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Improving the Performance of Engineering Students with Aspiration, Innate Ability through Competency based Education*

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The policy of economic liberalization pursued by India over the last two decades has attracted global players and intensified competition in the Indian market. To compete effectively in this scenario, Indian companies need to address competency gaps quickly. The rapid growth of Information Technology and IT enabled service sectors has spurred growth in engineering education, without the requisite improvements in governance, infrastructure and quality of faculty. Most students gravitate to studying engineering under parental or peer pressure rather than genuine aptitude, consequently their academic and subsequent careers suffer. Research shows that if aspirations are aligned to innate ability with greater engagement in learning new knowledge and skills, the student's potential and performance improves. This paper presents a study in which students were assessed for their innate ability and assigned appropriate roles and counselled to articulate their aspiration in terms of life and career goals. They were then subjected to competency based education in collaboration with engineering institutions. Interim assessments indicate that students who took part in the collaborative program performed significantly better and demonstrated greater industry and role readiness than the rest of the students.

Keywords: innate ability; aspiration; competency; engagement; potential

1. Introduction

India is a fast growing economy that offers abundant business opportunities in a highly competitive environment. The Indian economy has witnessed widespread economic reforms leading to the entry of many global companies [1]. Indian companies are required to compete with these global companies who have sound business models, mature business processes, core competence and strong brand equity. Indian organisations have to acquire scale and a sustainable competitive advantage in order to compete and grow in this rapidly changing environment.

The economic progress of a country is strongly linked to the quality of its education—especially technical education, which plays a vital role in the social and economic development of a nation [1]. The need to change the practice of engineering and engineering education is driven by the general technological advances, pervasive use of information technology, the modification of value-adding chains, the vast array of new materials and processes that broaden the engineers' design space, the increasing number and complexity of economic, political and ethical constraints, the need for teamwork and the fast pace of change calling for lifelong learning [2]. This is especially relevant to the automotive industry (to which the first author belongs), which is highly competitive and dynamic with innovation and change driven by customers, competition and regulation.

Indian higher education systems suffer from significant structural shortcomings and face huge challenges in meeting the current and future expectations [1]. The emergence of Information Technology (IT) and Information Technology Enabled Services (ITES) sector in India in the last two decades has led to the proliferation of a large number of engineering education institutions. The lack of awareness and effort of engineering educationalists to produce potential engineers resulted in disharmony between the requirements of the organisations and the capabilities of the engineers supplied. Very little effort has been exerted by the engineering educationalists to align the requirements of organisations with the capabilities of engineers supplied [4]. Engineering institutions have mushroomed without adequate infrastructure, effective governance and good faculty, resulting in poor quality of engineering education.

Some of the requirements to build capacity for Innovation include the transformation of large private companies and the creation of an incentive system for institutions of higher learning that is more consistent with the strengthening of industrial innovation capabilities [5]. The design, development and manufacture of products require a strong

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foundation in domain knowledge and lifelong learning to keep pace with rapid technological developments. Generally students focus more on clearing examinations and securing good grades, than on acquiring in-depth domain knowledge. Most students choose courses and careers in engineering based on their parents' aspirations or peer group influence, rather than their own aptitude and potential. Such students lack a passion for engineering, an essential quality for building capacity for innovation and superior performance.

Given this scenario, most companies resort to setting up finishing schools for entry level graduate engineers with structured courses and on-the-job training to acquaint them with fundamentals and make them fit for entry level roles. In the automotive sector, it takes up to two years for the engineers to become effective in their roles. By the time the engineers have become effective in the entry level role, they are moved to the next role for which they are not fully equipped. Most engineers lack genuine aptitude for engineering and are not fully committed to learning to equip themselves for current and future roles. The big challenge then boils down to educating students in the art of 'learning how to learn' and to empower them to take charge of their own education, within the context of an ever-increasing volume of subject matter to be comprehended [6].

Many educators agree that a major step in this direction will be to anchor engineering education in a more holistic perspective [6]. There ought to be superior alignment between societal needs, technologies, cross disciplinary integration and associated educational activities [6]. A major task is to prepare engineers who will be able to identify and solve problems which have not yet arisen with tools and methods not yet developed [6].

