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RESEARCH ARTICLE

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QUALITY SKILLS AS AN APPLIED KNOWLEDGE NEED IN EMPLOYABILITY OF ENGINEERING GRADUATES IN INDIA – EMPLOYERS' PERSPECTIVE

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ABSTRACT

Globalized competitive market, makes the industries to leverage the technological concepts like virtual factory, IoT (Internet of thing) etc., in getting the products faster to the market with least cost and execution of work by diversified global work force. Current day products, which are complex systems with many sub-systems and each sub-system has many components. With all these, if the product is not perceived as excellent in *'Quality' by the customer*, the industry has to face tough times in market, hence industries are conscious of *'Quality Excellence'* and *'continuous improvement'*. While hiring fresh graduates, industries expect the students are 'job-ready', as they do not have large time to train them on-the job. This changed trend of expectations vs availability of skills leaves many educational institutions' products defective in quality (unemployable), a cause of concern for all the stake holders of educational system. This research study brings-out the portion of the research work relating to quality as an applied knowledge of mechanical engineering graduates in India.

Keywords: Make in India**,** Skill Development**,** Employability, Engineering Graduates, Six Sigma, ANOVA, Regression,QFD, Educational Quality

I INTRODUCTION

India, due to its climate, knowledge potentials, least cost of labour, and well connected mode of transportation systems has attracted many of the MNCs (Multi National Accompanies) in last few decades to 'Make in India'. Strong industrial growth component of GDP forecast of 10.26% [1] for 2016 to 2022 reinforces the growth story of Indian industry. MNCs arrival in India has also contributed to the growth of Indian Industries and knowledge on global expectations. The growth of industries provided larger opportunities for employment and hence the growth of educational industries itself. Engineering institutions is one of the verticals of the educational industry, which produces engineering graduates. Current level of employable engineering graduates in India is around 25% as cited from the literature survey in [2 to 4]. As brought-out in [5 & 6] most of the literatures attributed the issue of lower employability to soft skills like communication, ethics etc., and there is little or no mention of applying theoretical knowledge to practical application (applied knowledge) as a factor in employability. It could be visualised from Fig.1 [7], applied knowledge

skill is an important factor not only in employability, but also in making the successful work place and is inter-linked with other skills. Ramanan et. al [5] have brought out five factors that are important in applying theoretical knowledge to practice. Out of these five factors and the attributes related to two of them are detailed in [6 & 8] by identifying significant factors that are important in applying theoretical knowledge to practice as perceived by the employers related to mechanical engineering graduates in India. This paper deals with third factor i.e. quality knowledge and their attributes from employers' perception to applied knowledge in the employability of mechanical engineering graduates in India.

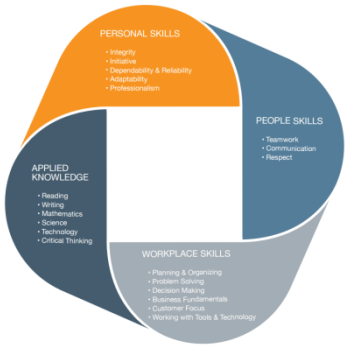

Fig.1 Interconnections of Employability Skills

II RESEARCH METHODOLOGY

Samples, Size, Distribution and Approach

Six Sigma quality management approach demonstrated with derived benefits and success by the industry has been leveraged in this research work. DMAIC and DFSS approaches and its application to educational industry are explained in detail in [4, 9 &10]. Details of five factors affecting the applied knowledge as found for this research work, samples, respondent distributions by industry segments and regions of India are detailed in [5,6& 8]. Integration of research study with DMAIC approach of six sigma is as in Fig 2. Each of the factors that have an influence on applied knowledge as perceived by the employers follows the process map as in Fig. 2. The multi-stage sampling includes both judgmental and snowball sampling approach in data collection. Total sample of 352 represents the respondents from different regions of India and also various industry segments [6].

