped in further analysis. However, correlation of Q_{1-1} with all other dependent and independent variables is low (0.73 to 0.78) when compared to others (0.84 to 0.96) as found in correlation matrix of Fig.4. Hence significance of Q_{1-1} can be inferenced from further research through Anova and regression analysis.

5.3 Anova and Regression Analysis

Further data analysis for statistical significance has been carried out using first order linear regression to find the fitness of the model and the coefficients. Regression analysis is robust and helps in finding the relationship and statistical significance of the independent variable on the dependent variable. It uses the Anova approach in analyzing the multiple variables at the same time, unlike that of correlation matrix which compares two variables at given time [Fig. 4].

Regression Analysis: Q1 versus Q1-1, Q1-2, Q1-3, Q1-4, Q1-5

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	5	45.1242	9.02485	163.10	0.000
Q1-1	1	0.1166	0.11657	2.11	0.148
Q1-2	1	1.2869	1.28689	23.26	0.000
Q1-3	1	0.5944	0.59444	10.74	0.001
Q1-4	1	0.8063	0.80629	14.57	0.000
Q1-5	1	0.5363	0.53630	9.69	0.002
Error	176	9.7384	0.05533		
Lack-of-Fit	9	2.6102	0.29002	6.79	0.000
Pure Error	167	7.1282	0.04268		
Total	181	54.8626			

Figure 5: Analysis of Variance

As seen in Fig 5 & 6, the independent variable Q_{1-1} can be inferred as insignificant and does not have an impact on dependent variable, as the P value is more than 0.05 for the 95% confidence interval considered; hence the null hypothesis H_{1-1} is accepted. This may be due to the fact, that there is a consistent focus of institutions on the soft skills of the students for the last few years by the institutions, hence employers might have not considered them important at this point time, when compared to the other skills. All other independent variables have P value less than 0.05 for the 95% confidence intervals, hence null hypothesis of H_{1-2}, H_{1-3}, H_{1-4} and H_{1-5} are all rejected & alternate hypothesis accepted

Further, the transfer function generated from the regression as captured in Fig 6, is indicative of good fit with Rsq and Rsq-adj values of around 82%. Higher percentage is indicative of goodness of the fit and the model.

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.235227	82.25%	81.75%	79.81%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	1.620	0.224	7.23	0.000	
Q1-1	0.0591	0.0407	1.45	0.148	2.99
Q1-2	0.3815	0.0791	4.82	0.000	5.51
Q1-3	-0.3158	0.0964	-3.28	0.001	14.19
Q1-4	0.3123	0.0818	3.82	0.000	14.64
Q1-5	0.2479	0.0796	3.11	0.002	18.46

Regression Equation

Q1 = 1.620 + 0.0591 Q1-1 + 0.3815 Q1-2 - 0.3158 Q1-3 + 0.3123 Q1-4 + 0.2479 Q1-5

Figure 6: Regression Model

5.4 Graphical Summary of Descriptive Statistics:

The details of the information as received from the respondents are captured in Fig 7 with the fit for normal distribution. Information on mean and standard deviation for the dependent and independent variables are as in Fig.7

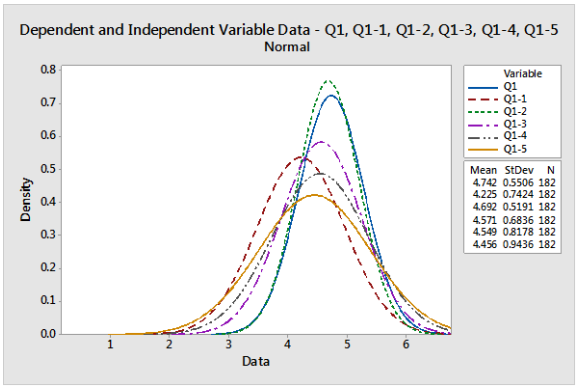


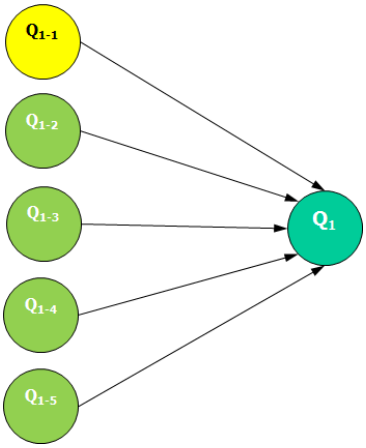
Figure 7: Descriptive Statistics on Variables