1.1 Teaching and learning process for engineering education

The education system in India is unfortunately rote based, memorizing the learning content without an understanding of the concepts and context. A concept known as 'Bloom Taxonomy' is a useful framework that enables students to learn in a systematic manner. It is based on two dimensions: cognitive process dimensions and knowledge dimensions [7]. There are six dimensions in cognitive process: Remember, Understand, Apply, Analyse, Evaluate and Create [7]. The knowledge dimension contains four categories: Factual, Conceptual, Procedural and Meta-cognitive [7].

Instruction (teaching or training) facilitates learning when it supports the internal processing of information. A structured instructional design framework plays a major role in improving the effectiveness of the teaching and learning process, along with Bloom Taxonomy. Instructional design has evolved as a science that supports outcome based teaching and learning, which is also known as 'competency based education'. Instructions are external events that must align with internal events to support internal learning processes [8]. Learning capabilities can be developed by leveraging intellectual skills, cognitive strategies, verbal information, attitudes and motor skills [8]. Competency based education aims at delivering competencies required to be demonstrated at the end of an education program that are relevant to the target roles.

Towards the objective of evolving a holistic approach to develop industry and role ready engineers in a competitive environment, the authors reviewed literature on the 'potential of people' and 'competency'. A high-potential employee is someone with the ability, engagement and aspiration to rise to, and succeed in, more senior and critical positions [9]. Ability comprises two aspects, which include innate ability and learned skills [9]. In order to get the best from people, it is necessary to align aspiration with innate ability. Competency comprises five characteristics: traits, motive, attitude, knowledge and skills [10]. Of these, traits and motive are part of the core personality of a person, which is nothing but innate ability.

It is necessity that one finds meaning in life even in adverse situations and a person who has a 'Why' to live can deal with almost any 'How' [11]. 'The Why' refers to the search for meaning that finds its way into our offices and factories, a search that motivates, inspires and defines us [12]. Humans are meaning-making machines who find inherent value in making sense out of life [12]. The meaning we create can make life feel rich and full, regardless of our external circumstances or give us the courage to change our external circumstances [12]. Employees who find meaning at work are more competent, committed and contributing [12]. If students' aspirations are aligned to innate ability and they are committed and engaged to learn the skills, their potential can be enhanced and hence their performance.

This paper presents a study in which a framework has been established to develop industry and role ready engineers by: (1) identifying, defining, assessing innate abilities for benchmarked roles and then determining the best fit of the role, supporting to set aspiration, (2) establishing competency based engineering education through a collaborative program with engineering institutes, (3) establishing projects for role readiness and qualify students for entry level roles and (4) assessing the academic performance and role fitment in the organisation where they become employed.

2. Defining potential and competence

Talent management processes in organisations aim to identify high-potential employees and develop them so that they realise their full potential. The Corporate Leadership Council (CLC), which is part of the Corporate Executive Board (CEB), has been doing pioneering work on strategies that build employee potential. Research shows that organisations that successfully identify and develop high-potential talent will enjoy short and long term advantages over their competitors [9]. The reality is that it is not easy to identify tomorrow's stars today and to ensure that they live up to expectations [9]. Most strategies aimed at identifying high-potential employees are inaccurate, as they rely on incomplete criteria. Of over three hundred strategies, programs and interventions examined in this study, fewer than 80 truly build employee potential [9]. A high-potential employee is a person with the ability, engagement and aspiration to rise to, and succeed in, senior and critical positions [9] (Fig. 1). The first author has adopted this framework to develop potential for engineering students, hired by his company. If individual 'potential' can be addressed while learning engineering, the probability of recruiting high-potential employees would be higher.

'The Ability' of an engineering student consists of 'Innate ability', which is part of his/her core personality and 'Learned skills', which are acquired through formal and informal learning. Engagement defines how a student emotionally connects with learning engineering knowledge and skills with passion. Aspiration concerns life and career goals. 'Potential' can be enhanced by strengthening these factors and aligning them better.

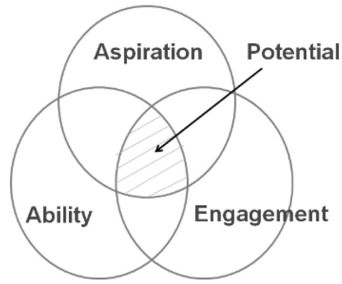

Fig. 1. Potential of employees (Source [9]).

