This dissertation is a reflection of an intervention - EnhanceEdu - designed to improve Information Technology education in South India, training over 500 teachers who in-turn trained over 6000 students.

This study developed new models for content development, teacher change, stakeholder interaction and empowerment, and a novel pragmatic framework called Design Story Research based on design science research, with wider implications in India and other developing countries with similar context.
ENHANCING INFORMATION TECHNOLOGY EDUCATION IN INDIAN CONTEXT – A DESIGN STORY
Sandhya Venkata Kode

ENHANCING INFORMATION TECHNOLOGY EDUCATION IN INDIAN CONTEXT – A DESIGN STORY

ACADEMIC DISSERTATION

To be presented by permission of the Faculty of Science and Forestry for public examination in the Louhela Auditorium, Science Park, Joensuu, on December 03, 2019, at noon.

University of Eastern Finland
School of Computing
Joensuu 2019
ABSTRACT

This dissertation is a reflective presentation of the design and implementation of an intervention called EnhanceEdu created to address the problem of low employability of newly graduated engineers in computer science and engineering in the wake of a boom in the software services industry in India. Instead of implementing student-training programs, that would need to be repeated every year, EnhanceEdu focused on teacher training programs, as a well trained teacher can influence many hundreds of students in a positive way. The research focus of EnhanceEdu was in over 70 engineering colleges in states of Andhra Pradesh and Telangana in South India where the number of engineering colleges grew from under 10 to over 500 from 1978 to 2008. EnhanceEdu interventions from 2008 to 2017, trained over 500 teachers, who in-turn trained over 6000 students.

One of the key concerns was the sustainability of EnhanceEdu. The software services industry in India is going through rapid growth and change. Skills, tools and technology tend to become obsolete within three to five years. Hence, to stay current and relevant, information technology (IT) education must continue to evolve in alignment with the industry, focusing on soft skills along with domain content. Focus of EnhanceEdu was on ensuring that teachers and college management became self-sufficient to manage this change by themselves in the future. They therefore needed to be empowered to lead the change.

This was easier said than done. In the Indian system of education, drawing or changing curricula is a slow process. It is the university that controls and restricts curriculum development—and it often seems like it is a barrier to change. I saw the need to proactively shift the onus of changing the curriculum, in a fast-paced, changing technology scenario, to those who deliver the education—the teachers. They need to be empowered and propelled into the scene of change. Mobilizing them needed a cultural awakening as well as sensitivity on the part of the administration.
and management of colleges and universities. This required a major change in attitudes on the part of the management of colleges and universities and with respect to the responsibilities of teachers as well.

EnhanceEdu interventions empowered teachers to bring change to sustain improvement within the colleges. A retrospective analysis of EnhanceEdu applying Design Science Research (DSR) to each intervention (design process) quickly got very complex with the number of iterations and interventions for various stakeholders. In order to address this complexity, a novel pragmatic method called Design Story Research (DeStoRe) was developed. DeStoRe is a theoretical and practical framework based on DSR, to develop new empowering educational interventions, based on lessons learned and analyzed through each step of the design story. This design story using DeStoRe was seen to have the rigor, relevance and design to address the wicked problems of student employability and teacher quality.

This analysis enabled recognition of the management and administration of colleges as important stakeholders, engaging with multiple stakeholders at the same time but in different ways, with the design of specific interventions for each, to empower teachers to effect changes to improve the education system. This is articulated in the EnhanceEdu stakeholder interaction model.

EnhanceEdu design story shares the design, implementation and evaluation of a teacher training program using learning by doing, with a technology enabled learning environment improving the confidence and effectiveness of participants, empowering the teachers with improved learning outcomes for their students. DeStoRe helped ascertain the rigor and impact of devising and implementing effective teacher training programs that had a positive impact on training students.

An overarching design story frames past, present and future work of an entity, seeing possibilities for innovation. New empowering innovations emerged from EnhanceEdu design story including Butterfly model (a new instructional design model for content), Art of Teaching (AoT), Wikiday workshops and the KODE model for empowerment. This design story provides a contribution to empowerment, innovation and change, with wider future implications of improved information technology education in India and other developing countries with similar cultural context.

**Universal Decimal Classification:** 004, 37.091.12, 377.36

**Library of Congress Subject Headings:** Information technology; Computer science; Education, Higher; Universities and colleges; Teachers; Training needs; Career development; Employee empowerment; Employability; College administrators; Sustainability; Change; Design; Developing countries; India, South

**Yleinen suomalainen ontologia:** tietotekniikka-ala; tietojenkäsittelytieteet; korkea-asteen koulutus; opettajat; opettajankoulutus; koulutustarve; työllistyminen; voimaantuminen; muutosvalmius; urakehitys; palvelumuotoilu; kehitysmaat; Intia
ACKNOWLEDGEMENTS

I am working on completing an “incomplete.” The work in this thesis was partly conducted as director, EnhanceEdu, and partly through my own efforts in devising tools (e.g., design story research) to explain the work done.

I thank the Ministry of Communication and Information Technology (MCIT), now MeitY, and the Ministry of Human Resource Development (MHRD), Government of India, for funding of projects that supported EnhanceEdu in enhancing education.

I thank Prof. Erkki Sutinen, who inspired me with his keynote at the IEEE Technology for Education Conference in 2014 in Kerala, India. When I shared my work on Outreach Education from 2008, he said, “Sandhya, you have done all this work; where is your PhD?” I remembered how, years ago I had passed my PhD qualifiers, back in Iowa but had not pursued the degree; I had moved to industry, saying I would do it later. I returned home and shared with Venkat, my husband, what Erkki said about doing a PhD. Venkat simply said, “Just do it. Complete your incomplete.” Things then moved rather quickly. Erkki visited Hyderabad for a week on his way back from Tanzania. This was a whirlwind week when we brainstormed what I would work on. A month later, I was in Finland, busy working on my application for a PhD. Past publications counting towards the PhD helped, as all I had done focused on improving education, addressing the underlying issues.

I thank Prof. Markku Tukiainen for his enormous patience, guidance and support in the writing of this thesis. Markku has been my supervisor since Erkki moved to the Univ. of Turku three years ago (Erkki continues as my co-supervisor). I am very thankful to Dr. Jarkko Suhonen for his constant and prompt support, right from gathering of course credits to dissertation review. I thank Prof. Matti Tedre for his editorial insights and comments that helped the making of this dissertation. I am grateful to Prof. Shailey Minocha and Dr. Mikko Vesisenaho for the considerable time they dedicated as external reviewers of this dissertation, and to Prof. Mats Daniels who is kindly serving as the honourable opponent at my public examination.

I am grateful to Prof. Raj Reddy, who trusted me enough to bring me into IIIT-Hyderabad in 2008, as director, Training and Development, Center for Education Technology and Learning Sciences. I was to lead the training program for the first cohort of 300 mentors for the then newly formed Rajeev Gandhi University of Knowledge Technologies, on three campus locations, to be run in learning by doing mode, with 1000 students starting on each campus. Prof. Reddy said, “She has 25 years of industry experience in VLSI and the software engineering industry with engineering and management roles, and she can do this well.” I am grateful to Prof. Rajeev Sangal, the then director of IIIT-Hyderabad, who asked me to lead the project to enhance IT education in engineering colleges, funded by MeitY, the Government
of India, beginning the EnhanceEdu story. My thanks to the present director IIIT-Hyderabad, Prof. P. J. Narayanan, who also allowed me a free hand as the principal investigator for the MeitY and MHRD projects.

I thank the many faculty members of IIIT-H for placing faith in me and working with the EnhanceEdu team in developing courses in computer science and electronics, in learning by doing and in the Butterfly model.

I am so very appreciative of my young EnhanceEdu team of Surya Kiran, Nithin, Vamsi, Vishnu, Sunita, Kaumudi, Lakshmi, Shuchita, Rakesh, Prabhakar and a long list of many more for believing in the work we did, never wavering in execution.

I thank Prof. Kinshuk for encouraging me to publish (and do a PhD) when we first met at the first Technology for Education (T4E) Workshop in 2009 at IIIT Bangalore. I thank colleagues from ICALT and POGIL communities for inspiration.

I thank Prof. Nori and Prof. Viswanath for believing in and supporting EnhanceEdu by speaking at various forums like the principals’ meetings and Open Day and for lending their conviction. I thank the principals and management of our partner colleges and all the teachers who took our training programs and helped train students, believing that they would be the change they wanted to see in this world.

I cannot thank Prof. Kesav Vithal Nori enough for believing in me and in the significance of my work, for guiding me and for prodding me on. He said, “You have the experience of CMM Level 5 and continuous improvement. You have realized we need management support and got the principals committed and so much more. Sandhya, stop beating yourself up, and start beating your drum!” Thank you, Prof. Nori for being my guide and mentor on this journey.

I thank my parents, both teachers, for the values, skills, courage and tenacity in facing challenges and life in general and for insights into patient teaching.

My father-in-law, Shri Kode Satyanarayana, is an inspiration to me with his service to education and health. I am very grateful for his encouragement. They say it takes a village; I thank my friends Kali Prasanna and Lakshmi B. for spurring me on and for their help in reviewing the manuscript. I thank Balamma for her help with many figures in the dissertation. I thank others not named but important from the EnhanceEdu family and my family.

I worked many days and nights writing in Pittsburgh, spending time with my son, Karthik Ram, and in Denver with my daughter, Sree Sathya. My husband, friend and strength, Venkata Ramana, has helped in being there for me in every way possible. His love and support has been my nourishment for this journey.

And here is the result of a journey that began 10 years ago, perhaps one that began 35 years ago, when I completed my PhD qualifiers—completing an incomplete!

Joensuu, October 28, 2019

Sandhya Venkata Kode
LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AoT</td>
<td>Art of Teaching</td>
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<tr>
<td>CIT</td>
<td>Certificate in Information Technology</td>
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<td>CT</td>
<td>Computational Thinking</td>
</tr>
<tr>
<td>CMM</td>
<td>Capability Maturity Model</td>
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<tr>
<td>DeitY</td>
<td>Department of Electronics &amp; Information Technology (Govt of India)</td>
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<td>DeStoRe</td>
<td>Design Story Research</td>
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<td>DS</td>
<td>Data Structures</td>
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<td>DSR</td>
<td>Design Science Research</td>
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<tr>
<td>EoI</td>
<td>Expression of Interest</td>
</tr>
<tr>
<td>HPL</td>
<td>How People Learn</td>
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<tr>
<td>ICT</td>
<td>Information and Communication Technology</td>
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<tr>
<td>IIIT</td>
<td>International Institute of Information Technology</td>
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<tr>
<td>IIIT-H</td>
<td>International Institute of Information Technology Hyderabad</td>
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<tr>
<td>IT</td>
<td>Information Technology</td>
</tr>
<tr>
<td>LBD</td>
<td>Learning by Doing</td>
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<tr>
<td>MeitY</td>
<td>Ministry of Electronics and Information Technology (Govt of India)</td>
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<tr>
<td>MHRD</td>
<td>Ministry of Human Resource Development (Govt. of India)</td>
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<tr>
<td>MoU</td>
<td>Memorandum of Understanding</td>
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<tr>
<td>NASSCOM</td>
<td>The National Association of Software and Services Companies</td>
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<tr>
<td>NBA</td>
<td>National Board of Accreditation</td>
</tr>
<tr>
<td>NPTEL</td>
<td>National Program on Technology Enhanced Learning</td>
</tr>
<tr>
<td>POGIL</td>
<td>Process Oriented Guided Inquiry Learning</td>
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<tr>
<td>SEI</td>
<td>Software Engineering Institute</td>
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<tr>
<td>SGSG</td>
<td>Start Green Stay Green</td>
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<tr>
<td>STEM</td>
<td>Science, Technology, Engineering and Math</td>
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<tr>
<td>STEP</td>
<td>STudent Enhancement Program</td>
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<tr>
<td>TPO</td>
<td>Teachers' Pre-orientation Program</td>
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<td>TPD</td>
<td>Teacher Professional Development</td>
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<tr>
<td>TTP</td>
<td>Teacher Training Program</td>
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LIST OF ORIGINAL PUBLICATIONS

This dissertation is based on the following articles, referred to by the Roman numerals I–VII. Seven publications are used. The outcomes of these papers are geared towards various empowering interventions to enhance information technology education in India.


AUTHOR’S CONTRIBUTION

The author is the principal contributor to the original publications, PI, PIII, PIV, PV, PVI and PVII, and is the parallel principal contributor to PII. The papers PI, PII, PIII and PIV focus on the design and implementation of a teacher training program, its evaluation and its transfer to student training and on improving success. PV, PVI and PVII share innovation offshoots of this process. Coauthor Prof. Erkki Sutinen’s support and guidance was very valuable in the publication of PVII.

Apart from the author, her team (EnhanceEdu) and coauthors have contributed to content development and portal development and to teacher training and student training implementation for teachers from various locations in the southern states of Telangana and Andhra Pradesh in India.

I. The author was the principal contributor for the overall design of the teacher training program (TTP) and the processes for implementation with management as a stakeholder. The coauthor contributed to the writing, content development and teacher training coordination, executing the ideas.

II. The author was the primary editor of the paper. The authors were co-contributors to the writing of the paper. The coauthor gathered the data from the survey results, and both authors analyzed the data and decided how it should be interpreted and written up.

III. The author was the primary contributor to the writing of the paper and the design of the program, and the coauthors were key in implementing the Student Enhancement Program (STEP) at the colleges. The coauthors gathered data on why it worked/did not work. The author analyzed the data and made decisions on the plan of action. All the authors reviewed and approved the final version.

IV. The author was the primary contributor to ideas for engaging management and students. The coauthors were co-contributors in implementing the ideas. The animation (support) team implemented the idea of the newsletter to engage the management, teachers and students. The author was the primary editor of the paper.

V. The author was the primary contributor to the design of the Butterfly model. The authors together wrote the paper and conducted workshops based on
the courses designed using the Butterfly model. The authors analyzed the data gathered from the workshops and reported in the paper. The Butterfly model improves on the existing learning by doing (LBD) model and enables experts from different subject areas to develop content.

VI. The author was the primary contributor to the paper. Prof. Kesav Vithal Nori, coauthor, provided guidance and helped in the writing and reviewing.

VII. The author created the concept of design story research (DeStoRe). DeStoRe came out of a discussion on design science research with the coauthor Prof. Erkki Sutinen, whose insights and comments were extremely valuable in bringing out this concept.
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1 INTRODUCTION

This dissertation is a reflective analysis, using design science research (DSR), of an intervention that was deployed in India from 2008 to 2017, called EnhanceEdu. EnhanceEdu was created at the International Institute of Information Technology, Hyderabad (IIIT-Hyderabad) in 2008 with funding from the Ministry of Communications and Information Technology (MCIT), Government of India, to enhance information technology (IT) education in engineering colleges. It was devised as part of the “Manpower Development Scheme” of MCIT (now MeitY) as a capacity-building initiative, because of a clarion call by the National Association of Software and Services Companies (NASSCOM), an industry body that oversees the development of the software services industry in India; their concern was that people who were candidates for jobs in the industry were not employable on several counts. A study by NASSCOM reported that only 25% of graduating engineers were employable (NASSCOM-McKinsey, 2005). This situation demanded a holistic, sustainable intervention in the IT and engineering education systems in India. This thesis recounts the birth of EnhanceEdu as an intervention as well as its implementation. It researches the rationale for this intervention’s design and clearly demonstrates that college management, faculty and students are the stakeholders who must be simultaneously addressed, rather than individually focused on, for a successful and sustainable intervention.

This intervention included college administration and management empowering teachers and teachers’ grasping the concepts to be taught and evolving their instruction skills. The most important impact would then be the trained teachers giving their students the motivation and necessary tools to switch from learning by rote (or learning by memorizing) to learning by doing (LBD), empowering them to learn how to learn.

Our goal was to make information technology and engineering students employable by the IT services industry. We were clear that the intervention should be self-sustaining and that it must evolve independently with the rapid changes occurring in IT education and the IT services industry. This implied that the design of the intervention itself was also as important as the initial goal of improving the employability of IT and engineering students. The design of EnhanceEdu is the first step in this process and is the principal focus of this story.

EnhanceEdu worked towards empowering individuals and communities by enhancing education to make graduates industry ready. We accomplished this goal in

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1 Candidates are considered employable if they have the necessary skills first to get a job and then to be able to deliver on the job.
three ways: first, by training the faculty and students of engineering colleges in the Certificate in Information Technology (CIT) course and advanced courses; second, by conducting hands-on workshops on current and relevant topics in IT and soft skills, and third, by community-building through collaboration.

With over 25 years of industry experience in engineering and management in large-growth companies and start-ups both in India and the US, I was given a wonderful opportunity in 2008 to train and mentor 300 new teachers for a new university being created across three campuses in Andhra Pradesh, India. This felt like a calling to do something different after I had attended a human values workshop in 2007, a year prior to moving back to India from the US.

My experience being the founding director of the Motorola Software Center in Hyderabad, growing the center from 0 to 150 people and to SEI CMM Level 5 (Herbsleb, Zubrow, Goldenson, Hayes, & Paulk, 1997; Paulk, 1993) in a matter of just two years from 1997 to 1999 taught me many management lessons. To establish EnhanceEdu in 2008 as its chief mentor and director, a team of mentors had to be created. In the beginning, the team was made up of graduates with a two-year master’s degree in IT (MSIT) using LBD. As they were familiar with LBD, I would have them help in mentoring the teachers (mentees) in the teacher training program (TTP). However, they would be much younger than many of the teacher participants, so preparing them for that role and preparing the teachers to be mentored by this young team were both interesting challenges. To overcome these challenges, two key elements were utilized that I brought to EnhanceEdu—culture and process orientation. There are many definitions of culture, and the one I have chosen to use is from Schein (1990), “Culture is 1) A pattern of basic assumptions, 2) invented, discovered, or developed by a given group, 3) as it learns to cope with its problems of external adaptation and internal integration, 4) that has worked well enough to be considered valid and, therefore 5) is to be taught to new members as the 6) correct way to perceive, think, and feel in relation to those problems”. Thus, I refer to culture as the shared values, beliefs and behaviors of an organization, group or society.

1. **Culture:** I created and designed cultural elements referred to as teaming for excellence and taking ownership.

   - **Teaming for Excellence:** I placed an emphasis on synergistic alignment, so the sum of the parts was greater than the parts simply added together. This meant that the team members who had good skills put out the best they could without worrying about who was better; they worked towards the overall goal. Governance around the agreed behavior was established, with team members consciously correcting each other. This made working together towards goals much easier and more fun. Everyone felt it was his/her own goal that was being achieved.
• **Taking Ownership**: I called on the team not just to align with the goal but to take ownership of it. This meant that they would own, breathe and be EnhanceEdu. For example, if the goal was to have 100 teachers go through the TTP program in summer, then a plan needed to be established and executed accordingly. In one instance, one of the training coordinators devised a strategy where each team member was responsible for five nominated teachers and made sure arrangements for their travel and stay were taken care of. This led us through a 100% completion cycle. This culture, along with LBD, became part of the EnhanceEdu life.

2. **Process Orientation**: We were engineering a design and managing it. All the plans and processes were version-controlled and documented through wikis. We were a community of learners along with our stakeholders. The debriefing sessions between mentors and mentees were also captured through wikis. This shared information helped all our mentors with problem resolution.

Apart from the above two key elements, we believed that a cultural change was necessary, resulting in a marked change in attitude. We derived several principles from culture and process orientation:

- I am not alone. I am part of a larger team. (Collaboration & collective self-efficacy)
- Individually we cannot, but together we can. (Reaction versus response)
- A 100% completion cycle (Ownership of getting the job done and not just a part of it)
- Three Cs (Completeness, correctness and consistency in reviewing work and documents)
- Respect, integrity, care for the environment (Reinforcing core values)
- Waiting is a word removed from the EnhanceEdu dictionary. (Be proactive)
- Have fun doing what you are doing. (Cognitive absorption and flow)
- Process orientation (For continuous improvement and bringing in agility)
- Goal setting, detailed planning milestones, evaluating risk (Project management)

To create a sustainable EnhanceEdu, we first had to choose an appropriate pedagogy, customize it to suit our special circumstances and drive pilot implementations to achieve results and refine the design to meet the needs of various stakeholders in the educational system. Focusing on students would not be enough, as there would be a fresh cohort of students every year in need of corrective education to make them employable. In the Indian system, where teaching is often treated as just a job, as a source of employment rather than a vocation, the right focus of the intervention is the teachers. Are they empowered, do they have the right tools, can the content be
improved to improve its effectiveness? These were critical questions to be addressed. But we also saw the need to include the managers of the educational system, namely principals and directors of educational institutions. Do they provide the needed infrastructure and empower their staff? All in all, EnhanceEdu must keep a constant watch on the change indicators of the evolutionary needs of the educational system, not waiting for further NASSCOM reports to address but envisioning them on our own, being prepared to go through cycles of intervention design and implementation. This was a lofty goal, although not wholly realized. This thesis is about this journey, and it has several lessons for us to learn and apply.

1.1 BACKGROUND AND MOTIVATION

As India is the context of our research, this background will cover the demography of India and the region of our research study where the intervention was introduced and deployed. It also reviews the state of higher education in India and the major issues and challenges in this area. The demography of India includes the following (Figure 1.1).

- India consists of 29 states with a population of 1.3 billion. as of July 2016 (Figure 1.1)
- There are 122 spoken languages in India, with 22 officially recognized in the constitution.
- India’s land area is 2,973,190 square kilometers, with a density of 382 people per square kilometer.
- India’s land area is 2.4% of the world’s total area.
- India’s population is 17.5% of the world’s population.
- There are over 2000 ethnic groups and all known religions.

Andhra Pradesh and Telangana are two states in South India (Figures 1.2a and 1.2b). This was the region of the research study. The interventions were conducted in educational institutions in these two states from 2008 to 2017.

The following are these states’ population and population density statistics:
- Andhra Pradesh population: 49,386,799: 34,951,234 (rural) 14,610,410 (urban)
- Population density: 308 people per square kilometer
- Telangana population: 35,193,978: 21,585,313 (rural) 13,608,665 (urban)
- Population density: 307 people per square kilometer
Figure 1.1. Map of India (adapted from www.mapsofindia.com)
Figure 1.2a. Map of Andhra Pradesh state in India (adapted from www.mapsofindia.com)
Employability can be defined in various ways. According to Yorke (2004), employability is a set of achievements—skills, understandings and personal attributes—that make graduates more likely to gain employment and be successful in their chosen occupations, which benefits themselves, the workforce, the community and the economy. Khare (2014) deduces that employability depends on a number of factors that can be broadly classified under three headings—knowledge, attitude and skills—which align with the
three domains of Bloom’s taxonomy (Bloom, 1956; Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956; Krathwohl, 2002).

Most of the graduating engineers have huge gaps in the skills required for industry—domain skills, soft skills and communication skills (Aspiring Minds, 2011, 2014). In today’s swiftly globalizing economy, a country’s competitiveness and movement up the value chain beyond simple production processes and products is mostly a function of its quality of higher education and training (Schwab, 2010).

For our purpose, employability is defined as having the necessary skills to both get a job and be able to deliver on the job. A key aspect that distinguishes the IT industry from others is the need for employees to keep pace with rapid technological change. Skills, tools and methods can become obsolete in a matter of three to five years. Hence, it is important to develop in students a “learning to learn” capacity and continuous learning (as an attitude) at the foundational level.

1.1.1 The state of higher education in India

Higher education in India offers programs leading to a degree or diploma. This refers to post-senior secondary-level education. The universities have the authority to conduct programs at the undergraduate and postgraduate levels and award degrees to successful candidates (Varghese, 2014).

India achieved its independence from British rule in 1947. The 27 nationally important institutions of higher learning grew to more than 130 universities and nearly 5000 colleges during the next 35 years. By 2012, the university and college system in India grew to 348 universities and 17,625 colleges, with an average enrollment of 600 students, compared to the average enrollment of about 4,000 students in the university and college systems of the western world. In terms of the number of institutions offering higher education, India is the largest in the world and the third largest, after China and the US, in the number of students pursuing higher education. This makes the Indian higher education system highly fragmented and hard to manage and ensure high standards (Agarwal, 2006).

With the passage of the Private Universities Act in several states, there was a significant proliferation of private universities starting in the late 1980s (Varghese, 2012; Varghese, 2014). In a span of one decade, up to 2012, around 178 private universities were established in India, forming a significant percentage of the 348 universities in India (as of 2012).

A review of higher education in India shows that the primary component is undergraduate education leading to a bachelor’s degree. In 2011, about 80% of the students were in undergraduate courses and less than 0.5% in research programs (Varghese, 2014). Postgraduate and research programs consistently have very low
enrollments. This places severe constraints on higher education, since this is the feeder system for qualified teachers. There is a significant gap between the number of qualified teachers and current higher education student enrollment.

The teaching–learning process depends on several factors, including the adequacy of course content, the availability of appropriate tools, teacher competency, the classroom teaching–learning environment and the motivation and commitment of teachers and students.

The demand for information technology (IT) graduates to work in software companies (local and foreign) grew enormously in the 1990s and 2000s. To meet this demand, the number of engineering colleges also grew 50-fold, especially in states like Andhra Pradesh and Telangana. The demand for teachers also grew as a result.

1.1.2 Socio-cultural context and challenges for higher education in India

This section outlines the socio-cultural context and challenges for higher education in India. The social environment, social context, socio-cultural context or milieu refers to the immediate physical and social setting in which people live or in which something happens or develops. It includes the culture that the individual was educated or lives in, and the people and institutions with whom they interact (Barnett & Casper, 2001).

The systems view of higher education in India (Figure 1.3) includes a very large number of players and stakeholders—IITs, IIITs, NITs, state universities, deemed universities, affiliated colleges, regulatory bodies and funding agencies, management, teachers, students, parents and employers. By 2015–2016, the number of universities and the number of colleges grew to 799 and 39,071 respectively (MHRD, 2016). Of these 799 universities, 268 are affiliating universities having colleges affiliated with them; 277 are privately managed universities; and 307 universities are located in rural areas. These institutions are central (federal Indian government-supported), state (state government-supported) and private (with no support from center or state), with most of the colleges being private or state.

The affiliated college system is a key overall structure that defines a major portion of Indian higher education. A small percentage of students are enrolled in university colleges. A majority of students, 90+% of undergraduates, study in private colleges that are affiliated with universities. These affiliated colleges conduct classes and examinations based on the curricula specified by the universities they are affiliated with. But the problem is that in some cases, there are several hundred to more than one thousand colleges affiliated with a single university. This presents a considerable challenge to these universities in regulating and ensuring quality control at these colleges. Exceptions apart, a majority of these colleges fail to maintain minimum
standards laid down by regulatory bodies like the University Grants Commission (Agarwal, 2006; Heslop, 2014).

Figure 1.3. Systems view of the higher education system in India

Figure 1.4 shows how an affiliating university has several hundred affiliated colleges of varying types, many private and unaided, a few autonomous and many in rural areas. Accreditation through the National Assessment and Accreditation Council (NAAC) (Stella, 2015) and the National Board of Accreditation (NBA) (Patil & Codner, 2007) of all universities and colleges has been made mandatory. A huge exercise is underway to accredit the two-thirds of universities and four-fifths of colleges that do yet not have accredited status (Heslop, 2014).

Indian universities and their affiliated colleges face several major challenges. A few of these, like uneven opportunity and a supply-demand gap, are systemic and linked to the whole socioeconomic fabric of the country. But others, like the low quality of teaching, the low availability of qualified faculty and the openness of students to learning and doing research, are open for academia to look at and address (Agarwal, 2006; Heslop, 2014).
Figure 1.4. Affiliating university and affiliated colleges

The main challenge is the persistent shortage of good teaching and research staff (Heslop, 2014). Most bright people are reluctant to join the teaching profession and those who join, do it as a last resort. They get disillusioned soon after they join when they find that they have no incentive to perform (Blom & Saeki, 2011). Many treat their teaching jobs as a stopgap while they look for industry jobs (Subbarao, 2013). The curricula are rigid and dated, and the teaching and examination system is focused on rote learning as opposed to higher-order thinking, for example, critical thinking. Nor are collaborative work, analytical reasoning and problem solving given due importance, either in the learning process or during skills assessment (Heslop, 2014). The importance of research and of instilling an interest in teachers and students to do research has not been adequately addressed by the university system. When teachers do not have an interest in research, they risk becoming outdated and out of touch with the fast-changing requirements of the world. This results in students graduating with subpar skills, and their employability is affected (Heslop, 2014; Kumar & Ambrish, 2015; Sheikh, 2017).

This low quality of teaching and learning has resulted in graduates with low employability, a common feature across South Asia (NASSCOM-McKinsey, 2005) and an inadequate basis for moving to higher levels of study and research. These problems are endemic across higher education institutions in India, including many of the “top tier” institutions, but particularly in affiliated colleges and state universities (Heslop, 2014).
The research focus in this study is on affiliated colleges and state universities. The university system in India is centrally administered by the University Grants Commission (UGC). The curricula are set by the university. In our research we found that it is the teaching faculty who should be involved in curriculum change. The teachers should be empowered to change curricula according to the needs and times. This is what we experimented with in two south Indian states. Though our experience is with the university system and affiliated colleges in South India, we believe that our approaches are applicable to all of India and have a pan-India character.

1.1.3 Government-driven reforms

The three central pillars of the Government of India’s twelfth five-year plan (2012–2017) for education were expansion, equity and excellence (Planning Commission, 2012). The government intended change in all aspects of higher education, all the way from funding to accountability and quality assurance. There was a large emphasis on international collaboration, leveraging technology for education and strengthening teaching and research. Emphasis was placed on strengthening existing institutions (Heslop, 2014).

The excellence principle calls for multidisciplinary courses in response to changing economic and industry needs, the provision of varied career opportunities for students and the bringing of teaching and research to new highs (Heslop, 2014). Technology is leveraged in a major way, with large investments in information and communication technology (ICT)-enabled infrastructure and education, enabling multidisciplinary collaboration and the development of technology-enhanced learning and teaching, including massive open online courses (MOOCs).

A national mission for “teachers and teaching” was established with a focus on the capacity- and quality-building of faculty, the adoption of internationally recognized accreditation and assessment systems, increased opportunities for for-profit private education, the funding of a large number of teaching–learning centers of excellence and other capacity-building initiatives.

While the government plans and initiatives are steps in the right direction, with the on-the-ground realities of the huge education system, results will take time to ripple to the colleges, as the mechanism to change such a huge system of multiple stakeholders is very large and unwieldy.

EnhanceEdu was established in 2008 as an intervention, and it offered the CIT program in the states of Andhra Pradesh and Telangana in India.
In Figure 1.5, a CIT poster depicts the knowledge domain of the intervention, addressing education in computer science and engineering. The certificate in IT included core topics of IT training, such as computational thinking, Java, data structures, soft skills, assessment training and productivity-enhancement tools like Moodle (Moodle, n.d.) and wikis. The various interventions that were done, with the feedback at every stage from content development to teacher training to student training in the colleges, can also be seen.