It could be observed from the graph, higher mean with a sharp bell curve for Q_1 indicates „must have preference of employers" and consistency amongst most of the respondents on the need. The independent variable Q_{1-1} is appearing to be having lower mean value and comparatively larger standard deviation, when compared to all other independent variables. However the mean 4.23 for 5 explains the importance of the skill need. Inferring by the P value from Fig 5 & 6, it can be concluded that Q_{1-1} need not be considered in further research and constructs, as it is of less significance. However, this will be confirmed after the sensitivity analysis as in 5.6, as mean is 4.23. Independent variable Q_{1-2} assumes higher importance from the statistical information as captured in Fig.7 and found to have a larger consensus amongst the respondents. There appears to be larger variation in the perception of the respondents on Q_{1-5} as observed in Fig. 7, with its mean is also lower when compared to all other independent variables. However, as observed earlier it is statistically significant [Fig. 5 & 6] from the employability aspect of the students

and as found in literatures [14]. The variable and its significance for Q_{1-4} on domain knowledge and its resultant knowledge gap gets the confirmation as reported under specific skills in [8]. The importance of the variable Q_{1-2} is in confirmation with the many literature surveys reported in [2], while importance and significance of Q_{1-3} has been demonstrated in [5, 6 & 7] on the defect produced due to lack of quality knowledge. As found in literature [5 &15] that the theoretical knowledge is available with the students and curriculum, but failure happens in applying them to practice.

5.5 Outcome of the Research:

Objective of this research work is to find few significant factors that are important from the customers (employer) perceptions that are easy to implement and shall deliver significant impact is captured in Fig. 8



$$Q_1 = 1.620 + (0.0591*Q_{1-1}) + (0.3815*Q_{1-2}) - (0.3158*Q_{1-3}) + (0.3123*Q_{1-4}) + (0.2479*Q_{1-5})$$

Figure 8: Dependent and Independent Variable Relationship

The decision on the term Q_{1-1} to be included in further construct is taken from sensitivity analysis [5.6], by using the transfer function (Fig. 8) by including or excluding the Q_{1-1} term in the sensitivity analysis with the data from [Fig. 7].

Further constructs based on this decision for each of these independent variables will analyzed as a part of the on-going research.

5.6 Predictive Model and Sensitivity Analysis:

Sensitivity analysis is carried-out using the predictive modeling approach, by utilizing the transfer function developed in the Monte Carlo simulation. Mean and standard deviation for the dependent variable is predicted using the transfer function with the mean and standard deviation of the independent variables [Fig.7] using the algorithm *Devize* [16] from Minitab for different sample sizes.

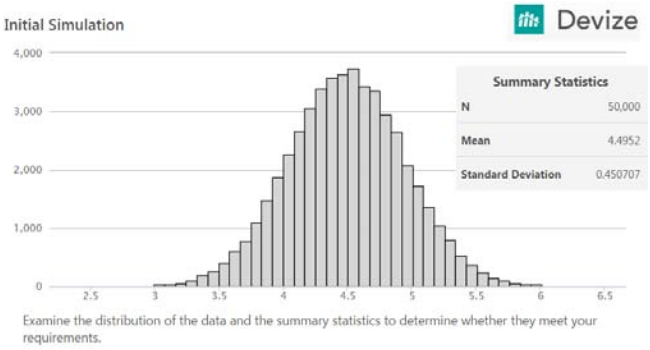


Figure 9: Dependent Variable Variance Prediction Using the Independent Variables Statistical Data and Relationship – Without including the term Q_{1-1}

Monte Carlo Simulation has been performed considering various sample sizes and the mean and standard deviation are predicted in analysisng the sensitivity and significance to include Q_{1-1} in further constructs [Fig 10].