2.1 Competence

A popular and widely referred work on competency is *Competence at Work* by Lyle M. Spencer and Signe M. Spencer. Competency is an underlying characteristic of an individual that is causally related to criteria—referenced effective and/or superior performance in a job or situation [10]. The following are five types of competency characteristics [10] as shown in Fig. 2.

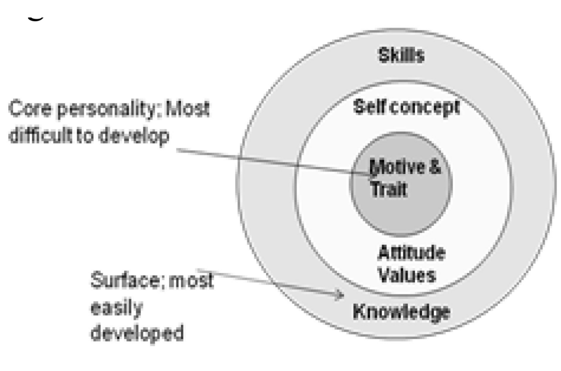

Fig. 2. Characteristics of competency (Source [10]).

1. Motive: The thing a person consistently thinks about or wants that cause action.
2. Traits: Physical characteristics and consistent responses to situations or information.
3. Self-concept: A person's attitude, values or self-image.
4. Knowledge: Information a person has in specific content areas.
5. Skill: The ability to perform a certain physical or mental task.

Surface level knowledge and skill competencies are relatively easy to develop through education and training. However, motive and trait competencies are more difficult to assess and to develop. This is equivalent to the innate ability mentioned in the CLC research. Organisations should assess motives and trait competencies as the basis for selection and then teach knowledge and skills required to do specific jobs [10].

3. Assessment of innate ability and role fitment

Most of the students in India who join engineering courses are driven by parental aspirations or peer group influences rather than their own desires or their innate abilities. Hence there is no alignment with the discipline of engineering, the organisations and the jobs they choose. Many are not fully engaged during their studies, career and life. They do not learn the skills required to improve performance in their studies, current and future roles. They just take available jobs rather than considering a career that leverages upon their abilities.

3.1 Identification and definition of innate ability

The author, along with an applied psychologist and line managers, identified the motives and trait competencies for three benchmarked roles in his organisation—Computer Aided Design (CAD)/

Design Engineer, Proving/Process planning engineer and Team/Group leader. The traits considered included: rigor, an eye for abnormality, self-discipline, compliance and decisiveness; examples of motives included achievement and affiliation. The traits and motives were clearly defined by the team. For example, Sociability was defined in five dimensions: inclusion, belongingness, intimacy, collaboration and empathy. The elements of Sociability were defined as below:

- Inclusion—paying attention to a person and treating them as important.
- Belongingness—willingness to join others on tasks, particularly in challenging situations.
- Intimacy—interpersonal openness, being close, affectionate.
- Collaboration—supporting and complementing, adding value.
- Empathy—sensing the difficulties of others, concern for others' difficulties, being in the shoes of others.
- Rigor was defined in six dimensions: Commitment to purpose, Attention to details, Eye for abnormality, Self-discipline, Compliance, Decisive. The elements of Rigor were defined as below: commitment to purpose—goal orientation, achievement orientation.
- Attention to details—data gathering, information gathering, sharp micro/macro data perception.
- Eye for abnormality—ability to differentiate.
- Self-discipline—willingness to sacrifice, withstanding criticism.
- Compliance—meticulous spirit to follow norms, rules, systems.
- Decisive—decision making plus perseverance.

The team identified traits and motives required for benchmarked roles as showed in the Table 1.

