Methodology to Bridge the Gaps between Engineering Education and the Industry Requirements

Ravi Shankar Pillutla [#1], Anuradha Alladi [*2]

[#] *Tata Consultancy Services Limited*
Hyderabad Andhra Pradesh, India
[1] p.shankar@tcs.com
[2] alladi.anuradha@tcs.com

Abstract— **Learning methods and the right curricula are both critical for the development of right competence in individuals. Learning pedagogies practiced by traditional educational centers, universities and corporate training groups are largely based on the knowledge needed to perform various kinds of work/ roles. In the knowledge industry, where both competence and work definitions are intangibles and based on tacit understanding of deliverables, it is hard to design a curriculum that promises ability in individuals to build quality deliverables in the allowed time. Such competence is critical to the industry. In particular, the software industry today is seeing a lot of change in the environment and tools and techniques. The changes are rapid and dynamic. Methods of building competence in the individual needs focus, as the emergence of new methods, technologies resulted in paradigm shift in business. Building people with the right competence to deliver in short times is the need of the hour. Accordingly Training curricula and methods that can support such a scenario are critical to the survival and good performance of software organizations. The paper describes current educational practices, identifies the gaps along with the reasons for these gaps. The paper describes a methodology to bridge the gaps. The methodology explains how to identify the current user needs and required competencies, deriving competencies and how to build competencies. The paper also shares various concepts like Competency, Skill, Process Ability and Knowledge with definitions which are being used widely. The methodology enables one to understand the task to be accomplished with better clarity, thus resulting in higher productivity in less time.**

Keywords: Competence, Skill, Knowledge, Process Ability, deliver, Curricula

I. INTRODUCTION

The focus of most educational curriculum is on developing knowledge in job related areas. While this is necessary for the development of competence to do the work given, the results of such training has been merely to improve knowledge, but not so much to deal with the quality building processes in projects. Quality and productivity which are critical to run the business, is still a concern. There is apparently a gap between the knowledge and the competence to build quality deliverables. The new methodology proposed in this paper will ensure and enable individual to build quality deliverables.

What should be the way to build competence that assures ability to deliver in a given time? How should the curricula be designed to meet this need? How can training be imparted to realize these ends? How do we ensure a good correlation between training performance and actual project performance so that training ensures certainty in individuals to deliver promised work? These are some of the questions that must be answered by the new methodology. How does an individual transition from university learning and knowledge certifications to the corporate scenario where ability to deliver is the mantra for successful performance of work.

Knowledge is the foundation for doing any work. The objective of universities is to impart knowledge in students to perform given tasks. Engineering education and professional curriculum have to be complimented by corporate training to make university pass outs productive in the organization. The focus of traditional education in universities is more on imparting knowledge since 'this forms the basis for learning' [1]. Delivering results in work is a specific application of knowledge. Inculcating in people, an ability to apply the knowledge and deliver results need more focus.

Delivering results, performing various activities based on the knowledge acquired during the engineering education is what is expected from the employees in an organization. Most evaluations, like exams or certifications, entrance tests and the like are based largely on knowledge, in the context of developing countries. Consequently, the transition from applying knowledge effectively to deliver results has been a gap. The need therefore is to develop a process to transition the individual from knowledge gained in university to building an ability to deliver employer organization expectations.

This paper studies the issue of curricula design in the context of an individual transitioning from university education to being able to perform in industry. In this paper, authors proposed solution namely – deliverable derived curricula definition associated training methods and assessment of resultant competence. This paper examines the issue of what should be the basis for the design of training curricula so that it gives a near certainty that the trained person will be able to build deliverables with quality and on time. Such an approach will necessarily lead to higher competence and thereby substantially improved quality and productivity, which is critical to industry. Experiments done on this have lead to the development of strategies to build in employees an assured

ability to build quality deliverables and to be productive during development of a project.

The industry is employing wide variety of training methodologies from traditional class room training to web based training using structured course content, executing case studies as extensions of class room training, to impart knowledge and develop competencies among the associates. Associates are expected to perform given tasks, using these trainings. However, the results of such trainings are not completely contributing for a successful project execution.

A. AS IS Scenario

Industry recognizes the gap between performance in training imparted and individual performance in project work using the training learnings. Following are some of the challenges the projects commonly encounter in spite of these trainings. These are some of the findings from the various studies conducted by the authors with respect to competencies in the form of surveys in the Project groups [2]. They are:
1. High induction time in projects (varying)
2. Poor hit ratio in client interviews (20%-80%)
3. Poor correlation between training project productivity (20%-90%)
4. High cost of quality (40% - 28%)

Competence plays a dominant role in knowledge industry like software industry. Building competence in individuals is a critical factor for the success of an organization. Another important challenge in building competencies is, emerging technologies and customer expectations. Coping with the change is one of the important challenges an organization' need to prepare for.