1.2 RESEARCH QUESTIONS

1.2.1 Problem statement

In higher education in India, there is a severe shortage of qualified faculty, a poor quality of teaching and learning and a lack of support from government. The large numbers of engineering colleges (mostly private) experience a paucity of qualified faculty (Gupta & Gupta, 2012; Subbarao, 2013). This issue is also linked to few graduates interested in pursuing postgraduate education, preferring an industry job...
(Subbarao, 2013); many become teachers only if they are unable to get a job in the industry. Both the lack of quality and lack of motivation of faculty members deter their interest in getting further training and using technology for education. Teaching in engineering colleges is primarily lecture-based and teacher-centered. There is considerable pressure on faculty to complete the prescribed syllabus from the regulatory bodies and affiliating universities, and hence the primary concern of faculty members is to do this, and they do not pay enough attention to their students’ needs, learning styles, learning pace and learning outcomes (D’Souza & Rodrigues, 2015). Teachers do not want to spend additional time, for which they may not get any specific compensation, on either learning or using technology for education to achieve better learning outcomes.

Since research shows that this low quality of teaching and learning has resulted in engineering graduates with low employability (NASSCOM-McKinsey, 2005), one of the key factors affecting employability in the IT industry is the low quality of teaching and learning in IT and engineering education. This is the problem statement for this research.

This research problem appears to be a wicked problem. Rittel and Webber (1984) first gave wicked problems the following characterizations:

- unstable requirements and constraints based on ill-defined environmental contexts;
- complex interactions among components of the problem and its solution;
- inherent flexibility to change design processes as well as design artifacts;
- a critical dependence upon human cognitive abilities (like creativity) to produce effective solutions and
- a critical dependence upon human social abilities (like teamwork) to produce effective solutions.

This problem statement led to the main research topic, addressing the problem with solutions that can enhance IT education in engineering colleges in India. Interventions that directly train students who are not employable do help the students, but these are not sustainable, since they do not improve the education system per se, nor do they improve teaching and learning. Teacher professional development is a much more effective and sustainable way to address the problem. This led to conducting a review of the literature on teacher professional development, on content and pedagogy to be used for it and on how to facilitate change in IT education, such that the newly designed and developed TTP impacts teacher change and improves student learning.
1.2.2 Framing the research questions

The problem statement also now leads us to frame the following research questions. Table 1.1 shows the research questions outlined to help realize the goals of this dissertation, through which the EnhanceEdu interventions can be examined. The questions RQ1 and RQ2 arise from the issues raised by NASSCOM of low employability in India, and also from the MCIT, government of India, which wanted to Enhance IT Education in engineering colleges. Table 1.1 also associates the research questions and the published papers along with the chapters in the dissertation where the research questions are further discussed. Answering RQ1 leads us to the next question, RQ2, that of the stakeholders and how they should be treated to support the improvement of IT education in the Indian context.

However, with many iterations of training programs in many colleges and many stakeholders from different colleges, it was hard to explain or keep track of issues related to each. The complexity in answering RQ2 is high, and this led to the next research question, RQ3, to determine the characteristics of a design-oriented research method that would support the development process of new empowering educational interventions to enhance IT education.

Table 1.1. Research questions and mapping to papers and chapters in the dissertation

<table>
<thead>
<tr>
<th>Questions</th>
<th>Papers</th>
<th>Chapter</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1 How do we design a teacher training program to be effective in enhancing information technology (IT) education in engineering colleges in the Indian context?</td>
<td>PI, PII, PV</td>
<td>4, 5, 6, 7</td>
</tr>
<tr>
<td>RQ2 Who are the stakeholders, and what kinds of interventions are needed for each of the stakeholders to enhance information technology (IT) education in the Indian context?</td>
<td>PIII, PIV, PVI</td>
<td>4, 5, 7</td>
</tr>
<tr>
<td>RQ3 What are the characteristics of a design-oriented research method that support the development process of new empowering educational interventions to enhance information technology (IT) education?</td>
<td>PVII</td>
<td>5, 6, 7</td>
</tr>
</tbody>
</table>

EnhanceEdu was conceived as an exploratory design intervention and was tested in South India in over 70 colleges. However, as is shared in section 1.1.2, the socio-
cultural context is similar throughout India with the concept of affiliating universities and the associated large number of affiliated colleges. Thus, these research questions and the results of EnhanceEdu are relevant across India.

Further, the discussion yields deeper reflections on what the factors for change could be for enhancing the information technology education in India.

Figure 1.6 summarizes the relationship between the different papers PI–PVII. The figure contains three key paths. The path in the middle, involving PI, PII, PIII and PIV (RQ1 and RQ2), discusses the IT TTPs and student training programs. PI and PII examine the design of a methodology for a TTP to enhance IT education and the evaluation of the TTP related to RQ1. PIII and PIV discuss the challenges of the trained teachers in conducting student training in the colleges and the necessary support systems required from management and EnhanceEdu, related to RQ2. The path on the left with the Butterfly model (PV) (RQ1) leads to instructional design and smart learning artifacts, the content portion of the TTP. The path on the right (PVI) leads to generic teacher training without being domain-specific, using educational technology.
This last path was created on demand from teachers of other departments and branches of engineering and arts to increase their self-efficacy and make them be more reflective teachers (RQ2). PVII discusses RQ3 and also ties all the streams together with a unifying method to represent the interventions.

1.3 STRUCTURE OF THE THESIS

This dissertation includes a seven-chapter introduction and a collection of seven original papers, PI to PVII, that the dissertation is based on. The first chapter introduces the subject matter of the dissertation, the objectives of the research and the background and motivation for a DSR-oriented design for the problem. The problem statement and research questions, which encapsulate all the published papers, are also outlined in the first chapter.

Chapter 2 is the review of literature on content and pedagogy, teacher professional development, change models for IT education, and design and design stories.

Chapter 3 is the research design and methodology. DSR is employed as an approach to reflect on the EnhanceEdu interventions. The chapter elaborates on DSR and discusses why DSR was chosen and also addresses the context and methods used in this research. The chapter concludes with ethical considerations.

Chapter 4 is implementation and intermediate results, and it addresses the reflection on the actions taken to address the big problem of improving IT education. The various sections address the different facets of implementation, content development and each of the stakeholder groups, including management, teachers, students and EnhanceEdu. Chapter 4 draws from PI, PII, PIII, PIV, PV and PVI.

Chapter 5 goes over the key results – answering research questions, and Chapter 6 addresses the discussion of the results with respect to literature, their implications and their application in other contexts. Chapter 7 provides the conclusion and future work drawing from the seven articles (PI-PVII) and identifies the major contributions of this dissertation as well as the retrospection and lessons learned, and future work and research directions. Chapter 7 is followed by the bibliography, appendices and the collection of seven original papers, PI–PVII.
2 REVIEW OF LITERATURE

_The only person who is educated is the one who has learned how to learn…and change._

Carl Rogers

Historically, engineering education was expected to impart domain-specific skills and knowledge. However, since the 1980s, several more skills, such as communications and problem-solving skills, were added to the list of expected skills. Today, information technology (IT) and engineering education across the world expects graduates to have soft skills, communication skills and domain-specific skills (Bringula, Balcoba & Basa, 2016; Depieri & de Deus Lopes, 2014; Nylen & Pears, 2013; Yuzainee, Zaharim & Omar, 2011). Indian information technology (IT) and engineering education shows similar requirements (Blom & Saeki, 2011; Goel, 2006a; Kode & Reddy, 2010; Rekha, Adinarayanan, Maherchandani, & Aswani, 2009; Shinde & Kolmos, 2011; Warriem, Murthy, & Iyer, 2013). A literature review shows that engineering job requirements are changing and that the knowledge and skills required are not well addressed at the school and college levels. Significant gaps are present. These include problem solving skills, creativity, higher order thinking skills, integrity, reliability, team working, communication skills and willingness to learn (Aspiring Minds 2011; Blom & Saeki, 2011).

Apart from this, higher education system in India has quality issues in many institutions: there is poor quality teaching, shortage of good quality faculty, outdated curriculum and pedagogies, and a lack of accountability (Heslop, 2014). These findings suggest significantly changing the testing system to focus less on memorization and more on higher order thinking skills, and promote teaching-learning sessions where students can actively develop their analytical and evaluating skills instead of simply listing and taking notes (Blom & Saeki, 2011). This would need significantly increased academic autonomy of institutions, a switch of focus from content teaching to learning outcomes, improved recruitment and substantial professional development of teachers (Blom & Saeki, 2011; Heslop, 2014).

As this is a multidisciplinary study addressing educational systems, content and methodology, teachers and students, management, change, and design, the literature review is divided among four different areas:

1. Content and pedagogy (what is to be taught and how)
2. Teacher professional development (what kind of training is to be imparted to IT teachers and how)
3. Change models for IT and higher education that enhance teacher professional development, which will positively impact student learning
4. Design and design stories


### 2.1 CONTENT AND PEDAGOGY

Information technology companies have carved out a significant place for jobs in India in the last few decades. They range from IT services to IT product companies. Hence graduates are required to have strong coding and algorithm skills. Aspiring Minds (2011, 2014) study found major skill gaps in graduates in a study conducted across India. They also found that there is a lot of rote learning as opposed to higher order thinking skills. In the Indian context, as seen in Chapter 1, the university and affiliated college system has curricula set by universities with teachers having little or no control on what is taught, or how the students are tested. Teachers teach to the exam and students’ learning is often narrow and theoretical (Heslop, 2014). Assessment of student learning is based on rote learning, which is lower-order thinking (Blom & Saeki, 2011; Heslop, 2014). Most studies show the need for higher-order thinking skills in students’ learning (Aspiring Minds, 2011, 2014, 2016; Blom & Saeki, 2011).

The idea of pedagogical content knowledge introduced by Shulman (1986) leads to thinking not just about content but how it should be taught. Bloom’s (1956) taxonomy was early work with respect to the fast-changing field of computer science, but it is still relevant. It is also applicable to other engineering disciplines. It focuses on a taxonomy oriented towards learning, it can be adapted to the teaching process and it can be used for testing as well. Learning processes related to understanding, through cause, analysis and evaluation, and ending in solving practical problems, are part of thinking skills, which make up cognitive skills (Quellmalz, 1985). Bloom’s taxonomy in cognitive domain discusses lower-order to higher-order thinking skills (Bloom, 1956; Krathwohl, 2002).

Students need to “learn by doing” (LBD) applying knowledge to real-world problems in order to develop skills or new ways of thinking (Lewis & Williams, 1994). LBD refers to a theory of education expounded by American philosopher John Dewey (1938), who stated that learning should be relevant and practical, not just passive and theoretical. LBD helps develop skills and the learning of information in the context in which it will be used (Schank, Berman, & Macpherson, 1999). LBD can help students be more hands-on and self-reliant, enabling them to learn to learn.

Constructive alignment is one form of outcome-based teaching and learning. Any learning needs to have clear intended learning objectives and learning through tasks (or activities) that matches these objectives as well as assessments that measure the learning. Biggs’ constructive alignment is one way of achieving this alignment (Biggs, 1996; Biggs & Tang, 2010). Learning activities that are too low a level to achieve the intended learning outcomes are referred to as comprising a ‘surface’ approach to learning, for example memorizing to give the impression of understanding.
Activities that are appropriate to achieving the outcomes are referred to as a ‘deep’
approach. At university, intended outcomes would be high level, requiring students
to reflect, hypothesize, apply and so on (Biggs & Tang, 2011).

When students participate and engage in a well-designed activity, they gain
knowledge at the conceptual level, leading to deep learning (Biggs & Tang, 2011;
Norton, Richardson, Hartley, Newstead, & Mayes, 2005). This approach is student-
centered learning. Students who learn through information and knowledge trans-
mission from teachers, on the other hand, are at a surface learning level (Trigwell,
Prosser, & Waterhouse, 1999). This approach is teacher-centered learning. Research
in higher education shows that teachers adopting a more student-centered approach
to teaching are more likely to produce students who adopt a deep learning approach
rather than a surface approach to learning (Gow & Kember, 1993; Prosser & Trigwell,
1999). When teachers use the knowledge transmission approach, the students’ “use
of deep approach is likely to decline through the period of the course of study” (Kem-
ber & Gow, 1994, p.67). The inverse is also true; the use of teaching methods that
facilitate the use of deep approaches to learning will discourage the use of surface
approaches (Kember & Gow, 1994).

A large body of work discusses student-centered approaches for active learning
(Bonwell & Eison, 1991; Prince, 2004), LBD (Dewey, 1938; Schank et al., 1999), prob-
lem-based learning (Boud & Feletti, 1997; Prince, 2004; Prince & Felder, 2006), project-
based learning (Prince & Felder, 2006), a story-centered curriculum approach
(Schank, 2002) and just-in-time teaching (Novak, Patterson, Gavrin, & Enger, 1998).

In general, industry prefers undergraduate engineers with the content knowledge
and ability to solve real-world problems (Berges, Mühling & Hubweiser, 2012;
Carter, Vouk, Gannod, Burge, Anderson & Hoffman, 2011; Kasurinen, Mirzaeifar &
Nikula, 2013). This is no different in India (Aspiring Minds, 2011, 2014; Blom & Saeki,
2011; Heslop, 2014). To solve real-world problems, one needs to have problem-solv-
ing skills and the ability to apply, analyze, evaluate and create. Students need to be
technically sound and be able to apply their domain knowledge to solve information
system problems. Problem-based learning in higher education is a good way of map-
ing real-world problems to concepts (Schwartz, Mennin, & Webb, 2001). Shinde and
Kolmos, (2011) observe that there are challenges in the implementation of problem-
based learning in higher education in India.

The cognitive science-based how people learn (HPL) framework (Bransford,
Brown, & Cocking, 1999) is another well validated framework that supports student
or learner centered environment. The HPL framework calls for the following:

- A learner-centered environment that takes into account the knowledge, skills
  and attitudes of the learners. It establishes the relevance of course material
  and gives learners the freedom to choose among alternatives. To support this
environment, at least one workshop facilitator must come from a similar discipline to that of the participants.

- A knowledge-centered environment, meaning that the content being taught should focus on the most important principles and methods associated with the subject of the presentation and should build on the learners’ current knowledge and concepts. The presentation should utilize techniques known to promote skill development, conceptual understanding and metacognitive awareness rather than simple factual recall.

- An assessment-centered environment, which suggests that feedback is regularly provided in various forms to help learners understand where they stand in terms of meeting the learning objectives of the program, with opportunities to reflect and practice immediately after feedback.

- A community-centered environment characterized by supportive interactions among learners and a de-emphasis of individual competition.

Content may be organized using Bloom’s taxonomy in the cognitive domain with lower-order to higher-order thinking skills in a learner centered environment. Content may be structured using constructive alignment to satisfy the needs of outcome-based teaching and learning that most accreditation agencies use. Content may also be organized using technology-enabled methods, as in the National Program in Technology Enabled Learning (NPTEL) (Ananth, 2011; Krishnan, 2009) and MIT OpenCourseWare (Lerman & Potts, 2006; MIT, n.d.).

If the HPL environment is technology-enabled, with each of the above features integrated into the design, then it would be a technology-enabled learning environment that suits the HPL framework and is also aligned with technological pedagogical content knowledge (Koehler & Mishra, 2009).

The HPL environment considers content, pedagogy and technology. However, it is not sufficient to have content, pedagogy or technology without appropriate training on when, where and how the content is usable and how students can benefit. This leads us to teacher professional development.

## 2.2 TEACHER PROFESSIONAL DEVELOPMENT

It is important to review literature on what features of a successfully designed training program help enable teacher behavior change and a change in instruction. Any training program should be evaluated for its effectiveness. Facilitators of professional development programs also need to recognize faculty as adult learners and their professional development as adult learning. By recognizing the literature and theory from adult education, a teacher training program (TTP) for adult learners can be
purposefully designed. This section on teachers’ professional development (TPD) is viewed from three perspectives:

- Features of effective TPD.
- TPD as adult learning.
- Analyzing and evaluating TPD.

Good teaching involves getting most students to use the level of cognitive processes needed to achieve the intended outcomes more uniformly in a class (Biggs, 2011). An engineering graduate degree holder cannot be declared ready to be a teacher. No master’s graduate with good credentials immediately becomes a good teacher (Grossman, 1990). Other studies show that after a teacher professional development program of 4–18 months, teachers may become less teacher-centered and more student-centered (Gibbs & Coffey, 2004). Pedagogical change takes at least a year (Postareff, Lindblom-Ylänne, & Nevgi, 2007).

*Effective professional development involves teachers both as learners and as teachers and allows them to struggle with the uncertainties that accompany each role. … Teachers learn by doing, reading and reflecting (just as students do) by collaborating with other teachers, by looking closely at students and their work and by sharing what they see. This kind of learning enables teachers to make the leap from theory to accomplished practice.* (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009)

It was seen in Chapter 1, that there was a huge expansion in the numbers of engineering colleges in India, and a shortage of teachers that could teach in these colleges. The mismatch between the number of higher education institutions and teaching faculty is a major cause of worry as this is bound to aggravate the problem of low quality education (Khare, 2014). It is clear that there is a quality issue in the engineering teaching faculty, due to a severe lack of good teachers. A good teacher is the pivot around which the whole teaching-learning process revolves in an educational institution (Thankachan, Sharma & Singh, 2010).

Further, unlike the teachers of K-12, teachers in engineering colleges are not required to undergo teacher education and most engineering colleges teachers have only a bachelor’s or a master’s degree (Subbarao, 2013). The literature has it that good student learning is obtained by good teaching (Biggs, 2011). It has also been pointed out that Indian engineering education sector needs to focus on competence-building by transforming its traditional teaching-centered teaching, learning and assessment processes (Goel, 2006b). There are several national TTPs in India, like the large-scale virtual classroom training T10kT (Atrey, Parmar, Shiriskar, & Dhebar, 2016; Kannan & Narayanan, 2015), the National Institute for Teacher Training and Research (Tulsi & Poonia, 2016) and the UGC Academic Staff Colleges. However, we are not aware
of any reports on the impact of training programs on the learning of the students of the participants. This is a gap. This is the Level 3 evaluation that Chism and Szabó (1997) have defined and that Felder and Brent (2010) refer to. In this research, an important aspect is the effect of teacher training on teacher behavioral change and impact on students.

2.2.1 Features of effective teacher professional development

There is literature on what constitutes good teacher professional development for both K–12 and higher education. Five key features have been identified for an effective TTP. These are content focus, active learning, coherence, sustained duration and collective participation. With these TTP features, Desimone (2009) suggests that there is higher likelihood of impact on both teacher behavior and student learning. We look more closely, below, at what each of these means (Desimone, 2009):

- **Content focus**: activities focused on subject matter content and how students learn that content;
- **Active learning**: opportunities for learners to actively engage in doing or analyzing rather than passively listening to lectures;
- **Coherence**: content, goals and activities consistent with the curriculum and teacher knowledge and beliefs, needs of students, school and state policies;
- **Sustained duration**: professional development activities that are ongoing, including at least 30 hours of contact time and
- **Collective participation**: a group of teachers from the same grade, subject or schools participate in professional development activities together to build an interactive learning community.

2.2.2 Teacher professional development as adult learning

Teacher professional development involves teaching adults. Adult teaching effectiveness can be determined through the adults’ motivation to learn (Wlodkowski, 1999, 2003).

Factors that motivate adult learning include the following (Wlodkowski, 1999):

- **Expertise of presenters**: Adults expect their teachers to be experts in the material being taught, to be knowledgeable and well-prepared and to show interest in the needs of the students.
- **Relevance of content**: Adults may quickly become impatient with material they cannot easily relate to their personal interests or professional needs.
- **Choice of application**: Adults respond well when given options about whether, when and how to apply recommended methods, and they are
skeptical of “one size fits all” prescriptions.

- **Praxis (action plus reflection):** Adults appreciate opportunities to see implementations of methods being taught and to try the methods themselves and then to reflect on and generalize the outcomes.
- **Group work:** Adults enjoy and benefit from sharing their knowledge and experiences with their colleagues.

It is easy to see that adult learning as shared by Wlodkowski (1999) aligns well with HPL (Section 2.1) and if one is followed then the other is addressed (Felder & Brent, 2009). Thus, using an environment like HPL for content enables the advantages of learner centered environment which enables deep learning, while also addressing adult learning issues.

### 2.2.3 Analyzing and evaluating teacher professional development

Many researchers have made a connection between *teacher professional development* and *students’ learning* (Darling-Hammond, 2000; Desimone, Porter, Garet, Yoon, & Birman, 2002; Fullan, 2001; Garet, Porter, Desimone, Birman, & Yoon, 2001; Huberman, 1995). As Guskey (2002) puts it, “Teacher professional development programs are systematic efforts to bring about change in the classroom practices of teachers, in their attitudes and beliefs, and to the learning outcomes of students.”

Desimone (2009), in a frequently cited paper, suggests a framework based on theory for a path model, as in Figure 2.1. This framework includes the paths to test for a *theory of teacher change* and a *theory of instruction*, both of which are required for successful TPD (Wayne, Yoon, Zhu, Cronen, & Garet, 2008).
Guskey (2002), in another frequently cited paper, reiterates that teachers change in attitudes and beliefs once they observe improvement in student learning (see Figure 2.2).

Whitworth and Chiu (2015) have observed that effective change to teaching practices can occur when leadership support is provided. Figure 2.3 incorporates the aspect of leadership into Desimone’s (2009) path model. Other literature also highlights the fact that management support enhances positive change in teaching practices (Fullan, 2001; Guskey, 2002).
It is important to be able to evaluate a training program systematically. Any training program can be evaluated using the four levels of Kirkpatrick’s model (1979). The four levels are:

- **Level I: Reaction** is a measure of learners’ reactions to the course.
- **Level II: Learning** is a measure of what they learned.
- **Level III: Transfer** is a measure of changes in their behavior when they return to the job after the training program.
- **Level IV: Results** is a measure of the business outcomes that occur because they are doing their jobs differently.

Chism and Szabó (1997) observe that the evaluation of a faculty development program can be performed at three levels, defined by the following questions:

- **Level 1**: How satisfied were the participants with the program?
- **Level 2**: What was the impact of the program on the participants’ teaching practices and on their attitudes towards teaching and learning?
- **Level 3**: What was the impact of the program on the participants’ students’ learning?

The ultimate goal of teaching is learning, so the ultimate measure of the effectiveness of a TTP is the resultant improvement in the learning of their students (Level 3). Just because a teacher is satisfied with the training they attended (Level 1), this does not translate to improved student learning. A positive change in teachers’ attitudes and teaching practices after the training program (Level 2) can then be a measure of the effectiveness of teaching (Chism & Szabó, 1997).

Gibbs and Coffey (2004) and Ho, Watkins and Kelly (2001) indirectly measured students’ approaches to studying this and produced results showing that deep learning approaches helped students with improved learning outcomes, as compared to surface learning methods. To understand deeply, learners must experience successful learning-centered and learner-centered teaching practices. Even in the west, faculty do not change to learner-centered pedagogy, as it takes more time, classrooms are not appropriately laid out and most importantly, there is no incentive to change and no penalty for not changing (Henderson & Dancy, 2007).

Clearly, moving to learner-centered pedagogy from the present lecture-based, teacher-centered pedagogy requires teachers to learn this themselves before they apply it in their classrooms. This is particularly important in the Indian context, as described earlier, with respect to the fact that teachers have very little autonomy in curricular matters. It is also observed that having good e-content and making teachers attend training programs does not really result in use or application (Rogers, 2010; Heath & Heath, 2010; Zemsky & Massey, 2004). We need to focus on strategies for change. Obtaining and sustaining new attitudes, beliefs and practices will require...
other structures and support from outside and inside, which brings us to the literature review on the change models.

2.3 CHANGE MODELS IN HIGHER EDUCATION

Change is the one constant in life. But while the literature provides guidance, there is no set recipe for change. Educational change is “technically simple and socially complex” (Fullan, 2001). Culture also plays an important role in change (Kamppuri, Tedre, & Tukiainen, 2006). There are many factors at play when one considers change, especially educational change. Change agents are often guided by one change strategy. Focusing too narrowly on one perspective increases the chances of overlooking influential factors and processes (Borrego & Henderson, 2014). What does it take to design a robust change effort?

Changing teaching practices in education has been an important issue for education leaders and policy makers for many decades (Emerson & Mosteller, 2000; Levinson-Rose & Menges, 1981; Perry & Smart, 1997). Considering levels of change at the level of an individual instructor, department, college, university or broader educational system adds more complexity. As there are stakeholders in the education system that range from individuals to organizations and beyond, we need models of change that can be applicable to these various levels. Complex higher education change processes addressing individual and organizational levels have been researched and summarized (Heath & Heath, 2010; Henderson, Beach, & Finkelstein, 2011; Kezar, 2001). In this section, we will look at a few models of change that have been widely used that are applicable to individuals and organizations, followed by Rogers’ theory of diffusion of innovations (Rogers, 2010), which has been very popular in various fields and in education in particular for scalability in change. Then we will take a look at applying multiple strategies of change to facilitate change in STEM (Science, Technology, Engineering and Management) education, as proposed by Henderson et al. (2011). In reviewing 191 journal articles from 1995-2008, for promoting change in undergraduate STEM instructional practices, Henderson et al. (2011) found that most training programs are compartmentalized, with the focus on either student training, teacher training with focus on pedagogy, or higher education researchers with focus on how change happens but with little guidance on strategy for change. They theorize that that employing multiple perspectives on change will lead to better results, but there is little empirical evidence or theory-based rationale to support or refine this assertion (which itself is an important direction for future research) (Borrego & Henderson, 2014). The multiple strategies of change model are particularly relevant in the context of this research in information technology education.
2.3.1 Lewin’s and Kotter’s models for change

Lewin’s 3-stage model of change (Lewin, 1947) (Figure 2.4), including unfreeze, change (or transition) and freeze (or refreeze), applies both to individual change and at an organizational level. In this model, Lewin first works on unfreezing the situation of the individual, then applies the change or transition and then brings about the idea of freezing so that the change is now a part of the individual.

![Figure 2.4. Lewin’s 3-stage model of change (adapted from Lewin, 1947)](image)

Kotter’s (1995) 8-step process for leading change has been refreshed in order to remain relevant in the current competitive business environments, and it applies to organizational contexts (Figure 2.5). It is also interesting to note that the eight steps proposed by Kotter align with the 3-stage model of change proposed by Lewin. In Figure 2.5, ‘creating a climate for change’, one can see the unfreeze; the ‘engaging and enabling’ serves as the change or transition; the ‘implementing and sustaining’ serves as the freeze. Thus, one can use Kotter’s model for leading change for individuals or organizations.

![Figure 2.5. Kotter’s 8-Step Model (adapted from Kotter, 1995)](image)
2.3.2 Rogers’ theory of diffusion of innovations

Everett Rogers (1995) created a comprehensive, well-studied and widely used theory of diffusion of innovations. His key assumption is that communication is necessary for change. This is a valid and viable theory for effecting change in higher education and has also been applied in many other disciplines, including medicine and telecommunications.

Rogers (2003) describes innovation adoption using a five-stage framework of awareness, interest, evaluation, trial and adoption.

1. **Awareness**: One is aware of the innovation but does not have complete information about it.
2. **Interest**: One’s interest increases in the innovation, and one seeks more information about it.
3. **Evaluation**: One decides to try or not try the innovation based on the current and future situation.
4. **Trial**: One uses the innovation.
5. **Adoption**: One continues to use the innovation.

Further, Rogers (2003) talks of stages of adoption (knowledge, persuasion, passive rejection, decision, implementation, active rejection and confirmation) to describe the participants and study their responses according to the context.

2.3.3 Change strategies in information technology and higher education

Fullan (1985) suggests that change creates anxiety and uncertainty for those who are involved. When everyone is involved in the higher education change process, then they must work on resolving this anxiety and uncertainty. To do so requires guidance, direction and some pressure from educational leaders who have a vision of the outcome. A combination of pressure and assistance has been powerful in educational improvement programs (Borrego & Henderson, 2014; Guskey, 2002; Henderson et al., 2011; Huberman & Crandall, 1983; Whitworth & Chiu, 2015).

While these reviews help in understanding the complexity of change in a higher education system, there is no cookie-cutter change process, as such, that can be applied to a given situation (Borrego & Henderson, 2014). Henderson et al. (2011) devised four categories of strategies for creating change in undergraduate Science, Technology, Engineering and Management (STEM) education. These categories describe change at individual and organizational levels in prescribed and emergent ways. The four categories of change model was enhanced by Borrego and Henderson (2014), where two possible strategies for change in each of the four categories were developed (Figure 2.6), leading to eight strategies of change.
Figure 2.6. Four categories of change strategies (adapted from Borrego & Henderson, 2014)

The eight strategies of change are diffusion, implementation, scholarly teaching, faculty learning communities, quality assurance, organizational development, learning organizations and complexity leadership. These change strategies model is potentially relevant for our research in information technology education. Below are detailed descriptions of the eight strategies of change (Borrego & Henderson, 2014):

1. **Diffusion**: This refers to Rogers’ diffusion of theory of innovations, as in Section 2.3.2. A diffusion strategy is based on developing good products and spreading the word about them so they may be tried and adopted.

2. **Implementation**: An implementation strategy is deliberate and direct. The strategies focus on designing a set of activities to successfully put the innovation into practice (Fixsen, Naoom, Blasé, Friedman, & Wallace, 2005). Implementation strategies are not yet widely used in higher education.

3. **Scholarly teaching**: This has been defined as

   ...a method of finding out what works best in your own classroom so that you can improve student learning, which fits in the center of a continuum ranging from
personal reflection at one end to formal educational research at the other. (Mettetal, 2001, p. 1)

The main characteristics of teaching-as-research include trying new methods of teaching and learning, gathering data and reflecting and acting on observations. The teacher engages in an iterative loop of research driving practice and of practice driving research, drawing also from education research.

4. **Faculty learning communities**: They help create a social and support network around ideas for improving teaching. Cox (2004) defines faculty learning communities in higher education as a type of community of practice:

   ...a cross-disciplinary faculty and staff group of six to fifteen members...who engage in an active, collaborative, yearlong program with a curriculum about enhancing teaching and learning and with frequent seminars and activities that provide learning, development, the scholarship of teaching, and community building. (p. 8)

This strategy is dependent to a great extent on faculty motivation to sustain the communities.

5. **Quality assurance**: This includes setting goals, creating a self-study report with evaluation evidence, enabling an external review by peers and responding to the external review report (Ewell, 1997; Rhoades & Sporn, 2002).

6. **Organizational development**: This involves planned changes to the work environment, where behavioral changes in employees create improved organizations. This top-down approach is initiated by management when a mismatch is identified, so a planned change effort can be implemented (Porras & Silvers, 1991).

7. **Learning organizations**: Organizations need to continually learn and improve in an environment of rapid change. Learning organizations need to fulfill two essential conditions: (1) new ideas must originate and be developed within the organization and (2) these ideas must lead to changes in the way the organization operates (Dill, 1999; Nonaka & Takeuchi, 1995; Senge, 1997).

8. **Complexity leadership theory**: This suggests that innovation occurs through the collective action of self-organizing groups in the system. This collective action can be stimulated but not controlled (Goldstein, Hazy, & Lichtenstein, 2010). A key phenomenon is emergence and cycles of emergence. Within each cycle, the role of the leader is to create conditions for productive emergence to take place and then to take the productive results from this process and ensure that these are integrated into the organization (Schreiber & Carley, 2008). Leaders can use the three mechanisms of disrupting existing
patterns, encouraging novelty and acting as sense makers to encourage emergence (Plowman et al., 2007).