3.2 Assessment of innate ability

Assessment of innate abilities, such as trait and motive, is a challenging task. Innate abilities are tracked from the behavioural manifestations or cognitive responses to hypothetical situations. Traditionally The Sixteen Personality Factor (16PF), Guilford–Zimmerman Attitude Survey and Personality Attribute Questionnaire (PAQ) are used by organisations for decisions on selection. However they are not found amenable for assessing specific traits used for this purpose and role fitment. The authors, along with an applied psychologist, designed a two day assessment process by adopting appropriate assessment tools. The team identified set of questionnaires and designed individual tasks and group tasks which were administered on day-1. These tools assessed some of the traits and motives. In addition, a Behavioural Event Interview (BEI) was used to assess the remaining traits and motive on day-2. BEI is based on the concept of Appreciative Inquiry (AI). AI is an art of discovering and developing others by focusing on their strengths, positive experiences and moments of excellence. David Cooperrider and Suresh Srivastva of Case Western Reserve University, Cleveland has contributed to the development of AI approach, which involves open ended generative questions and deep listening. Observers were identified for the first day assessment and panel members were identified for BEI. They were trained with a formal workshop and qualified for improving accuracy of assessment.

Table 2 shows the final output of trait and motive scores and suitable roles for the candidates. It was seen that a few candidates were found suitable for more than one role and some for one of the roles.

In the selection centre, students were selected for the collaborative programmes of the first author's organisation with a polytechnic and an engineering institute. The selected students were sponsored with a residential programme and commitment for employment on completion of the programme. A workshop was organised to enable the students to articulate their aspirations. The workshop was aimed to create awareness about themselves, develop perspectives about professional self, set personal and career goals and align subsequent actions. The innate ability scores were shared with the students. These scores, along with information

Table 1. Traits and motives for benchmarked roles

	Computer Aided Design (CAD)/Design engineer	**Proving/Process planning engineer**	**Team/Group leader**
Traits	Rigor (H) Sociability (M) Idea orientation (H) Abstract reasoning (H) Flexibility (M)	Rigor (H) Sociability (M) Idea orientation (M) Abstract reasoning (M) Flexibility (H)	Rigor (H) Sociability(H) Influencing (H) Urgency (H)
Motives	Achievement (H)	Achievement (H)	Achievement (H) Affiliation (H)

H—High, M—Medium, L—Low.

Table 2. Selection and role fitment using traits and motive

											Roles during selection*			
#	Name	Rigor	Idea orientation	Abstract reasoning	Flexibility	Influencing	Sociability	Urgency	Motives	Values	CE	PE	TL	Role assigned
1	AAAA	77	60	100	90	70	75	79	80	80.5		×		PE
2	BBBB	90	30	95	70	72	71	77	75	80			×	TL
3	CCCC	91	53	100	90	79	73	85	85	81.8		×	×	TL
4	DDDD	93	60	95	80	59	67	91	70	76	×	×		CE
5	EEEEE	91	45	100	80	69	71	80	85	74.8		×		PE
6	FFFFF	95	55	100	90	74	75	97	85	87.3		×	×	TL

* CE—CAD engineer, PE—Proving engineer, TL—Team leader.

obtained from discussions with the students on their reflections, were used to assign future roles. The workshop helped by guiding them in making well informed choices of possible roles.

4. Engaging to learn the skills-competency-based engineering education

Real engagement in engineering institutes occurs with a well-designed and contemporary approach for teaching and learning aligned to target roles in the industry. Unfortunately, Indian engineering educationalists have devoted very little effort towards aligning the requirement of employers with the capabilities of students [4]. A competency based approach has been in existence for a while and is used in education, and in the corporate world. This is also called outcome based teaching and learning. Competency based education has remained essentially unchanged since the 1960s, with regard to features such as a focus on outcomes, greater workplace relevance, outcomes as observable competencies, assessments as judgments of competence, improved skills recognition, improved articulation and credit transfer [13]. The effectiveness and efficiency of any educational program is largely dependent on the philosophy of the curriculum design with focus on specific competencies [14].

