Certificate in Information Technology (CIT):

A program to enhance the quality of IT education in engineering colleges

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***Abstract*— Education needs to cope with the changing industry demands and generate productive manpower. Various recent surveys have identified significant gaps between academics and industry as lack of problem solving ability, inability to map real world problems to programs and soft skills. To bridge these gaps, we have designed an innovative Certificate in Information Technology (CIT) program, using the "learning by doing" (LBD) methodology. We have identified 36 engineering colleges in Andhra Pradesh, trained their faculty and have begun implementing this program to the students through the faculty at their respective colleges. From the initial feedback we received from the participants, we conclude that the CIT course will enhance the IT skills of faculty as well as students in the participating engineering colleges. The transition from conventional learning to LBD is simple and achievable. In the long run, CIT is not an end by itself but will lay the foundation for making other courses more practice oriented.**

Keywords- learning by doing, problem based learning, training program, employability, gaps in education

I. ABBREVIATIONS

IT	Information Technology
CIT	Certificate in Information Technology
TTP	Teacher Training Program
IIIT-H	International Institute of Information Technology, Hyderabad
MCIT	Ministry of Communications and Information Technology
LBD	Learning by Doing

II. INTRODUCTION

A. *Problem statement*

India produces about 500,000 engineering graduates every year. But, only about 25% of these engineering graduates are employable [1]. It is also foreseen that there will be a shortage of 500,000 knowledge workers by 2010 [1].

IT companies have responded to the projected manpower shortage and expedited freshman recruitment process lowering down their recruitment standards to meet the numbers. In a fast world that we are in today, organizations hire resources expecting them to contribute from day one and their clients have limited tolerance for inept performance. Hence, attempts to overcome manpower shortage without addressing the core issue of skill shortage are not likely to be useful [2].

Besides the technology aspect, industries also need an array of competencies like soft skills, team building, overall attitude and values. These demands both in numbers and quality, makes the situation difficult for students. Unfortunately, having a certificate or a degree with good grades does not assure proficiency in these skills or knowledge.

Engineering graduates are found to be lacking in problem solving skills and communication skills. The availability of good quality faculty in colleges is another concern [3]. Considering these gaps, we can say that the students churned out by the engineering colleges are not equipped to meet the current industry requirements and often companies have to incur additional expenses (in terms of time and money) to train new recruits. In the current economic scenario, organizations do not want to invest on training of new employees and instead, are expecting "market ready" people [4].

B. *CIT program: Its goal and significance*

To make the engineering graduates more "market ready", the Certificate in Information Technology (CIT) program was started as a joint initiative by the Ministry of Communications and Information Technology (MCIT), Government of India and IIIT-Hyderabad (IIIT-H). The objective of this program is to enhance the quality of IT education in engineering colleges so that the shortage of quality manpower in IT industry can be addressed. The goal of this program is to train 12,000 engineering graduates.

Colleges that were identified as the participating engineering colleges (refer Appendix A) had to satisfy the following conditions:

i. Should have graduated at least one batch of students
ii. Should have support of college management in implementing the CIT program
iii. Should commit to train 150, 300 and 600 students in the first, second and third years of implementation of the CIT program.

In our endeavor to enhance the quality of IT education, we have addressed issues like measuring the higher order thinking, scaling the training process to students and attracting the faculty members to the training program given that there is a dearth of faculty at the engineering colleges. The following sections discuss in detail our methodology applied, the different phases involved in the CIT program, our discoveries and our future plans.

Lecture based teaching	Learning by doing
Grading mostly done on knowledge and retention levels	Grading done on the application, analysis and the synthesis levels
Student to faculty ratio is high.	Student to faculty ratio is 10:1. This accounts for personalized mentoring which helps in student's growth.
Students handle multiple courses simultaneously	Students work on one course at a time. This helps in immersive learning.
Most of the learning is through lectures.	Most of the learning is through application.