Engineering curriculum today in the universities is a necessary base for students to transition into industry. Manufacturing and traditional streams normally have mature training programs to meet the requirement of their professional work beyond the training in colleges. Unlike this, software projects require ability to meet diverse requirements depending upon the client needs, which are expected to change with the market needs. This poses difficulties in preparing oneself in meeting the competence requirements in a short time. This scenario therefore, demands a unique method of imparting trainings, and eagerness of the employee to learn and go through the strenuous and continuous change in developing relevant competencies. There comes the need to develop improved methodologies to impart knowledge and build competencies among the employees, for organizations' success.

B. Definitions

We will discuss briefly what the terms Competence, Skill, Process Ability and knowledge means in this paper. The definitions are adopted from the PCMM document [3] to provide an accepted basis for understanding the ideas in this paper. To reiterate, training is interpreted as providing knowledge to enable people to perform their work.

Competence building means "developing the ability to build quality deliverables". [1][4][5][6] 'Competence is defined as the 'ability to do' something or 'ability for a Task'….Knowledge may be understood as "theoretical or practical understanding" [5]. For an individual, competence comprises of knowledge, skills, and process abilities. Other aspects such as psychological and motivation perspectives, and others that contribute to this delivering value to the work, are not in the scope of this study.

Knowledge means piece of information and understanding over a given subject, to be used to perform a given task successfully. 'Knowledge provides the basis for performing a skill.'[1] This includes both tacit and explicit knowledge.

Process ability is the capacity to 'perform individual skills in the specific sequencing, order or method' [1]. It represents knowing the process steps that must be executed to realize the expected outcomes.

Skill is the ability to interact with interfaces. This includes all the interfaces, whether they are with software systems, people, machines or others and 'may involve behaviours that directly accomplish the task or that provide the support of, or coordination with, others involved in accomplishing tasks' [1]

II. PROBLEM STATEMENT

Curricula are designed to build competence in people to deliver expected outcomes in the target work address the needs. The principle objective of curricula design is to ensure that those who adopt the curriculum and qualify in it should be able to deliver expected results in the target industry for which the curriculum is designed.

In the case of Engineering Students, the higher level objective is to ensure that they have the ability to perform given work. For instance an engineering graduate who takes the job in an IT services organization delivering software products to its clients, must be able to apply his software language and Computer science competencies to deliver web applications, provide maintenance and support services. He must be able to apply his knowledge to deliver these services by effectively applying the learning and knowledge he acquired during engineering studies. This is the key objective and Curricula design must aim to build this ability in him.

The fundamental problem therefore is to understand and design the curriculum that builds in people the ability to apply his learning to deliver. The problem statement can therefore be stated as follows:
1. Define the needs of the target industry to which the students who pass out of the engineering colleges must get employment from.
2. Develop the learning objectives and hierarchies that will enable realize the above needs
3. Define the Competencies required to address above needs
4. Derive the Curricula on the basis of the needs
5. Define the methods to build these competencies
   The paper focuses on steps 3 and 4

III. CONTEXT

Many times new associates joining the industry are not aware of the customer requirements. The process involved in understanding the requirement in which the domain customer is operating is some of the challenges the new entrants encounter. In addition to this associates are not sure about

how to develop a product per the requirements provided. The learnings' from the engineering education are more oriented towards understanding knowledge and basic concepts, and are not focused to perform per the expectations from the industry.

Organisations' engage these new associates in specific trainings to make them productive before allocating them to the projects. Once the organizational training is completed these associates will be allocated to the projects. Employees are expected to understand project requirements to develop various applications.

Employees depending on their capability will be able to perform the tasks. It is not always possible to get all the project team members skilled and experienced. Some of them will be able to complete in time, whereas some employees require more time to accomplish given tasks. To overcome these hurdles employees either need to put additional effort or go for more training to perform and meet the expectations. This will take more project time than estimated, which could result in delayed delivery.

Keeping these challenges in view, authors have come up with the Competency methodology. The Competency methodology is derived from the project requirements and expected deliverables itself. This methodology will help medium to large size projects to overcome the challenge of people with right skills.

IV. METHODOLOGY

In this approach, we understand the target user for whom the engineering students are to be useful are the IT or other industry, who are employers. Hence the Curricula design targets the needs of this industry.