4.1 Competency based engineering education

The competency based approach needs to bring clarity to how the curriculum brings a focus on competencies in terms of the level at which students learn and practice them, what teaching strategies and assignments are used, what assessments (methodologies, resources and instruments) are chosen for the students to master the competences, how to develop and improve indicators in order to achieve the learning outcomes [15]. Owing to market competition and tight resources in today's world, industries not only expect technical skills, but also professional skills, such as effective communication, teamwork, leadership, business knowledge, entrepreneurship, and project management in engineers [16]. It is now a common practice for undergraduate curricula to be finely balanced between disciplinary knowledge and the more universal generic skills. Such demands come from stakeholders in higher education [17]. Engineering education needs to create a *holistic engineers' profile* with a system perspective view, an interdisciplinary approach, and project-based learning strategy, symbiotic relationship between research, education and innovation [18]. It was found that most important active teaching/learning methodologies include Cooperative learning, Peer-assisted learning, Problems/Projects based learning, Work-based learning and Reflexive learning [19]. A successful implementation of new engineering education will lead to Integrated and holistic education, Professional updating, Varied learning and evaluation methods, Research and development orientation, Professional competence and practical skills, International expertise, Interdisciplinary, innovation and entrepreneurship[20].

The authors studied Bloom's Taxonomy framework developed by Lorin W. Anderson and David R. Krathwohl, based on research carried out on cognitive process and knowledge dimensions of learning. There are six dimensions of cognitive process: Remember, Understand, Apply, Analyse, Evaluate and Create [7]. These six dimensions represent cognitive complexity; that is, 'Understand' is believed to be more cognitively complex than 'Remember'. 'Apply' is believed to be more cognitively complex than 'Understand' and so on. The knowledge dimension contains four categories: Factual, Conceptual, Procedural and Meta-cognitive. These categories are assumed to lie along a continuum from concrete (factual) to abstract (Meta-cognitive). In addition to Bloom Taxonomy, another methodology that would be useful for developing competency based education is Instructional design. Learning outcomes can be delivered through a structured design of instructions, activities and projects. Instruction facilitates learning when it supports the internal events of information processing [8]. Instructions are external events that must align with internal events to support internal learning processes [8]. Operations Research (OR)

Instructions must align with internal events to process information to support internal learning processes.

Learning capabilities can be classified into one of the five domains of capabilities which comprise intellectual skills, which are to do with symbols, such as putting things into categories, applying rules and principles and solving problems, cognitive strategies that govern the individual's own learning, remembering and thinking behaviour that are developed with experience, verbal information that are the facts organised and stored in the learner's memory that provides the learners with structure or foundation upon which to build other skills, attitudes that amplify an individual's positive or negative reaction to some person, thing or situations and lastly motor skills that underlie performances whose outcomes are reflected in the rapidity, accuracy, force or smoothness of the body movements [8]. Any effective learning process has to address most of the above capabilities. It is not enough to concentrate the instructions on any one or two of these capabilities.

In addition to a literature survey, the authors benchmarked universities in the United States, United Kingdom and Australia that follow a competency based education framework. In these universities, engineering programs have clearly articulated program objectives. Moreover, the content of the courses and pedagogies are aligned to deliver the program objectives. There is a good balance between lectures for knowledge and understanding, and tutorials for acquiring skills. In addition, hands-on live projects involving design, manufacturing and testing are an integral parts of the programme. There is also emphasis on multidisciplinary awareness in terms of the choice of courses and projects. The programmes not only prepare their students for their immediate roles, but also provide the perspectives, learnability and professional development that are required for preparation for their future roles.

The authors have established a framework for competency based engineering education based on the literature survey, a study of engineering education in a few overseas universities and the authors' experience. The first author led an initiative to establish a collaborative education programme by entering into a memorandum of understanding (MOU) with a polytechnic for diploma programme in Mechanical Engineering and an engineering institute for an undergraduate programme in Mechanical Engineering and Electrical & Electronics Engineering. Twenty to thirty students in a Bachelors' Engineering (B.E) Programme were selected during their first year for the first author's organisation and were fully funded for their entire programme. The authors have closely worked with the institutes to evolve and implement a competency based education framework. While the academic inputs were common for all the students in the Mechanical and Electrical & Electronics engineering discipline, the students selected for the collaborative programme were offered behavioural programmes and internships during vacations.

As a first step, entry level roles and next level roles were analysed for the first author's organisation. The competencies required for such roles in the foreseeable future were established. Based on these, programme objectives were established for the academic and behavioural part of the collaborative programme. The programme objectives were described as below.