In summary, a structured application of change strategies is important to effect change in the education system. Several models have been examined, from Lewin’s and Kotter’s models, which support viewing strategies from individual and organizational levels, to Rogers’ theory of diffusion of innovations, which can help with ideas of scaling and sustaining change. Borrego and Henderson’s eight strategies in four categories shed further light on possible change strategies to apply in a given situation to effect change in information technology education.

2.4 DESIGN AND DESIGN STORIES

This section will consider design and design stories. Norman and Verganti (2014) view design as a process of “making sense” of things:

*Design: The deliberate and reasoned shaping and making of our environment in ways that satisfy our needs and give meaning to our lives.*

Norman and Verganti (2014) further share the view that radical innovation brings new domains and new paradigms, and it creates a potential for major changes. Incremental innovation is how the value of that potential is captured. Without radical innovation, incremental innovation reaches a limit. Without incremental innovation, the potential enabled by radical change is not captured. These authors have also devised an innovation framework in four quadrants in which to position design, with meaning change and technology change as the axes (Norman & Verganti, 2014).

The framework in Figure 2.7 connects the innovation dimensions of technology and meaning with the drivers of technology, design and users (market). Technology-push innovation comes from radical changes in technology without any change in the meaning of products. This definitely does not come from users. Meaning-driven innovation involves no new technology but a radically new meaning and language. Technology epiphanies involve a radical change in meaning and new technologies or the use of existing technologies in new contexts. This is not what customers are looking for, and thus, it might be difficult to promote adoption of such technologies. Market-pull innovation category helps satisfy users’ needs with a product design. Culture plays a key role in design and innovation (Kamppuri et al., 2006). In India, the design of educational systems is influenced by the important factor of culture. What may work for the western world may not be suitable for all cultures. Indian
Figure 2.7. Innovation framework in two dimensions and with four types of innovations (adapted from Norman & Verganti, 2014)

users, for example, may find it difficult to give negative or individual opinions (Kamppuri et al., 2006).

In our research context, the design of a training program and the process of how it is communicated to various constituents depends on the local culture. Colleges in India, especially private colleges, tend to be more authoritarian and management driven. Management support is required for teachers and students to meet training and certification goals.

With the increase in use of technology, digital storytelling is a great way to communicate and personalize the message. Hence, storytelling research and design have received more attention in recent decades (Duveskog, Kemppainen, Bednarik, & Sutinen, 2009; Lugmayr et al., 2017; Myller & Nuutinen, 2006; Simon, 1996; Suhonen & Sutinen, 2006). Duveskog et al. (2009) share how people are able to communicate even hard personal problems like HIV and AIDS through digital storytelling.

The relevance of digital storytelling is the possibility of capturing the complex story of EnhanceEdu as well as individual stories of success or problems. These individual stories can be shared publicly through this process to inspire others to try new ideas to be more successful or to avoid those ideas that may lead to problems.
3 RESEARCH DESIGN AND METHODOLOGY

Solving a problem simply means representing it so as to make the solution transparent.

Herbert Simon

This chapter elaborates on the research design, context and methodology used in this study.

The research problem of the low quality of graduating engineers in India and, hence, their low employability is a wicked problem. Addressing this problem by training students directly is not sustainable in the long run. Therefore, EnhanceEdu aimed to train teachers so that, in turn, the learning outcomes of their students can be improved. The interventions needed to address this problem include pedagogy, content, curriculum, technology, process, teachers, management, universities, regulatory bodies and many more. The systems view of higher education in India (Figure 1.3) indicates the complexity of the problem. As this is a wicked problem, the design of the solution is as important as the solution itself. Hence, we need to use a research method based on design, for example, design research (Edelson, D. C., 2002).

Educational researchers are increasingly incorporating design into their research activities and are having a more direct impact on education. These design efforts include designing curriculum, professional development, school organizations and school community collaborations. This new wave of research is characterized by iterative design and formative research in complex real-world settings.

Within the last decade, even the most commonly accepted name for the field has changed from design research (DR) to design science research (DSR) (Vaishnavi, Kuechler, & Petter, 2004, 2017). Further, Vaishnavi et al. state that DR is research into or about design, whereas DSR is primarily research using design as a research method or technique. DSR is a good candidate for my reflection and analysis of the EnhanceEdu story, as it uses design as a research method. Section 3.2 indicates the method and process followed for the conduct of EnhanceEdu interventions.

3.1 DESIGN SCIENCE RESEARCH

The design science research (DSR) paradigm has its roots in the engineering and sciences of the artificial (Simon, 1996). DSR is fundamentally pragmatic, due to its emphasis on relevance, addressing a real need in the application environment (Hevner, 2007). DSR is also learning through building, addressing important unsolved problems in unique or innovative ways or solving problems in more effective or efficient ways (Owen, 1997; Vaishnavi, Kuechler, & Petter, 2004, 2017). As Simon (1996) has
suggested, several academic disciplines, including engineering (Archer, 1984; Eekels & Roozenburg, 1991; Fulcher & Hills, 1996), information systems (Hevner, March, Park, & Ram, 2004) and computer science (Preston & Mehandjiev, 2004; Takeda, Veerkamp, & Yoshikawa, 1990) have accepted design science as a research program.

DSR addresses what are considered to be wicked problems, characterized by Rittel and Webber (1984) as being constrained and complex and depending on human creativity and teamwork to produce solutions (see Section 1.2.1 for a more detailed characterization). DSR is pragmatic and is fundamentally a problem-solving paradigm. This is in line with our idea of devising a pragmatic design solution for a real-world wicked problem. For these reasons, DSR has been chosen to reflect retrospectively on the various interventions in this study. Two purposes are served in this process, one, I can analyze the interventions as implemented by EnhanceEdu for their rigor and relevance by using DSR. Another, one can clearly identify the artifacts and the theories that have validated them. Thus, retrospection in this thesis is referring to reflecting on the interventions in the EnhanceEdu design story as they were implemented, and analyzing them for new perspectives and observations.

March and Smith (1995) explained that “the design science paradigm seeks to create innovations that define the ideas, practices, technical capabilities, and products through which the analysis, design, implementation, and use of information systems can be effectively and efficiently accomplished.” Further, they identify two processes and four products of design science. The processes are building and evaluating. The products are constructs, models, methods and instantiations. They also stated that the main end product of DSR is to meet desired goals with these products. In this study, I can relate to the building and evaluating as well as the products as key parts of every intervention. The products are the purposeful artifacts that are built to address heretofore unsolved problems. Their performance can then be evaluated with respect to the utility provided in solving those problems. Constructs provide the language in which problems and solutions are defined and communicated. Models aid in understanding the real world and enable exploration of the effects of design decisions and changes in the real world. Methods provide guidance on how to solve problems. Instantiations demonstrate feasibility, provide empirical evidence that an artifact is suited to its intended purpose and enable researchers to learn about the real world and how an artifact affects it.

On the process and output of DSR, Hevner et al., state the following:

*Design is both a process (set of activities) and a product (artefact)—a verb and a noun. It describes the world as acted upon (processes) and the world as sensed (artefacts). This platonic view of design supports a problem-solving paradigm that continuously shifts perspective between design processes and designed artefacts for the same complex problem. The design process is a sequence of expert activities [i.e. the science of design,]*
that produces an innovative product, i.e. the designed artifact. The evaluation of the artefact then provides feedback information and a better understanding of the problem in order to improve both the quality of the product and the design process. This build-and-evaluate loop is typically iterated a number of times before the final design artefact is generated. During this creative process, the design-science researcher must be cognizant of evolving both the design process and the design artefact as part of the research. (2004, p. 78)

In this research study, I can relate to the above definition of Hevner’s of design being both a process and a product. The design process was defined and refined in the multiple iterations, and the final artifact, is the product that addresses the problem. The build and evaluate loop of multiple interventions are iterated many times before the final artifact is generated. During the course of the EnhanceEdu design story, 9 iterations of the training program have been made.

Hevner (2007) pointed out that “the utility of the information system and characteristics of the organization, its work systems, its people, and its development and implementation methodologies together determine the extent to which that purpose is achieved.” Therefore, it is necessary for researchers in design science to have in-depth knowledge about the users and their requirements (Johannesson & Perjons, 2012). In doing DSR, one can use Hevner’s 3-cycle model (Hevner, 2007) or a process model (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007). In Hevner’s (2007) 3-cycle framework, the three cycles are represented as the relevance cycle, the rigor cycle and the design cycle. This is a further development over the Hevner and March (2003) information systems research cycle. For this research study, the idea of having the three cycles is suitable as there is an explicit possibility of identifying the theories that drive a particular design intervention in the rigor cycle, clearly identifying the stakeholders and the environment constraints in the relevance cycle, and building and evaluating the solution to address the requirements in the design cycle.

Figure 3.1 shows the 3-cycle DSR by Hevner. The relevance cycle includes people and organizations (stakeholders) and their requirements as well as technology (infrastructure and environment) and its constraints. The rigor cycle includes foundations (theories, frameworks), experience and expertise, and methodologies (data analysis and validation techniques) that ground the research. The design cycle is where the solution is built and evaluated to address the requirements from the relevance cycle, using the theories from the rigor cycle. The design solution feeds into the relevance cycle for field testing, and any changes to be made can be completed in the design cycle until the requirements are satisfied. The artifacts thus build feedback into the rigor cycle as additions to the knowledge base.
The fundamental basis of DSR projects usually starts with understanding the context and identifying the problem to be solved for which a solution is needed (Au, 2001; Mramba, Apiola, Kolog, & Sutinen, 2016).

Hevner et al. (2004) devised seven guidelines for a problem to be considered a candidate for viewing through a DSR lens. These are shared below and have helped me to use these guidelines to ascertain the study to be viewed as DSR:

1. **Design as an Artifact**: An identifiable and viable design artifact, as in March and Smith (1995), must be produced.
2. **Problem Relevance**: The design must address a relevant and important problem.
3. **Design Evaluation**: The utility, quality and efficacy of the design artifact must be rigorously evaluated.
4. **Research Contributions**: The contribution must be clear and verifiable. Contributions are seen to arise out of the novelty, generality and significance of the designed artifact. Contributions include the design artifacts themselves,
new foundations (constructs, models, methods and instantiations) and new [evaluation] methodologies.

5. **Research Rigor**: Research methods must be rigorously applied.

6. **Design as a Search Process**: Research must be conducted with knowledge of other competing approaches and should approach the process as a cyclical problem-solving process in which solutions are tested against each other and against their efficacy for solving the full problem.

7. **Communication of the Research**: Presentation of results needs to address both the rigor requirements of the academic audience and the relevance requirements of the professional (e.g., managerial) audience.

Since the goal of DSR is utility, Hevner et al. (2004) emphasize Guideline 3, noting that “evaluation is a crucial component of the design process.” They further note that the evaluation method must be matched to the artifact and any evaluation metrics. I used the 3-cycle Hevner model as a framework for analyzing the many interventions in this research study. In this dissertation, I have framed the theories used in the EnhanceEdu story in the rigor cycle, the stakeholders and their environment, in the relevance cycle, and the required solution built and evaluated in the design cycle. I then reflected on and analyzed the work with respect to the seven guidelines which ascertains the work to be viewed as DSR. One can see this in the upcoming chapters on the implementation and intermediate results, key results – research questions answered, and discussion.

### 3.2 CONTEXT AND METHOD

In alignment with EnhanceEdu’s research aims, we proposed to train teachers who would then train students, thus improving the possibility of a sustainable intervention. In a typical TTP, the invitation or announcement goes out to teachers so they can sign up for the program. The teachers may need to get approval of the management to attend the training program. However, in the literature review in Chapter 2, we have seen that the measured and reported cases of Level 3 (trained teachers causing an improvement in student learning) were negligible. Hence, EnhanceEdu made a conscious decision to first involve management in the process and get their support before approaching teachers, even though we were conducting a TTP. Colleges and their management were involved in this decision making of partnering with EnhanceEdu to ensure that the benefits of their teachers’ training in the teacher training program gets passed on to their students and also to make sure that the outcomes get measured across the entire chain. Appropriate memorandum of understanding
(MoU) agreements were executed between EnhanceEdu and the potential partner college, making a new EnhanceEdu partner college. This was particularly important in the cultural context in India, especially in the affiliated private engineering colleges, where teachers had no academic freedom and were mostly directed by management with respect to their tasks, content and process. The EnhanceEdu partner college program for teacher training involved 575 teachers from over 70 participating colleges in nine iterations. The research method involved conducting several iterations of TTPs for computer science and IT teachers from engineering colleges, in an active learning hands-on way, along with management support (PVI).

The design process included three major steps (described below) for each cohort who participated in teacher training (PI). Feedback and lessons learned from each step helped improve and innovate for the later iterations:

1. **Content Development**: Develop course content in LBD for CIT on a technology platform.

2. **Teacher Training**: Conduct training program in CIT for teachers from engineering colleges according to a training plan and calendar, using the content developed in Step 1.

3. **Implementation**: Conduct training for students at the colleges using teachers trained (in Step 2) in CIT, using the same content and technology platform.

Each of the above steps is part of our study design. The following sections review the process flows designed for our methods. The first process (Figure 3.2) shows the initiation of the TTP for Step 2, while the second process flow (Figure 3.3) shows the student training (STEP) in CIT by trained teachers (Step 3) at their colleges.

The process included management understanding the benefits of the TTP and the CIT program for the teachers and students, how this would have an effect of increasing the students’ knowledge and how it could then lead to improving the students’ employability. Figure 3.2 covers the method of both initiating a TTP and concluding it. Each TTP was preceded by a principals’ meeting where the college management were invited and made aware of the program being offered to teachers and students along with the support provided by EnhanceEdu. Colleges convinced about the benefits of the program signed up with an expression of interest (EoI) and a memorandum of understanding (MoU), becoming EnhanceEdu partner colleges as eligible. Partner colleges nominated teachers for the TTP and committed to providing computer lab availability to conduct the student training in CIT. The TTP was conducted for the teachers and concluded with Open Day, where management was again present for the graduation of the teachers from TTP and for reviewing the implementation plans for training students in their colleges.
Figure 3.2. Process of initiation and conduct of teacher training program (TTP)
The process flow steps in Figure 3.2 are:

Step 1. The principal and other management heads at the principals' meeting represent colleges interested in participating in an EnhanceEdu partner college program.

Step 2. To be eligible for being a partner college, a college should have been in existence for at least 5 years and have graduated at least one batch of students. The ‘no’ branch indicates college is ineligible and therefore does not participate further in the process. It may participate in a future Principal’s meeting when eligible.

Step 3. Colleges interested in partnering complete an EoI and MoU. Colleges that do not complete an EoI and MoU (‘no’ branch) are not considered in the next steps. These colleges could participate in the next Principals’ meeting.

Step 4. The partner college principal completes the teacher nomination form, nominating at least five eligible teachers to TTP and completes the computer lab form for implementation of CIT for students in their college.

Step 5. Conduct Teacher Pre-Orientation, explaining process of training to teachers.

Step 6. Teachers can choose to participate in TTP or decide not to (‘no’ branch).

Step 7. Nominated teachers confirm to participate in TTP, and logistics are arranged.

Step 8. The TTP is conducted.

Step 9. Teachers that have successfully completed TTP graduate from TTP. Those that have not completed the TTP, would attend the next TTP or complete tasks and be reevaluated.

Step 10. On Open Day, graduating teachers are awarded an L-Board\(^2\) in the presence of their management, certifying the teachers’ readiness to train students in CIT. L-Board is similar to a learner’s permit to drive a car.

Figure 3.3 shows the process of initiating student training - Student Enhancement Program (STEP), for a Certificate in IT (CIT), when the teachers return to their college after their TTP. As this program is meant for students, they are invited to a student orientation organized by the trained teachers with the support of their college management and EnhanceEdu. The student orientation explains the benefits of this certificate course, which is a value-add or enrichment program that the student can sign up for. Signed-up students will be given the timetable for attending the STEP/CIT class in the computer labs. Students undergo the training with their teachers mentoring. At the end of the student training, successful students are awarded certificates in IT, with a mentors’ certificate awarded to the teachers who had trained them. The trained teachers, who had received L-Boards after their TTP, become eligible to receive a “mentor’s certificate” after successfully conducting at least one program of student training in CIT.

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\(^{2}\) L-Board – A Learner-Board is similar to a learner’s permit to drive a car. To the teacher, an L-Board certifies that the teacher is ready to train students in the certificate in IT, using the new methods and content learned by doing in the teacher training program.
Each step within the process flows in Figures 3.2 and 3.3 led to different types of data collection techniques, including survey questionnaires, interviews, field notes by trainers (mentors) on wiki during the training, focus group interviews, college visit field notes, formative assessments and summative assessments of tasks done by learners (teachers and students). The mixed methods research used most closely resembled a concurrent embedded strategy (Creswell, 2009) with the use of one data collection phase where both quantitative and qualitative data were collected simultaneously. The surveys included both closed-ended and open-ended questions allowing concurrent collection of quantitative and qualitative data (Creswell, Plano Clark, Gutmann, & Hanson, 2003). The primary method was quantitative, which guided the project, and the secondary method was qualitative providing a supporting role in the procedures. Further, surveys were conducted on various stakeholders at multiple levels, teachers in TTP at EnhanceEdu, management in the colleges (before and after TTP, and after students complete their training), students in colleges in STEP/CIT, teachers after completion of training students (mentors’ survey). This is a multi-level design (Tashakkori & Teddlie, 1998).

Self-reported surveys were used for several purposes including their own assessment of competency gain, and adaptability to learning by doing. The use of data collection for the various levels of stakeholders (management, teachers, and students) helped gain research perspectives from different levels in the study as well as from different types of data (surveys versus interviews). The instruments were validated by practice and feedback over multiple iterations. Further, technical competence was assessed for the courses undertaken primarily by means of formative and summative assessments, and mentor field notes (PIII, PVI). This data helped validate the self-reported surveys. The 260 teachers who participated in the four TTPs and surveys had experience ranging from zero to seventeen years (PI), and so the data gathered in the surveys helped removed a potential bias that could have entered if all teachers were very experienced or very inexperienced. The bias that was also planned to be eliminated and eliminated to a large extent was rural or urban bias, as there was a good mix of teachers from rural and urban colleges for the TTP.
Figure 3.3. Process of initiation of STudent Enhancement Program (STEP) with CIT training
As shown in Table 3.1, **RQ1** (How do we design a teacher training program to be effective in enhancing information technology (IT) education in engineering colleges in the Indian context?) and **RQ2** (Who are the stakeholders, and what kinds of interventions are needed for each of the stakeholders to enhance information technology (IT) education in the Indian context?) were investigated using the mixed research method explained earlier, and the techniques for data collection included the use of questionnaires, observation, interviews, field notes and formative and summative assessments at various stages in the process. But **RQ3** (What are the characteristics of a design-oriented research method that support the development process of new empowering educational interventions to enhance information technology (IT) education?) was investigated using a constructivism approach, designing what was required as perceived. The data gathering research techniques for **RQ3**, as seen in Table 3.1, included observation and interviews. The DSR cycles (relevance, rigor and design) that are considered for each of the research questions are shown in Table 3.1. The papers that cover each of the research questions are also shown in Table 3.1.

### Table 3.1. Research methods and techniques for each research question

<table>
<thead>
<tr>
<th>Research Method</th>
<th>DSR Cycles</th>
<th>Paper</th>
<th>Research Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RQ1</strong></td>
<td>Mixed research</td>
<td>Relevance, rigor &amp; design cycles for content dev. and design cycles for TTP</td>
<td>P1, PII, PV</td>
</tr>
<tr>
<td><strong>RQ2</strong></td>
<td>Mixed research</td>
<td>Relevance and design cycles for each stakeholder group</td>
<td>PIII, PIV, PVI</td>
</tr>
<tr>
<td><strong>RQ3</strong></td>
<td>Constructivism/ design</td>
<td>Rigor &amp; design cycles</td>
<td>PVI</td>
</tr>
</tbody>
</table>

Hevner et al.’s seven guidelines (2004) and the 3-cycle DSR (Hevner, 2007) were used to reflect on and analyze the interventions of the various parts of the EnhanceEdu story. This is seen in the next two chapters dealing with the implementation and intermediate results and key results – research questions answered.

### 3.3 ETHICAL CONSIDERATIONS

The environment, the problem space and the relevance cycles consist of people, business organizations and existing or planned technologies. The environment in our research includes universities, affiliated colleges, management and administration, teachers, students, parents, the IT industry and regulatory bodies for education. To
review the ethical considerations, we shall restrict ourselves to a smaller subset of these stakeholders, as shown in Table 3.2. These include the funding agency — MCIT, the management and administration of colleges, teachers, students and the research group. Are the desired outcomes from different stakeholders aligned or not? If not, what ethical issues arise? Table 3.2 brings to the fore a few ethical challenges.

Table 3.2. Stakeholders, desired outcomes and ethical issues

<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>Desired outcomes</th>
<th>Ethical Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Funding agency</td>
<td>Train maximum number of students</td>
<td>Conflict of interest with research group and potential for placing pressure to achieve desired outcome</td>
</tr>
<tr>
<td>Management of colleges</td>
<td>Get positive outcomes for college</td>
<td>Conflict of interest with teachers and students who might not want to put themselves out; having higher expectations from the research group than agreed upon in MoU</td>
</tr>
<tr>
<td>Teachers</td>
<td>Interested in growing themselves, but not always interested in getting trained; not interested in working overtime</td>
<td>Conflict of interest with management and students; Privacy and confidentiality, Informed consent</td>
</tr>
<tr>
<td>Students</td>
<td>Interested in becoming more employable</td>
<td>Conflict of interest with other stakeholder groups with potential unaligned desired outcomes</td>
</tr>
<tr>
<td>Research group</td>
<td>Interested in objectively seeking research answers Research Plan</td>
<td>Conflict of interest with funding agency and management Give highest priority to reliability and validity of research results, including data collection process</td>
</tr>
<tr>
<td></td>
<td>Content development for IT courses in leaning by doing Research dissemination (sharing) through publications and conferences</td>
<td>Awareness of plagiarism and misconduct for content development and for publications Setting culture with respect for all, integrity, taking ownership, teaming for excellence and care for environment</td>
</tr>
<tr>
<td>Values</td>
<td></td>
<td>Promoting collaboration and cooperation</td>
</tr>
</tbody>
</table>

Of the various ethical considerations discussed in the following, in my research, we can see that the key criteria like informed consent, privacy and anonymity of surveys conducted are met, aligning with the understanding of the Finnish Responsible Conduct of Research, based on the guidelines given by the Finnish Advisory Board of Research Integrity (2012), and the use of ethical norms in research, as well as the ethical considerations as per the India context.
Research ethics processes in this research. The following were some of the key research ethics guidelines followed in the conduct of this research study:

1. **Informed consent**: We conducted surveys with informed consent. We explained to participants that their personal information would not be shared, and that anonymized data would be used and reported as statistical data.

2. **Privacy and anonymity/confidentiality**: Privacy and confidentiality were important, and we used informed consent and anonymization of data by ensuring that only a small group of responsible people in the research team had access to the raw data, and statistics and anonymized data would be made available for the sharing of research in publications and other forums.

3. **Right to withdraw**: Trained teachers and colleges could withdraw from the program (voluntary participation) at any stage. While management nominated teachers, teachers' participation was voluntary after a full understanding of the training program and process.

From a broader perspective, we can see the key factors of values, rules and consequences reflected in our research study, considering also human factors.

1. **Values**: The research group embraced values that embodied ethical norms. These included a culture with values such as respect for all, integrity (doing the right thing even under difficult circumstances), taking ownership, teaming for excellence and care for the environment. This greatly enabled even the young team of mentors in the research group to deal with teachers coming for training with respect and care. (These teachers had zero to twenty years of experience.) When teachers felt cared for and heard, this greatly enhanced their motivation to cooperate and collaborate with the group and other teachers and to stay and imbibe the training and the new methodology.

2. **Rules**: A large number of processes were defined to mitigate the risk of individuals making ethical and process mistakes. We created a process of “individually you cannot, but together you can.” This greatly enabled the right decision to be taken when collective thinking took place rather than one individual making a potentially hasty decision.

3. **Consequentialism**: Many decisions fell into this category of weighing benefit vs. harm. There could be several ways we could act, but we would finally decide on one that gave more benefit in the given context and situation.

Over the course of this research study, we came across many ethical issues. Several issues surfaced from the conflict of interest between stakeholders in Table 3.2. We consider a few of these here and go over how we addressed them. Several more issues are included in Appendix 4.
1. **How to decide which colleges to invite to participate in the research?** This is an ethical issue in that if we restricted the participation to a certain set of colleges and excluded others it would be biased. The principals’ meeting was open to any engineering college that had graduated at least one cohort of students. This research focused on enhancing IT education. It is not unethical to improve the education system, and the research was not limited to any subset of students and teachers. The final selection of partner colleges was based on management agreeing to the expectations spelled out for all parties per the MoU.

2. **How should the teachers be selected for the training program and preserve their autonomy?** While management nominated teachers, teachers’ participation was voluntary after they were given a full understanding of the training program and process. Pre- and post-surveys were conducted with informed consent.

3. **Which students should participate in the CIT program? Are their rights and interests protected?** An orientation program was conducted for students, presenting the benefits of the program. They self-selected for CIT program paying a subsidized fee of Rs. 1000/- ($15). Trained teachers followed the new methodology with rubrics for grading students. This protected the students’ interest in learning. Students could withdraw at any time.

4. **What are the different issues related to conflict of interest?** (Table 3.2) **How is conflict of interest between different sets of stakeholders handled?** In order for each stakeholder group to be in alignment with their desired outcome, we held separate stakeholder group meetings, such as the principals’ meeting for management, TTP teachers’ pre-orientation program (TPO) and orientation for students. In these meetings, while specific concerns related to the different stakeholder groups were addressed, all stakeholders were aligned with the main purpose of improving student employability as an overriding factor. This enabled the management to support teachers and students. This is one example of how conflict of interest between different sets of stakeholders was handled.

In summary, for design research and methodology, Hevner’s seven guidelines and 3-cycle DSR (Hevner, 2007) are planned to be used to reflect on and analyze the interventions in the EnhanceEdu story. The design process included three major steps (content development, teacher training and implementation) introduced in this chapter in Sections 3.1 and 3.2, and their implementation will be elaborated upon in Chapter 4. Research methods and techniques for the research questions (RQ1, RQ2 and RQ3) were described in Table 3.1. Section 3.3 described the ethical processes and the key factors of values, rules and consequences undertaken in this research.
4 IMPLEMENTATION AND INTERMEDIATE RESULTS

You are not alone. You are part of a larger team that is not inside these 4 walls.

EnhanceEdu

This chapter is a reflective study of the implementation of the EnhanceEdu interventions. It is divided into five sections: Content Development (4.1), Teacher Training Program (4.2), Management Involvement (4.3), Student Enhancement Program (4.4) and EnhanceEdu (4.5). In each section, the implementation is analyzed and reflected through the design science research methodology using Hevner’s 3-cycle DSR model (Figure 3.1) and the seven guidelines discussed in Chapter 3 (Hevner, 2007). It must be noted that it is not required that an intervention must comply with all seven guidelines for it to be considered a viable DSR.

4.1 CONTENT DEVELOPMENT

In this section, design science research is applied to reflect on and analyze the CIT content development.

4.1.1 Design science research view of content development

Figure 4.1 shows what was done using the Hevner 3-cycle DSR framework in retrospect. In the relevance cycle, the business needs of all the stakeholders—teachers, students, colleges and management, with technology, computing equipment and internet constraints were identified.

The rigor cycle informs the design, with theories, models, expertise and experience. In this case, the rigor cycle showed use of LBD, Bloom’s taxonomy, Biggs’ (1996) constructive alignment, Bransford et al.’s HPL (1999), computer science knowledge and continuous improvement (PI, PVI).

The design cycle includes the build and evaluate cycles. CIT course content included the following IT courses (PI, PII, PVI):

- Computational Thinking
- Object-Oriented Programming using Java
- Data Structures.
The problem was one of designing a set of IT courses usable by teachers and students in engineering colleges dispersed over a wide geographical area in urban and rural areas of two Indian states of Andhra Pradesh and Telangana. These colleges had poor internet connectivity and different levels of knowledge. The following is the analysis and reflection on content development using the key Hevner guidelines.

**Design as an Artifact:** Artifacts that came out of content development comprised the complete CIT course content, including three courses—Computational Thinking (CT), Object-Oriented Programming using Java, and Data Structures—along with rubrics for all the tasks to be done by LBD and on the online portal for e-learning layered on Moodle, an open source course management system (Dougiamas & Taylor, 2003). This worked out to about 200 hours of task work by the learner.

**Design Evaluation:** The utility of each of the courses is rigorously evaluated by means of comprehensive testing which was called batting practice (PVI) and using the principles of constructive alignment across multiple iterations of the training programs. Batting practice is similar to comprehensively testing a computer program before it is released as a product for general use. EnhanceEdu and college students
who were willing to spend time to test the course content did the batting practice. The CIT portal (the e-learning platform) built over Moodle was tested with simulations, followed by field testing. Naturalistic methods of testing (with real people and real environments) were followed for the content testing along with technical (software and simulation) testing for the technology-enabled learning environment (CIT portal).

**Research Rigor:** Methods from LBD, Bloom’s taxonomy (Bloom, 1956; Krathwohl, 2002), rubric design (Biggs & Tang, 2010), problem-based learning and story-centered curriculum (Schank et al., 1999) and HPL (Bransford et al., 1999) were used in the CIT course content development. Figure 4.2 shows the process (PI) that was followed in the development of the content and its use in teacher and student training. Subject matter experts were consulted in content development or enhancement as needed, particularly in the initial phases of mapping a subject into its key modules. One of the factors that was different in the LBD course in comparison with a traditional course was that tasks were defined in each module for learners to complete before going to the next module.

The key distinguishing factor, in the process of developing new courses, was the shift to problem-based learning and conceptual learning at higher-order thinking levels. Conceptual learning could help connect the concepts learned. These experts designed the content in modules, with individual tasks and assessments mapped to the learning objectives keeping the instructional design in mind (see Figure 4.3, adapted from PI). This brought rigor to the process of building the content, and testing and evaluating it with respect to the design principles of constructive alignment.

![Figure 4.2. How learning happens (redrawn from PI)](image-url)
Design as a Search Process: The CIT content was refined, for example, by adding scaffolding and toy problems to tasks to make it easier for those who felt the tasks were difficult as well as by adding more videos (just-in-time lectures) and tasks to address a wide variety of learners. The e-learning platform, the CIT portal, was also enhanced to address the problem of poor internet connectivity at partner colleges. Colleges worked with their local copy of the CIT portal, and synchronized upload of tasks when the internet was available. This led to a system that would work in a distributed teaching and learning mode. Mentoring (using a combination of short lectures/videos plus LBD and the assessment of tasks—a blended learning approach) was refined over multiple design cycles of teacher training and student training in partner colleges.

Communication of the Research: Results, including the artifacts, research rigor and design as a search process, were published and communicated at conferences and in other forums (PI, PIII, PVI).

4.1.2 Sample instance of content development

Given below in Tables 4.1, 4.2 and 4.3, is an example of content development for Data Structures course in which a student is expected to learn different data structures and apply the learning to design a mini-search engine (PI). A project/story-centered
curriculum was used for the students to participate in real-world scenarios (Blumenfeld et al., 1991). The following table 4.1 is a description of the different components used in designing the content using LBD (PI). This methodology of doing Data Structures offers the learner confidence in building a mini-search engine, while learning and building other components needed to create the necessary functionality like crawling, searching and indexing. Further, the learner completes each module and submits the task before going to the next module.