Table 1. Comparison of LBD and lecture based methodologies

III. THE METHODOLOGY

We observed that the students are learning different concepts but are not learning it in the way the industry wants them to. The industry looks for application of the concepts while our examination system measures the retention levels. Based on these observations, we chose a more practice oriented approach, "Learning by Doing" (LBD) methodology through the "Problem based learning" (PBL) approach over the lecture based (conventional) mode of teaching.

The LBD methodology through PBL is built on the constructionist approach and promotes a learner-oriented learning environment. In this learning environment, lesson/unit goals and expectations are set at the outset, so that learners understand what they are trying to achieve and the level of that achievement. Multiple strategies of solving the problems are explained by the mentor. This allows the learners to understand the various ways of solving the problems that they encounter. Feedback is given by the mentors during learner interactions (through presentations and discussions) which allows the learners to revise their projects/artifacts. Lastly, an involvement with application in the real world allows the learning process to take place in a more meaningful context (elaborated in detail in section 3, designing the content).

The LBD methodology fosters skill development and the learning of factual information in the context of how it will be used [6] and aims at giving a hands-on fulfilling experience which helps the students understand the practical implementation aspects and the concepts associated. In this methodology, mentors assist the students in their course work by "providing hints and not solutions". Unlike, the conventional mode of teaching, the student to teacher ratio in this mode is 10:1, which allows for personalized mentoring and growth of the student (refer Table 1).

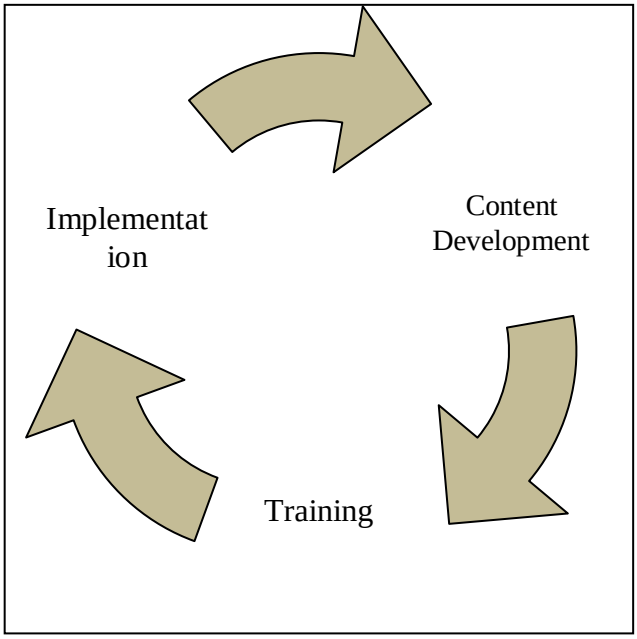

Figure 1. Phases involved in the CIT program

In addition, we have enhanced the LBD methodology by employing the international pedagogical concepts of formative and summative assessment to design rubrics for learning as well as grading phases. The rubrics map the learning objectives of the module and measure them on various parameters. These rubrics benefit in that the faculty can justify the marks given and the student can know how he/she will be assessed. Using these rubrics, faculty can give better feedback to the student. Most importantly, the use of rubrics provides a standardized way of reducing biased judgment and human errors while evaluation.

We went through a three phase process (refer Figure 1) in delivering this program. First we designed and developed the content, then trained the faculty members from the participating engineering colleges on the content and finally implemented the CIT program at those participating engineering colleges.

In each phase of CIT we adopted different approaches. For developing the content, we employed the LBD methodology. Mentoring approach was employed during the training phase. Remote mentoring and monitoring through use of tools were employed during the implementation phase. Figure 3 explains how the learning happens.

A. Designing the course content

The CIT program was designed to cover Linux, Data structures using Java, Soft skills and productivity skills and Computational Thinking courses.

The computational thinking course was designed **t**o give a smooth transition for people from a non-programming background. This course inculcates thinking and enhances the logical ability of the students/faculty members. We have used an open source tool RAPTOR to train our faculty/students in this course [7].