At the end of the programme, the students will:

- apply scientific principles and concepts relating to development of products and processes;
- design and develop products and processes that deliver the requirements of the target customer group and related quality functions;
- use modelling and simulation to analyse systems' behaviour and optimise for results;
- demonstrate working level understanding and appreciation of interdisciplinary domains that are required for design of products and processes;
- check the design for all desirable attributes (dfx)—assembly, manufacture, cost, quality and reliability, serviceability, re-cyclability, environment, ergonomics;
- choose appropriate quality tools and techniques for problem solving;
- understand the industrial and business environment in which the enterprise operates.

After the programme objectives were identified, the course objectives for each of the courses were articulated by a team of faculty members and experts from the author's organisation. The course objectives were further broken down into multiple Enabling Objectives. Enabling Objectives define the skills, knowledge, and behaviours, that students must attain in order to achieve terminal objectives successfully. The course objectives and enabling objectives were classified using the Bloom cognitive process and knowledge dimensions. The appropriate teaching and learning methodologies were selected based on the knowledge and cognitive dimensions of the course objectives. Some of the methodologies used were power point slides with explanations, diagrams, models with explanations, cartoons, photographs, video clips, demonstrations and simulations as shown in Table 3.

A content review was conducted by a team of experts and the content was developed. Teachers who were to take the class were oriented towards the

Table 3. Teaching methodologies

Knowledge dimension	Cognitive process dimension					
	Retention			**Transfer**		
	Remember	**Understand**	**Apply**	**Analyse**	**Evaluate**	**Create**
	Recall State Define	Explain Describe Interpret	Solve Apply Practise	Compare Contrast Deduce	Choose Justify Appraise	Design Compose Formulate
Factual (Basics of a subject, Unquestioning facts)	Repeat in the class, use PPT and photos	Describe using video and use QBD	Exercises, Solving problems	Individual and group exercises/ activities in class and in the workplace	Individual and group exercises/ activities in class involving comparison of results and against standards	Multidisciplinary projects
Conceptual (Classification Models, concepts)	Lecture—verbal representation, Pictorial representation (PPT, Photos, video), Black/ White board-talk and chalk	Explanation with good and bad examples, Use of photos & videos, Cases study discussion , Derive on black/ white board	t solving problems/ exercises Individual and group activities	Individual and group exercises/ activities in class and in gemba	Individual and group exercises in class and in gemba involving comparison with a standard	Multidisciplinary projects
Procedural (Specific techniques, General techniques, How to choose the apt technique)	Flow chart, Bullet points, 1, 2, 3 steps, Demonstration of steps	Flow chart, bullet points with explanation, Demonstration of steps by faculty with cause and effect explanation, If, then chart, Solve problem	Participant solving problems/ exercises, Demonstration, Activity or post learning project by participant, Role play,	Individual and group exercises/ activities in class and in gemba, Case study	Individual and group exercises/ activities in class and in gemba against a standard, choice, Case study	Multidisciplinary projects, Producing a design/object against a goal

content and methodology. A pilot project was conducted and a review carried out to make necessary improvements, prior to regular delivery of the programme. The learning evaluation was carried out using assignments, continuous assessment tests and examinations. An algorithm was developed with a number of questions for each of the course objectives for Bloom and knowledge dimensions.

One of the challenges in accomplishing competencies for a given industry and roles is for students to understand the courses to chose for a given specialisation for the roles. Engineering institutes are not familiar with the roles and the tasks and hence the streams of courses. Hence students are not guided on choice of electives. Students choose electives at random, which does not prepare them for the roles. The authors, along with the team of faculty and industry experts, developed streams of courses for design and manufacturing streams. While the programme continues to be Mechanical Engineering, the authors used the streams to bring orientation to the roles in automotive industry. The course structure, streams and specialisations are tabulated in Table 4.

In addition, internships were offered in the first author's organisation during semester vacations, which were aligned with roles and related competencies. During the final semester, projects were assigned to enable students to acquire the specific competencies required for specific roles. This collaborative programme involves setting up a contemporary automotive laboratory in the engineering institute for the students to do projects based on automotive application.

Similarly, behavioural objectives were established and the training sessions were organised for students as a part of the collaborative programme. Some of the behavioural objectives include sound health, ethics and values, communication, interpersonal relationship, learning and adapting to change.