The specific methodology adopted in the studies done in this paper use the idea of a Product Break down structure commonly used in manufacturing industry to breakdown the end product. Here, in the context of Curricula design, the end deliverable is an ability to build' needed deliverables.

A. Defining content in the curricula

The need for the product breakdown has its base in the definition of competence. "Competence is the cluster of Knowledge, Skills and Process Abilities required to work. This will be the basis on which we will understand Associate Competence. Further, Process ability knows the process steps that must be executed to build the deliverable. It follows that we must know the deliverable to be able to define the process steps. Hence Competence has to be specified as a deliverable slice only. Knowing HTML language is knowledge, whereas build an HTML Page is Competence" [8]. For this reason it is necessary to develop a breakdown to derive the competencies for each of the potential applications of knowledge that the student will have to manage in his working life. This is the key step in the methodology to build curricula.

The next important step in the design process is to identify the primitive knowledge elements and include them in the curricula.

B. Defining methods of imparting competence

Delivering the curricula is the other key element which is traditionally not a focus for engineering institutes or for the Employers training schools.

1) Imparting primitive knowledge

In Para Above, the idea of how primitive Knowledge elements are to be determined is mentioned. Once these are defined in adequate detail, traditional training methods that colleges use today are good to deliver this knowledge.

2) Imparting competence

The key differentiators between traditional training methods and the competence model described and deployed in pilots later is this. The slices of deliverables which can be building and are commonly needed to deliver standard functions in standard scenarios are targeted in this step. For instance, knowing HTML and its components is primitive knowledge. Being able to build the HTML Page is having competence to apply the HTML Knowledge to deliver a page that will potentially deliver User Interfaces and the like. These competencies can be imparted using case studies.

C. Curricula definition

Using this set of competencies identified, logical grouping of these again in relation to the larger products they can deliver are listed out and such groupings are Competency Menus that together define the curricula at a sufficiently granular level and in an executable form.

The methodology helps to build skills required to perform the project specific functions in less possible time and be productive in a short time.

Authors have conducted pilots on various batches of employees to see the effectiveness of the methodology and building skills in employees. The pilots conducted proved, authors intention to improve learning methods and help to solve the problems projects facing with respect to getting the employees trained. As a result, employees will be able to perform given tasks in the projects well. The developed methodology helped to overcome the challenges project teams were facing, resulting them to complete the project on time.

D. Methodology applied

In a typical software development project, customers will provide requirements to develop an application. The development team will try to understand the requirements, convert them to design then develop an application/tool etc. In a project scenario project deliverables are stated based on the requirements. People are expected to have good knowledge on the technology they need to work to deliver the requirements in the form of project deliverables.

The project team, who has experience over the project management and technology, will identify various project deliverables list. Accordingly project team will identify the list of competencies required. The lists of competencies are small slices of deliverables which are either repeatable or independent entities of code.

Figure 1- Current approach to induct employees into projects in IT projects
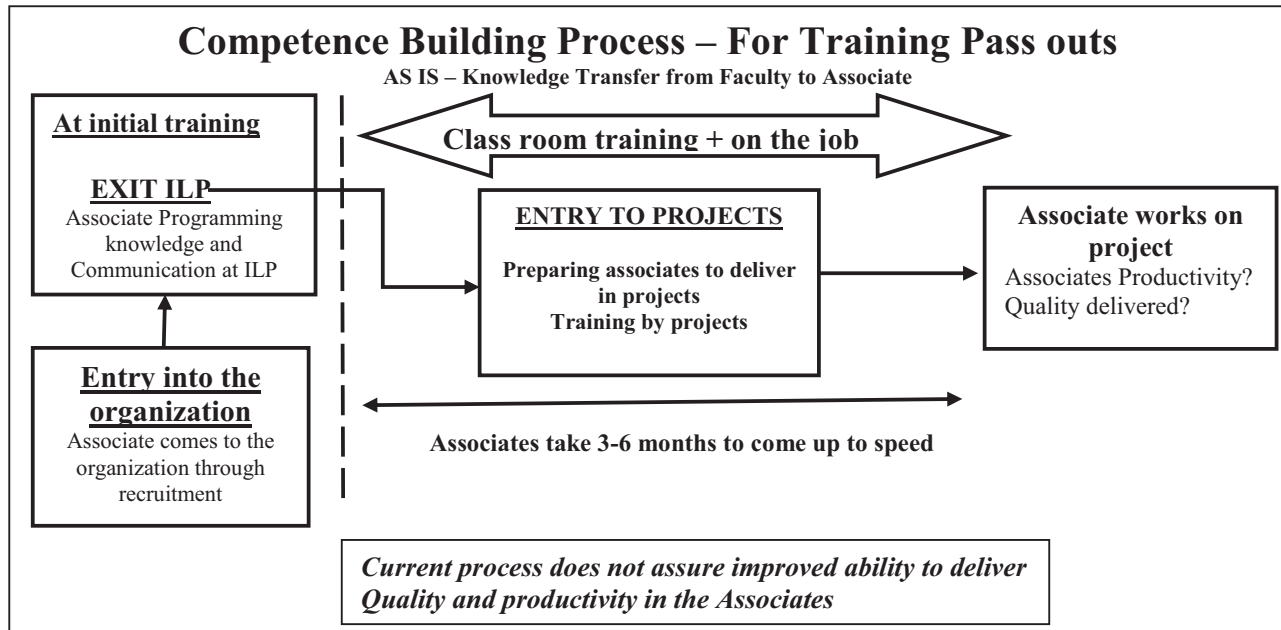
Identifying the list of competencies for a given project is one of the crucial activities for the project team. The list of competencies is called Competence Menu. Accordingly Competence Asset (CA) is prepared to train the new employees into the project. Please see table No. illustration with list of competencies required for a given project.