Table 4.1. Example of Data Structures course implementation (adapted from PI)

<table>
<thead>
<tr>
<th>Implementation of Data Structures course using Learning by Doing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Motivation</strong></td>
</tr>
<tr>
<td><strong>Learning Objectives</strong></td>
</tr>
<tr>
<td><strong>Story Line</strong></td>
</tr>
<tr>
<td><strong>Role</strong></td>
</tr>
<tr>
<td><strong>Scenario Operations</strong></td>
</tr>
<tr>
<td><strong>Resources</strong></td>
</tr>
<tr>
<td><strong>Feedback</strong></td>
</tr>
</tbody>
</table>

A sample rubric for the Data Structures course is given in Table 4.2. The rubric is used in formative assessment of task by mentor. The pseudo code standards and flow processes are shown in Tables 4.3 and Figure 4.4, respectively (PI).
Table 4.2. A rubric used for a module in the Data Structures course (adapted from PI)

<table>
<thead>
<tr>
<th>Rubric element</th>
<th>Grade 0</th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
<th>Grade 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem understanding</td>
<td>Unable to recall any of the concepts</td>
<td>Able to recall only some concepts with assistance provided</td>
<td>Able to recall some concepts without assistance being provided</td>
<td>Able to recall all concepts</td>
<td>Able to recall all concepts with proper explanation</td>
</tr>
<tr>
<td>Generating pseudo code</td>
<td>No idea about pseudo code or algorithms</td>
<td>Included 2 out of the 5 standards</td>
<td>Included 3 out of the 5 standards</td>
<td>Included 4 out of the 5 standards</td>
<td>Included all the standards</td>
</tr>
<tr>
<td>Implementing the program</td>
<td>Has not implemented any of the processes listed in Table 4.3</td>
<td>Program is implemented without following the request handling and halting process</td>
<td>Program is implemented. Handling requests are also followed.</td>
<td>Program is implemented in accordance with the flow process.</td>
<td>Program is implemented in accordance with the flow process. Code optimization done.</td>
</tr>
</tbody>
</table>

Table 4.3. Pseudo code standards used for the rubric in Table 4.2 (adapted from PI)

<table>
<thead>
<tr>
<th>Pseudo code standards</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>Should have zero or more inputs externally supplied</td>
</tr>
<tr>
<td>Output</td>
<td>At least one quantity is produced</td>
</tr>
<tr>
<td>Definiteness</td>
<td>Each instruction is clear and unambiguous</td>
</tr>
<tr>
<td>Finiteness</td>
<td>For all the cases, the algorithm terminates after a finite number of steps</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>The pseudo code should be effective enough to work properly without producing errors when implemented</td>
</tr>
</tbody>
</table>

The CIT course-wise module listing and screenshots are given in Appendix 5. One screenshot is of a project-based task in the Data Structures course to design and build a web calculator. The web calculator is linked to prerequisites like stack and infix to postfix notation. As content needed to be developed in other subjects as well, a new instructional model, Butterfly model was developed (PV). In Appendix 5, screenshots of a couple of courses in computer science and electronics are shown.
Reflection and analysis using DSR of the entire CIT content development process show rigor with use of theories like LBD, Bransford et al.’s HPL (1999), rubrics and constructive alignment, continuous improvement and SEI CMM. The relevance cycle considered all the important stakeholders’ requirements including the infrastructure limitations. The iterative process that DSR calls for also is satisfied by the iterations of content development with inputs and learnings from the multiple iterations of application in teacher training programs.

4.2 TEACHER TRAINING PROGRAM

In this section, design science research is utilized to reflect on and analyze the interventions for teachers.
4.2.1 Design science research view of teacher training program

The TTP was conducted as per the process steps described in the research design and methodology (Figure 3.2), using the content created in the Content Development section (Figure 4.1) for the CIT. Figure 4.5 shows what was done for the teacher training program using the Hevner 3-cycle DSR framework in retrospect.

Figure 4.5. The 3-cycle DSR of the teacher training program

The TTP included the TTP training calendar, the training using the CIT course content, the Art of Mentoring, AoT, Soft Skills and Communication Skills modules (PI, PVI).

In the relevance cycle, business needs of the stakeholders—teachers from the partner engineering colleges, management, students and EnhanceEdu, were identified. The teachers came from partner colleges in both rural and urban areas. They were nominated by the college management to undergo the training and later to train their students using the same content and methodology. The TTP needed to train teachers
to be confident about the content, technology and pedagogy. Teachers also needed
the self-efficacy to run a similar program in their colleges for their own students. This
meant that the new teaching methodology had to be embraced by the teachers so
they could impart it to their students. Further, just like they planned a lab or class,
they needed to make sure they understood the hardware and software resources
needs for the class (PI, PII, PVI).

The rigor cycle showed use of methodologies such as LBD (Dewey, 1938; Schank
et al., 1999), Moore’s (1999) features of a good training program, self-efficacy (Ban-
dura, 1997), the capability maturity model—CMM Level 5 continuous improvement
process (Paulk, 1993). The CIT course content created through content development
(Figure 4.1) was used and refined through TTP implementation. For evaluation, the
rigor cycle included Kirkpatrick’s model of training evaluation (PII).

The design cycle includes the build-and-evaluate components. The TTP course con-
tent was built using the theories in the rigor cycle and was evaluated via comprehen-
sive testing (batting practice) by the EnhanceEdu team and by subsequent TTP par-
ticipants, whose feedback continues to help develop better teacher training pro-
grams. The TTP was further evaluated using Kirkpatrick’s method (PII).

The problem was one of designing a training program that could be used to train
teachers in engineering colleges, so they could go back to their own colleges, dis-
persed over a wide geographical area and with poor internet connections, and be able
to conduct training for their students. Teachers reflected on and learned to self-eval-
uate their own task submissions, so that they knew how to evaluate student submis-
sions using the same rubrics. An analysis and reflection on the implementation of the
TTP using Hevner guidelines follows.

**Design as an Artifact:** The TTP included artifacts designed for the TTP—a train-
ing calendar with modules from the CIT course content and the Assessment and Ru-
bric Design, AoT, Art of Mentoring and Soft Skills modules along with the orienta-
tion program, which included human values and culture-building. Further, the train-
ing calendar was created, including the CIT course modules, mapped to an academic
schedule for the duration of the TTP as well as the names of mentors and the labs
used. The training calendar also included weekly college implementation planning
sessions and industry talks. The schedule for the first TTP was 16 weeks, and this
was refined over multiple design cycles to 8 weeks as a stable design and offering.
Technical content was built using LBD, principles of constructive alignment and ru-
brics. Evaluation was conducted by mentors and an independent review team, fol-
lowing the principles of constructive alignment and rubrics, during the TTP. Each
instantiation enabled the artifacts to become more robust, with continuous improve-
ment applied. The artifacts at the end of multiple design cycles were available in the
knowledge base for others to use.
**Design Evaluation:** The utility and efficacy of the TTP was evaluated by several means. The TTP was evaluated using batting practice through multiple instantiations of the TTPs at several locations, including in the virtual classroom mode. Further, rubrics were a means of evaluating tasks for modules in the course and for self-reflection and feedback from mentors for the teachers. Batting practice was the process of working through the training calendar and the course content in a self-regulated fashion with various learner volunteers (students and the EnhanceEdu team) while systematically checking the time taken for module task completion and quizzes. The training calendar was also checked for completeness for the duration of the TTP, with primary mentors leading each session. The survey feedback also constituted a key component of the evaluation. Besides these elements, Kirkpatrick’s (1979) method of four levels of evaluation (*Level I: Reaction; Level II: Learning; Level III: Transfer; Level IV: Results*) was also conducted for the TTP to assess its effectiveness.

![Figure 4.6. Kirkpatrick's model: The phases involved and the measurement of levels](image)

For the TTP, Levels I and II were measured (Figure 4.6). A process was instituted by which the EnhanceEdu mentors could observe the learning from the beginning to the end of the TTP, evaluating the faculty members’ deliverables (formative assessment) from the start. Through this model, the learning process of the faculty members was completely tracked, their rates of learning observed, and their competency gains validated. When learning was measured (Level II), it could be determined to what degree the skills, knowledge and attitudes of the faculty members had changed.

The LBD methodology was enhanced by employing formative and summative assessment, with rubrics for learning as well as for the grading phases. The rubrics mapped the learning objectives of the module and measured them based on various parameters. Using these rubrics, faculty could give better feedback to the learner.
Most importantly, the use of rubrics provided a standardized way of reducing bias and human errors.

The research data showed that there was a set of teachers who did well and obtained mastery for their students, while other teachers could not do as well. When the reasons for this were examined, it was found that the teachers who did not benefit lacked interpersonal communication skills. They were also not equipped to interact with their trainers to resolve their doubts. To empower all teachers with improved communication skills, soft skills classes were added to the TTP training curriculum, starting with the third iteration of the TTP. Some of the activities are presented in Figure 4.7. The data showed that the implementation of student training after this TTP improved over that of the previous period.

While the TTP ensured in this manner that teachers learned the new content, pedagogy and technology, what was really important was to ensure that they applied this learning to change their instruction and create an impact on student learning.

Research Contributions: The design of the TTP was informed by several theories, models and pedagogies, including LBD, Bloom’s taxonomy, assessment and rubric design and Bransford et al.’s HPL (1999). This approach to teacher training and evaluation was published at conferences and disseminated in national talks on transforming education, using LBD, blended learning and open education resources (PI, PIII, PIV, PVI, PVII).

Research Rigor: The following were used in the design, delivery and evaluation of TTP: LBD, Bloom’s taxonomy, rubrics, culture-building with a growth mindset, teaming for excellence and Kirkpatrick’s method of evaluating training programs.

Examining the design of the TTP environment, following the theory of HPL (Bransford et al., 1999; see the Review of Literature Section 2.2.2), one could see that the approach provided the building of a learner-centered, knowledge-centered, assessment-centered and community-centered environment.

A learner-centered environment is designed to take into account the knowledge, skills and attitudes of the learners. The course content was relevant to the teachers and students. Having at least one workshop facilitator who came from a similar discipline to that of the participants also supported learner-centeredness. In our case, a 1:10 ratio of mentors to teachers was provided for. So, in cohort sizes of 100 teachers in training at a TTP, there would be more than 10 mentors from the IT discipline in the team.

The example of the mini-search engine task-building in the Data Structures course (in Section 4.1) shows that the CIT course was designed as a knowledge-centered environment. Here the content being taught focused on the most important principles and methods associated with the subject and built on the learners’ current knowledge and concepts. The presentation utilized techniques known to promote skill development and conceptual understanding rather than simple factual recall. The idea of
starting with the concept of search and then building other modules like crawling, indexing and others as needed also helped address the mapping of real-world problems to concepts.

The use of rubrics and the mentoring approach during the teacher training provided an assessment-centered environment. The teachers had ample opportunities to practice the tasks using the LBD method and to reflect on their own with the rubrics and also receive immediate feedback on their efforts from their mentors. This practice helped establish an assessment-centered environment.

The culture-building during the orientation of the TTP provided a community-centered environment characterized by supportive interactions among learners and a de-emphasizing of individual competition. The de-emphasis of individual competition and moving towards teaming for excellence was a key cultural element that helped achieve community-centeredness. Including discussions in the classroom and working together to complete group tasks also helped achieve community-centeredness. Thus, the HPL environment was created.
There were settings where smaller groups would gather to practice soft skills activities or do presentations. Here the mentor led off with a presentation, and the teachers followed with short presentations of their own.

The human values and culture orientation at EnhanceEdu reinforced the values of respect, integrity and care for the environment that the participants were already familiar with. These rules of engagement set the expectation of behavior in the TTP so people who had come from rural areas and did not feel comfortable speaking in English did not feel disrespected in any way. It was accepted that one would give respect to the human being regardless of what they knew or where they came from. What was new was taking ownership and teaming for excellence. EnhanceEdu focused on improving the self-efficacy of the teacher using various non-technical training methods, including human values discussion, orientation sessions, culture and soft skills sessions, and personal and health development sessions like yoga, meditation and table tennis. The last set was optional and was left to the individual’s choice.

Teachers came with their own different sets of backgrounds and experience, and it was quickly found that a few teachers could make their way much faster through the tasks, while others would be slower. A couple of weeks into the TTP, the mentors organized the teachers into two groups (fast and slow learners) and personalized their learning experience (Kode & Reddy, 2010). This was an intra-TTP correction (refining in the build-and-evaluate cycle).

Many teachers felt considerably more confident (PI) after the TTP, as they learned by doing and were hands-on with the CIT content and technology. Going over and discussing the art of mentoring also helped their student-teacher interactions after they returned to college.

**Design as a Search Process:** The design of the TTP kept evolving, through teacher feedback, mentor observation and overall learning, over nine major design and implementation cycles (Figure 4.8). The TTP was reduced in length from 16 weeks to 12 weeks and was finally stabilized at 8 weeks. This stabilization was based on teacher feedback, critical analysis and planning with respect to what should be key components to use in the training, what to keep and what to drop and how to ensure that more was done in less time, using ideas of personalization and customization (Kode & Reddy, 2010).

The training program towards the later part of the research study was conducted in a 4-week + 4-week format during the summer and winter, respectively. In a later version, the winter program was conducted in a virtual classroom mode using the A-VIEW tool (A-VIEW, n.d.), making it more convenient for teachers to go through the program from their own college locations. EnhanceEdu approach to mentoring, taking field notes on wiki and providing feedback to teachers (face-to-face and remotely using Skype and discussion forums) continued to evolve; the process was refined over multiple design cycles of teacher training, in multiple locations and formats.
Communication of the Research: The results were published, including the artifacts, research rigor and design, as a search process in conferences and other forums (PI, PII, PIII, PIV, PVI).

After the training, the teachers were to take forward what they had learned and conduct student training in their own colleges. EnhanceEdu had program dashboards, called Start Green Stay Green (SGSG), that monitored several parameters, including teachers’ workloads, and reported on the health of student training at the colleges (see PIII). The college would show up as green, yellow or red, based on the weighted state of the parameters. The strategy to motivate teachers to use their own training to train students at the colleges was to award them an L-Board (Learner’s board, similar to a learner’s permit to drive) at graduation (Open Day) after 8 weeks of the TTP. Teachers were awarded a full teacher training certificate (a mentor certificate) after they had used mentoring to train at least one cohort of students at their own colleges (PVI).

4.2.2 Teacher efficacy and empowerment

Key elements in the TTP calendar were the training and implementation plans the teachers developed during weekly sessions. In some of these sessions, they would assume their own roles as teachers and discuss things with the members of the group from their own college (five from each college, i.e., their college implementation team). They honed their presentation and negotiation skills by doing mock presentations with EnhanceEdu mentors and the rest of their college implementation team. Members of the college implementation team were given roles such as coordinator or technical lead. They consulted with each other and connected with their
management to finalize the academic calendar for implementation of student training in their own college.

All this was conducted in a hands-on manner, making these participants responsible as they took ownership of their roles. In these sessions, it was easy to see rapid increases in self-efficacy as the teachers’ management continued supporting their implementation plans. They would ask for the computer lab for eight hours per week, for example, would be allotted six, and would replan around that time span. This entire process made them feel in control of their own future.

This confidence showed in the teachers as they presented to their colleagues and to the management of the partner colleges at Open Day (their graduation day and also the day when all the management from partner and potential new colleges gathered).

There were usually five teachers from each college, and along with the EnhanceEdu coordinator for their college, this team would complete the detailed implementation plan, including dates, before the TTP was completed. A few enterprising teachers even planned the dates for the student orientation in their calendars and received a commitment from the EnhanceEdu mentors and their management for those dates. After going back to their colleges, supported by EnhanceEdu and their management, they organized a student orientation for their second- and third-year students, which began the process of student training.

One could clearly see the shift in attitude and in the behavior of the teachers as EnhanceEdu focused them on a positive and a growth mindset. Their positive attitude and motivation increased when they realized that the courses they were taking had been designed by taking into consideration what they knew, that they were the first beneficiaries of the training and that they could then pass this training on to the students. During the continuous weekly sessions to plan the implementation and processes for interaction and communication, each team of teachers arrived at a clearer picture of their own implementation. Each participant was inducted into EnhanceEdu as a member for life. Artifacts included the EnhanceEdu philosophy and culture, including taking ownership, teaming for excellence and posters that said, “You are not alone; you are part of a larger team.”

One of the activities in a TTP was a poster competition for participants to express what they thought of EnhanceEdu and the CIT and TTP. It was a pleasant surprise to see the teachers’ artistic creativity and increasing resilience, displayed both in their body language and in their “keep going until done” attitude. They were taking full ownership of their roles as mentors and as members of EnhanceEdu for life (feeling the support of EnhanceEdu, feeling confident that they could speak to and reach out to the team and to me if they needed to). The change and empowerment were visible as a tangible force in the teachers.
Teachers awarded an L-Board after the TTP were interested in getting a mentor’s certificate. So, they worked on the implementation plan with EnhanceEdu in organizing a student orientation at their colleges to select and train students.

Even as all the criteria for an effective TTP were satisfied and teachers were empowered with the implementation plans they had made, there was a still a question of their being able to effectively utilize this training to impact student learning:

*Unless our educational system is restructured in ways that embed sound principles of learning in a comprehensive and systematic fashion, it will fail to have a significant impact on the overall improvement of student learning and, as a result, will become increasingly irrelevant.* (Mazoué, 2012)

Further, remembering Guskey’s (2009) words about context:

*Context clearly trumps over content and process. The most powerful content will make no difference if shared in a context unprepared to receive or use it. Similarly a seemingly powerful professional development activity poorly suited to a particular context will likely fail miserably.* (Guskey, 2009)

In the context of India, especially in the private affiliated colleges, teachers do not have the autonomy enjoyed by their western counterparts; nor do they enjoy the academic freedom afforded by most colleges and universities in the west or in Tier 1 institutes in India (Altbach, 2003). This contextual problem and the system needed to be worked with to ensure that the teacher training was meaningful to the colleges and students. To ensure this, we involved the management.

### 4.3 MANAGEMENT INVOLVEMENT

In this section, I apply design science research and Hevner’s 3-cycle DSR to reflect on and analyze the interventions made for the management stakeholder group. A key success to the overall program is the involvement of this stakeholder group. Figure 3.2 shows that a principals’ meeting, where the management was made aware of the details of this program, preceded each TTP being offered to teachers and students along with the support provided by EnhanceEdu. Colleges convinced about the program signed up to participate through an EoI (Expression of Interest) and MoU.
4.3.1 Design science research view of management engagement

Figure 4.9 is a retrospective DSR view of work done in the creation of a management engagement program. This included the principals’ meeting, Open Day, SGSG dashboard, college visits and newsletters.

In the relevance cycle, business needs of the stakeholders—teachers from partner engineering colleges, management, students and EnhanceEdu, were identified. Management was a key stakeholder group.

Everett Rogers’ four decades of research on the diffusion of innovations has shown that in order to succeed in a community, technology must be relevant in a number of ways (Rogers, 2003). Among Rogers’ different aspects relating to relevance, two were specifically significant from our point of view. First, new innovations have to be relevant to local users. Systems that are hard to use are adopted more slowly than those that link to knowledge the user already has. Second, new innovations have to be relevant to the local culture and society (Kamppuri et al., 2006; Rogers, 1995). For this program to be successful, management’s participation in every partner college was critical. Management can be seen in the relevance cycle of Hevner’s 3-cycle DSR (Hevner, 2007), as shown in Figure 4.9.

The rigor cycle informs the design, with theories, expertise and experience. In this case, the rigor cycle shows use of Rogers’ theory of diffusion of innovations (Rogers, 1995), Kotter’s strategies for change (Kotter & Schlesinger, 2008) and the author’s knowledge of continuous improvement and enabling culture change. EnhanceEdu used and refined course content created (Figure 4.9) through TTP implementation.

The design cycle includes the build-and-evaluate components. The management engagement program course content using the theories from the rigor cycle and evaluated by the EnhanceEdu team, with subsequent iterations based on feedback from participants. Below is my analysis and reflection, using the key DSR guidelines (Hevner et al., 2004), on the implementation of the management interventions.

Design as an Artifact: In the case of management as a key stakeholder, there were two main interventions created, the principals’ meeting and Open Day, along with several key documents and tools, such as the EoI, MoU and the SGSG dashboard, as identifiable and viable design artifacts. In addition, there were college visits (PI, PIII).

Design Evaluation: The utility and efficacy of the principals’ meetings and Open Day were well evaluated through multiple design cycles, as they sandwich the TTP between the principals’ meeting beforehand and Open Day right after the completion of the program. EnhanceEdu purpose of creating awareness, interest and decision-making to interest colleges in signing up as partner colleges during principals’ meetings worked well, as many colleges signed MoUs right after the principals’ meetings.
Research Contributions: The idea of formally engaging management as a key part of the TTP with an MoU, with support systems and tools for continuing involvement to empower teachers to step up to learner-centric teaching and learning, is both novel and significant in the Indian context.

Research Rigor: Rogers’ theory of diffusion of innovations, Kotter’s strategies for change, knowledge in engineering and management and SEI CMM were applied to reduce resistance and increase the enthusiasm of the management staff of colleges to partner with EnhanceEdu and actively participate in the process. In particular, these were applied at the principals’ meeting.

The principals’ meeting introduced the TTP, seeking management commitment and teacher nominations through the MoU and other artifacts. Principals, directors and department heads were all invited to this meeting; these are the people who wield considerable influence on what goes on in an engineering college in India (Figure 4.10).

Testimonials from partner college principals and teachers who had benefited from attending the TTP were shared at the principals’ meeting. This was a transparent process, with presentations followed by a question-and-answer session.
Management needed to see themselves in their real roles as leaders of the new change that was needed in the education space and to take responsibility and ownership of introducing this program into their colleges. Management was to nominate teachers who were passionate about teaching and had at least two years of experience, so they could experience the full benefit of the TTP and build their efficacy to provide student learning. When management plays a role from the inception of the program and all along its roadmap, they are very engaged and experience real benefits from the partnership with EnhanceEdu and IIIT.

Management was usually interested in the program by the end of the meeting and wanted to understand the cost to their college. So, when it was announced that for the initial teacher training, there was no direct cost to them, many felt that this would be worth trying. Several lead colleges also showed interest in the program. As an example, in the first principals’ meeting, EnhanceEdu was successful in encouraging 13 colleges to sign MoUs, with 52 teachers nominated for the first TTP (TTP1).

**Design as a Search Process:** The multiple instantiations of the principals’ meeting and Open Day served to bring principals and other heads of organizations together,
first to receive and then to offer advice and suggestions to other colleges to partner and participate. As a planning process, partner colleges were considered as serious partners in planning new events, and several partner college principals spoke (rather than EnhanceEdu members) at these events, which helped to convince new colleges to join as partner colleges. Newly graduated teachers speaking of their experience along with earlier graduates from the TTP also seemed to help encourage new colleges and teachers to participate. This process was continually refined through multiple iterations and design cycles to empower all the stakeholders to independently engage with EnhanceEdu, IIIT and other organizations to further their growth.

Open Day was another special event where the principals and management were specially invited to listen to talks and also to listen to their faculty sharing their own experience in the TTP. Open Day allowed management a good view of the readiness of their faculty to implement the program in their college. The management was also reminded about the program and their commitment, through the MoU they had signed, to become a partner college in the program.

The all-hands Open Day meeting was followed by the management of each college being seated at a table specific to their college and seeing a presentation of the implementation plan from their own team of teachers who underwent the TTP. Figure 4.11, in frame 4, College XT, shows an Open Day table discussion in progress.

Communication of the Research: The research results were published in conferences and other forums and, more importantly, helped in the college environments as tools to support the management involvement, a key factor in empowering teachers to embrace change and mentor students for the CIT in LBD.

Newsletter: Management also liked the EnhanceEdu newsletter (PIV), which served two purposes. One was to engage management to check how their college was doing in implementation. The other purpose was to allow them to see the ranking of colleges, placed according to the participation activity levels of their students and teachers (including posting on the forums). Further, the newsletter also served to publicize our invitation to new partner colleges (see Appendix 3).

The data showed that the principals’ meeting and Open Day had also helped the community of senior management of colleges meet and exchange ideas and discuss their own gains in this program. From the second principals’ meeting onward, it was clear that our own presentation in sharing the benefits was good and helpful. But the live testimonials of teachers who had participated in earlier TTPs as well as those of the principals who had benefited were really important in convincing new colleges to join as partner colleges. Overall, over nine iterations, EnhanceEdu enlisted 70 partner colleges from the two states of Telangana and Andhra Pradesh. These colleges are listed in Appendix 1.

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The next step after the Open Day and the graduation of the teachers from the TTP was the student training program, which brings up the next major stakeholder group, the students.

4.4 STUDENT ENHANCEMENT PROGRAM

In this section, design science research is applied to reflect on and analyze the interventions for students.

The STEP was conducted as per the process steps seen in the research design and methodology chapter (refer to Figure 3.3), using the content created in the Content Development section (refer to Figure 4.1) for the CIT.

4.4.1 Design science research view of student engagement

Figure 4.12 represents the retrospective view of student interventions with respect to Hevner’s three cycle DSR, including student training, student orientation and STEP.
In the *relevance cycle*, business needs of the stakeholders—teachers and students from the partner engineering colleges as well as management and EnhanceEdu, were identified. Students are a key stakeholder group for the success of this program, as they are the ultimate beneficiaries of the IT courses offered through the partner colleges. Their success through employability is a success for the representative colleges and thereby to EnhanceEdu.

The *rigor cycle* shows use of Rogers’ theory of diffusion of innovations (Rogers, 1995), Kotter’s strategies for change (Kotter & Schlesinger, 2008), LBD, SEI CMM and EnhanceEdu mentor experience and expertise as well as the CIT course content developed, as described in the Content Development section 4.1.

The *design cycle* includes the build-and-evaluate components. The student training program course content (student orientation, STEP) was built using the theories from the rigor cycle and was evaluated by teachers from the partner colleges and by the EnhanceEdu team, with subsequent iterations based on feedback from students.

The problem involved designing a set of IT courses usable by teachers and students in engineering colleges dispersed over a wide geographical area, with poor internet connections and different levels of knowledge. Below is my reflection and analysis of the implementation of the student training program using the Hevner guidelines (Hevner et al., 2004).

**Design as an Artifact:** With respect to the student as a stakeholder, EnhanceEdu built the student orientation and STEP along with rubrics and the online portal for e-learning as identifiable and viable design artifacts. Rubrics for all the modules provide a transparency between learner and mentor, and the teacher also explores his or her role as a mentor.

**Problem Relevance:** The problem of student employability is indeed relevant and important.

**Design Evaluation:** The utility of the CIT content and portal was rigorously evaluated while implementing student orientation and STEP and through batting practice. Rubrics designed as part of the content were used as a means to evaluate tasks for modules in the course.

**Research Contributions:** The student orientation served to reduce resistance and enabled and empowered many students to take up a new methodology of student-centric learning as opposed to the teacher-centric information transmission approach. The orientation was also conducted through a virtual classroom, using the A-VIEW software tool. Using this tool to address large groups of teachers and students made it possible to conduct TPOs and student orientations. Without traveling to college sites, EnhanceEdu could connect with the students in their labs for regular updates and meetings.
Research Rigor: Change theories and models such as Kotter’s steps of change and Rogers’ theory of diffusion of innovation were used to work with students, teachers and management to reduce their resistance to new methods. For students, the student orientation made them aware of the program, so they could decide whether or not to participate in the training (Rogers, 1995).

Management and faculty hosted student orientations in their colleges for second- and third-year students (as in Figure 4.13, frames 1 & 2). Trained teachers who had graduated from TTP presented the STEP program and its benefits for employability to their students. Management’s presence and participation also helped, as their commitment to support the program was visible. This gave confidence to students and teachers, and students wanting to improve their employability signed up for the program. Further, STEP program was implemented with trained teachers mentoring students and students learning by doing, doing tasks in the modules from the online system per the methodology, and students received CIT certificate on successful completion (example as in Figure 4.13, frames 3 & 4).
**Design as a Search Process**: Even though colleges had signed MoUs, many challenges were faced in implementing the program in the colleges (PIII). EnhanceEdu refined the content (adding scaffolding) and approach to mentoring (using a combination of lectures plus LBD, a blended learning approach) over multiple design cycles, arriving at a blended learning mix that would work well for colleges that were already in yellow or red in their SGSG dashboards and were not successful in their initial passes at conducting student training.

Students joined STEP and committed 4–10 hours per week to labs mentored by their faculty and to LBD. They were exposed to computational thinking, logic programs, problem solving and peer learning and started sharing their own personal stories to inspire other students.

![Figure 4.13. Student orientation (frames 1 & 2); STEP program, mentoring by trained teachers and learning by doing by students; student receiving CIT upon successful completion](image)

**Communication of the Research**: The research results were published at conferences and in other forums (PI and PVI) and more importantly, helped in the college environments as tools to support student involvement, a key factor in empowering teachers to embrace change and mentor students for the CIT in LBD. The newsletter (PIV) also helped bring visibility to the program. Incentives were very motivating for
the students, including the fact that if a student was a CIT holder with mastery, he or she was eligible to come to EnhanceEdu during their summer or internship time and participate in a project.

All in all, one could see a development of these students as holistic individuals with empathy for others (their peers, their mentors and their management that supported them and also for EnhanceEdu). They also developed the ability and confidence to apply their knowledge to solve real problems (practice they achieved during CIT, as the problems were based in that way, as seen in PI) along with learning to learn (as expressed by a director of a leading institute in Hyderabad). Placement officers in colleges were also happy, as they were encouraging better companies to visit their campus after placing a few CIT-trained students. Many colleges were keen to engage with EnhanceEdu in more ways than just through CIT, inviting us to talk with college faculty and students and to forums like the career arena of AT College, and conducting AoT workshops for all faculty. EnhanceEdu also conducted workshops to familiarize faculty with Bloom’s taxonomy and technology, to help them learn lesson planning with questions involving higher-order thinking skills and also to help them present classes in this way.

4.5 ENHANCEEDU

EnhanceEdu was the new lab I created in 2008 to work on the project, under the Manpower Development Scheme, for enhancing the quality of IT education in engineering colleges, funded by the Government of India, Ministry of Communication and IT, now MeitY (Ministry of Electronics and Information Technology), in partnership with IIIT Hyderabad.

In this section, the interventions for EnhanceEdu are discussed. The building of EnhanceEdu was conducted as per the process steps seen in the research design and methodology chapter (Figure 3.3), using the content created in the Content Development section (Figure 4.1) for the CIT.

4.5.1 Design science research view of EnhanceEdu

Figure 4.14 represents the retrospective view of EnhanceEdu using Hevner’s 3-cycle DSR, where I reflect and analyze how the team is built, its culture, tasks and goals are established, the content is developed, and teacher- and student training goals are set.

The relevance cycle includes the stakeholders, the technology infrastructure (environment) and the processes. It identifies the needs of the stakeholders, namely the
teachers, students and management from the partner engineering colleges, and also identifies the environment of the partner engineering colleges. The environment included college IT labs with poor internet facilities. For EnhanceEdu to be successful, all stakeholders had to participate and be committed to the program; this was clearly observed during implementation.