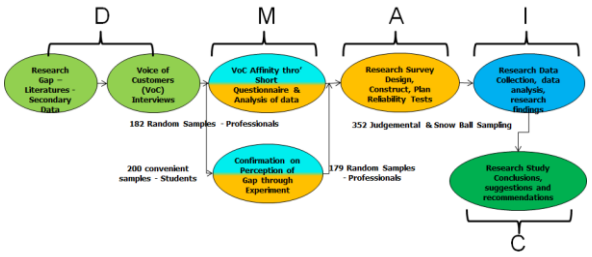

Fig.2Six Sigma Integration in Research Study

Survey Design and Instrument

Self-Administered research questionnaire covers the factors as detailed in [6 & 8] takes into accounts the attributes as reported in NBA (National Board of Accreditation), Washington Accord, literatures and the opinions expressed during initial survey [5] that are perceived to have an impact on the factors and purpose related to applying theoretical knowledge to practice. This paper restricts the discussions to quality skills and its related attributes. Research survey questionnaire structured into two components 1) rating on the importance and need and 2) ranking on the skills available with fresh engineering undergraduates related to quality factors and attributes towards applied knowledge as perceived by employer. Both of these components are used in quantifying gap and solution development. The dependent and Independent variables are as in Table 1 and the simplified questionnaire is as Table 2.

Table 1. Dependent and Independent Variable

Independent Variable	Dependent Variable
Defect Awareness	Quality Engineering & Tools Skill
QC Tools	
Risk Prediction	
Engineering Statistics	
Reliability	
Quality System	
Sources of Variation	

Question Code	Simplified Question from the description of survey questionnaire	Pl. rate the importance of the Need	Pl. rank the skill of fresh graduate
		Strong Agree - 5 Agree - 4 Neither agree nor Disagree - 3 Disagree - 2 Strong Disagree - 1	Good - 5 Above Ave - 4 Average - 3 Below Ave - 2 Bad - 1
QE	Quality Engineering knowledge and tools skills from theory to practical application		
QE-1	Quality, awareness of defects and its impact on product or process knowledge		
QE-2	QC Tools skills on SPC, trend charts, process capability etc towards applied knowledge		
QE-3	Risk prediction approach using FMEA etc., application from theory to practice		
QE-4	Theoretical knowledge from engineering statistics to practice.		
QE-5	Knowledge from theory on reliability testing and awareness to practical application		
QE-6	Quality System and documentation awareness.		
QE-7	Knowledge on sources of variation and its impact in quality		

Table 2 – Simplified Survey Questionnaire for Quality and its attributes

As detailed in [2] the questionnaire was color coded to distinguish the scores for rating of importance and ranking of skills availability as perceived. The ratings and rankings are received on Likert scales as shown in Table 2.

Research Hypothesis

Following research hypothesis (null-hypothesis) were developed for the research questions related to the analytical and problem solving skills.

Hqe-a – Quality engineering & tools applied knowledge gap amongst mechanical graduates is not significantly different across regions.

Hqe-b– Quality engineering & tools applied knowledge gap amongst mechanical graduates is not significantly different across industry segments.

Hqe-1a– Quality, awareness of defects and impact on product or process applied knowledge gap is not significantly different across regions.

Hqe-1b– Quality, awareness of defects and impact on product or process applied knowledge gap is not different across industry segments

Hqe-1c– Quality, awareness of defects and impact on product or process applied knowledge gap is not influencing applied knowledge of quality engineering skills.

Hqe-2a– Quality tools application knowledge gap not significantly different across regions

Hqe-2b– Quality tools application knowledge gap is not different across industry segments
Hqe-2c– Quality tools application knowledge gap does not have an influence on applied knowledge of quality engineering skills.
Hqe-3a– Risk prediction application knowledge gap is not significantly different across regions
Hqe-3b– Risk prediction application knowledge gap is not different across industry segments
Hqe-3c– Risk prediction application knowledge gap does not have an influence on applied knowledge of quality engineering skills.
Hqe-4a– Applied statistics knowledge gap is not significantly different across regions
Haps-4b– Applied statistics knowledge gap is not significantly different across industry segments
Hqe-4c– Applied statistics knowledge gap does not have an influence on application knowledge of quality engineering skills.
Hqe-5a– Reliability testing awareness knowledge gap is not significantly different across regions
Hqe-5b– Reliability testing awareness knowledge gap is not significantly different across industry segments
Hqe-5c– Reliability testing awareness knowledge gap does not have an influence on application knowledge of quality engineering skills.
Hqe-6a– Gap in Quality system documentation knowledge is not significantly different across regions
Hqe-6b– Gap in Quality system documentation knowledge, is not significantly different across industry segments
Hqe-6c– Gap in Quality system documentation knowledge does not have an influence on does not have an influence on application knowledge of quality engineering skills.
Hqe-7a– Knowledge gap to identify sources of variation, is not significantly different across regions
Hqe-7b– Knowledge gap to identify sources of variation, is not significantly different across industry segments
Hqe-7c– Knowledge gap to identify sources of variation does not have an influence on application knowledge of quality engineering skills.