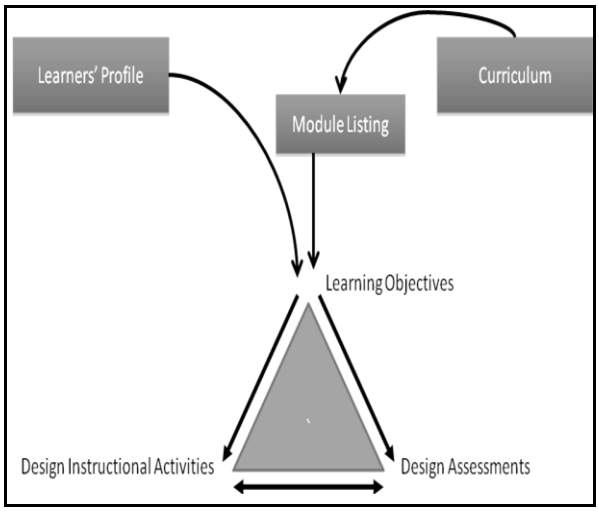

Figure 2. Framework for course design

In addition, we included modules on art of mentoring, assessment and rubric design for faculty. The total content spanned over 200 hours.

The content is primarily developed by a Domain expert in conjunction with an LBD expert. The domain expert and the LBD expert design the curriculum, break it down into modules, map it to the learning objectives and design individual tasks and assessments keeping the instructional design in mind (refer Figure 2).

For a programming course, the learning objectives can be reading programs, comprehending programs, writing and explaining programs. The instructional activities/tasks can be to identify and correct the errors in a program, identify and label the expressions, statements and blocks in the source code, etc.

An example:

We consider the data structures course in which a student is expected to learn different data structures and apply the learnt concepts to design a mini-search engine. Specifically, we employed the project/story centered curriculum, wherein students participate in real-world scenarios [8]. We explain the different components in designing the content in the LBD methodology through this course.

Motivation: The domain expert provides the motivation for the student why he/she should be taking this course and what the benefits are of taking this course. This is recorded as a video and given as a resource to the student.

Learning objectives: These state what the student will learn after completing this course. These can range from learning basic data structures to evaluating their importance and necessity.

Story line: Students are encouraged to design a mini-search engine in this course. An overview of "what the student will do and how he/she will do" is given in the story line.

Role: Students work in teams of three and each is assigned the role of an engineer. The mentor acts as the team lead and sets deadlines and gives feedback.

		Grade				
		0	**1**	**2**	**3**	**4**
sretemaraP	**Problem understanding**	Unable to recall any of the concepts	Able to recall only some concepts with assistance being provided	Able to recall some concepts without assistance being provided	Able to recall all concepts	Able to recall all concepts with proper explanation
	Generating pseudo code	No idea about pseudo code or algorithms	Included 2 out of the 5 standards	Included 3 out of the 5 standards	Included 4 out of the 5 standards	Included all the standards
	Implementing the program	Not implemented any of the processes listed below	Program is implemented without following the request handling and halting process	Program is implemented. Handling requests are also followed.	Program is implemented in accordance to the flow process.	Program is implemented in accordance to the flow process. Code optimization done.

Table 2. A rubric used for a module in the Data structures course

Pseudo code Standards
1) Input: Should have zero or more inputs externally supplied
2) Output: At least one quantity is produced
3) Definiteness: Each instruction is clear and unambiguous
4) Finiteness: For all the cases, the algorithm terminates after a finite number of steps
5) Effectiveness: The pseudo code should be effective enough to work properly without producing errors when implemented

Table 3. Pseudo code standards used for the rubric in Table 1

Flow Process
1) Write pseudo code for controller program of elevator
2) Handle requests coming from users for the lift properly
3) Halt on the current floor if no request are made

Table 4. Flow process used for the rubric in Table 1

Scenario operations: These are the modules that the students need to perform so as to complete the mini-search engine. There are different modules for each operation (crawling, searching, indexing, presenting, etc.). The building of the search engine is divided into modules and each module is dependant on the preceding module. In a way, we ensure that the student has completed each and every module (a check on learning).

Resources: Video lectures and PPTs by the domain expert and Just In Time (JIT) lectures by the mentors. Considering the different learning styles we have designed resources in different formats (text, animation, video, and

audio). In addition to these, Frequently Asked Questions (FAQs) are provided to the students as resources.