The **rigor cycle** shows use of methodologies such as growth mindset (Dweck, 2008), teaming for excellence, ownership, SEI CMM, continuous improvement, human values and EnhanceEdu mentor experience and expertise (PI, PVI, PVII). Dweck (2008) summarized her evidence from decades of research with differently aged subjects, showing that when students developed what she called a “growth mindset,” they believed that intelligence and “smartness” could be learned and that the brain could grow from exercise. Knowing this, I worked on the team with respect to the culture-building view that “you are not alone; you are part of a larger team,” along with taking ownership, teaming for excellence and respect for all. People simply

![Diagram of the 3-cycle DSR view of EnhanceEdu](image)
worked towards the EnhanceEdu goals, working together, without competition, all working towards excellence.

The *design cycle* includes the build-and-evaluate components. EnhanceEdu, the portal course content and the culture and process orientation were built using the theories from the rigor cycle and evaluated through batting practice and mentoring, with subsequent iterations based on feedback from all stakeholders. Below is my reflection and analysis of EnhanceEdu implementation using the key Hevner guidelines.

**Problem Relevance:** The problem was one of designing a set of IT courses usable by teachers and students in engineering colleges dispersed over a wide geographical area, with poor internet connections and different levels of knowledge. Also, in the regional context of India, teachers affiliated with private engineering colleges are not empowered to make decisions on curricula, teaching methods and introducing change. The EnhanceEdu program was created to address these problems. The success of TTP and STEP are very relevant to the success of the EnhanceEdu program; these programs are intermingled, whereby a confident, empowered teacher (TTP) can help motivate a student to learn with the right tools (STEP) and eventually become employable.

**Design Evaluation:** Evaluating new hires into EnhanceEdu was a process. The MSIT placement officer evaluated the needs of EnhanceEdu and found appropriate candidates who could fill the role. A testing track allowed two weeks’ time for the new person to test the EnhanceEdu work environment for suitability and either choose to continue or leave. Similarly, EnhanceEdu could observe the new hire during the testing track and choose not to make an offer. Evaluation, once the person was hired, continued for the two weeks, through the person emulating mentors working with other senior mentors and progressing on to real mentoring, working with teachers in TTP. Team members were evaluated with respect to the EnhanceEdu goal, and everyone worked towards that goal. The EnhanceEdu team also evaluated programs such as TTP, STEP and the CIT through emulation prior to actual execution.

EnhanceEdu worked on continuous improvement of all aspects of its work through feedback on content development, TTP and STEP as well as on CIT portal performance.

**Research Contributions:** The TTP conducted by EnhanceEdu needs to train teachers not only in the content but also in becoming empowered to conduct the training for students. This is an important factor, as the training now is learner-centered, and they need to mentor the students as opposed to lecturing to them (a change in process). The design artifacts, including the CIT content and the portal environment in which the teachers were trained, are brought into the colleges (into the environment) for the teachers to use in training the students, using the same
methodology. These design artifacts were published (PI, PIII, PVI) and were disseminated at national and international conferences.

**Research Rigor:** In the design, delivery and evaluation of EnhanceEdu, teaming for excellence and taking ownership, self-efficacy (Bandura, 1997), the capability maturity model—CMM Level 5 continuous improvement process (Paulk, 1993) and the author’s experience and expertise building a SEI CMM Level 5 organization (Hersbsleb et al., 1997; Paulk, Curtis, Chrissis, & Weber, 1993) were used. The design was also informed by the growth mindset (Dweck, 1986, 2008) and by the CIT course content developed in the earlier content development process.

Batting practice was used to evaluate the content (PVI). Examining the design of culture-building with a growth mindset and teaming for excellence, I created a team that took on challenges that even experienced people would back off from. The team tried and succeeded and believed in themselves more and then tried even harder and succeeded; the growth mindset was indeed personified within the team. They were empowered through cycles of building the culture and initially testing it with small tasks and then with larger ones, building mature individuals who felt ready to take on bigger challenges.

A few members of the team were hesitant to present or speak to college management, and I had to start communicating on the phone. As they watched me speak, and through my mentoring of EnhanceEdu team members, the necessary change took place, and these hesitant team members could later confidently visit colleges, speak to management, ask for support, empower teachers, speak at student orientations and motivate students to join the STEP to obtain the CIT.

**Design as a Search Process:** Process is a great leveler. I learned this through all my years of experience both as an entrepreneur and as the founding director of the Motorola Software Center in Hyderabad, setting my sights on SEI CMM Level 5 (Paulk, 1993) for the young center. No one in the software team had people management experience coming into the team. They were very good technically, but they did not know what it meant to work with customers and other people. This was the journey of EnhanceEdu, where people were not only transformed by their apparently unlimited ability to learn and be continuous learners but were also transformed for the most part by following processes that simply needed to be done and by ensuring that there was backup. This saved a great deal of time and effort and increased speed. The “extra” time gained from following processes allowed them to learn and develop themselves further. The process orientation and continuous improvement paid great dividends.

Because of the continuous improvement process, EnhanceEdu would conduct major updates of content from year to year, especially with respect to removing items such as the IT workshop that included MS Office for the first TTP. In later TTPs, the IT workshop was eliminated, believing that teachers needed to learn components like
MS Office on their own; this became a norm within a year or so. Similarly, Linux became an elective workshop for a college. The technical content was limited to CT, Java and data structures, and new content, like Wikiday and Moodle, was added, to familiarize people with these tools, as they would need to use them in their colleges. As mentioned, the length of the TTP was revised down to 12 weeks and then to 8 weeks, stabilizing at that level. TTP was also conducted in a 4+4 weeks format in summer and winter, with the winter session conducted in a virtual classroom mode.

Further, based on the observation of a need for improvements in content development and in supporting multiple disciplines, a new instructional design model, the Butterfly model (PV) was developed. This had the necessary structure to support the personalization and customization of smart learning artifacts (PV, PVII).

What was interesting was that in software engineering, there are processes for developing code and estimation recording, but at EnhanceEdu, there were processes for activities beyond software development. These included activities such as content review, college visits, prototype presentation, portal systems software, dashboard development and meetings.

The orientation session was built using the ideas from the growth mindset, human values and culture. The technical content was built using LBD methodology, principles of constructive alignment and rubrics. An independent review team conducted evaluation according to the principles of constructive alignment and rubrics. Each instantiation enabled the artifacts to be more robust, with continuous improvement applied.

Communication of the Research: The research results were published at conferences and in other forums (PI, PIII and PVI). The newsletter (PIV) also helped bring visibility to the program.

EnhanceEdu had many processes and guidelines to realize its mission and vision to empower people and communities to enhance education. The EnhanceEdu culture substantially helped the team be creative and devise several ideas for workshops. First, a new idea was tested with our team and the teachers in TTP, as one or two “prototype” workshop offerings. If the workshop received good traction, it would be made a “product” and more workshops were offered. “Mission Impossible,” a team book reading and sharing, helped to create the change management workshop, Switch (Heath & Heath, 2010). Switch also included a “Follow the bright spots” change strategy, a positive deviance approach (Singhal, Shirley & Marston, 2010). Switch was subsequently integrated into the TTP.

EnhanceEdu’s process orientation helped us be more independent of people. It helped us through the movement of research team members to industry and the induction of new members, and it enabled continuity in conducting new TTPs and student enhancement programs. Many of the EnhanceEdu team moved on to industry with references as the large funded project came to a close, and the team members
continued to help this endeavor from the outside. Defining EnhanceEduians as members for life helped. I like to think that many members worked as long as they did, some of them for the entire 5+ years of the project, taking far less than industry salary, because they believed in the work.

Figure 4.15. EnhanceEdu team under the Jaagruti (Awaken) banyan tree; Mentoring faculty; College visit, meeting management, asking Why STEP?; Preparing for principals’ meeting (behind the scenes)

Figure 4.15 shares pictures of the team under the “Jaagruti” banyan tree, symbolizing “awakening,” as well as a frontline activity (meeting with management at a college visit), a behind the scenes activity (preparing for a principals’ meeting) and one mentoring during TTP.
5 KEY RESULTS – ANSWERING RESEARCH QUESTIONS

You must understand the whole of life, not just one little part of it. That is why you must read, that is why you must look at the skies, that is why you must sing, and dance, and write poems, and suffer, and understand, for all that is life.

Jiddu Krishnamurti

In this chapter, I will review answers to each of the research questions and look at the results achieved through the EnhanceEdu study that started in 2008.

5.1 RESEARCH QUESTION 1

RQ1 was “How do we design a teacher training program to be effective in enhancing information technology (IT) education in engineering colleges in the Indian context?”

The design of a TTP that can enhance IT education in engineering colleges should follow the below process steps:

1. Relevant content should be designed and developed in LBD mode for use in the TTP (PI; Section 4.1).
2. The TTP should be designed and delivered in such a way that the teachers’ knowledge and competence in the subject increases, along with improvement in their attitudes and beliefs (PI, PVI; Section 4.2).
3. The TTP should include a plan for student training that the teachers develop during the training program (PVI).
4. Trained teachers should train students in their colleges, so the students’ knowledge and competence increases (PI, PII; Section 4.4).

The design of the TTP included content (domain technical skills and soft skills) learned in an LBD manner; included collective participation from each college, with teacher nominations; trained teachers like students with mentoring support for a period of at least four weeks; and helped teachers develop implementation plans for training students in the same content for a semester or academic year, synergized with the goal of improving student learning for all stakeholders. The TTP included content and pedagogy built into a technology platform, so it was available in the same way for all users, teachers and students alike.
This TTP was effective as it accomplished the following:

- It improved the learning and skills of teachers.
- It gave teachers new content, pedagogy and tools.
- It helped them apply these in their classrooms.
- It put them on a path of self-improvement and a reduction of future interventions.
- It thereby improved the “employability” of their students.

With the implementation of the TTP (Section 4.2), the data showed the following:

- Competency gains were observed from the formative and summative assessments, actual assessments conducted by the mentors during the program as the teachers completed tasks on a daily basis; summative assessments were also conducted at the end of each course in the certificate. (PI, PVI)

- Pre- and post-surveys were conducted with 260 teachers from the first three cohorts of teacher training, completed in March 2009, June 2009, and June 2010. The survey used a Likert scale of 1–5, and the data show that teachers gained competency. This was a self-reported survey using the sample survey instrument in Appendix 2.

- Faculty nominees showed an increase in competency. The data showed a 45% gain in Computational Thinking (CT), 28% in Java, 21% in data structures, 28% in soft skills and productivity tools and 40% in Linux (refer to Figure 5.1).

![Competency gain](image)

**Figure 5.1.** Competency gain in faculty members before and after teacher training (Rating on a scale of 1–5)
The data show that in spite of LBD being a new methodology for the teachers, a total of 99% respondents were either comfortable (50.66%) or very comfortable (48%) adapting to this methodology, while only 2 of the 260 surveyed were very uncomfortable in adapting to it (refer to Figure 5.2).

The faculty members were able to appreciate their own capabilities, understand their strengths and work on their areas of improvement. These faculty members shared positive feedback about their experiences in the training program, along with an eagerness and commitment to implement the program for students in their respective colleges. The following is a testimonial from a teacher right after the completion of the TTP.

*I am feeling very happy that I got an opportunity to attend this Teacher Training Program conducted by IIIT, Hyderabad. This program is mainly focused on Learning by doing. Since technology is changing drastically especially in Computer Science, it is very essential that teachers should learn the things by attending such programs. I feel students can be benefited if teachers train them using the approach learning by doing and they can be Industry Ready.*

A quote by an Associate Professor in CSE Department in a rural college in AP

The TTP’s effectiveness was evaluated based on Kirkpatrick’s (1979) four levels of evaluation discussed in Section 4.2, with the data showing the following (PII):
1. Level I – Reaction

What the learners felt: Learner enthusiasm was very good for learning through LBD; 98% of the faculty members trained said that they were either comfortable or very comfortable adjusting to the learning methodology (Figure 5.2). They also indicated that students would easily adjust to this type of training methodology.

Additional data was gathered on how faculty members felt about using the LBD methodology to teach IT. The questions measured how the participants in the training program felt about their experience. Were they satisfied with what they learned? Did they regard the material as relevant to their work? Did they believe the material would be useful to them on the job? These questions do not measure learning; they measure how well the learners liked the training session. Of the 260 faculty members EnhanceEdu surveyed:

- 89% would take a similar course if offered again;
- 86% would refer this course to their colleagues and
- 92% said this course would benefit the student community at large.

2. Level II – Learning

When EnhanceEdu measured the learning, the data showed the following:

- Faculty members gained competency in CT, object-oriented programming using Java and data structures, using the LBD methodology delivered through the mentoring mode (refer to Figure 5.3).
- The rubric-based formative assessments throughout the training program showed the faculty members’ improvement in knowledge and skills. Each module of the course had tasks to be submitted before proceeding to the next module. Mentors conducted formative assessments on a daily basis during the entire training period (Section 4.2). This assessment process was made transparent by using rubrics. Mentors also conducted summative assessments, one for each of the three courses in CIT: CT, Object-oriented Programming using Java, and Data Structures.
Figure 5.3. Faculty members’ competency gain

3. Level III—Transfer

Bregman and Jacobson (2000) state that a training program succeeds, by definition, when the training changes employees’ behaviors in ways that matter to their customers. Relating this to my research, one can consider the training program successful when the faculty members’ behaviors change in ways that matter to their students. In this case, 80% of the faculty members stated that they gained confidence in providing solutions to real-world problems in class (PII) (refer to Figure 5.4).

Figure 5.4. Comfort levels of faculty members
A number of instances made evident a connection between measures of behavioral change and the hoped-for consequence, solid business results (Level IV). The partner colleges claim that EnhanceEdu training program has produced a significant change in faculty-student relations.

To quote the director of a reputed institution, “All of our faculty members who have undergone the TTP have shown a remarkable improvement in their ratings from students. Some faculty members have even received upwards of 95% rating from the students.”

A marked improvement was also observed in students. To quote a management representative of a rural college:

> CIT is important to us because of the following reasons.
> 1. We see a marked improvement in technical skills in students.
> 2. Students learn to adapt to latest technologies.
> 3. We see an increase in motivation to learn.

With other programs, students spend 3 hours of lecture time in lab and the matter ends there. Students do not become sound in their knowledge. Learning by doing methodology offered by CIT program makes them stronger.

4. Level IV – Results

Level IV evaluation attempts to measure the results of training as it directly affects a college’s productivity—a challenging task for many reasons. Kirkpatrick noted that the number of variables and complicating factors make it difficult, if not impossible, to evaluate the direct impact of training on a business (or, in this case, on colleges).

The data showed that the training program for students impacted their outcomes by over 90% in the four categories below (Figure 5.5):

1. Found LBD methodology beneficial.
2. Ability to apply LBD to other courses.
3. Recommend this course to others.
4. Improvement in academics/programming skills.
Colleges reported improved learning for students as well as improved placements. An example placement report following an interview states as follows:

_We had started STEP program to our students in the Academic Year 2012–13 and continued for 3 years successfully. In total 181 students got registered and out of which 153 were certified i.e., 85% of enrolled students got certified through the program. Out of which 149 students (97%) got placed in premium/medium level organizations._

_Quote from a Department Head of CSE, from a college in State A_

### 5.2 RESEARCH QUESTION 2

RQ2 was “Who are the stakeholders, and what kinds of interventions are needed for each of the stakeholders to enhance information technology (IT) education in the Indian context?”

The candidates for stakeholders include management, teachers, students, EnhanceEdu (the research group), parents, employers (industry), universities, regulatory bodies and funding agencies. There are many stakeholders in the higher education system in India, as seen from the systems view in Figure 1.4, redrawn below as Figure 5.6. However, for the purposes of this research, testing the introduction of the
CIT for students, the set of stakeholders includes management, teachers, students and EnhanceEdu. The results reported here apply to this set of stakeholders.

Why only this set of stakeholders among the very large set in Figure 5.6? As is clear from the systems view, there are a large number of stakeholders, with very complex interrelationships. For example, if a curricular change is to be made, the stakeholders involved include the affiliating university, the University Grants Commission, the All India Council for Technical Education and members of boards of studies. The time taken to change the curriculum may be very long, sometimes a matter of a year or two, after boards of studies’ meetings discussing and debating the issues. If a change does happen, the university must make the curricular change and then ripple it to the affiliated colleges. On the other hand, the change may not be accepted. The entire exercise may be futile.

Given this background, EnhanceEdu chose to involve a limited number of stakeholders related to an institution, those that were necessary and sufficient to effect
change. Clearly, this set includes the teachers and students, while management involvement is less obvious. However, given the lack of empowerment of most teachers in private engineering colleges, especially in Tier 2 and Tier 3 cities, management engagement is required (Section 4.3). The management can then empower the teachers to train students using the new pedagogy and technology in which they have been trained.

The first treatment for the stakeholder groups was to reduce any resistance to the program and showcase its benefits, so there would be both buy-in and motivation to participate. This was done with the introduction of the TPO, the student orientation, and principals’ meetings and Open Day for management. As seen in Chapter 4, I used Rogers’ theory of diffusion of innovations to reduce resistance and increase awareness and interest.

Table 5.1 summarizes the treatments for the four sets of stakeholders. The table also shows the important tools and technologies used. These enabled distributed teaching and learning to take place at the various colleges. Further comments show key actions and results.

In this research, innovation was the use of a known technique/intervention in a new context (Rogers, 1995). There are five perceived attributes of the innovation, as exhibited in Table 5.2.

Table 5.2 includes each of the five attributes of innovation for each stakeholder. The LBD content and training program benefits were communicated, and the relative advantage was bought into, because the program claimed to enhance student employability and earlier cycles had shown this to be the case. Also, an MoU with EnhanceEdu at IIIT-Hyderabad was seen as a significant partnership, a relationship that the colleges valued. The compatibility, complexity and trialability were all tested when the TTP was in progress. Based on the needs and levels of participants, the content was refined (scaffolding added as needed), improving compatibility and simplicity. This is also consistent with the requirements of design science, where artifacts are thoroughly tested and evaluated before release into the field (Simon, 1996). Although the TTP was a relatively long eight-week program, the length also increased the chances of adoption, as the trialability (the degree to which innovation was experimented with, in full) was also high. The observability was high, as the colleges, teachers and students were figured prominently in our newsletter with their implementation tracking and forums. Further, students and employers valued the CIT learning and certificate.
Table 5.1. Treatments for the stakeholder groups

<table>
<thead>
<tr>
<th>Stakeholder Group</th>
<th>Treatment 1</th>
<th>Treatment 2</th>
<th>Tools and Technology</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management</td>
<td>Principals’ Meeting (Section 4.3; PVI)</td>
<td>Open Day Newsletter (Section 4.3; PIV, PVI)</td>
<td>CIT e-Learning Platform, SGSF, virtual meetings</td>
<td>End-to-end engagement by management empowering teachers</td>
</tr>
<tr>
<td>Teachers</td>
<td>Teachers’ Pre-orientation (Section 4.2; PVI)</td>
<td>Teacher Training Program (TTP) Open Day (Section 4.2; PI, PII, PVI)</td>
<td>CIT e-Learning Platform, virtual classroom, Moodle, Wiki</td>
<td>Moving from teacher-centered to learner-centered, Art of Mentoring</td>
</tr>
<tr>
<td>Students</td>
<td>Student Orientation (Section 4.4; PIII, PIV)</td>
<td>Student Enhancement Program (STEP) w/Certificate in IT (CIT), discussion forums (Section 4.4; PIII, PIV)</td>
<td>CIT e-Learning Platform, Virtual Classroom, Remote mentoring</td>
<td>Learning by doing, Learning to learn, Improved retention in course</td>
</tr>
<tr>
<td>EnhanceEdu</td>
<td>Team-building, Culture-building (Section 4.5; PVI)</td>
<td>Mentor Training, Process for Content Development, TTP planning, CIT e-Learning Platform development (Section 4.5; PI, PIII, PVI)</td>
<td>CIT e-Learning Platform, virtual classroom, virtual meetings, dashboards, Moodle, Wiki</td>
<td>Culture, Process orientation, Continuous improvement</td>
</tr>
</tbody>
</table>
Table 5.2. Perceived attributes of the innovation for stakeholder groups: Relative advantage, compatibility, complexity, trialability and observability.

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Relative Advantage</th>
<th>Compatibility</th>
<th>Complexity</th>
<th>Trialability</th>
<th>Observability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>They would get jobs&lt;br&gt;They saw their seniors get jobs</td>
<td>They could sit with peers and mentors and learn</td>
<td>Survey response was that it was easy to use the portal with tasks</td>
<td>They got immediate feedback within a week when they did their first course, Computational Thinking, and they had an entire semester to work with</td>
<td>They coveted the certificates; they saw the nice certificates their mentors got; they saw their seniors get good jobs&lt;br&gt;Survey shared that their confidence was at its highest point</td>
</tr>
<tr>
<td>Teachers</td>
<td>They would learn student-centred teaching–learning approach—an advantage for them</td>
<td>Worked and tested with their own computer systems and labs</td>
<td>Survey response showed they felt the method was easy to use</td>
<td>At least 4 weeks trial</td>
<td>They and their students were getting visibility through newsletters, forums, L-Board and mentors' certificates, small monetary reward for mentoring</td>
</tr>
<tr>
<td>Management</td>
<td>Feedback at Open Day and principals' meetings was very good, Students getting placement, Teacher–student relationship improving, Low-cost or no-cost investment, Software Moodle was open source</td>
<td>They were satisfied that teachers got trained, teachers and EnhanceEdu had planned and tested their systems with the software and content</td>
<td>Their teachers and students felt comfortable and liked the first tool, Raptor, for Computational Thinking</td>
<td>Survey results showed they really liked the TTP and STEP courses and felt they were getting enough visibility to try again; the proof came when they came back to get more teachers trained and more students trained</td>
<td>They could see the improvement in confidence and the eagerness with which teacher and students were working, could see the improvement of their own college ratings in the newsletter, their people recognized, and their students' placements improving</td>
</tr>
<tr>
<td>EnhanceEdu</td>
<td>Convinced of the content and process due to MSIT experience and expertise in industry, and prior iterations of CIT</td>
<td>Tested with students and teachers at batting practice before TTP or STEP</td>
<td>Got good feedback from all users on ease of use, maintained content in easy-to-use mode for users</td>
<td>Made sure there was good hands-on use and testing and a novice could pick up in the time given</td>
<td>Helped with the observability, publications gave EnhanceEdu visibility, known in the teaching–learning community, trained teachers looked for more, well respected by colleges</td>
</tr>
</tbody>
</table>
The main purpose of treatment 1 was to work on the concerns or resistance of the particular stakeholder group (Figure 5.7). The principals’ meeting demoed how the CIT program focused on addressing the gaps perceived by industry in graduating students. The meeting focused on how these gaps would be bridged, first in the content, then in teachers during the TTP and finally, in student training in colleges. The content would also be online and available to colleges.

The data showed improved engagement and task submission by students, with the use of discussion forums during treatment 2 of STEP for students. The data also show that students who were active on forums had a higher average number of task submissions than those inactive on forums.

Figure 5.8 shows the number of students from each college who participated in discussion forums over the period of the discussion forum study.
College and student participation in forums

Number of participating colleges (15)
Number of participating students (2000)

Figure 5.8. Colleges’ and students’ participation in discussion forums

Figure 5.9 showed the number of submissions increased every month during the period of study. In colleges where students were active on discussion forums, the data show that the average number of submissions per student per month was better than that for colleges inactive on discussion forums, as seen in Figure 5.10 (PIV).

Number of student submissions

Number of participating colleges (15)
Number of participating students (2000)

Figure 5.9. Number of student submissions
The data show that after EnhanceEdu interventions, more colleges were motivated to participate in discussion forums (Figure 5.8) and build a social community.
The empowerment was felt by all stakeholders, taking ownership and completing tasks and supporting other stakeholders (Figure 5.11). The data showed that teachers were trained in LBD pedagogy by mentoring, with their knowledge and skills improved as a result of the training. Teachers also improved their attitudes and beliefs and were empowered to create implementation plans to train students at their colleges.

A teacher’s success story and analysis: The success story of a teacher, shared through an email, is analyzed and represented in Table 5.3.
Table 5.3 One teacher's story describing the experiences before and after TTP, and analysis

<table>
<thead>
<tr>
<th>Before attending TTP</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;My personal growth and career development were in slow pace and not very active. In classroom, interaction limited to subject only and very little interaction about general things like motivational aspects. I am interested to contribute something to the students and college but unable to identify proper direction and path. Not very much confident about myself I don’t know in which way I can help students&quot;</td>
<td>Low on attitude and beliefs Low of ownership for student motivation Low of clarity of goals Low self-efficacy, low confidence</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>After attending TTP</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;That is the longest training program I attended so far and helped me to change myself in many ways: My first experience is I enjoyed TTP as it was not listening to the class continuously but LBD. Actually, I felt little bit challenging as long back I have taught programming subject but still I worked well and utilized complete time (9am to 6 pm) finally got mastery. It gave me very good confidence that I can do anything. I made new good friends and still we are sharing things. It gave me direction that how I can help my students and I decided to implement the same to my students. Initially I struggled a lot to implement the program in terms of timetable changes, faculty participation for extra work, separate resources etc. I took the whole responsibility to resolve all sorts of challenges and finally it worked out. This kind of exercise revealed my strengths to myself that I can Manage people, manage resources, do something useful to others (students, faculty &amp; college). I took the responsibility of (being a) NBA coordinator and submitted the application (for my college &amp; department of Computer Science &amp; Engineering). I also helped three other departments submit NBA applications. We got NBA accreditation with A grade for applied departments. I was ratified as professor from Affiliating University XY (affiliating university) and became head of the department (of Computer Science and Engineering). Now I can do better things for my faculty as well as students. That one-month program brought so many changes in my personal as well as my professional life. One more thing I cannot forget is: you made us to do some simple exercises ...very helpful for CSE people who work on computer always. Still I am doing them. Being a lady, balancing personal and professional responsibility is a very big challenge. You are the source of inspiration for many women employees and believe me, I (was) inspired a lot. Thank you so much ma’am for listening to my long story and thank you so much for all that you gave me.”</td>
<td>Teachers’ changes Enjoyed training and learned by doing Took ownership and worked to mastery High teacher efficacy, self-efficacy, empowered Community-building Toook ownership for students, decision to change behavior and instruction, overcome barriers, collective efficacy &amp; teamed for excellence, empowered to gather resources required Took complete ownership &amp; action to reach goal Able to see own strengths (reflection) and empowered after implementation cycle, improved attitude and beliefs Next empowerment cycle, took ownership, teamed for excellence – led NBA application for own and other departments (action) Experienced success, empowered for larger responsibilities Next empowerment cycle (larger goals, action, empowerment) High degree of empowerment for larger community goals Reflection (internal action) and recognition of changes in life - empowerment Took ownership for health and holistic living, took action (exercising), empowered Reflection, improved attitudes and beliefs, self-motivation and efficacy, empowered self and for larger community Took ownership &amp; communicated (doing) (sent email), empowered</td>
</tr>
</tbody>
</table>
The survey data and testimonials showed that the administration and management of colleges were engaged in supporting and empowering teachers to learn new pedagogies and practices, providing lab infrastructure and time in the academic calendar to attend a certificate course in IT, and supporting teachers with lower workloads so they could effectively apply the new methodology in their classrooms. The data also showed that management supported students in taking STEP/CIT training and empowered them to learn. The data included SGSG dashboards (Section 4.3, PIII, PVI).

The field notes and survey data showed that students were trained using an LBD pedagogy with formative and summative assessments, using rubrics, and they were mentored to complete the CIT, which enhanced their knowledge and skills, their ability to learn and their ability to problem-solve and adapt to new technologies (PIII). The data showed that students who completed the CIT training were successful in getting placements in industry and in higher studies, locally or abroad.

The data showed that EnhanceEdu, the change agent, created the content using LBD and developed a story-centered curriculum (Section 4.1, PI), mentoring more than 575 teachers from more than 70 partner colleges (Section 4.5, PVI, Appendix 1). These trained teachers enabled the training of several thousand students at their colleges, using the technology-enabled learning environment developed for CIT on Moodle (PVI).

The stakeholders were EnhanceEdu, management, teachers and students. The treatment given to each stakeholder group was different, as the individual group needs were different. Using Rogers’ theory of diffusion of innovations, short interventions (a half-day to a full-day program) were designed first to create awareness and remove any resistance to the program from each stakeholder group (Figure 5.7). These interventions served the purpose, and it was observed that there was motivation and full engagement with the actual program and content at each stakeholder group level.

However, there were nine iterations of TTPs, many iterations of student training in many colleges and many stakeholders from different colleges. It was hard to keep track of them individually and collectively along with the issues related to each, so this led up to the next research question.

5.3 RESEARCH QUESTION 3

**RQ3** was “What are the characteristics of a design-oriented research method that support the development process of new empowering educational interventions to improve information technology (IT) education? (PVII)”
The evolving story of EnhanceEdu was easy to share as a story (in Section 4.5). While this format worked, the concern was that the rigor of the DSR would be lost in the individual interventions as the story evolved. Also, as the design story was getting more and more complex, with more interventions and activities being introduced, there was a definite need to create some way of keeping this entire evolving story in a good representational form.

I then devised the idea of a frame that would be one intervention or part of the story that could be analyzed using DSR, as the problem at hand was still a wicked problem to deal with. The frame is represented in Figure 5.12. This is another way of representing the 3-cycle DSR by Hevner (2007), condensed and easy to use as a component in design story research (DeStoRe). The three corners of the frame represent the rigor (Ri) cycle, the relevance (Re) cycle and the design (D) cycle, including build-and-evaluate components. Now one could take each of the story's evolving threads and represent them using frames connected with one another in a sequence going from one to the next. This representation is now what is called DeStoRe. Here each frame is analyzed using DSR.

![Figure 5.12. A frame in design story research representing the 3-cycle Hevner model](image)

My concept for a design story comprises a series of design processes (which are called frames), each inspiring the next, to work towards a goal. A frame can operate independently or concurrently with others, as in a story. Arcs from one frame to another denote dependencies (see Figure 5.14). To develop the design story, an arc can be broken and a new frame inserted to depict a new intervention or design process. In a design story, new frames can be inserted into the next iteration of the instantiation, depicting new interventions.

**CIT Content Development Frame:** The content development process is shown as a design story frame (see Figure 5.12) in the EnhanceEdu design story. The frame is
expanded to Hevner’s 3-cycle DSR representation to analyze with rigor the design story frame (see Figure 5.13). The frame represents the building of the CIT course content, including the three courses, CT, Object-oriented Programming using Java and Data Structures. This was seen in detail in Section 4.1. Here I use DSR and De-StoRe to view and analyze the design story.

The **relevance cycle** show the requirements of a system with a set of IT courses that could be used by teachers and students to improve their domain-specific skills in IT in a hands-on manner. The course content also needed to serve learners of different levels of knowledge and colleges that were not well connected to the internet. The content needed to serve a large number of colleges spread over a wide geographical area.

The **rigor cycle** includes the foundational theories that ground the design. They include LBD (Dewey, 1938; Schank et al., 1999), Biggs’ (1996) constructive alignment and related rubrics (Biggs & Tang, 2010), the capability maturity model—CMM Level 5 continuous improvement process (Paulk, 1997) and the experience and expertise that I gained in building an SEI CMM Level 5 organization (*Research Rigor – Guideline 5*).