III RESEARCH FINDINGS

Data collected from the respondents are used in commuting the gap as an employer perception. Statistical analysis was carried-out using the multipurpose commercial statistical algorithm Minitab version 17 [11].

Gap in Quality Engineering Application Knowledge

The perceived opinion and view of the individual respondents as the representative of the employer has been used in computing the gap between expectation vs availability with fresh mechanical engineering graduates. Fig. 3 explains the gap with the means of the dependent and independent variables, through interval plot, related to quality engineering applied knowledge skills for this research paper.

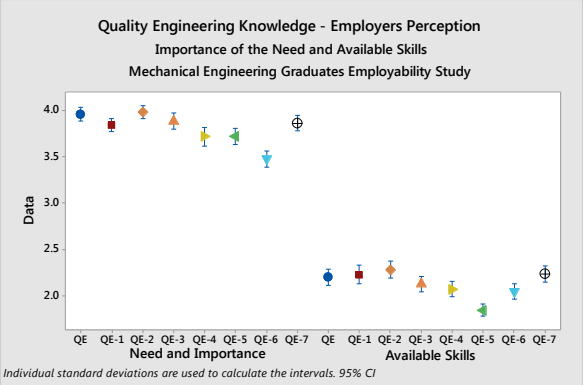

Fig. 3 Employers' Perception on Importance and Availability of Quality Engineering Applied Knowledge – A factor in Employability Skills of Mechanical Engineering Graduates

As could be seen from the interval plot in Fig 3, employers perceive the importance for quality engineering applied knowledge with a mean of 4.0, while the availability of the knowledge skill with fresh mechanical engineering graduates are 2.2, explaining a gap of 1.8 on a 5 point scale, which can be quantified as a gap of 36%, between expectations vs availability. A similar analysis for the other independent variables is carried out to analyse the gap and is captured inFig.4 as a box-plot. A close look at the data as captured from the perception of employers reveals that there are portion of respondents who feel there is no gap with a score of '0', while some of them even feel the applied

knowledge availability on quality engineering is more than their expectations with the scores ranging up to -2 on a 5 point scale. Boxplots are indicative of outliers for QE-1 & 2, 6&7 as in Fig. 3, this prompts for further investigations on the perceptions. Analysis of QE-1 as captured in Fig.5 reveals that, only a very smaller section of the respondents (~5%) alone feel that the available skill for QE-1 is more than their expectations{ with negative scores), while 9.7% of respondents feel there is no gap. Interesting a very small percentage of employers (3.7%) feel the gap is very high with a score of 4 for the gap on the scale of 5. Overall, 85% respondents the gap between their expectations and availability exists and an opportunity for closing the gap from the institutional initiatives for improving the employability of mechanical engineering graduates

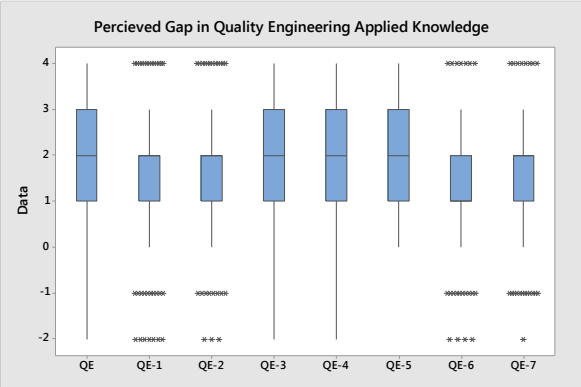

Fig.4 Perception of Employers on Gap in Quality Engineering Knowledge and Attributes