Feedback: Timely feedback from the mentors allows the students to improve their work. We applied rubrics to measure the students' knowledge during the formative and summative phases. A sample rubric for the data structures course is given in table 2. The pseudo code standards and the flow processes are shown in Table 3 and Table 4 respectively.

The content is designed to cultivate higher levels of thinking (analysis, synthesis and evaluation) abilities of the students. Moreover, we distinguished between surface and deep learning which are critical for academic advancement. These are characterized by the students' approach to the task of learning course material. Surface learning can be described as using low-level cognitive skills and minimum effort to complete course requirements. On the other hand, deep learning involves understanding, engaging in higher-level cognitive skills, making connections within and across disciplines, and thinking conceptually about a topic.

B. Providing training to the faculty members

Before the program is launched in the colleges, it is mandatory for faculty to undergo a rigorous training so that they can teach the students effectively. We have trained 161 faculty members at IIIT-H through two training sessions of 4 months and 3 months duration respectively.

Apart from the basic IT skills and the programming skills, the training program for the faculty members included the art of mentoring and the operational procedures of the CIT training program.

In addition to these we trained the faculty members on active learning techniques [9] and Bloom's taxonomy.

C. Implementing the CIT program at the engineering colleges

An important aspect of CIT program is to implement the same at the participating engineering colleges to benefit the students. We have designed processes to help the trained faculty to implement the CIT program for students at their colleges. We also empower the trained faculty members to customize the course and use it in their class and lab sessions.

The process of implementation at the colleges is the third phase in the CIT cycle (refer Figure 1). This completes the loopback process and provides inputs to further improve the content. We have begun implementation of the CIT program at 10 of the participating engineering colleges with our trained faculty. 657 students are being trained at these colleges.

A student enrolled in the CIT program spends 10 hours a week on the course. The student to mentor ratio stands out to be 10:1, which provides for personalized mentoring. Course orientations and task orientations by the mentors permit the students to enhance their comprehension and to work on the deliverables. Assessments are made based on the quality of the project delivered. Students are assigned individual workstations with internet facility. Lectures delivered by eminent people relevant to each course are all made available on a server to enable understanding of the concept.

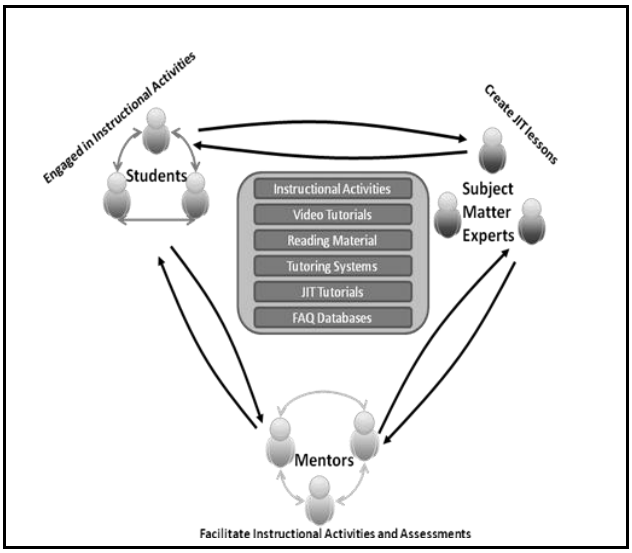

Figure 3. How learning happens

ICT environment makes it possible for students to work on problems at an individual pace. This method also helps the student tap his quest for research by getting into the depths of that particular concept.

CIT follows a sequential pattern of offering courses in a linear fashion where one course is offered at one time as against the conventional programs which offer courses in a parallel fashion. This sequential pattern adopted at CIT would enable a student to master one course a time, understand the relevant concepts, give him some scope to explore in depth into core concepts and move on with the next course (refer Table 1).

Our emphasis is on 'Learning to learn'. The basic goal is that every person should be taught the skill of "Learning to Learn" since after graduation from universities one does not have access to teachers for the remaining years of their life. The second important underlying skill that a student should have is the ability to apply knowledge to solve problems. In the past, emphasis has always been on demonstrating that you understand concepts and not in the ability to apply concepts using knowledge to solve problems.