The **design cycle** includes the build-and-evaluate components, where the course content is built and evaluated, addressing the needs from the relevance cycle and informed by the theories in the rigor cycle. In the design cycle, a set of CIT courses were *built* in LBD on a portal with a learning management system, *evaluated* (*Design Evaluation – Guideline 3*) through batting practice by the EnhanceEdu team, emulating teachers and working through the content like real users and capturing time taken, issues in content, difficulties in solving problems and the like (Section 4.1, PVI). Further evaluation was conducted by an independent review team, following the principles of constructive alignment and rubrics, as well as during the TTP instantiation.

Each instantiation enabled the artifacts to become more robust, with continuous improvement applied (*Design as a Search Process – Guideline 6*). The artifacts built included IT courses using LBD, a portal with a learning management system and rubrics for evaluating each task in each module of each course, fed into the relevance cycle as part of *field testing*. Teachers could evaluate student submissions using the rubrics, and an EnhanceEdu coordinator at another location could monitor and calibrate*3 (PVI). These design artifacts were published (PI, PIII, PVI) (*Research Contributions – Guideline 4 and Communication of Research – Guideline 7*; see Content Development – Section 4.1 and PI).

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*3 Calibrate – An EnhanceEdu coordinator would track teachers at colleges during implementation and check whether the teachers’ grading of students’ tasks was being done correctly per the rubrics. If this calibration was off, the teachers would be approached and guided on grading per the rubrics.*
Design Story Itself as an Evolving Frame: The first design story had one frame, EnhanceEdu, and then developed three more frames, as per the research design process (Section 3.2), that is, content development, TTP and student training (CIT) (PI, PVII). However, based on the literature as well as experience, it was clear that these alone would not work, because having good e-content and training teachers did not imply automatic use or application (Heath, & Heath, 2010; Zemsky & Massy, 2004). The design story was expanded with more frames, as in Figure 5.14.

Past, present and future design processes can be represented as frames in the design story. The EnhanceEdu story weaves in design interventions for various groups of stakeholders to empower them (see EnhanceEdu stakeholder model in Figure 5.11). Thinking about what improves the employability of students helped conceptualize custom designs (artifacts) for each group (inspired as in Norman & Verganti, 2014; Treatments 1 & 2 in Table 5.1).

In Figure 5.14, in the EnhanceEdu frame, the team is built, its culture, tasks and goals are established, and content development, teacher training and student training goals are set. The content development frame in Figure 5.13 builds the IT course...
content (Section 4.1, PI). The principals’ meeting frame introduces the TTP, seeking management commitment and teacher nominations through the MoU and other artifacts, using Rogers’ theory of diffusion of innovation in the rigor cycle (Section 4.3, PVI). The TTP frame builds methods to train teachers, readying them for training students (Section 4.2, PI, PII). Students interested in the CIT course and its advantages sign up for it in the student orientation (Section 4.4, PIII). The CIT frame builds methods for teachers to conduct training for the signed-up students in their colleges, with formative and summative assessments (Section 4.4, PIII, PVI). Students completing the CIT course develop improved confidence and technical skills (PIII, PVI). Each frame in the design story analyzed using DSR results in building artifacts, such as methods and instantiations (meta-artifacts added into the knowledge base, as shown in Figure 5.13).

The DeStoRe is a sequence of frames connected to one another and evolving in time. The design story could also evolve in learning. As continuous feedback is included as part of the system, there are feedback loops going from each frame to each previous frame. What does this mean in terms of a process or story? This feedback goes back to improve the “meta-story” that, when instantiated another time, will now have the feedback rolled in and considered in some way. For example, feedback from teacher training program 2 (TTP2) would result in improved content for teacher training program 3 (TTP3), an improved TTP process and an improved principals’ meeting. So each frame could potentially improve, based on the feedback, and be like a “meta-frame” from which a new derivation or instantiation could be derived. This
model also enables contextualizing for another situation, where further frames could be added into the story as needed. If the same model holds good, then similar design processes and artifacts may be used directly to enhance information technology education.

The instantiation of a part of the EnhanceEdu design story is shown in Figure 5.15. The design story of work done is viewed, addressing the larger theme of graduating engineer employability over multiple iterations. The far right in Figure 5.15 shows CIT being conducted for students by trained teachers in their colleges. Each of these instantiations provides feedback to the preceding frames of content development, teacher training etc., which then consider these as new business needs from the relevance cycle and improve the design of the artifacts. The question arises of how a historically earlier frame can learn from feedback. The feedback goes to enhance the frames (the particular design process or intervention) in the generic model (meta-story) of EnhanceEdu, which then can be instantiated with the new learnings in the next iteration.

Each iteration is shown with an incremental number, and each instantiation within the iteration is shown with that number, for example, principals’ meeting 2, TTP2. Each faculty member from, say, the TTP2 instantiation came from multiple colleges, C1…Cn, and thus, potentially, student orientations and CIT student training were instantiated in colleges C1 to Cn. Our problem-solving approach uses design, Design as a Search Process (Guideline 6), design of the many artifacts and a sequence of design processes to engage various stakeholders to gain their commitment and support for the interventions to be introduced and used.

The DeStoRe is also working on a wicked problem, where each of its frames is also being worked on by DSR, as the individual frame works on some dimension(s) of the wicked problem. Now the entire story can be viewed with respect to a theory, theme or perspective.

For example, the design story of EnhanceEdu can be viewed from the perspectives of Rogers’ theory of innovations, LBD etc. These two examples of DeStoRe follow.
Learning by Doing Perspective of the Design Story: The design story can also be viewed from the perspective of a single theory. In this case, the design story is viewed from the LBD perspective, this being one of the theories used to inform the design of the CIT course content. LBD ripples through all the frames of the instantiated story (Figure 5.15), with implications for each frame and for each stakeholder group. The LBD perspective is carried through the design story, with each stakeholder understanding and supporting the new methodology. Teachers learn by doing in the TTP, and they begin behavior modifications to demonstrate commitment by conducting a student orientation for students in their own colleges and conducting the STEP/CIT programs for interested students. This perspective is visible and important even in the last frame of CIT student training, where the students learn by doing the tasks in the content, and the trained teachers act as mentors (PIII, PVI). EnhanceEdu created many artifacts, such as scaffolding for course content, dashboards to monitor implementations, early correction processes (PI, PIII, PVI) and the CS and electronics and communication engineering (ECE) courses built using the Butterfly model (PV; Karri & Kode, 2011).
The EnhanceEdu Story from Rogers’ Theory of Diffusion of Innovations Perspective – a Design Story Research Use Case: Innovation, for the purpose of this research, is the use of a known technique/intervention in a new context (Rogers, 2003). Rogers’ theory of diffusion of innovations informs the EnhanceEdu design story for various stakeholders. The innovation is learner-centered, doing LBD tasks in the courses of CT, Java and Data Structures, on a learning management system (Moodle), with rubrics to evaluate the formative submissions. Teachers were used to teacher-centric, lecture-based classrooms and systems, so trying to implement a classroom that moved from teacher-centric to learner-centric was calling for a huge change. This change needed to be managed and communicated in such a way that the stakeholders both understood and appreciated the change and the need for change and would try to adopt the innovation.

![Figure 5.16. Design story research frame of EnhanceEdu design story](image)

The theory of diffusion of innovations (Figure 5.16) informs the rigor cycle. The relevance cycle includes the environment—the stakeholders—students, teachers, management and EnhanceEdu, the research group. In this theory, there are five steps of the innovation decision process. The first three are the knowledge, persuasion and decision stages of committing to try or not. The next two steps are implementation and confirmation (adoption or rejection).

Taking the design story stakeholder set from the relevance cycle of the problem at hand, the needs of these stakeholders were to be considered and the proposed changes introduced.

The context is India, and the culture is very different than in the west, particularly when the culture in academia in Tier 2 and Tier 3 institutes is examined. The culture plays an important role in the design and use of any intervention (Kamppuri et al., 2006). The teacher has very little control over the syllabus of the subject that is being taught and very little academic freedom; he or she is guided and supported by management (Altbach, 2003). The management, especially in the private engineering
colleges, many of which were set up as for-profit institutes, has a great deal of say. Given this context, EnhanceEdu design story begins first by approaching the management of the colleges, even though its intent is to train teachers.

Figure 5.17a shows the feedback loops from each frame to the previous frames, as inputs for continuous improvement. In Figure 5.17b, the design story of EnhanceEdu opened up with a sequence of design interventions without the feedback loops, which are simply assumed. The IT content was developed using LBD, but now, to introduce its use in colleges, appropriate steps were needed to be taken to diffuse this innovation.

For management, a principals’ meeting was organized, where the benefits of the new pedagogy and content with its LBD activities in the IT courses were presented. The benefits of TTP for the principals were explained along with the information that their up-front investment would be low, as their teachers would be trained at no cost to them. However, they would need to commit to implementation by signing the MoU. The principals’ meeting served the purpose of the first three steps in the theory, knowledge, persuasion and decision (to go forward or not). The student employability was expected to improve. Once the management understood this opportunity to
train their teachers and then their students, for almost no cost up-front, several enterprising principals were interested.

EnhanceEdu followed up with the management who had given their EoI to get confirmations to participate. Those that decided to go forward entered the partner college process and then completed the partner MoU and agreements. The last two steps, of agreeing to implement and adopt, were then complete for management.

There were several principals who were leaders and a few who were new to their role and were enterprising, fitting the bill of innovators in the S curve (Rogers, 1995). They had come to the meeting ready to sign the EoI and MoU. This prompted others (early adopters) to jump aboard in the second instantiation of the principals’ meeting. The artifacts built in this frame of the design story, of the principals’ meeting, included the MoU, the EoI, a brochure, models of engagement artifact and our website. Other artifacts included mail templates, follow-up Excel worksheets for confirmations, follow-up tracking of EoIs and MoUs, lists of nominations of five teachers for the TTP and signed acceptance of support for lab and computer resources for student training in their colleges.

In subsequent years, one could see this innovation follow the S curve (Figure 5.18), with early majority, late majority and laggards. In some sense, although this followed the S curve, one can say that in the limited time that this program was funded (six years), even the laggards could be considered innovators, as they were among the fewer than one hundred colleges that were ready to adopt this innovation among the several hundreds of colleges in the regional context of the study in India.

The TPO served as a vehicle to prepare and motivate teachers for the TTP. This was an opportunity for teachers to clear their doubts and understand what they would be doing for two months during their summer training program. They then made the decision whether or not they would attend the TTP. If one college teacher could not attend for whatever reason, the principal would nominate another teacher from the college. The decision to participate was made jointly with management when the teachers agreed to be nominated, but the TPO event also made it possible for teachers to make their own decision by overcoming their inhibitions or doubts. This is a subtle difference, but our experience has shown us that it makes a lot of difference in the teachers’ approach to learning. In effect, the first three steps of knowledge, persuasion and decision are complete for teachers before they begin the TTP. Teachers can then come with a relatively open mind to learn during the TTP.

The TTP of eight weeks’ duration prepared the teachers with not only the technical and communication skills but also with an implementation plan for their colleges. As the teachers prepared this plan (Pl, PVI), it increased their clarity and confidence in implementing the CIT program in their colleges, further motivating them. By the end of the TTP, they were empowered and ready for implementation and adoption.
At the end of the TTP, a graduation event, called Open Day was held, where the management were guests, with a guest from industry and/or NASSCOM to discuss the importance of this new innovation and training. At this event, the graduating teachers spoke of their experiences during the TTP and about their new learning, receiving the L-Board certificate of completion of TTP, read as an L-Board (akin to a driver’s learner’s permit). This certificate would go to those teachers who had attempted and completed both the formative and summative assessments and who were graded at a mastery or reaching mastery level. The L-Board bestowed eligibility upon the teachers to offer the training to students in their own colleges.

Their final teacher training certificate was the mentor certificate, as they would need to change their behavior to mentoring students as opposed to lecturing; this was linked to performance. When teachers completed implementation of training for at least one cohort of students in the CIT, they would be eligible for this certificate.

Similarly, when teachers returned to their colleges, they organized orientation meetings for students, supported by their management, senior faculty and EnhanceEdu. Interested students were invited to sign up for the CIT (PI, PIII). Here too, the knowledge, persuasion and decision stages were completed before their training program started. Teachers led the process of student orientation at their colleges. After the student orientation, teachers recruited interested students, made time in the academic calendar for the slots in the computer labs, using one of the implementation models and adopted the innovation.

The principals’ meeting, the TPO and the student orientations at each of the partnering colleges, which each took less than a day, were the communication channels

Figure 5.18. S curve of the number of faculty signing up at the nine different TTPs
for the knowledge, persuasion and decision steps in the process with the three major stakeholder groups. These events (artifacts) went a long way towards smoothing the path for implementation and confirmation (adoption or rejection).

EnhanceEdu would handhold the last two stages of implementation and adoption at the various colleges to keep the experience smooth, with the help of phone calls, emails, college visits, forum discussion, mentoring and newsletters. The structure at EnhanceEdu, post-training, was set up so there would be an EnhanceEdu coordinator for each college who would be the college’s single-point contact for any questions or issues. The policy was that EnhanceEdu would respond with solutions within a day, and every coordinator had a backup. The dashboard artifact SGSG (PIII, PVI) helped to see whether the implementation was going according to plan, and necessary ongoing support was provided.

For various stakeholders, the path was cleared through Rogers’ diffusion of innovations lens to enable implementation to take place. The artifacts created in various frames in the design story are described in our publications (PI, PII, PIII, PIV).

Through the EnhanceEdu design story, the design and implementation of an effective TTP, was successfully demonstrated, training 575 teachers in over 70 partner engineering colleges in the states of Telangana and Andhra Pradesh in India, in the CIT program, in LBD mode, working towards mastery and imbibing the culture of taking ownership and teaming for excellence (PVI). The EnhanceEdu initiative successfully managed to actively engage the management and administration of the partner colleges to empower the trained teachers to effect change in their behavior and to mentor students in the CIT training program, in LBD mode, in their own colleges.

As the design story of EnhanceEdu is a very complex one with many threads and stakeholders, with multiple branches and feedback loops and with teacher training and student training programs starting and completing at various times, it was hard to share the story and explain the multi-level design, processes from multiple perspectives and with multiple foci. Thus, I devised the idea of DeStoRe. The result is the development of a DeStoRe description based on DSR; it is a rigorous framework that affords the ability to design, build and view a story with many threads and analyze it from multiple perspectives and with multiple foci. In the case of EnhanceEdu, DeStoRe allows us to step back and see the systems view, with all the partner colleges and programs at various stages. It then allows us to step closer to see the on-ground view at a college, with the management (as a frame) or in a classroom with students and mentors, or step even closer to observe the reflections of a student or teacher as they record their experience as feedback in the CIT portal or share it with their mentors.
6 DISCUSSION

This section brings the key results to the fore and reviews them in light of the literature.

6.1 TEACHER PROFESSIONAL DEVELOPMENT

An effective design of a TTP (Desimone, 2009) is one that trains teachers using the same methodology and tools that they will in turn use to teach their students, including the following:

- learning by doing (active learning);
- using appropriate content focus (domain technical skills and soft skills);
- encouraging collective participation (five teachers from each college participated in the TTP);
- synergizing the goal of improving student learning for all stakeholders (coherence);
- running the training for a sustained duration of at least four weeks (meets duration criteria of greater than 30 contact hours) and going to a semester or academic year including implementation for students.

Research reveals consensus on the five core features present in an effective TPD program. If these core features are present in a TTP, there is a great likelihood of observing teacher change and resultant student learning (Desimone, 2002; Garet et al., 2001; Hawley & Valli, 1999; Kennedy, 1998; Wilson & Berne, 1999).

Based on the teacher professional development EnhanceEdu conducted, the TTP designed and used included the five core elements suggested by a consensus in effective professional development; it also included teacher perspectives through intra- and post-training feedback. The team measured knowledge and skills improvement during and after training, through formative and summative assessments, and observed an increase in skills (PI, PII) as well as increased self-confidence, efficacy and empowerment (PI, PII, PVI). And when student training is completed and these trained teachers mentor them, and when the students are similarly evaluated using formative and summative means, their own confidence, knowledge and skills grow, and their beliefs and attitudes undergo a change (PIII, PIV).

We will look at two models, one by Desimone (2009), and another by Guskey (2002), and will reflect on our TTP in light of these models in relationship to the theory of teacher change and the theory of instruction. Desimone (2009) published the path model shown in Figure 6.1, containing core features of effective professional development by consensus, showing how knowledge and skills and/or attitudes and
beliefs change subsequent to the professional development (teacher change). Changes in attitudes and beliefs bring on a change in instruction, which leads to improved student learning.

Guskey (2002) maintains that professional development and teacher change happen differently (see Figure 6.2) and that teachers, especially experienced teachers, wait to implement the change in instruction. It is after improved student learning that the teachers experience a change in attitudes and beliefs rather than right after professional development.

Figure 6.1. Path model for teacher change (adapted from Desimone, 2009)

Figure 6.2. A model of teacher change (adapted from Guskey, 2002)
The new EnhanceEdu model of teacher change, as shown in Figure 6.3, incorporates both Desimone’s path model (2009), and Guskey’s (2002) model of teacher change. This is seen through teacher improvements in knowledge and skills as well as in attitudes and beliefs. Once after teacher professional development as indicated in Desimone’s path model (2009), and again after student learning improvement as suggested by Guskey (2002). And along with a change in teacher classroom practices, a definite change in student learning was found, as measured by surveys and formative and summative assessments.

Matusovich, Streveler and Miller (2009) and Deci and Ryan (2000) say that faculty motivation is the foundation for transformational change. Efforts were made to ensure that the faculty were motivated before starting the training. During the first week of orientation, content on human values, relatedness and culture helped in establishing that EnhanceEdu cared and that teachers, no matter where they came from, were important and respected as individuals, regardless of what they did or did not know. Faculty motivation is not only desired but is also needed in the Indian context, where teachers do not consider their work as a vocation but as a job (i.e., a means just to earn a livelihood without a passion for the work). A motivation to be teachers and then to teach in order to change students’ learning was a critical element. Work done on faculty motivation and relatedness laid the foundation for faculty conceptions to change. The research group worked on collective self-efficacy (teaming for excellence), motivation, a positive and growth mindset (Bandura, 1997; Deci & Ryan, 2000; Dweck, 2008) and culture-building, to lay the ground upon which change could take place.
Whitworth and Chiu (2015) observed that effective change to teaching practices can occur when leadership support is provided. However, in the EnhanceEdu initiative, I observed that leadership in the form of management plays a far more critical role (Chapters 4 & 5). Figure 6.4 shows the EnhanceEdu view of management, which has an end-to-end function, from signing the MoU to identifying and nominating teachers for the training and then supporting them through training, helping them plan for implementation of student training and providing resources in the form of computer labs. Management also functions to enable and empower teachers to offer the changed instruction in the form of LBD in the CIT program, supporting teachers through a reduced workload so they can work on this new additional class. The recognition of the importance and role of management in the success of teacher professional development is a key contribution of this research.

6.2 DISCOVERING A MODEL FOR EMPOWERMENT

Owen (1997) discusses how the design disciplines have a long history of building their knowledge bases through making, that is, through the construction (creation) of artifacts and the evaluation of the artifacts’ performance followed by reflection and abstraction. He also shows that for various subjects from math, physics and chemistry to product design, the model shown in Figure 6.5 is useful in generating
and accumulating knowledge. He shows the process as a cycle in which knowledge is used creatively to do (tasks), and the work is evaluated to build knowledge.

![Figure 6.5. A general model for generating and accumulating knowledge (adapted from Owen, 1997)](image)

Thus, in IT, which is a design discipline in the realm of practice, using knowledge and doing tasks and reflecting on criteria increases the inherent knowledge base in the discipline over time.

Based on deeper reflection on Owen’s knowledge-using and -building model, I can relate to the actions of both teachers and students who have gone through the CIT training programs. During the TTP, teachers were mentored and guided through the process of using knowledge and doing tasks, and this helped build their confidence and knowledge. Without mentoring, many teachers would have dropped out of the course. The mentors encouraged the teachers to take ownership of the tasks and complete them. The teachers did work on and complete the tasks, resulting in building knowledge and also in building their confidence (as shared with mentors in daily and weekly interactions, field notes and surveys) and self-efficacy, thus becoming empowered. Initially, the mentor guides the learner to “do” LBD and build knowledge, and the learner goes through multiple cycles of this process, module-by-module, in a course (Figure 6.6).
Thus, when presented with knowledge and principles, and when mentored, if one takes action (doing), then one can build knowledge of the discipline. The culture-building that EnhanceEdu is overtly doing (rather than embedding it in cognitive learning), that is, helping learners take ownership, starts to play a role in their becoming more self-motivated. As a result of increased confidence, increased self-efficacy and the learner’s own feeling of being in control, he or she feels more empowered and becomes a candidate for self-regulated learning. This is represented in Figure 6.7.
Figure 6.7. Process for doing and building knowledge with ownership and empowerment; Knowledge – Ownership – Doing – Empowerment (KODE) model

The figure shows the model of empowerment, as deduced from teachers’ learning and from the observation of teachers and students as they went through the TTP and STEP programs. Their success stories constitute the Knowledge-Ownership-Doing-Empowerment cycles (K-O-D-E), or the KODE model of empowerment.

Figure 6.8. KODE model for empowerment and knowledge-building with mentoring (colored) and without mentoring (not colored)
I arrived at this model based on the research observations, mentor notes, field notes, meetings with mentees and formative and summative assessments. The KODE model can be further visualized as a growing spiral (Figure 6.8), with mentoring support for several cycles (pink colored inner spiral), until the individual is ready to break out of the mentoring loop by becoming empowered to drive his/her own knowledge-building.

This model was created (Design as an Artifact - Guideline 1) by using Design as a Search Process (Guideline 6 of the DSR guidelines; Hevner et al., 2004). The non-colored spiral area shows how the individual steps up on their own to take on more responsibility and ownership, becoming more empowered. The mentoring support required to achieve self-powered empowerment varies by individual.

6.3 BENEFITS AND APPLICATION OF DESIGN STORY RESEARCH

In this section, DeStoRe benefits are reviewed and a few applications in the real world are included.

6.3.1 Benefits and application of design story research

There are many benefits to using DeStoRe, as listed below. A few examples and applications of DeStoRe are examined.

The ability to take a design story and frame each of its interventions, design processes, instantiations etc. using DSR: This was shown in the Results chapter, where DeStoRe was explicated, in the example of building a design story for EnhanceEdu.

Framing the past, present and/or future work of an entity for tracking and improvement: This was seen as an example of EnhanceEdu, in a partial instantiation, where past work, present work and future work could be mapped. This allowed for a view of past TTPs, Open Days, CITs etc., and it also allowed me to envision the future, with TTPs evolving in time and with respect to learning. I also was able to devise a few what-if threads (or paths) and evaluate scientific work (Venable, Pries-Heje, & Baskerville, 2016) using the DSR thread, through simulation, mathematical formulation or some other artificial means. Of course, past and present work can be evaluated both scientifically and naturallyistically (in the real environment with real people and real circumstances). Venable et al. (2016), have proposed a model for evaluating DSR along two dimensions, using four strategies.
Tracing the productivity and effectiveness of organizations: This was shown through the example of EnhanceEdu working on content development and TTP through multiple iterations and continuous improvement (Chapter 4).

As a strategic planning tool: Planning strategy over a period of a few years is like building the future story of an organization. This maps well into DeStoRe, as one can have frames in the story calling for a solution to a problem or meeting a goal, viewed through a DSR lens.

This effort can be viewed as an extension of the ideas in framing the past, present and future, where one plans the future of an organization and does what-if evaluations to finalize what will be the appropriate future story of the organization. Each of these what-if threads works to allow future realization of the goal/goals set by the organization. The DeStoRe can map the evolution of the design story in time and also show an evolution in learning. The latter is similar to the way in which I showed a partial instantiation of the EnhanceEdu story.

Work partitioning among teams (having clear artifacts as outputs of one instantiation, feeding back to the knowledge base informing another intervention): This is a more straightforward application of DeStoRe, starting to diverge into several paths for the design of several artifacts, with several realizable goals, evaluated in a scientific or a naturalistic manner, depending on the task/goal. After the artifacts have been proven to add utility, efficiency and effectiveness, they may be considered for addition back into the knowledge base.

Seeing possibilities for radical innovation: The design story offers a unique perspective to an expert with rich experience, even without an explicit relevance cycle or explicit user needs. He/she can find opportunities for new models, constructs etc. for an as-yet unnamed need—opportunities for radical innovation. I used the sense making and technology ideas for radical innovations (Norman & Verganti, 2014).

Several new empowering innovations emerged when the systems view and the EnhanceEdu design story intersected, as shown in Figure 6.9. These innovations included the Butterfly model, AoT and Wikiday workshops (PV; PVI; Kode & Karri, 2012; Kode, Nagaraju, Gollapudi, & Reddy, 2013), shown in the figure as frames starting their own threads as new design stories.
The benefit is seeing possibilities for radical innovation. The systems view in this figure includes many disciplines. It was for the CS/IT discipline that the design story was built, including content development, TTP and student training (CIT). The Butterfly model (PV; Karri & Kode, 2011) is the design story of a new instructional design model. With this model, design stories can be produced for other disciplines similar to those produced for CS/IT in the EnhanceEdu design story.

Another empowering innovation is the design story of AoT, for teachers of humanities, arts, sciences or engineering (PVI; Kode et al., 2013). The art of teaching included change management, active learning methods, Bloom’s taxonomy, lesson plan design, learning how to develop a wiki and presenting to the class. Teachers were able to reflect and gain knowledge about how to bring change into their own teaching, so they felt more comfortable introducing change. A few hundred teachers have benefited from the three-day AoT workshop (PVI; Kode et al., 2013).

### 6.3.2 Process for application of design story research to other cases

One can tell a design story using DeStoRe with a rigor that comes from grounding the design story in theory. As an example, if one were to apply a change management theory to their design story, how could one use DeStoRe to “tell” the design story? This would be an example of the first benefit listed in the Benefits section (6.3.1).
The following are the process steps:
1. Identify the various stakeholder groups in the design story. (This comes from the environment or the relevance cycle.)
2. Identify a change management theory that would be used for this design story. (This comes from the knowledge base or rigor cycle.)
3. Compile a set of resistances to change, barriers to change or concerns about the change separately for each stakeholder group.
4. Create an event (in DeStoRe, create a frame) to address each of the stakeholder groups with solutions for the concerns, with the goal of applying change management principles/ steps from the change management theory selected in Step 2. Each of these events would be considered a frame and would be analyzed using the 3-cycle Hevner DSR process.
5. Connect the frames to form a thread of the design story.
6. Add other process frames for creating any design artifacts/adding interventions by connecting the frames in the appropriate flow. Ensure that the resistance-reducing frames come before the other artifacts/interventions.
7. “Tell” the design story using the change management theory from the knowledge base, applying the principles of the change management theory.

6.4 FACILITATING CHANGE IN INFORMATION TECHNOLOGY EDUCATION

The first treatment for the stakeholder groups was to reduce any resistance to the program and showcase its benefits, so there would be both buy-in and motivation to participate. EnhanceEdu did this through the introduction of the TPO and the student orientation as well as the principals’ meeting and Open Day for management. Rogers’ theory of diffusion of innovation principles was used, as seen in the Key Results chapter.

As seen in the Review of Literature chapter, the four categories of change strategies (Borrego & Henderson, 2014) apply to both individuals and organizations (environments and structures); see Figure 2.6, redrawn as Figure 6.10.

6.4.1 Four categories of change strategies

Here I reflect on our TTP and student training programs and processes in information technology education from the perspective of the four categories of change strategies.
My approach to viewing the problem both from a systems perspective and from an individual or group perspective helped me in devising several strategies to support change at multiple levels. This system view of the problem and the approaches for addressing the parts of the problem helped EnhanceEdu tightly integrate our story and interventions. I saw research spanning multiple categories as an important direction for future research, in accordance with Borrego and Henderson (2014). When viewed using the four-categories lens, EnhanceEdu work spans multiple change strategies and multiple perspectives and categories. The strategies adopted in each of the categories were as follows (Figure 6.11).

Category I. Prescribed/individual.
In this category, the change strategies of implementation and diffusion are suggested. EnhanceEdu used the implementation of teacher training on curriculum and pedagogy in the TTP for faculty as our change strategy for this category. The change agent (the EnhanceEdu training team and mentors) helped the faculty learn the new
teaching conceptions and practices, learning the IT and other content, through LBD. EnhanceEdu solution aligns as a best practice developed and evaluated in line with Fixsen et al., 2005.

Figure 6.11. EnhanceEdu training programs mapped to the four categories of change strategies. (adapted from Borrego & Henderson, 2014)

Diffusion is another strategy within the same category. As these trained teachers carried this information back to their colleges and other social groups, their own personal enthusiasm and confidence in this new program and these practices spread to other teachers, who then signed up for subsequent training programs. This message spread by word of mouth and helped attract more teachers from their own and other colleges to the next TTPs. The diffusion strategy helped through more teachers signing up for later sessions of teacher training.

Category II. Individual/emergent - Developing reflective teachers.
By design, the TTP had rubrics for faculty self-evaluation and reflection and for when mentors gave feedback on their daily tasks. Thus, the teachers would have an opportunity for praxis and reflection to help improve their practice when in the training
program itself. The faculty that participated in a single course of training was grouped together as a community. They not only reached out to EnhanceEdu for help and support but also to one another as part of the faculty learning community. The change strategy in this case is developing reflecting teachers using faculty learning communities. Further, when they were back in their own institutions, and when they were supporting students in learning and were mentoring them, they worked to improve their practice on a daily basis through further reflection. Thus, many faculty cohorts who went through TTP became part of a larger faculty learning community.

Category III. Environments/prescribed - Enacting policy.
Here the goal or the prescribed outcome was very clear—to offer the CIT as an enrichment course to the students. This was an implementation strategy at the organizational level, where new environmental features encouraged new teaching concepts and practices, with the support of management and administration. Implementation was chosen as a change strategy in this category. Here the view by Fixsen et al. (2005) on implementation is valid for EnhanceEdu and for the stakeholders, who were held accountable through reporting and visits and observing through Moodle, as seen in Chapter 4 and in PIII and PVI. Fixsen et al. (2005) posit that what is needed is an “implementation perspective on innovation—an approach that views post-adoption events as crucial and focuses on the actions of those who convert it into practice as the key to success or failure.”

Category IV. Environment/emergent – Developing shared vision.
Here the clear example is that of EnhanceEdu, the research team itself. EnhanceEdu was first created with certain goals and a culture. The team members imbibed the ideas of taking ownership of its goals, of continuous improvement, of teaming for excellence and of a growth mindset; they did this so well that they empowered themselves to create new principles and operate in a way that worked towards the shared vision and goals of EnhanceEdu, in the spirit of a learning organization.

EnhanceEdu took the systems perspective for our problem and worked with several important stakeholder groups to see how student learning would improve. The authors of the four categories of change strategies model (Henderson et al., 2011), state that “it is sensible to assume that employing multiple perspectives on change will lead to better results, but the fact remains that there is little empirical evidence or theory-based rationale to support or refine this assertion.”

EnhanceEdu’s work spanned the four categories of change strategies. Also, multiple strategies of change within each category were considered. It was seen (with empirical evidence presented in the Results chapter) that a successful change in teacher instruction (from teacher-centric to learner-centric approaches), leads to
student learning improvement (through LBD, success in formative and summative tests, mastery learning [Bloom, 1968] and the obtaining of certification in IT).