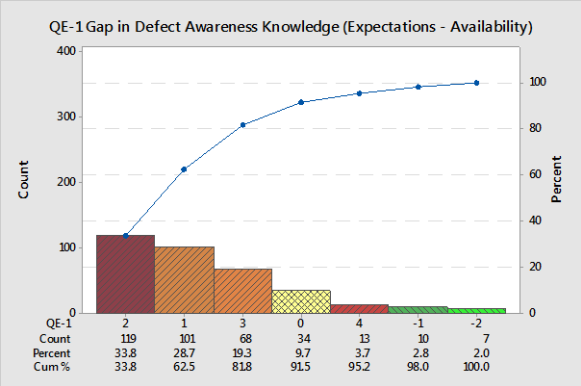

Fig.5 Perceived Gap in Defect Awareness Knowledge – An Attribute to Quality Engineering Applied Knowledge

Anova and Regression Analysis

To confirm the attributes relevance to the factor (independent variables significance with dependent variables) statistical analysis was carried-out with the confidence interval of 95%.

Regression analysis is carried out to test the hypothesis as stated earlier for the statistical significance for the importance of individual factors. The details of the hypothesized codes of questions with relevant statistical tools applied and the p values are as posted in Table 3

Hypothesis	Statistical Tool	p Value	Details
Hqe-a	One Way Anova	0.294	Regions of India
Hqe-1a		0.324	
Hqe-2a		0.276	
Hqe-3a		0.403	
Hqe-4a		0.141	
Hqe-5a		0.736	
Hqe-6a		0.602	
Hqe-7a		0.213	
Hqe-b		0.320	Industry Segments
Hqe-1b		0.680	
Hqe-2b		0.609	
Hqe-3b		0.024	
Hqe-4b		0.307	
Hqe-5b		0.450	
Hqe-6b		0.744	
Hqe-7b		0.323	
Hqe-1c	Linear Regression	0.000	Relation of Independent variables with dependent variable
Hqe-2c		0.000	
Hqe-3c		0.000	
Hqe-4c		0.020	
Hqe-5c		0.186	
Hqe-6c		0.001	
Hqe-7c		0.000	

Table 3.Hypothesis Testing and P Value

At the first instance, data was analyzed to confirm whether the trend on quality engineering knowledge gap is same across Industries segments and the regional locations of India from the perception of employers. Hypothesis testing (Haps-a & Haps-b) using one way Anova, found $p > 0.05$ [Table -3] with 95% confidence interval, thus null-hypothesis for Haps-a & Haps-b are accepted.

Significance of independent variables (Hqe-1a to Hqe-7a) relating to dependent variable of quality engineering knowledge are not found to be significantly different across regions of India and their respective null-hypothesis are accepted [p> 0.05 Table – 3].

Analysing the significance of independent variables (Hqe-1b to Hqe-7b) to the industries segments, relating to dependent variable of quality engineering knowledge, except for Hqe-3b are not found to be not significantly different across industries segments and their respective null-hypothesis are accepted [p > 0.05 Table – 3]. However, the independent variable relating to gap in knowledge of risk prediction approaches (Hqe-3b) is found to be perceived across industries segment as captured in the interval plot [Fig.6]. Industries segments identified by code numbers are detailed in [6] for their respective industrial segments. As could be observed from Fig.6, the attribute on risk prediction knowledge is perceived to be different as it is highly important to industries like Aero Space, Aircraft, Automotive etc., while some other segments do not feel the importance at the same level.