IV. RESULTS

Since the pedagogy of CIT is totally different from the conventional courses run in the participating engineering colleges, we knew we had an uphill task in the program's acceptance and implementation at the colleges. We conducted a post-training survey for the faculty members and we found that not only did they adapt comfortably to the LBD methodology but also they showed an increase in their own competency levels. These preliminary results encourage us to introduce the CIT program (and the LBD methodology) in more colleges.

A. Competency gain:

Increase in the competency levels of the faculty nominees showed that they gained 45.69% in Computational Thinking, 28.38% in Java, 20.9% in Data structures, 28.51% in soft skills and productivity tools and 40.11% in Linux (refer Figure 4).

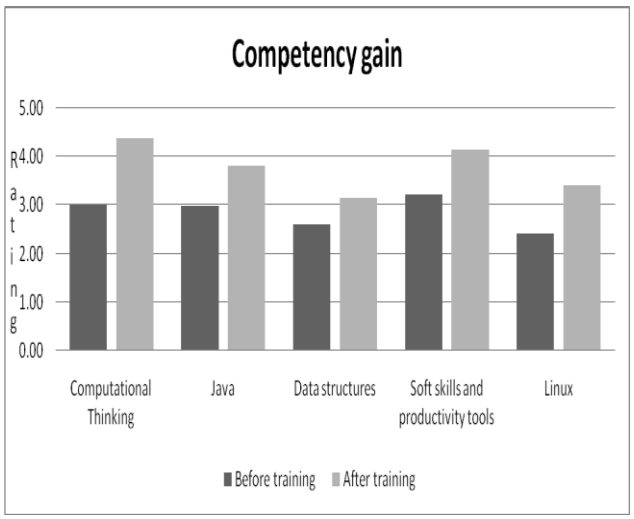

Figure 4. Competency gain in the faculty members before and after training (Rating on a scale of 1-5)

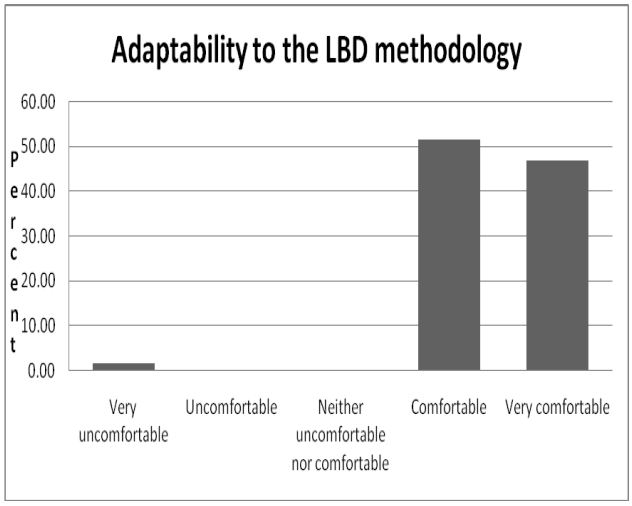

Figure 5. Adaptability to the LBD methodology by the faculty members (in percentage)

B. Adaptability to LBD methodology

At the same time, around 99% were either comfortable or very comfortable with adapting to the LBD methodology (50.66% were comfortable, 48% were very comfortable) while only 1.33% were very uncomfortable in adapting to the LBD methodology (refer Figure 5).

C. Satisfaction with learning experience

We have enhanced both our content and teacher training process which resulted in higher levels of satisfaction. This resulted in more interest to implement the CIT program at the colleges.

In addition to this, training the faculty members in the LBD methodology with personalized mentoring increased their confidence levels and in turn, their performance and satisfaction. The faculty members were able to appreciate their capabilities and thus understand their strengths and were able to work on their areas of improvement. These faculty members provided unsolicited positive feedback about their experience in the training program, and indicated their eagerness to implement the program in their respective colleges.