5. Performance of students in academics and role readiness projects

Students are admitted to the engineering institutes based on their cut-off marks obtained in their 12th standard in Mathematics, Physics and Chemistry. About twenty five students are hired annually by the first author's organisation for the collaborative programme, out of the total strength of 120 students in the mechanical engineering branch. The selection is carried out after the first semester, assessing their

Table 4. Electives for design and manufacturing streams. Electives classifications into streams (Rev. No. 8, 12 February 2013)

Semester	Elective #	Design Stream		Manufacturing Stream		
6	1	Automotive Fundamentals & Manufacturing				
	2	Project Management ***				
7	3	Systems approach for engineers ***				
		Design Stream		**Manufacturing Stream**		
	4	Automotive PowerTrain Design		Logistics Engineering		
	5	Vehicle Design and Engineering		Manufacturing Systems Engineering		
8	6	Powertrain (Engines & Transmission)	Vehicle (Chassis)	Assembly Engineering	Forming & Joining (Fabrication)	Metal Cutting (Machining)
		Powertrain Design 1	Vehicle Design Engineering 1 (Static Systems)	Designing of Assembly processes	Weld joint design & process engineering (simulation)	Metal Cutting Process Engineering
	7	Powertrain Design 2	Vehicle Design Engineering 2 (Dynamic Systems)	Assembly Engineering and Technology	Welding fixture & press tool design (simulation)	Metal Finishing Process Engineering
	8	Powertrain Design Optimisation	Vehicle Design Lab	Assembly Testing & Assurance of Performance	Metal forming & tube bending (simulation)	Tool Engineering

*** *are common electives.*

innate ability as explained in Section 3.3 and taking into comsideration their consistent academic performance. The authors have carried out a validity test to check whether the students' part of the collaborative programme perform significantly better than the rest. It was assumed that the students selected for collaborative programme had better career aspirations and were better engaged to learn and develop themselves.

Engineering programmes in India follow a semester system, with two semesters in each academic year. Admission to the engineering programmes is considered based on a cut-off mark obtained in the senior secondary school examinations. The cu-off mark is calculated based on three subjects such as mathematics, physics and chemistry, with weightings of 100, 50, and 50 respectively. A hypothesis test was carried out to validate the difference in the Cumulative Grade Point Average (CGPA) at the end of five semesters and Cut-off Marks in the senior secondary school examination between the students chosen to join the collaborative programme and the rest of the class. This study was carried out for those who were admitted during 2010. One of the distributions used for the hypothesis test is t-test. Using the mean and standard deviation of both the samples, the p-value is calculated to test the hypothesis.

As per Fig. 3, the p-value of two sample t-tests is 0.000, which is less than 0.05 and hence it can be concluded that the GCPA score of the students' part of the collaborative programme is significantly better than the rest of the class at 95% confidence level. As per Fig. 4, the p-value of the two samples is greater than 0.05 and hence it can be concluded that the Cut-off Marks of the students in the collaborative programme is not significantly higher than the Cut-off Marks of the rest of the class at 95% confidence level.

The first and second batch of engineers have now passed out of the polytechnic and carried out role readiness projects. They were assigned to three roles: CAD engineer in Research & Development (R&D) function, Proving engineer in Production engineering function and Team leader in Manufacturing operations. They have been evaluated for their project outcomes and adherence to the process. Formal reviews were conducted to verify whether the students had understood their deliverables and acquired the knowledge and skills

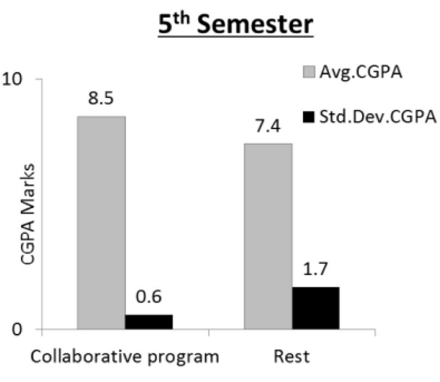

Fig. 3. CGPA (Cumulative Grade Point Average) score, Collaborative programme vs Rest.