Based on the list of competencies in the CM the project team will prepare the CAs. CA comprises of three important sections. (1) Requirement Statement (2) Process steps to execute given piece of work (3) acceptance criteria. Process steps are derived based on the requirements and the project deliverables to meet. Acceptance criteria talks about the time and the acceptable quality expectations from the new employees to perform a given task.

Table 1-competence Asset structure

Sl. No	Competence Asset	Description
1	Requirement Statement	Bed assignment in a health care facility, who is undergoing surgery
2	Process Steps	Log In.... Pwd... Patient Id... Nurse Id -
3	Acceptance Criteria	10 mts

Requirement statement: This section talks about what is the problem statement and what are the instructions required adhering to and what the outcome from the stated problem is, want to accomplish.

Process Steps: Is a list of process steps provided in the competence assets, to help the fresher to execute. These are a set of instructions to be followed in a systematic manner when executed will derive, desired outcomes. It is very important to identify applicable process steps, to accomplish a given task.

Acceptance Criteria: An Acceptance criterion is set by the expert in the field for every Competence asset prepared. This section states time allowed for a fresher to execute the process steps. If the fresher is not able to execute in a given time, has to iterate the process till he/she reaches the acceptable time limit.

CA will have above sections with clearly articulated process steps to be followed to complete a given task. Now the employee has both technology knowledge and understanding about the customers' requirements.

E. *Typical Competencies and primitives*

In the instance of curricula that targets web application development capabilities in Engineering pass outs, the following lines illustrate how the Curricula are designed for it.

Table 1 illustrates a typical web application competency Menu. Figure 3 illustrates the derivation of the Primitives from the competencies defined.

The curriculum is then derived out of the two tables that are shown in Figure 2 and 3. The Competency Menu shown in the Figure 2 drives the rest of the Curricula definition. Primitives, knowledge needed for the Primitives etc and the common skills are all part of the curricula definition process. This idea is shown in Figure 4, which is the overall methodology to define the Curricula. Similarly primitives are prepared for the rest of the identified competencies.

Table 2- Typical Competencies defining the Curricula

Competencies
Create HTML page
Java Script Validations
JSP Tags
Struts tags in JSP
JSTL/Core tag libraries
Post method
Session Management
Service integration
Redirection to appropriate view
Exception handling
Filters
Role declaration in DD
URL Patterns in DD

Table 3- Derived Primitives in Curricula

Competence	Most commonly used Primitives
Create HTMLL page	HTML Tags
	Lists
	Tables and Layouts
	Forms and input
	HTML Head., meta and URL's
	Standard attributes and even attributes
Java Script validations	Using Java script in an HTML page
	Variables, special characters and operators
	Flow control and exception handling
	Functions
	Events and handling
	DOM
	Form Validation

F. Deriving an integrated Curricula

It requires some amount of experience and understanding to prepare the CAs. Understanding the client requirements and expectations along with deliverable skills, will help prepare the CAs well. To understand what competencies are required to accomplish a given task is a challenge for the project management team. Once the list of competencies is identified and CAs is prepared it becomes easy for the team to train new employees joining the project.
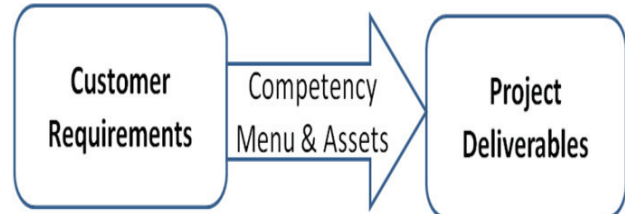

Fig. 2 Competence methodology

The new employees will go though the CAs and follow the process steps specified in the CA, will work on building within in the acceptable time frame. If anyone employee is not able to complete the entire CA in a given time, will have to iterate the process till they complete within acceptable time.