Presently we have faculty members from 10 engineering colleges implementing the CIT program at their respective colleges (refer Appendix A).

D. Involvement from the students

Based on the feedback we received from our trainees (faculty members), we find that the students enrolled for the CIT program are enthusiastic about this course. The LBD methodology and the mentoring mode have interested most of the students and is making them spend extra hours on the course and advance at a fast pace.

Presently, 657 students are undergoing the CIT training at their respective colleges (refer Appendix A).

V. FUTURE WORK

After careful analysis of the feedback obtained from students, faculty, Heads of Departments, principals and management of colleges and from few industry people the following action items have been identified.

A. Improvements planned in content development

Designing advanced course content: Encouraged by the initial response, domain experts have come forward to collaborate for developing content in advanced courses in different engineering streams. In addition, new modules in soft skills on leadership and basics of management are planned to be developed.

Reducing TTP duration: In view of the availability of faculty and also presence of trained faculty at the colleges, it is necessary to run the faculty training programs in short capsules (2-3 weeks duration) without compromising on the quality.

B. Improvements planned in implementation

We plan to develop a framework for ensuring the timely completion of the training at the colleges as per the implementation calendar. In future, we would like to spread this program outside of Andhra Pradesh.

C. Impact study of CIT

We plan to conduct impact studies on how the students trained on the CIT course are meeting industry standards. These studies will take some time to conduct as the students currently enrolled for this program are in their pre-final year of engineering. We are also collaborating with NASSCOM and its member companies in enhancing the content.

D. Research questions that need to be addressed

Can we create courses where concepts are understood without reference to programming language?

Can we apply story centered curriculum or LBD to all domains of knowledge?

VI. CONCLUSION

Although the methodology is new in the Indian context it is easy to get accustomed to. Moreover, the faculty

members trained by us have strongly felt that this methodology will benefit the student community at large. Our results indicate that the approach we have taken works. We are optimistic that this methodology will be embraced by the different universities and that we will truly enhance the quality of IT education.

ACKNOWLEDGMENT

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APPENDIX A: LIST OF PARTICIPATING ENGINEERING COLLEGES

College name	Place
Amara Institute Of Engineering and Technology	Narsaraopeta
Annamacharya Institute of Technology and Sciences	Hyderabad
Annamacharya Institute of Technology and Sciences	Rajampet
Arjun College of Technology and Sciences	Hyderabad
Aurora College of Engineering	Hyderabad
Bharat College of Engineering	Hyderabad
Chaitanya Bharati Institute of Technology	Hyderabad
Chirala Engineering College	Chirala
CVR College of Engineering	Hyderabad
DVR College of Engineering and Technology	Hyderabad
G Narayanamma Institute of Technology and Sciences	Hyderabad
Geetanjali College of Engineering	Hyderabad
Gokaraju Rangaraju Institute of Engineering and Technology	Hyderabad
Horizon Institute of Technology	Hyderabad
Joginpally B. R. Engineering College	Hyderabad
MLR Institute of Technology	Hyderabad
Murthy Institute of Technology and Science	Hyderabad
Nawabshah Alam Khan College of Engineering	Hyderabad
Padmashree Dr. B V Raju Institute of Technology	Hyderabad
Prakasam Engineering College	Prakasham
PVP Siddhartha Institute of Technology	Vijayawada
RRS College of Engineering and Technology	Hyderabad
S S Institute of Technology	Hyderabad
Shri Vishnu Engineering College for Women	Bhimavaram
Sree Dattha Institute of Engineering and Science	Hyderabad
Sreekavitha Engineering College	Khammam
Sreenidhi Institute of Technology and Science	Hyderabad
Sri Chaitanya College of Engineering	Karimnagar
TRR College of Engineering	Hyderabad
Vaageswari College of Engineering	Karimnagar
Vardhaman College Of Engineering	Hyderabad
Vidya Bharathi Institute of Technology	Warangal
Vidya Jyothi Institute of Technology	Hyderabad
Vignan Institute of Technology and Science	Hyderabad
VNR Vignan Jyothi Institute of Engineering and Technology	Hyderabad
VR Siddhartha Engineering College	Vijayawada

*Colleges marked bold have begun implementing the CIT program.