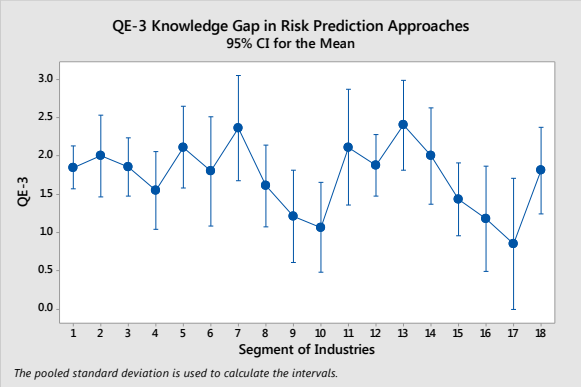

Fig. 6 Knowledge Gap in Risk Prediction Approaches

The relationship between independent variables with dependent variables has been established through linear regression, with R-Sq value of 64.14% and R-Sq(adj) of 63.41% and R-Sq (pred) 61.70%. Closeness in R-Sq values explains the good fit of the perceptions measured [Fig.7]. As reported in Table 3, the attribute Hqe-5C is not found to be significantly important from employers' perspective of applied knowledge gap resulting employability issue of mechanical engineering under-graduate students, from the regression analysis. Hence the term is dropped and the established relationship between dependent and independent variables through transfer function along with the residual plots for the regression as captured in Fig. 7

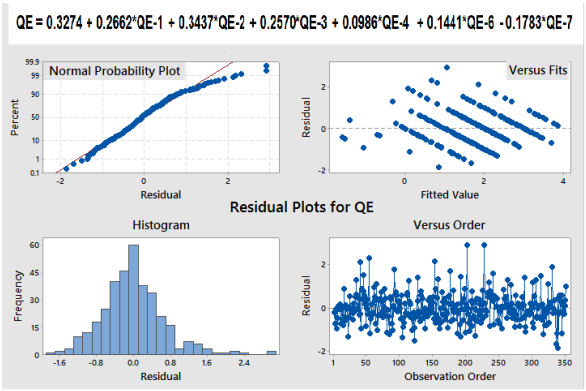

Fig. 7.Residual Plots

IVAPPROACH TO SOLUTION IN REDUCING GAP

Predictive Modeling– A Two Step Approach

In the first step the developed transfer function is utilised in predicting the variation in the output, by using the mean and standard deviation data from the survey. Predictive simulation using Monte-Carlo model in Devize [12] has been performed, with gap prediction ranging between 0 and 4. In first stage the model has been used to predict the out of spec range with higher gap to 2.5, and found to be ~17% as seen in Fig. 8 and it has been reduced to zero by controlling the input variations (Table 4) of the independent variables.

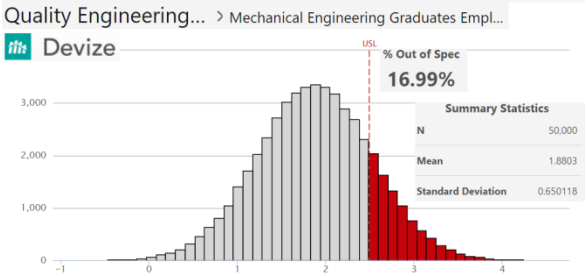

Fig.8. Quality Knowledge Skill Gap – Predictive Model (Using the Transfer Function and as Perceived by the Employers at the current level – Red indicate gap above 2.5 on scale of 5)

Second step of the solution development, focuses on shifting the mean to zero by focusing on the

strengths and weakness of individual institutions relevant to the independent variables in shifting the gap from the mean of 1.88 [Fig 9] to zero. This can be achieved in multi-stage or in single stage depending on the time, effort, commitment to the cause by the management of the institutions. QFD has been used in identifying the few factors that are impactful to all other variables as detailed in [8]

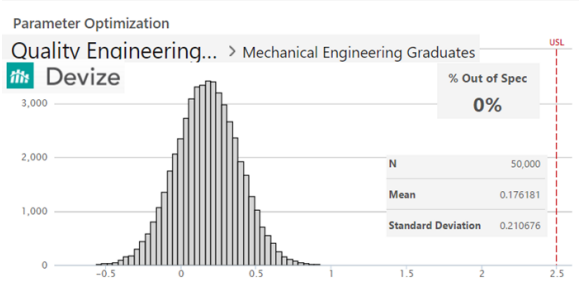

Fig. 9 Predictive Model for the Gap by Controlling Input Variations and Shifting the Mean

Statistics lab a solution, which is recommended for reducing the knowledge gap is also found to have an impact in reducing the applied knowledge gap of quality engineering. Similarly DFMEA and PFMEA recommended solutions for reducing the fundamental application knowledge in analytical skills are found to have an impact in reducing the gap due to risk predictions and mitigations.