Through this research, I claim that one of the key factors for facilitating change was employing multiple perspectives and strategies for change, engaging multiple stakeholder groups and keeping them all engaged and empowered, an approach that led to better results. I hope that this work has helped move forward the research on facilitating change in IT educational contexts by using multiple categories of change strategies.

6.5 POSITIONING THIS RESEARCH IN AN INNOVATION FRAMEWORK

Several artifacts have resulted from this research. These can be framed in the innovation quadrants per Norman and Verganti (2014) first seen in Section 2.4. The two axes are “meaning” (x-axis), or the sense making of the design, and “technology” (y-axis). Norman and Verganti (2014) argue that radical innovation is not always driven by technology but that in many cases, it is driven by meaning change. Based on my observations, several interventions/artifacts of this study have been classified in the four different quadrants (each of the four types of innovations), based on meaning and technology change (Figure 6.12).

The market-pull innovation quadrant is led by a need felt by the market. In this case, there was a need for soft skills training, and this need was met. This involved incremental change in both meaning and technology. In the technology-push innovation quadrant, with a smaller change in meaning and a higher use of technology, the Wikiday workshops and the CIT training programs for students are the examples. They were both radical innovations, using technology change.

In the meaning-driven innovation quadrant, I have DeStoRe, Art of Teaching (AoT), and the KODE model for empowerment. It is interesting to note that each of these artifacts have usefulness beyond information technology education. They have been used in and have applicability in other streams of higher education.

In each of the four innovation quadrants, there are artifacts which are also applicable to other streams of higher education. These include Wikiday, soft skills training and Butterfly model, in addition to DeStoRe, AoT and KODE model of empowerment, noted earlier.
The TTP designed by EnhanceEdu is situated in the technology epiphanies quadrant (Figure 6.12). Knowing that the TTP design would meet with challenges in its introduction, the EnhanceEdu team preempted them by a special design allowing us first to engage with management and gain their support. The EnhanceEdu TTP was very different from other teacher training programs in that the emphasis was placed on engaging and empowering the management to empower the teachers. The radical meaning shift was created when teachers felt empowered after the TTP to go back to their colleges and implement the program for students. In terms of technology use, this involved using existing technologies in new regional and rural contexts where there was limited and unreliable internet availability and where the technology was new to the users. Technology adaptation was conducted to provide a complete online platform for multiple levels of users, meeting the context requirements of synchronous and asynchronous use (PVI).
7 CONCLUSION AND FUTURE WORK

This thesis is a reflective presentation of the design and implementation of an intervention called EnhanceEdu created to address the problem of low learning outcomes for the newly graduated information technology engineers in India. Instead of implementing student-training programs that would need to be repeated every year, EnhanceEdu focused on training teachers as it would be more sustainable. The focus of EnhanceEdu was a set of teachers in over 70 engineering colleges in states of Andhra Pradesh and Telangana in South India where the number of engineering colleges grew from under 10 to over 500 from 1978 to 2008. EnhanceEdu implemented interventions in these colleges from 2008 to 2017, and trained over 500 teachers, who in turn trained over 6000 students.

7.1 RETROSPECTION AND LESSONS LEARNED

As I reflected on the EnhanceEdu design story in this dissertation, I can conclude that with appropriate involvement of all stakeholders namely management, college owners, teachers, students and a focused organization like EnhanceEdu, it is possible to achieve tangible results in a defined time-period (PI, PII, PVI). Further, any of these interventions in the design story, be it TTP for teachers, CIT for students or AoT, needs to be done in an iterative way for desired results (PIII, PVI).

7.1.1 Reflecting on research questions and design science research

The problem of low quality of teaching and low quality of learning by students, helped me frame three research questions RQ1-RQ3, repeated here to help conduct contextual evaluations of the RQs - RQ1 (How do we design a teacher training program to be effective in enhancing information technology (IT) education in engineering colleges in the Indian context?), RQ2 (Who are the stakeholders, and what kinds of interventions are needed for each of the stakeholders to enhance information technology (IT) education in the Indian context?), and RQ3 (What are the characteristics of a design-oriented research method that support the development process of new empowering educational interventions to enhance information technology (IT) education?).

RQ1 was investigated through reflection on the design and development of a TTP that enables teachers to learn through LBD, improving their knowledge and skills, and attitudes and beliefs (PI, PII). Teacher training was complete only when the teachers taught at least one cohort of students which is when they received a teacher training certificate (PI, PVI, section 4.2). The teachers adapted comfortably to LBD
and their competency levels increased (PI, PII). Further, the reflection of RQ1 with respect to literature yielded a model, EnhanceEdu model of teacher change, shown in Figure 6.3, which is an improvement on the ‘Path model of teacher change’ by Desimone (2009) and also ‘a model for teacher change’ by Guskey (2002).

Answering RQ1 leads us to the next question, RQ2, that of the stakeholders stated earlier and how they should be treated to support the improvement of IT education in the Indian context. The first treatment for the stakeholder groups was to reduce any resistance to the program and showcase its benefits, so there would be both buy-in and motivation to participate. This was done with the introduction of the Teacher Pre-Orientation (TPO), the student orientation, and principals’ meetings and Open Day for management (PIII). As there were many challenges in implementing the training for students in the colleges, the treatment for each stakeholder group was fine-tuned to the group, as the individual group needs were different (Table 5.1).

After EnhanceEdu interventions, more colleges were motivated to participate in discussion forums and build a social community (PIV, section 5.1). In this thesis, I reflected on these interventions and came up with a model for the EnhanceEdu stakeholders and interactions (Figure 5.11). The stakeholders took ownership and completed tasks and supported other stakeholders, becoming more empowered (PVI, section 5.2). Reflecting on this and knowledge-using and -building processes of Owen (1997), led to discovering the KODE model of empowerment (section 6.2).

RQ3 was framed because the design story of EnhanceEdu is a very complex one with many threads and stakeholders, with multiple branches and feedback loops and with teacher training and student training programs starting and completing at various times, it was a challenge to share the story and explain the multi-level design, processes from multiple perspectives and with multiple foci. Thus, I devised the idea of DeStoRe (PVII). DeStoRe is based on DSR (Figure 5.17) and is a rigorous framework that affords the ability to design, build and view a story with many threads and analyze it from multiple perspectives and with multiple foci. In the case of EnhanceEdu, DeStoRe allowed us to step back and see the systems view, with all the partner colleges and programs at various stages. It then allowed me to step closer to see the on-ground view at a college, with the management (as a frame) or in a classroom with students and mentors, or step even closer to observe the reflections of a student or teacher as they record their experience as feedback in the CIT portal or share it with their mentors. Past, present and future design processes can be represented as frames in the design story. DeStoRe allows one to move from a generic model in the research design and proceed to instantiations with multiple cycles of the design story, with iterative improvement (section 5.3).

DeStoRe was created for the purpose of explaining my research and the journey of EnhanceEdu. The biggest advantage of DeStoRe is its rigor. It demonstrates many benefits that can be used to solve a large set of problems, as shared in the benefits of
DeStoRe (PVII, section 6.3). DeStoRe offers possibilities for radical innovations (Figure 6.9) like Butterfly model (PV) and AoT. These and other artifacts generated through nine iterations of the EnhanceEdu design story, reflected in Norman and Verganti’s (2014) innovation framework are further evidence of innovations resulting from DeStoRe. (Figure 6.12, section 6.5).

Reflecting on the use of DSR as a lens for this retrospection served as a very good tool for framing the work using the 3-cycle Hevner model, and helped ascertain rigor, relevance and design cycles for the various interventions. In theory, DSR is defined for design of information systems. If I had limited DSR as a lens for purely information systems development, then it would not have worked as well as a tool for reflection, and we would have used it in a very limited way for this dissertation. Given that all interventions regardless of the intervention being an information systems development or not, were framed using DSR, I had the opportunity of investigating the full rigor needed for the particular intervention. Had DSR been available when EnhanceEdu was working on the interventions, it would have allowed a more systematic process of following the relevance, rigor and design cycles for even less experienced team members. I observed that continuous improvement was utilized as we worked on making fast iterations. This did not come from theory but from my own experience as founder director of Motorola Software Center in Hyderabad. As the design cycle is quite clear about the build and evaluate processes and the fast iteration required to improve on the design, EnhanceEdu would have specifically looked for theories and tools for rigor in iteration and potentially found suitable methodologies if they were using DSR toolkit in planning.

As seen in the DSR introduction in Chapter 3, DSR is applied to wicked problems to arrive at pragmatic solutions. DSR is a very useful and viable tool for other researchers interested in using it as a lens for planning, implementation or reflection. When one is looking to explore answers, the relevant criteria must be in place (relevance cycle). DSR with its 3-cycle Hevner model is a very powerful process for planning and execution. Along with the seven guidelines for checking if DSR is appropriately followed, it becomes even more powerful. This enables a clear-cut process for team members to follow to achieve the necessary rigor for developing, testing, disseminating a DSR artifact. As long as the problem being addressed is a wicked problem, DSR will serve well. When applying DSR, challenges can potentially arise if there are unknowns, especially in the relevance cycle. I also advise other researchers to leverage DeStoRe (Design Story Research) to enable them to overcome the kind of challenges that I faced in describing, planning, implementing and analyzing the complex EnhanceEdu journey with multiple threads, multiple stakeholders, multiple foci and multiple feedback loops.
7.1.2 Lessons learned

Management was recognized as a key stakeholder in empowering teachers to effect change in the classroom for improved student learning. Empowered teachers and students took ownership for themselves and for the larger community. To effect a smooth system change, multiple change management strategies and processes need to be applied. In retrospect I now recognize the need for systematic “engineering” and “management” of information technology and engineering education. In addition, I see the need to implement the program and conduct more contextualized research in multiple regions, which can then inform policy. And finally, I recognize that there is a need to effect policy changes at various state and central regulatory bodies and other related bodies to enable systemic changes in the education system, to enhance it.

If a similar opportunity was offered in the future, a more systematic approach in the definition and use of metrics to capture pre- and post-data including test scores, would be adopted. Rigorous collection of data on learning outcomes before and after the intervention in each of the participating colleges would be helpful in continuous improvement of the intervention. Systematic and absolute measures of teacher effectiveness (student surveys, for example), and student knowledge (test scores) before and after each intervention would help to increase confidence in the intervention. Another thing that could be done in the future is to engage with the industry from the start of the program and track placement and performance of new graduates.

The TTP was offered at no cost to the participating colleges (PI). This had two impacts. One lesson learned is that once the value of the program was recognized by the participating colleges, the cost of training teachers should be distributed to the colleges as well. More colleges would have continued the implementation regardless of principals changing or teacher attrition, if they had paid for the real value they were getting. A second issue was that time and resources were limited for other things that the resources could have been used for - in terms of how much data collection could be done, how many interviews conducted, how many colleges to visit, how much follow up to do before giving up on converting the SGSG ‘red’ colleges to ‘green’ (PIII). The resources could be utilized to provide incentives to teachers to sustain the student learning impact over a period of time.

Though our work and research spanned more than 70 colleges in a number of districts, both rural and urban, these were located in only two states in India, Telangana and Andhra Pradesh. Through the work, 575 teachers were trained in the CIT TTP, and over 6000 students took part in the STEP in these two southern states of India. More detailed studies need to be conducted to test this process-driven approach in other states of India and in other developing countries. A more detailed
A research study can be conducted for the categories of change (Figure 6.10) as well. Further, longitudinal studies would gather more insights.

### 7.2 RESEARCH CONTRIBUTION

The major part of the contribution of this dissertation stems from the selected publications. A core contribution is the design and development of an effective TTP that enables teachers to gain competencies through LBD, improving their knowledge and skills and attitudes and beliefs, increasing their self-efficacy and empowering them to change behavior in the classroom, creating an impact on student learning.

Another core contribution is the recognition of the critical role of management in empowering all stakeholders to bring about a cultural change in them. The key factors for change include adopting multiple strategies for change (Chapter 6), engaging multiple stakeholder groups with different interventions at the same time and keeping all these stakeholder groups engaged and empowered. The EnhanceEdu model (Figure 5.11) for stakeholders and interactions shares a powerful process for enabling and empowering change. This research is applicable across state universities and affiliated colleges in India due to the similarities of higher education in India. It is likely that in other developing countries, the scenario may be similar. In that case, the approaches taken in this dissertation would apply directly. Either way, the general findings would be similar even in different contexts. The methods, processes, addressing different stakeholder groups differently as needed, and culture-building of taking ownership and teaming for excellence are generalizable and can produce similar results.

The design and development of a new pragmatic method, DeStoRe, with its basis in DSR, is an important contribution. DeStoRe allows one to move from a generic model in the research design and proceed to instantiations with multiple cycles of the design story, with iterative improvement. DeStoRe offers possibilities for radical innovations. Further using all the DSR views and analysis in this design story are adding to the design science research body of work.

The KODE model of empowerment is a key contribution for knowledge building and empowerment. Other contributions include the Butterfly model, a new instructional design method and the design of Art of Teaching (AoT).

### 7.3 FUTURE WORK

The key takeaways from this research are Butterfly model, AoT, TTP and DeStoRe.
Expanding on these takeaways of the EnhanceEdu design story, Figure 7.1 shares multiple threads of future work possibilities:

The Butterfly model thread allows for smart design artifacts leading to smart learning environments, with appropriate metadata to guide these environments. There can be further course development in computer science, IT and electronics engineering courses using the Butterfly model and energizing and empowering teachers to use these courses in a blended learning mode, conducting studies of cognitive load reduction and personalization.

For group or team-oriented work which began in the TTP, the POGIL (Process oriented guided inquiry learning) thread can be further developed. The experiments with such learning can be furthered, building on existing work (Kode & Cherukuri, 2014), and can expand to build an interactive POGIL environment (iPOGIL), leading to smart learning environments for both individuals and groups of learners through learning technology. iPOGIL could help determine in real time the state of understanding of the entire class and to fine-tune class teaching and learning processes. Further research could be done both on iPOGIL and on the scholarship of teaching.

Figure 7.1 Future work based on research threads seeded in the regional context
and learning related to POGIL, studying different models for classroom use for the highest impact. Further team-based learning and assessment can also be conducted.

The Art of Teaching (AoT) thread can be followed through to further improve AoT and conduct deeper studies into the joy of teaching already initiated in EnhanceEdu. Studies can be conducted of reflecting teachers and scholarly teaching, analyzing what works in the classroom and conducting studies on “Why I’m teaching what I’m teaching” (WIT) and “Why I’m learning what I’m learning” (WIL). Another thread could involve the further application of multiple change strategies to effect change in the education system.

The learning analytics (PIII) thread can be followed on collecting student data to understand learning behavior, measuring engagement in the online STEP/CIT program and classifying students based on their interests and background. Such data collected and analyzed combined with metrics will yield a better understanding of student engagement and identification of success factors leading to more effective student enhancement programs. These can be developed for and applied to various possible other threads, such as personalization and customization, curricular analytics and smart learning environments.

The TTP thread so thoroughly discussed in this dissertation can be followed through for further studies on the proposed stakeholder engagement model with an improved smart learning environment. A Level 3 evaluation can also be conducted to improve the trained teachers’ impact on student learning. Further studies on the engineering and management of information technology education can be conducted. Further, use of positive deviance (Heath & Heath, 2010; Singhal et al., 2010) for creating higher impact in the faculty development communities can be explored.

The DeStoRe thread can be followed through to examine various applications of the DeStoRe method to enhance education, strategy planning and implementation, radical innovation creation and the application of the EnhanceEdu model in different contexts. DeStoRe needs to be explored further to bring rigor to design stories through systematic use of DSR. Also, future work includes further elaboration of DeStoRe, its features, methodology, uses and benefits. Another step would be to examine more design stories using DeStoRe approach. In particular, efforts to improve information technology education in India and beyond, using the EnhanceEdu model, may be furthered using the artifacts created as concrete steps in a design story.

My hope is that many PhD students will take up work on these and other possible threads and take the research in each of the threads to useful conclusions. By applying the ideas in this thesis to their own contexts, and by developing new designs and models to enhance education in India and other countries, a large body of contextual work would be produced that can influence policy and transform education. It is
with this hope that I embarked on this doctoral research, and I have enjoyed this journey tremendously.

I am very positive about this research and the EnhanceEdu design story and its potential for application. Given the results, the feedback and the enthusiasm of all the stakeholders and participants, be they management, teachers, students or EnhanceEduians, the present applications need to be more widespread. I am confident that this work when replicated across different regions and different disciplines will yield positive results with tangible benefits to teachers, students, colleges, industry and society.
8 BIBLIOGRAPHY


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## APPENDIX 1. PARTNER COLLEGES OF ENHANCEEDU

<table>
<thead>
<tr>
<th>Code</th>
<th>College Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>AITSH</td>
<td>Annamacharya Institute of Technology &amp; Sciences, Hayathnagar</td>
</tr>
<tr>
<td>AITSR</td>
<td>Annamacharya Institute of Technology &amp; Sciences, Rajampet</td>
</tr>
<tr>
<td>AITAM</td>
<td>Aditya Institute of Technology and Management, Tekkali</td>
</tr>
<tr>
<td>AITS</td>
<td>Aryabhata Institute of Technology and Science</td>
</tr>
<tr>
<td>ACTS</td>
<td>Arjun College of Technology &amp; Sciences</td>
</tr>
<tr>
<td>Auro</td>
<td>Aurora Engineering College</td>
</tr>
<tr>
<td>BEC</td>
<td>Bapatla Engineering College</td>
</tr>
<tr>
<td>BIET</td>
<td>Bharat Institute of Engineering &amp; Technology</td>
</tr>
<tr>
<td>BITIT</td>
<td>BIT Institute of Technology</td>
</tr>
<tr>
<td>CBIT</td>
<td>Chaitanya Bharathi Institute of Technology</td>
</tr>
<tr>
<td>CEC</td>
<td>Chirala Engineering College</td>
</tr>
<tr>
<td>CVRCE</td>
<td>CVR College of Engineering</td>
</tr>
<tr>
<td>DVRCE</td>
<td>DVR College of Engineering and Technology</td>
</tr>
<tr>
<td>MIC</td>
<td>Dr. DVR and DHS MIC College of Technology</td>
</tr>
<tr>
<td>ECE</td>
<td>Eswar College of Engineering</td>
</tr>
<tr>
<td>GIT</td>
<td>Gates Institute of Technology</td>
</tr>
<tr>
<td>GEC</td>
<td>Gudlavalleru Engineering College</td>
</tr>
<tr>
<td>GVPCE</td>
<td>GVP College of Engineering for Women</td>
</tr>
<tr>
<td>GVPCE</td>
<td>Gayatri Vidya Parishad College of Engineering</td>
</tr>
<tr>
<td>GCET</td>
<td>Geethanjali College of Engineering &amp; Technology</td>
</tr>
<tr>
<td>GNITS</td>
<td>G. Narayanamma Institute of Technology and Science</td>
</tr>
<tr>
<td>GRIET</td>
<td>Gokaraju Rangaraju Institute of Engineering and Technology</td>
</tr>
<tr>
<td>Hi-Tech</td>
<td>Hi-Tech College of Engineering and Technology</td>
</tr>
<tr>
<td>HITM</td>
<td>Hyderabad Institute of Technology and Management</td>
</tr>
<tr>
<td>Horizon</td>
<td>Horizon Institute of Technology, Hyderabad</td>
</tr>
<tr>
<td>JBIET</td>
<td>Jignapally B. Institute of Engineering and Technology</td>
</tr>
<tr>
<td>KCITS</td>
<td>Krishna Chaitanya Institute of Technology &amp; Sciences</td>
</tr>
<tr>
<td>KGRCE</td>
<td>KG Reddy College of Engineering and Technology</td>
</tr>
<tr>
<td>KLU</td>
<td>KL University</td>
</tr>
<tr>
<td>MGIT</td>
<td>Mahatma Gandhi Institute of Technology</td>
</tr>
<tr>
<td>MLEC</td>
<td>Malineni Lakshmaiah Engineering College</td>
</tr>
<tr>
<td>MRCET</td>
<td>Malla Reddy College of Engineering and Technology</td>
</tr>
<tr>
<td>Marconi</td>
<td>Marconi Institute of Technology</td>
</tr>
</tbody>
</table>
MLRIT  MLR Institute of Technology
MTIST  Mother Teresa Institute of Science and Technology
MITS  Murthy Institute of Technology and Science
NEC  Narayana Engineering College
NAKCE  Nawabshah Alam Khan College of Engineering
BVRCE  Padmasri Dr. B.V. Raju Institute of Computer Education
BVRIT  Padmasri Dr. B.V. Raju Institute of Technology
PEC  Prakasam Engineering College
PRRMEC  PRRM Engineering College
PVPSSIT  PVP Siddhartha Institute of Technology
RRSCET  RRS College of Engineering and Technology
SVECW  Shri Vishnu Engineering College for Women
SBIST  Swarna Bharathi Institute of Science & Technology
SIET  Siddhartha Institute of Engineering and Technology
SIST  Sreenidhi Institute of Science and Technology
SCCE  Sree Chaitanya College of Engineering
SCITS  Sree Chaitanya Institute of Technology Sciences
SCPGC  Sree Chaitanya PG College
SDIES  Sree Dattha Institute of Engineering & Science
SKEC  Sree Kavitha Engineering College
SVEC  Sree Venkateswara Engineering College
SVCE  Sri Venkateswara College of Engineering, Tirupati
SSIT  S. S. Institute of Technology
TEC  Tirumala Engineering College
TRRCE  TRR College of Engineering
TITS  Turbomachinery Institute of Technology and Sciences
VCE  Vaageswari College of Engineering
VMEG  Vardhaman College of Engineering
VBIT  Vidyabharathi Institute of Technology
VJIT  Vidyajyothi Institute of Technology
VBITS  Vignana Bharathi Institute of Technology & Science
VITS  Vignan Institute of Technology & Science
VIMTW  Vignan Institute of Management and Technology for Women
VIT  Vishnu Institute of Technology
VITAE  Vignan Institute of Technology and Aeronautical Engineering
VCET  Visvesvaraya College of Engineering & Technology
VNRVJET  VNR Vignana Jyothi Institute of Engineering and Technology
VJIM  Vignana Jyothi Institute of Management
VRSEC  VR Siddhartha Engineering College
YPRCET  YPR College of Engineering and Technology
APPENDIX 2. SURVEY INSTRUMENTS

Appendix 2.1 CIT Management Survey

Certificate in Information Technology (CIT) - Management survey

Dear Sir/Madam,

As part of the CIT program you have nominated faculty members of your college to the Teacher Training Program (TTP). You may have also implemented the program for students at your college.

We now like to take your inputs on this program. We deeply appreciate your taking the time and filling this survey. Questions marked in red asterisk are mandatory and need to be answered.

The survey takes 20 minutes to be completed and we greatly appreciate you dedicating time out of your busy schedule for this activity.

We extremely value your inputs and would use them to enhance the upcoming programs.

* Required

1. Name *

2. Designation: *
3. **College Name:**

*Mark only one oval.*

- Please select your college
- Alluri Institute of Management Sciences
- Amara Institute of Engineering & Technology
- Annamacharya Institute of Technology & Sciences - Hayatnagar
- Annamacharya Institute of Technology & Sciences - Rajampet
- Arjun College of Technology & Sciences
- Aurora College of Engineering
- Bharat Institute of Engineering & Technology
- Chaitanya Bharathi Institute of Technology
- Chirala Engineering College
- CVR College of Engineering
- DVR College of Engineering and Technology
- Eswar College of Engineering
- Gayatri Vidya Parishad College of Engineering
- Geethanjali College of Engineering & Technology
- G. Narayanamma Institute of Technology and Science
- Gokaraju Rangaraju Institute of Engineering and Technology
- Horizon Institute of Technology
- J.B. Institute of Engineering and Technology
- Joginpally B. R. Engineering College
- KG Reddy College of Engineering and Technology
- Malineni Lakshmaiah Engineering College
- Malladi Reddy College of Engineering and Technology
- Marconi Institute of Technology
- MLR Institute of Technology
- Mother Teresa Institute of Science and Technology
- Murthy Institute of Technology and Science
- Narayana Engineering College
- Nawabshah Alam Khan College of Engineering
- Padmasri Dr. B.V Raju Institute of Computer Education
- Padmashree Dr. B V Raju Institute of Technology
- Prakasam Engineering College
- PRRM Engineering College
- PVP Siddhartha Institute of Technology
- RRS College of Engineering and Technology
- Shri Vishnu Engineering College for Women
- Siddhartha Institute of Engineering and Technology
- Sreenidhi Institute of Technology and Science
4. Do you feel that the Teacher Training Program (TTP) is beneficial? * Mark only one oval.
   - Yes
   - No

5. In your opinion, how is the TTP beneficial?
   __________________________________________
   __________________________________________
   __________________________________________

6. Have you observed any significant changes in your faculty after undergoing the TTP? * Mark only one oval.
   - Yes
   - No
   - Can't say
7. If your answered “Yes” to the above question, what significant changes did you observe?

8. Did you find any difficulty in nominating faculty for the TTP? * Mark only one oval.
   - Yes
   - No
   - Can’t say

9. If you answered “Yes” to the above question, what were some of the difficulties that you faced?

10. Do you feel your objective of sending faculty to TTP has been met? * Mark only one oval.
    - Yes
    - No

11. Would you like to send additional faculty members from your college to get trained on the TTP? * Mark only one oval.
    - Yes
    - No

12. How can we improve the TTP?
    Please be as elaborate as possible
13. **Was the CIT program implemented for students at your college?** *Mark only one oval.*

- Yes  
  - Skip to question 14.
- No  
  - Skip to question 33.

**CIT for students**

14. **How many batches were you able to implement the CIT program for completely?** *Mark only one oval.*

- 1 - One
- 2 - Two
- 3 - Three
- 4 - Four
- More than 4

15. **After the students completed the CIT program, which of the following did you observe an improvement in?** *

- Check all that apply.

  - Academic grades
  - Confidence levels
  - Problem solving skills
  - Presentation skills
  - Other: __________________________

16. **To which of the following would you attribute the improvement/s to?** *

- Check all that apply.

  - Content provided by EnhanceEdu
  - Mentoring support of faculty members
  - Students self learning abilities
  - Management support for the program
  - Other: __________________________

17. **If you feel the faculty members had a significant role in improving the quality of students, would you like to incentivise them?** *Mark only one oval.*

- Yes
- No
18. What in your opinion would be a good price to offer this program to students? * Mark only one oval.
- Rs. 500
- Rs. 1000
- Rs. 1500
- Rs. 2000
- Offer it for free
- Other: ____________________________

19. Was there an increase in the placement numbers at your college after the implementation of the CIT program? * Mark only one oval.
- Yes
- No
- Can't say

20. Would you attribute this increase to the CIT program? * Mark only one oval.
- Yes
- No
- Can't say

21. Were you able to allot dedicated time for the CIT program? * Mark only one oval.
- Yes
- No
- Can't say

22. How many hours per week (on an average) were dedicated for the CIT program? * Mention time in hours per week

23. How did the mentors conduct the program? * Mark only one oval per row.

<table>
<thead>
<tr>
<th>Excellent</th>
<th>Good</th>
<th>Satisfactory</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>_________</td>
<td>___</td>
<td>_______</td>
<td>_____</td>
</tr>
</tbody>
</table>
24. Were all your CIT trained faculty members available in the lab during the CIT sessions? * Mark only one oval.
   
   - Yes
   - No
   - Can't say

25. Any difficulties faced while allocating the workload to the mentors? *

26. Were you involved in the implementation of the CIT program? * Mark only one oval.
   
   - Yes
   - No
   - Can't say

27. How were you involved in the CIT program? Check all that apply.
   
   - Discussions with faculty members
   - Discussions with EnhanceEdu coordinators
   - Discussions with students
   - Visits to/from EnhanceEdu
   - Other:

28. How often were you updated on the status of the CIT program by your faculty members? * Mark only one oval.
   
   - Daily
   - Weekly
   - Bi-Weekly
   - Monthly
   - Bi-Monthly
   - Never
29. What kind of feedback do you get from the faculty regarding CIT program at your college?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

30. How often were you updated on the status of the CIT program by EnhanceEdu coordinators? * Mark only one oval.
- Daily
- Weekly
- Bi-Weekly
- Monthly
- Bi-Monthly
- Never

31. What is your opinion on the course content? *

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

32. Did you observe any issues while implementing the CIT program at your college? Please be as elaborate as possible

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Skip to question 34.

CIT - for students II

33. What were the main reasons you could not implement the CIT program at your college? *

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Other information

34. Do you like the way CIT is being implemented in terms of training the faculty and taking their help in training the students?  
Mark only one oval.

☐ Yes
☐ No
☐ Can't say

35. Was your college able to meet the CIT Goals according to the MOU signed? If not, what were the difficulties faced. *

____________________________________
____________________________________
____________________________________
____________________________________

36. In your opinion, how is the CIT program different from other training programs?

____________________________________
____________________________________
____________________________________
____________________________________

37. Do you think Learning by Doing methodology is working at your college? Mark only one oval.

☐ Yes
☐ No
☐ Can't say

38. Please elaborate on your answer

____________________________________
____________________________________
____________________________________
____________________________________

39. Have you seen and read the EnhanceEdu newsletter? *
   We have released 11 issues so far. Please mention the number of issues that you have seen/read. Mark only one oval.
   
   [ ] 10+ issues
   [ ] 7-9 issues
   [ ] 4-6 issues
   [ ] 1-3 issues
   [ ] I have received the newsletters but didn't find time to go through them
   [ ] I haven't received any issue
   [ ] Other: _____________________________

40. From our other offerings which of the following have you taken benefit of? Please be as elaborate as possible
    Check all that apply.
    
    [ ] Open source workshops
    [ ] Advanced course workshops (Data mining Data warehousing, Design for Testability, Verilog, etc.)
    [ ] Principles of Programming Languages
    [ ] Guest talks
    [ ] Projects for students
    [ ] Other: _____________________________

41. In your opinion, how else can we contribute to enhance the quality of education? Please be as elaborate as possible

   ______________________________________
   ______________________________________
   ______________________________________
   ______________________________________
   ______________________________________

42. Rate the support provided by EnhanceEdu team
    * Mark only one oval per row.

   Excellent  Good  Satisfactory  Poor
   
   ----- ( ) ( ) ( ) ( )

43. Any other feedback

   ______________________________________
   ______________________________________
   ______________________________________
   ______________________________________
Appendix 2.2 Teacher Training Program Exit Survey

Teacher Training Program (TTP9) Exit Survey

Dear Mentees,

We would like to know your experience during the CIT Teacher Training program. Your feedback will help us enhance the training program and make it better the next time. Filling in the form will take 30-45 minutes.

* Required

1. Name *

2. College name
   Enter your college

3. What did you understand about Learning by Doing? *

4. Please rate your skills in the following
   * Mark only one oval per row.

<table>
<thead>
<tr>
<th>Skill</th>
<th>Excellent</th>
<th>Very good</th>
<th>Good</th>
<th>Poor</th>
<th>Very poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>English Speaking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English Writing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creative thinking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ability to convey your thoughts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge of OOPs concepts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ability to guide OOPs hands-on</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge of data structures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ability to guide data structures hands-on</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge of Linux</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ability to guide Linux hands-on</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5. Please select three skills that you have improved during the training program * Check all that apply.

- English speaking
- English writing
- Creative thinking
- Hands-on programming skills
- Computational Thinking skills
- Mentoring skills

Skip to question 6.