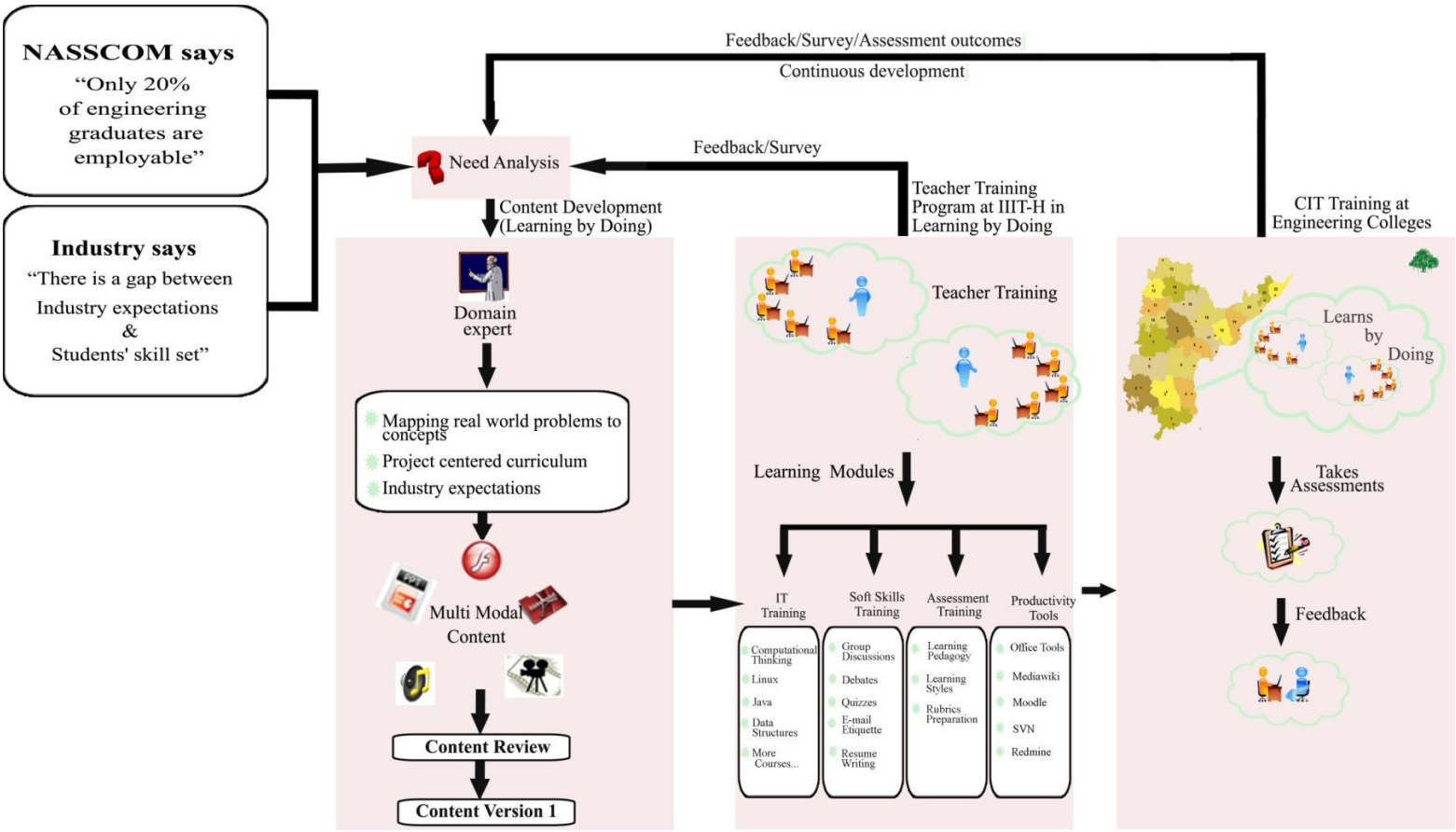

Figure 6: Certificate in Information Technology – The big picture