Table 4 - Competency Menu derived for web application development

Reusable Techniques				
Offering	Sub-Domain	Sub-Domain-2	GUI	Action Handler/DD
Development	Web application development	Login and Security	Create HTML Page	Session Management
			Java Script validations	Service integration
			JSP Tags	Redirection to a appropriate view
			Struts tags in JSP	Exception handling
			JSTL/Core tag Libraries	Filters
			Post method	Role declaration in DD
				URL Patterns in DD
		Create/Save new data	Create HTML page	Capture request parameters and populate DTO as required by service
			Java Script validations	Reading property files
			JSP Tags	Session management
				Service integration
				Exception handling
				Redirection to appropriate view

G. Pilot Studies

Authors have done pilot on employees formed into various batches, using the methodology to build competence among the fresh trainees in a project.

Pilot studies conducted by the authors on batches of newly trained people who had completed traditional engineering examinations. 6 batches of employees trained in software programs using the above methodologies, were subjected to tests on resolving specific cases, with all the necessary tools. Adequate care was taken to ensure that the batches were statistically similar and that the biases from various parameters that influence the process were minimized.

Pilot was done on 234 employees comprising of 6 batches. Each batch size was ranging from 11 to 56 employees. Each employee was provided with a Multithreading and Memory Management CA to execute. The pilot was done separately for each batch over a period of time. The performance results are captured for each batch against the parameters of correctness, time taken to execute, follow the process steps provided in the CA and the end deliverable or the end product.

Table No. 4 shows results from the pilots done, wherein employees who completed CA within the acceptable time frame are mentioned. In the first batch out of 42 associates who ran the CA, only 50- 52 % of them were able to execute the CA. Similarly data is presented for the rest of the 5 batches. Associates who were not able to complete within the guidelines were asked to iterate the process till they meet the passing out criteria.

From the results it was evident that even though employees, who are trained in knowledge areas, out of which only 20% to 55% of them were able to build the deliverables using CA. The high variation was observed during the pilot studies. The less number of people being successful are indicators for the need to enhance the process of building in them an ability to deliver, rather than training just for knowledge.

Table - 4 Pilot Results for 6 batches of employees

Pilot	Pilot details	Results
Pilot P1 Paper Test	Sample Size = 42 Multithreading & Memory Mgmt	52%
Pilot P2 Paper Test	Sample size = 59 Multithreading & Memory Mgmt	53%
Pilot P3- Live Environment	Sample size = 11 Multithreading & Memory Mgmt	55%
Pilot P4 On Systems	Sample size = 56 Multithreading & Memory Mgmt	27%
Pilot P5 On Systems	Sample size = 33 Multithreading & Memory Mgmt	29 %
Pilot P6 On Systems	Sample size = 33 Multithreading & Memory Mgmt	20%

The pilot studies proved there is absolute need for additional training methodologies to ensure that the employees can learn faster and be productive. The methodology adopted to conduct these pilots helped to bridge the gaps in employee competence levels, thus resulting in project success. The methodology helped to overcome the competence related challenges in the project. The methodology can be applied for any technology/domain. Similar exercises were carried out in Telecom, HiTech and other domains to ensure the correctness and completeness of application of the methodology. More than ten thousand freshers have used Competence asset methodology to acquire competencies in the organisation.

V. CONCLUSION

In an ever dynamic environment it becomes difficult for the projects to run without skilled employees. Projects with limited time schedules it becomes difficult for the project team to invest more time in up scaling their employees and deliver on time. Hence the need for such approaches to the rescue of the project teams in building the teams with required skills faster.

The above methodology also helps when employees move from one project or domain to the other. Learning the new concepts technology will become faster with the said approach

Thus the need of the hour is to have a mechanism to address the problems while transitioning from university education to project training is provided suggested. The pilots conducted proved that the process of deriving competencies from the project deliverables found to be the best method to train employees and induct in to the project.

The results from the pilots done on various batches of employees have proved that the above approach was able to address the gaps and the challenges projects normally encounter with. Projects were able to bring the new employees on board in less time with quality deliverables on schedule. This approach also ensures a +90% correlation of performance in training and project work, resulting in higher productivity.

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