Samples	Mean Q1 with Q1-1	Mean Q1 without Q1-1	Std Dev Q1 with Q1-1	Std Dev without Q1-1
10000	4.740	4.490	0.459	0.457
20000	4.740	4.489	0.453	0.452
30000	4.740	4.491	0.452	0.450
40000	4.741	4.491	0.453	0.450
50000	4.742	4.493	0.453	0.451

Figure 10: Dependent Variable Prediction - With and without the term Q_{1-1}

Paired T Test has been conducted to statistically conclude that there is no difference by including or excluding the term Q_{1-1} in the proposed research model. The null hypothesis developed for this analysis is as follows

H_{Q1-1-M} – Dependent variable Q_1 is not sensitive to the means by including Q_{1-1}
H_{Q1-1-S} – Dependent variable Q_1 is not sensitive to the standard deviation by including Q_{1-1}

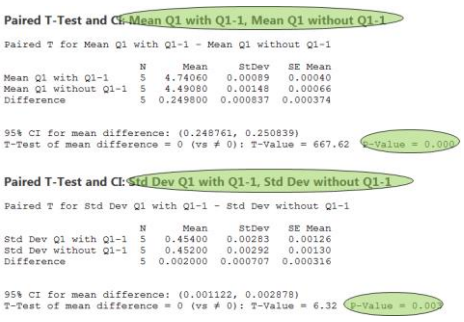
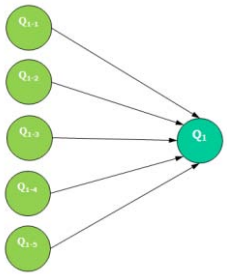


Figure 11: Paired T Test for Statistical Significance of Including or Excluding Q_{1-1} Term in Predictive Model

From the paired T Test as reported in Fig. 11, it is observed that the P value is less than 0.05 for both mean and standard deviation for 95% confidence interval. Hence we have to reject the null hypothesis of H_{Q1-1-M} and H_{Q1-1-S}. It implies that, there is a significant difference in the output of dependent variable by including Q_{1-1}. Hence the final model for further construct and transfer function from this research work are delivered as in Fig.12.



$Q_1 = 1.620 + (0.0591*Q_{1-1}) + (0.3815*Q_{1-2}) - (0.3158*Q_{1-3}) + (0.3123*Q_{1-4}) + (0.2479*Q_{1-5})$

Figure 11: Predictive Model for Knowledge Gap and Employability of Mechanical Engineering Graduates

6. Results and Conclusion

Following interpretations can be made from this research:

- Knowledge gap in applying theory to practice is across institutions in India
- Application of theory to practice is one of the most important variable that shall deliver a significant impact on reducing the defect on employability of mechanical engineering graduates
- Soft Skills, Analytical knowledge, knowledge on quality, domain knowledge and the faculty"s knowledge on practical applications significantly impacts the objective of reducing the knowledge gap of applying theory to practice, thus increasing employability rate of mechanical engineering students.
- The dependent and independent variable relations and correlation has been computed for further constructs.
- The regression equation has been developed and validated with predictive modeling approach from the data collected for this research
- Predictive Model delivered from this exploratory research work for the objective of reducing the knowledge gap, is though focused for mechanical engineering graduates, but can be adopted for other branches of engineering for plucking the low hanging fruits with appropriate constructs with relevant attributes of the domains.
- Though from the survey results, soft skills did not appear to be significant and its importance on the predictive model has been validated using sensitivity study and quantified through statistical analysis for inclusion of it in further research.
- The research work utilizes larger industry participation and many segments from larger locations of the country and states of India, results and the predictive model delivered can be used by all the engineering institutions offering mechanical engineering across India.

7. Further Work

Further attributes which are significant relevant to each of the independent variable shall be identified through further constructs, which shall be of immense help to the institutions in implementing solutions at the institutional level and thus making a significant impact on mechanical engineering student community.

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