Measurement System Analysis (MSA) which is essential and is currently not the practice in most of the institutions' practical lab on Metrology Lab, which was found to have high impact in reducing the knowledge gap on domain skills of mechanical engineers, is also found to be highly helpful in reducing the gap in applied knowledge due to quality skills.

It could be seen from Fig.10 of QFD, flowing the significant Xs for the Y relating to quality knowledge, one can observe, employers expect knowledge on root cause analysis, sources of variation, MSA, data analytics, Risk prediction analysis, defect awareness and quality impact in the order of importance. However, they do not expect graduate mechanical engineering students to have the skills at the same importance of those mentioned earlier.

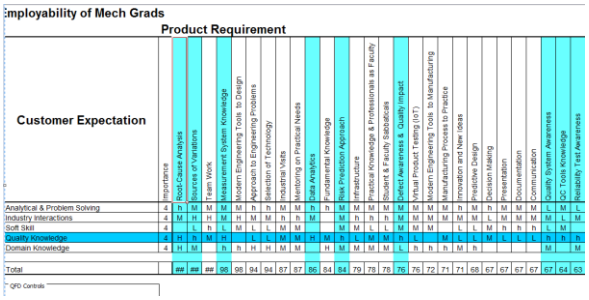

Fig. 10Significant Attributes for Quality Skills in Applied Knowledge

Out of the above, Xs, if we flow back most of them covers the other employability factors expected by the employers [Fig 11]. Thus there is no specific effort needed to be separately to reduce the gap in quality expectations.

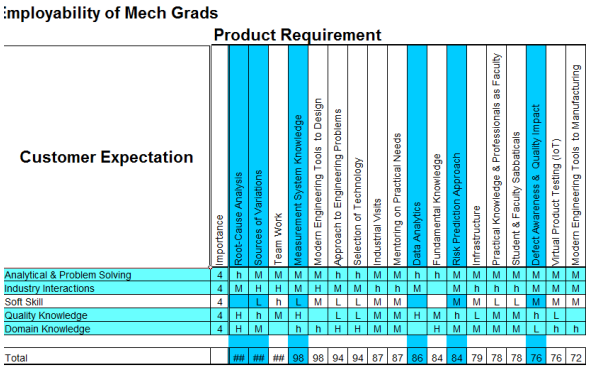

Fig. 11Significant Attributes of Quality Skills (Xs) that Fulfils Other Expectations (Ys) in reducing the Applied Knowledge Gap of Mechanical Engineering Students

In the absence of a structured approach like the QFD, one might have concentrated on a skill like awareness to quality systems and building the skills, which would not have paid the dividends. Thus, a structure approach in choosing few significant Xs that have large impact on all Ys as presented here is important.

The author with his extensive expertise on process and product quality excellence with the leaders of the industry, as a subject matter expert (SME) can support educational institutions striving for achieving quality excellence.

V RESULTS AND CONCLUSSIONS

The following conclusions can be arrived from this research work.

- Quality engineering applied knowledge gap is across regions of India and industry segments.
- Recommended solutions like Statistics lab, FMEA, analytical lab for reducing the gap in applied knowledge gap due to analytical skills are found to have an impact in reducing the applied knowledge gap in quality engineering
- Measurement system analysis approach in the lab recommended to the metrology lab in reducing the applied knowledge gap in domain skills is found to be useful in enhancing the quality engineering applied knowledge.
- QFD usage in identifying critical few factors that impact all other dependent variables are helpful in identifying easy to implement factor.
- Regression model developed can be adopted by the engineering educational institutions for improving analytical and problem solving skills.
- Predictive model approach developed and as presented in this work can be embraced by institutions to reduce the analytical and problem solving skill gap by reducing the variations on the independent variables as demonstrated in this work through predictive modelling

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Ramanan, is an entrepreneur of RAISE Consultancy Services, Bengaluru, is an alumnus of IIT Madras, studded with patents, publications in his 35+ years of experience with multi domain, product & cross functional expertise from global poles with Leaders like GE, TVS, Indian Railways etc.,. He earned many prestigious awards & titles like 'Pillars of Pride' from GE India and a six sigma quality champion. He has been a Jury for the National Six Sigma award conducted by CII -Institute of Quality, India and serves many Industries as a Subject matter expert in Quality, Robust Design and Technology domains.

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