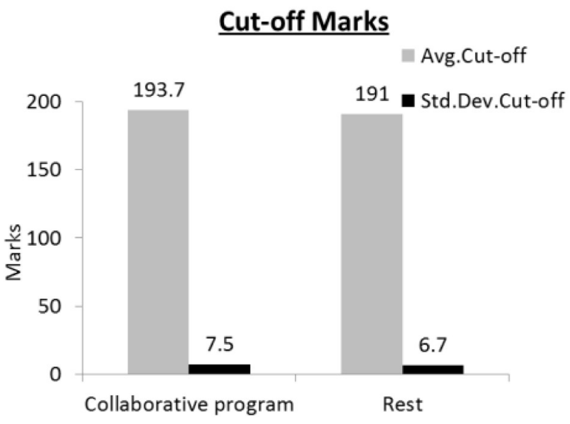

Fig. 4. Cut-off marks, Collaborative programme vs Rest.

required to execute the projects. They were oriented to understanding and using the Standard Operating Procedures (SOP) to carry out the projects. The students developed project plans and managed their time to complete the projects and to accomplish the deliverables of the projects. A formal evaluation was carried out by a panel of faculty and managers, qualified for the target role as shown Table 5.

The engineers who had been groomed through the collaborative programme were assigned to handpicked managers who were committed to the development of people. The managers have found that the engineers who were deployed from the collaborative programme after role qualification were able to cope with the expectations of the role much more quickly than the engineers joining from the normal stream, based on the qualitative feedback. The authors are currently working on the target setting for performance measurement and achievement every quarter. With this, it is possible to perform hypothesis testing to check if the students coming from the collaborative programme are significantly better compared with the rest. Currently, the role readiness projects are applied only for the engineers evolving through the collaborative programme and hence the authors are unable to compare them with the rest of the engineers. Based on the learning, the authors are planning to introduce role readiness projects for engineers coming from the other streams.

6. Limitations of the study

This study has few limitations while considering wider applications and institutionalisation.

- The authors have studied a few roles and related innate abilities for the organization chosen. Such a concept needs to be extended to cover most of the generic roles of similar organisations. This requires a detailed study of more roles and more organisations by a team with good understanding of this framework.
- Innate abilities are assessed by observing behavioural manifestations and assigning scores during individual tasks, group tasks and BEI. This requires extensive training and qualification of the observers to ensure accuracy of their observations and scoring consistently.
- Entry level roles are assigned to the engineers based on their innate abilities. Ensuring this alignment and validation through their career will take considerable time and effort. Statistical validation of the same will take a few years to get a critical mass of engineers joining the target roles.

7. Conclusion

This study used a focused approach for assessing the innate ability of engineering students to select and identify the most appropriate role/roles. Subsequently they were offered a workshop and mentored for articulating their career and life goals. Students selected for the collaborative programme have are clear about the organisation, career and role they will start with and, therefore, they are engaged very actively in learning both functional competencies and behavioural competencies within a competency based education framework. Internships during their vacation accelerated their learning towards their role. At the end of their programme, the students from the polytechnic had undertaken three projects that were focused to their roles.

Table 5. Role readiness score for the first batch of Diploma Engineers from the Polytechnic

Diploma in Mechanical Engineering students 2008 Batch—Role readiness score (out of 100)

Roll no.	Name	Function*	Project outcome	Process adherence	Readiness score	Remarks
08MS03	AAAA	R&D	78	74	76	Process
08MS17	BBBB		80	64	72	adherence
08MS07	CCCC		90	74	82	score is less
08MS06	DDDD	PED	95	70	83	
08MS05	EEEE		85	70	78	
08MS14	FFFF		90	80	85	

* R&D—Research & Development, PED—Production Engineering Department.

They were qualified for the identified roles based on their performance in the projects. This approach has shown significant differences in the way that the students belonging to the collaborative programme are motivated, get actively engaged and perform in their academics when compared with their peers.

The challenge is to sustain their energy, enthusiasm and engagement even after they take up a corporate career by continuously raising the bar for performance in their roles. In addition, the engineers must engage themselves in lifelong learning to enhance their potential and prepare themselves for future roles. A competency based education and training framework is currently being established in the organisation to enable the engineers to learn new competencies for future roles. Once the entry level employees come with required competencies, they become role ready soon after assuming the role, it is possible to qualify employees prior to or soon after assuming the higher level goals.

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