Feedback on the methodology and mentoring

6. Do you feel the Learning by doing methodology is beneficial * Mark only one oval.

- Yes
- No
- No idea

7. How was your feeling when adapting to learning by doing methodology * Mark only one oval.

- Very comfortable to adapt to
- Comfortable to adapt to
- No idea
- Uncomfortable to adapt to
- Very uncomfortable to adapt to

8. In your opinion, how would the students react to this methodology?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

9. What according to you is “Mentoring”? *

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
10. Who is/are your mentor/s? *

11. Please rate your mentor in the following skills
* Mark only one oval per row.

<table>
<thead>
<tr>
<th></th>
<th>Very good</th>
<th>Good Average</th>
<th>Poor</th>
<th>Very poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of the course</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication skills</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ability to clear doubts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Availability during the lab hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

12. What did you gain/learn from the "mentoring" experience *

13. Please share any feedback that you may have about your mentor/s *

Feedback on the course

14. Do you think the learning objectives were met
* Mark only one oval per row.

<table>
<thead>
<tr>
<th></th>
<th>Very much</th>
<th>To an extent</th>
<th>Not at all</th>
<th>No idea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computational Thinking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Java</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data structures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

15. Standard of the tasks *

Mark only one oval per row.

<table>
<thead>
<tr>
<th></th>
<th>Very difficult</th>
<th>Difficult</th>
<th>Average</th>
<th>Easy</th>
<th>Very easy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computational Thinking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Java</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data structures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft skills</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
16. Resources provided * Mark only one oval per row.

<table>
<thead>
<tr>
<th>Very much sufficient</th>
<th>Sufficient</th>
<th>Insufficient</th>
<th>Very much insufficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computational Thinking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Java</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data structures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft Skills</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

17. Time allotment for the tasks * Mark only one oval per row.

<table>
<thead>
<tr>
<th>Very much sufficient</th>
<th>Sufficient</th>
<th>Insufficient</th>
<th>Very much insufficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computational Thinking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Java</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data structures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft Skills</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

18. Standard of the assessments * Mark only one oval per row.

<table>
<thead>
<tr>
<th>Higher difficulty</th>
<th>Similar difficulty as the tasks</th>
<th>Lesser difficulty than the tasks</th>
<th>Did not take the assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computational Thinking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Java</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

19. Time allotment for the assessments * Mark only one oval per row.

<table>
<thead>
<tr>
<th>Very much sufficient</th>
<th>Sufficient</th>
<th>Insufficient</th>
<th>Very much insufficient</th>
<th>Did not take the assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computational Thinking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Java</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

20. What changes would you like to see in the course content or structure * Any courses that you would like us to include/exclude

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Feedback on the talks, sessions, workshops and schedule

21. Please share your comments on the following talks
* Mark only one oval per row.

<table>
<thead>
<tr>
<th>Talk</th>
<th>Very benefical and very informative</th>
<th>Very benefical but not informative</th>
<th>Not benefical but informative</th>
<th>Neither benefical nor informatve</th>
<th>I missed the session</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. Reddy Raja's - &quot;Distributing Computing&quot;</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Dr. Prasad Pingali - &quot;Information Access Technology&quot;</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Ms. Keerthi Garg - &quot;Software Engineering&quot;</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Dr. Vasudava Varma - Cloud Computing</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Ms. Kavitha Vemuri - &quot;Systems Engineering&quot;</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

22. Please share your comments on the following soft skills sessions
* Mark only one oval per row.

<table>
<thead>
<tr>
<th>Session</th>
<th>Very benefical and very informative</th>
<th>Very benefical but not informative</th>
<th>Not benefical but informative</th>
<th>Neither benefical nor informatve</th>
<th>I missed the session</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective Communication</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Emotional Intelligence</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Self-evaluation and Goal setting</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Mentoring and coaching</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Time management</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

23. Please share your experience of these talks/sessions
*
24. Please share your comments on the following workshops * Mark only one oval per row.

<table>
<thead>
<tr>
<th>Workshop</th>
<th>Very beneficial and very informative</th>
<th>Very beneficial but not informative</th>
<th>Not beneficial but informative</th>
<th>Neither beneficial nor informative</th>
<th>I missed the workshop</th>
</tr>
</thead>
<tbody>
<tr>
<td>MediaWiki</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOODLE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Principles of Programming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jeevan Vidya</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

25. Please share your experience of these workshops

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

26. What other topics would you like to see included in the schedule *

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

27. Are you satisfied with the schedule? Mark only one oval.

☐ Yes
☐ No
☐ No idea

28. Any comments for improvement *

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Overall feedback

29. What features of the CIT training program did you like? *

________________________________________

________________________________________

________________________________________

30. Did you enjoy your training at Vignan?
   * Mark only one oval.
   - Yes, very much
   - No idea
   - No

31. Would you recommend this course to a friend/colleague? *
    * Mark only one oval.
    - Yes
    - No
    - No idea
Appendix 2.3 CIT Student Survey

Student Survey: AITS - Rajampet

* Required

1. Name *

2. Gender *
   Mark only one oval.
   - Male
   - Female

3. Roll Number *

4. Branch and Year *

5. GPA *

6. College Name *

7. Email Id *

8. Phone Number *

9. CIT taken during *
10. Caste *
This mandatory information is collected for statistical purpose only as this project is MCIT (Govt. of India) funded project. 

*Mark only one oval.

☐ SC
☐ ST
☐ BC
☐ OC
☐ OBC

11. Religion *
This mandatory information is collected for statistical purpose only as this project is MCIT (Govt. of India) funded project.

12. What do you understand by Learning-by-Doing methodology? *

13. Do you feel the Learning by doing methodology is beneficial? * Mark only one oval.

☐ Yes
☐ No

14. In your opinion what are the positive and negative aspects of LBD methodology? *

15. Were you able to apply this methodology to other courses * Mark only one oval.

☐ Yes
☐ No
16. Did you find improvement in your academic performance after taking up CIT program? * Improvement in your grades  
Mark only one oval.

☐ Yes  
☐ No

17. Please rate the below aspects of CIT program  
* Mark only one oval per row.

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Excellent</th>
<th>Good</th>
<th>Satisfactory</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mentoring</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tasks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessments</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grading mechanism</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

18. Would you recommend this course to others?  
* Mark only one oval.

☐ Yes  
☐ No

19. What other course would you like to have in CIT program? *

_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

20. Was there any part in the program which was challenging? * Mark only one oval.

☐ Yes  
☐ No

21. If Yes what / If No why? *

_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
Mentoring

22. Who is your mentor?  
* Mark only one oval.  
☐ V. V. N. Bhaskar  
☐ M. Sankara Prasanna Kumar  
☐ V. Sathyendra Kumar  
☐ D. Sudhakar

23. Please specify all the activities that your mentor is performing. Please check all that apply  
* Check all that apply:  
☐ Provides timely feedback on my tasks  
☐ Provides sample problems for me to understand concepts better  
☐ Talks to me in a friendly manner  
☐ Provides feedback on my assessments  
☐ Identifies my areas of improvement  
☐ Encourages me to think "out of the box"  
☐ Clarifies my doubts by giving direct answers  
☐ Provides hints to any doubts that I have  
☐ Shares the rubrics before the assessment  
☐ Other:

24. Rate your mentor on 1 – 5 scale  
* Mark only one oval per row.  

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

25. Why?  

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

26. The mentor who helped you the most?  
* Mark only one oval.  
☐ V. V. N. Bhaskar  
☐ M. Sankara Prasanna Kumar  
☐ V. Sathyendra Kumar  
☐ D. Sudhakar
27. Any suggestion for mentors *

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________

28. Please rate the below *
Mark only one oval per row.

<table>
<thead>
<tr>
<th></th>
<th>Always</th>
<th>Often</th>
<th>Sometimes</th>
<th>Rarely</th>
<th>No idea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CIT content</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CIT Portal links</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CIT Portal access</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mentor presence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power supply</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 2.4 CIT Mentors’ Survey

Mentors Survey on CIT program

Dear mentor,

Please take time to fill in the below survey. Your inputs are of value and importance to us.

* Required

1. Name *

2. When did you attend the TTP?
   * Mark only one oval.
   - December '08 - April '09
   - May '09 - July '09
   - May '10 - June '10
   - Dec '10
   - May '11 - July '11
   - Dec '11

3. Do you feel you have benefitted from attending the TTP?
   * Mark only one oval.
   - Yes
   - No
   - Can't say

4. Please rate the following aspects of the TTP *
   Mark only one oval per row.

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Excellent</th>
<th>Good</th>
<th>Average</th>
<th>Needs improvement</th>
<th>Not available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mentoring</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facilities (accommodation, food, internet, etc., at IIIT-H)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guest talks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workshops</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5. Which other courses would you like to see included in the TTP?

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

6. In which areas is the learning by doing methodology useful in? * Check all that apply.
   - Learning programming
   - Increasing confidence
   - Increasing problem solving skills
   - Adapting to new technologies
   - Learning on my own
   - Other:

7. Are you currently teaching?  
   * Mark only one oval.
   - Yes  Skip to question 8.
   - No  Skip to question 16.

About your job - Teachers

8. After the TTP, which of the following have you found an increase/improvement in? * Check all that apply.
   - Confidence levels
   - Competence in hands-on programming
   - Ability to guide projects
   - Presentation skills
   - Use of active learning techniques
   - Interaction with students
   - Other: ____________________________
9. Which college are working in?
* Mark only one oval.

- Alluri Institute of Management Sciences
- Amara Institute of Engineering & Technology
- Annamacharya Institute of Technology & Sciences - Hayatnagar
- Annamacharya Institute of Technology & Sciences - Rajampet
- Arjun College of Technology & Sciences
- Aurora College of Engineering
- Bharat Institute of Engineering & Technology
- Chaitanya Bharathi Institute of Technology
- Chirala Engineering College
- CVR College of Engineering
- DVR College of Engineering and Technology
- Eswar College of Engineering
- Gayatri Vidya Parishad College of Engineering
- Geethanjali College of Engineering & Technology
- G. Narayanamma Institute of Technology and Science
- Gokaraju Rangaraju Institute of Engineering and Technology
- Horizon Institute of Technology
- J.B. Institute of Engineering and Technology
- Joginapally B. R. Engineering College
- KG Reddy College of Engineering and Technology
- Malineni Lakshmaiah Engineering College
- Malla Reddy College of Engineering and Technology
- Marconi Institute of Technology
- MLR Institute of Technology
- Mother Teresa Institute of Science and Technology
- Murthy Institute of Technology and Science
- Narayana Engineering College
- Nawabshah Alam Khan College of Engineering
- Padmasri Dr. B.V Raju Institute of Computer Education
- Padmashree Dr. B V Raju Institute of Technology
- Prakasam Engineering College
- PRRM Engineering College
- PVP Siddhartha Institute of Technology
- RRS College of Engineering and Technology
- Shri Vishnu Engineering College for Women
- Siddhartha Institute of Engineering and Technology
- Sreenidhi Institute of Technology and Science
10. If you answered "Other", which college are you working in?

11. What is your designation?
   * Mark only one oval.
   ○ Programmer
   ○ Lecturer
   ○ Assistant Professor
   ○ Associate Professor
   ○ Professor
   ○ Other

12. If you answered "Other", what is your designation?

13. Which department are you working in?
14. Which of the following skills/concepts learnt in the TTP are you currently using? Check all that apply.

- Computational Thinking
- Object Oriented Program using Java
- Data structures
- Linux
- Presentation skills
- Mentoring skills

15. Have you implemented the CIT program for students at your college? * Mark only one oval.

- [ ] Yes  Skip to question 20.
- [ ] No  Skip to question 30.

**About your job - Non-Teachers**

16. Where are you working now? * Mark only one oval.

- [ ] IT/ITES sector
- [ ] Public sector
- [ ] Private (non-IT)
- [ ] Set up my own business
- [ ] Unemployed
- [ ] Other: ________________________________

17. Which skills learnt in the TTP are you currently using? * Check all that apply.

- [ ] Ability to adapt to new technologies
- [ ] Presentation
- [ ] Mentoring
- [ ] Learning to learn
- [ ] Other: ________________________________

18. What is the main reason behind your job change? Check all that apply.

- [ ] For better pay
- [ ] For better learning experience
- [ ] To be independent
- [ ] Prefer not to disclose
- [ ] Other: ________________________________
19. Have you implemented the CIT program for students before you moved to your current job? * Mark only one oval.

☐ Yes  
☐ No  
* Skip to question 20.
* Skip to question 30.

About CIT implementation

20. How many batches of CIT have you implemented at your college? * Mark only one oval.

☐ 1
☐ 2
☐ 3
☐ 3+

21. Would this course benefit the students? 
   * Mark only one oval.

☐ Yes
☐ No
☐ Can’t say

22. How would this course benefit the students?

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________

23. What areas did you observe an improvement in students after their undergoing the CIT program? * Check all that apply.

☐ Problem solving
☐ Confidence
☐ Ability to adopt to new technologies
☐ Presentation skills
☐ Interaction with faculty
☐ Ability to get their point across
☐ Other: ______________________________
24. What support did you receive from management during the CIT implementation? * Check all that apply.
   - [ ] Appropriate work load allocation
   - [ ] Weekly discussions on CIT progress
   - [ ] Monetary benefits
   - [ ] Other: ___________________________

25. Was the appropriate workload allocated to you?
   * Mark only one oval.
   - [ ] Yes
   - [ ] No

26. Rate the support provided by EnhanceEdu team
   * Mark only one oval per row.

27. Please rate the below aspects of CIT program
   * Mark only one oval per row.

28. What issues did you face when implementing the CIT program for students?

29. What other course/s would you like to be included in the CIT program for students?

Skip to question 31.
About CIT implementation II

30. What could be the reason/s for not implementing the CIT program at your college? * Check all that apply.

☐ Inadequate support from management
☐ Inadequate support from students
☐ Inadequate support from co-mentors
☐ Inadequate support from EnhanceEdu
☐ Other: ____________________________________________

Other details

31. How can we enhance the CIT program to make it more beneficial to students/faculty members?

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________
APPENDIX 3. SAMPLE NEWSLETTERS

EnhanceEdu Bulletin
Issue #22
28th March, 2012

EnhanceEdu has seen tremendous progress in STEP initiative, thanks to all our stakeholders (management, mentors and students). Your participation and commitment to the program makes it a Win-Win prospect for all of us!

**Top performers for the period : 15th March - 28th March**

<table>
<thead>
<tr>
<th>Name</th>
<th>College Name</th>
<th>Assignments Submitted</th>
<th>Submitted Assignments Graded</th>
<th>Assignment Score</th>
<th>Quizzes Attempted</th>
<th>Quiz Score</th>
<th>Total Score</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Divya Meka</td>
<td>Vignan Institute of Technology and Science</td>
<td>14</td>
<td>2</td>
<td>175</td>
<td>5</td>
<td>43.00</td>
<td>218</td>
<td>87.2%</td>
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<td>35.41</td>
<td>130.41</td>
<td>86.94%</td>
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<td>49.00</td>
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<td>342</td>
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<td>76.59%</td>
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**Forum Statistics**

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<th>Metric</th>
<th>Total Posts</th>
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<th>Highest posts posted by a Student</th>
<th>Highest posts posted by an EnhanceEdu Coordinator</th>
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<td>Total Posts</td>
<td>5</td>
<td>4</td>
<td>Pradeep Peesara, VITS</td>
<td>Sana Ahmadi</td>
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**Congratulations!!!
VITS Java assessment 1 results**

Total Students who took Assessment = 35  
No. of students who achieved Mastery = 34  
No. of students who achieved Reaching Mastery = 1
<table>
<thead>
<tr>
<th>S. No.</th>
<th>College Name</th>
<th>Total Mentors</th>
<th>Total Students Registered</th>
<th>Computational Thinking</th>
<th>OOPS Java Phase 1</th>
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<tr>
<td>1.</td>
<td>Alluri Institute of Management Sciences</td>
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<td>4.</td>
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<td>Section 1: Introduction to Java Section 3: Control Statements in Java</td>
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<td>Section 1: Introduction to Java Section 6: Arrays in Java</td>
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</table>
Principals’ meeting on 22nd March 2012

EnhanceEdu conducted a Principals’ meeting on 22nd March 2012 at IIIT Hyderabad (IIIT-H). 36 college representatives (principals, HODs, faculty members and placement officers) attended this meeting.

Ms. Sandhya Kode (Chief Mentor and Director, EnhanceEdu, IIIT-H) welcomed the college representatives. She shared her experience of the lack of hands-on knowledge in the graduating students. She stressed on the “Learning by Doing” (L&D) methodology implemented in Certificate in Information Technology (CIT) program, which gives students not only better understanding of subjects to excel in academics but also be more employable.

Prof. Kesav Nori, Chief Information Officer (Retd.), TCS and now Distinguished faculty at IIIT-H, pointed at the gap between the industry and the academia and how this is affecting the students. He also stressed on the fact that India should move from being a services providing nation to a product developing nation.

Mr. Surya Kiran (Program Manager, EnhanceEdu, IIIT-H), gave a brief overview of the CIT program and its different phases namely the content development, teacher training and student training.

Dr. Viswanath, Research Professor of Eminence, spoke about the management model of computing and how this is being employed to train students and faculty members break down a larger problem into smaller/manageable units.

Dr. Krishna Chalam, Principal, Sree Chaitanya College of Engineering, Karimnagar shared his experience of implementing CIT for all his 2nd year students. He specifically shared the importance of the program and how it has enhanced the skills of both his faculty members and students. He also shared that he has observed a significant increase in the academic scores of the students after undergoing this program.

The meeting was followed by lunch at EnhanceEdu. The participants discussed their questions over lunch and interested colleges stayed back to sign the Expression of Interest and Memorandum of Understanding (MOU).
Warm Greetings to our partner colleges!

It gives immense pleasure to begin this Newsletter with a "Wow" factor. This year, thirty seven engineering colleges all over Andhra Pradesh have signed MOUs with EnhanceEdu and have sent their faculty for Summer-2012 Teacher Training Program (TTP). This depicts a clear sign of colleges expressing increasing interest in this program and its value addition.

Orientations are on for the students of partner colleges who have joined EnhanceEdu this year and till date we have covered eight colleges. We request you to contact the EnhanceEdu coordinator for your college at the earliest, in case your students need orientation. Some colleges have already started implementing STEP, and we owe a sincere thanks to the mentors who are highly motivated to implement STEP for their students.

EnhanceEdu takes this opportunity to re-state the roles and responsibilities of college management and mentors in order to "Start Green and Stay Green" with respect to STEP.

College Management

- Need to incorporate STEP calendar into college academic calendar
- Allocate appropriate hours of regular course work to the trained faculty so that they do not get over loaded. Allocate each trained faculty at least 8-10 hours per week for the execution of STEP and 8-10 hours for evaluating students’ work.
- Regularly observe trained faculty and students and ensure students are making progress as per the agreed time lines.
- Participate in monthly video/audio calls with EnhanceEdu team College Mentors

College Mentors

- Ensure sessions are being conducted as per the STEP calendar
- Ensure participation in all STEP sessions and guide students
- To identify each student’s potential and motivate him/her to achieve their targets
- Evaluate deliverables as per the guidelines mentioned in the “Monitoring STEP” section
- Ensure attendance of the students in all sessions.
- Update session status report of all students.
- Participate in monthly video/audio calls with EnhanceEdu community.

EnhanceEdu hopes that the above guidelines are strictly followed at all colleges. We are excited & motivated with our current achievements and are confident that we will be able to serve a larger student community in coming days. We hope to achieve this by improving their confidence and making the students more employable through STEP implementation. This would definitely not be possible without your continuous support and guidance, and we look forward for the same.

Best of Luck!
EnhanceEdu team

Congratulations to MIC College of Technology

Vijayawada for being the first college to complete Computational Thinking (CT) in STEP this year.
A total of 50 students took the assessment test and all of them cleared it (Mastery - 35; Reaching Mastery - 4; Pass - 11).
“Joy of Teaching”, a two-week Faculty Development Program (FDP) is a framework based on contemporary research in the fields of cognitive science, social psychology and pedagogical sciences. This program is inline with our philosophy of Learning by Doing, integrative learning and working towards excellence with joy and so has activities to reinforce the same.

**Art of Teaching**
- Pedagogy and its meaning
- Educational taxonomies and their relevance
- Students’ learning styles
- Active teaching techniques
- Assessment and Rubric design

**Personality Development**
- Communication Skills
  - Listening and Hearing
  - Reading and Writing
- Time Management
- Human Values
  - Trust/Examining the root cause of anger
  - Happiness/Prosperity
  - Conflict Resolution
  - Desires vs Wants

**Technology Toolkit**
- Wikiday
- Moodle
- Documentation, collaboration tools
- Computational Thinking Activities/sharing
- Activity and Presentations

...more

Leadership
Teacher Training Program – 7 (TTP7) Report

EnhanceEdu conducted Teacher Training Program (TTP) for faculty of engineering colleges during the months of May, June and July - 2012. This year, we have introduced VR Siddhartha Engineering College as a nodal centre for TTP. Training was conducted in two batches at IIIT-H campus and one batch at VR Siddhartha Engineering College.

Training was conducted on the contents of Certificate in Information Technology (CIT) and other broader educational courses like "Art of Teaching", "Communication Skills", "Leadership", "Time Management", "Conflict Resolution", etc. We also had guest talks from the industry on topics like "Teachers for Engineers" "Cloud Computing" and "Practical Project Management Methodologies".

Below table shows schedule and Phase-I status of each batch participants:

<table>
<thead>
<tr>
<th>Training Venue</th>
<th>Start Date</th>
<th>End Date</th>
<th>Number of Participants</th>
<th>Mastery</th>
<th>Competence</th>
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<tr>
<td>IIIT-H</td>
<td>23 April, 2012</td>
<td>16 June, 2012</td>
<td>38</td>
<td>18</td>
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<tr>
<td>VR Siddhartha</td>
<td>23 April, 2012</td>
<td>19 May, 2012</td>
<td>29</td>
<td>24</td>
<td>5</td>
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<td>IIIT-H</td>
<td>14 May, 2012</td>
<td>7 July, 2012</td>
<td>57</td>
<td>36</td>
<td>11</td>
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</table>

38 faculty members participated in batch1 training conducted at IIIT-H. 29 faculty members participated in training conducted at VR Siddhartha and 57 faculty members participated in batch2 training conducted at IIIT-H.

In total, 124 faculty members from 34 colleges took part in TTP7. Out of this, 78 faculty reached mastery in Phase-I. We congratulate all faculty members who successfully finished the training program.

EnhanceEdu would like to thank all the mentors and faculty members who were involved in the training program. We would also like to thank all college managements for the support they have provided.

EnhanceEdu wishes a successful STEP implementation at all partnering colleges in the academic year 2012 – 2013.
The 4th IEEE International Conference on Technology for Education

The IEEE International Conference on Technology for Education (T4E) took place with full fervor with around 216 participants from India and various parts of the world such as UK, US, Taiwan, Greece and Malaysia. The week-long event started with the pre-conference workshop by Dr. Shaleen Minocha, Open University, UK at VNR VJIET and VIJIM campus on "Evaluating the effective use of emerging technologies in education" on July 16th. This was followed by two events on the 17th of July namely a workshop on "Using social media Technologies for Teaching and Research" by Dr. Shaleen Minocha, and National Mission on Education through ICT (NMEICT) Awareness Workshop and Exhibits. On NMEICT Awareness day, various National Mission projects such as AVIEW, NPTEL, Spoken Tutorial, Virtual Labs and Aakash tablet were demonstrated. These projects were displayed throughout the four days of the conference.

The main conference was held between the 18th and the 20th of July. The inaugural was attended by eminent personalities such as Dr. Raj Reddy (founder and only Indian winner of the Turing Prize) and Prof. Rajeer Sangal (Director, IIIT Hyderabad). Around 50 papers from India and different parts of the world such as Malaysia, Taiwan, Canada, UK and US were presented at the conference.

The following are the keynote speeches which were presented during the conference.

- Prof. Gautam Biswas, Vanderbilt University, US: Open-Ended Choice-Rich Learning by Teaching Environments to Promote Metacognition in Middle School Science Classrooms
- Prof. Vasudha Kamat, SNDT University: New Trends in Education for 21st Century
- Dr. Shaleen Minocha, Open University, UK: How Social Media is transforming learning, teaching and research dialogues
- Prof. Gwo-Jen Hwang, National Taiwan University of Science and Technology, Taiwan: Research Issues and Applications of Mobile and Ubiquitous Learning
- Dr. M. Sasi Kumar, CDAC, Mumbai: Personalized Instruction in e-learning

The T4E conference was also supported by various sponsors who exhibited their work. Sri Vishnu Educational Society displayed exhibits of their Assistive Technologies Lab for the physically challenged. Some of the highlights were the walking stick for the blind, automated wheel chair for the handicapped, learning alphabets for the deaf and the blind. Valuable Group also presented their work on distance education for schools via satellite dish and plasma TVs at the studios and classrooms.

The main conference was followed by post conference workshops. Dr. Cliff Kussmaul conducted a workshop on “Improving Student Outcomes through Guided Inquiry Activities” while Dr. Panagiotis Zervas presented a tutorial on “Digital Systems and Services for open access Education and Learning”. It was announced that the next Technology for Education conference will be held at IIT-Kharagpur in December 2013.
APPENDIX 4. ETHICAL CONSIDERATIONS

Ethical considerations in my research (Reflections and Solutions).

Here are a few more ethical issues in our research and how we addressed these:

1. **How do we include in the research plan considerations that address ethical issues?** Establishing values for ethical norms (virtue), processes (like rules), transparency in grading, validity and reliability in data collection and management, privacy & confidentiality.

2. **How does the research group cooperate and collaborate with trust?** The research group established a culture based on values to enable cooperation, accountability and trust. These values included respect for all, integrity (doing the right thing even under difficult circumstances), teaming for excellence, ownership and care for the environment. The shared values and culture were established through a special process of conducting orientation sessions based on human values, culture and continuous effort, with reminders to one another as well as taking ownership and living the values over the entire two-month full-time training period.

3. **How are the desired outcomes of the funding agencies not biasing the research that was to be kept objective?** The funding agency did not mandate how we worked but looked for results, and they were happy with the progress. The research group followed its research plan. The reality is that the intervention did not work the same way for all people and for all colleges. While there were many successes, as reported, there were also colleges that withdrew from implementation, due to a lack of sufficient resources (people, computer labs or internet).

4. **How were the desired outcomes of the management of the colleges not biasing the research process?** Management was kept at arm’s length from the research, while we provided them a high-level status update on training and obtained their support for the process as needed.

5. **Could research participants be trusted in their survey and interview responses?** How should the research participants be kept accountable? After the orientation and human values sessions, mentoring from the research team and the respect and welcome they received, the research participants felt they were in a safe and caring environment, and they opened up with honest inputs. The expectation that they were responsible adults and would manage their time and breaks while completing the tasks, with assessments with rubrics on Moodle and support by mentors, led to their being more accountable.

6. **Teachers were not used to sitting in front of a computer for five hours per day doing tasks. Would this affect their physical or mental health?** They were taught a few simple hand, neck and wrist exercises to do during break times. They were also given opportunities for holistic health with yoga, meditation, walking, gym and table tennis.
7. Did mentors grade with rubrics the tasks submitted by the teachers in training? Was there room for partiality? There were risk mitigation strategies, for example, a mentor group following up with a set of teachers, so a cross-check of the grades by a fellow mentor would ensure that partiality did not occur. For student research participants, even though remote, Moodle provided the data regarding their progress in the class, and their teacher/mentor random-checked for correctness through rubric grading.

8. **How should the research group be accountable to the public in the use of funds for this project?** By planning appropriate use of funds using ethical norms and reporting to the funding agencies. Ensuring no misuse of funds for nonproject-related purposes and supporting the training of teachers, as promised in the principals’ meeting. By training teachers and training students and publishing (sharing with society the processes used).

9. **How could you know whether the teachers were implementing the training correctly at their colleges, away from the research group?** This was part of the research plan and the training—a two-level cascade of knowledge and a cascade of our experimental study design. There were risk mitigation strategies to cross-check during the conducting of research in implementation; we instituted processes of random checks and visits, regular status reports and Moodle checks on rubric-based grading for the task submissions by students. This proves the reliability of the experiment. The way the experiment was conducted and the way data was captured and stored can be represented as an ethical practice.

10. **How could you protect the research group from the funders?** A typical requirement from funders is dissemination through publications. But there were no publication goals set by the funding agency. This was a big boon. Unlike many funding agency requirements for publications in high-impact journals, we were focused on getting the research and trainings done, and the publications were a by-product of the research. The funding agency’s requirement was to train a large number of students (12,000). However, as the trained teachers and colleges could withdraw from the program (voluntary participation), this put more strain on the research group. At funding agency review meetings, the research group was able to defend their position by showing the numbers of teachers trained and the colleges reached, discussing how the research code allowed voluntary participation and the way most withdrew due to a lack of appropriate resources in their colleges (lab infrastructure or numbers of teaching faculty).
Certificate in Information Technology (CIT)
Course-wise Modules List

CIT Phase 1:
Computational Thinking
Object-oriented Programming using Java Phase 1

CIT Phase 2:
Object-oriented Programming using Java Phase 2
Data Structures

Each of the CIT Phases 1 and 2 takes approx. 100 hours to complete.

Computational Thinking (CT)
Module 1: Introduction to Raptor
Module 2: Conditions
Module 3: Loops
Module 4: Arrays
Module 5: Strings
Module 6: Functions
Module 7: Recursion

Object-Oriented Programming - Level1 (OOPS) Java Phase 1
Section 1: Introduction to Java
   Module1: Introduction to Java
Section 2: Datatypes and Operators
   Module1: Datatypes
   Module 2: Operators
Section 3: Control Statements in Java
   Module 1: If Condition
   Module 2: Switch-Case
   Module 3: Loops
Section 4: Object-Oriented Programming - Level1
   Module 1: Classes and Objects
   Module 2: Access Specifiers
   Module 3: Constructors
Section 5: Packages
   Module 1: Creating packages
   Module 2: Using Java API
Section 6: Arrays in Java
   Module 1: Arrays (Single and multidimensional)
   Module 2: Array of Objects
Section 7: Strings in Java
   Module 1: Strings in Java
   Module 2: String Builder and String Buffer
Section 8: Object Oriented Programming - Level2
   Module 1: Inheritance
   Module 2: Polymorphism
   Module 3: Abstraction and Interfaces
Section 9: Exceptions in Java
   Module 1: System Generated Exceptions
   Module 2: User Defined Exceptions
Section 10: File I/O
   Module 1: Basic File Operations
   Module 2: Streams and Readers
   Module 3: File Serialization
Section 11: Object Oriented Programming - Level3

Object Oriented Programming - Level1 (OOPS) Java Phase 2
Section 1: Concurrent Programming
Section 2: GUI using Swings
Section 3: Socket Programming
Section 4: JDBC
Section 5: Collections

Data Structures Phase 2
Section 1: Big O Notation and Program Complexity
Section 2: Abstract Data Type
Section 3: Linked List
Section 4: Stack
Section 5: Queue
Section 6: Sorting
Section 7: Searching
Section 8: Dictionary
Section 9: Trees
Section 10: Priority Queues
Workshop mode curriculum as used in TTP8 (Virtual Classroom Mode):

CT Workshop Mode
Session 1: Introducing Raptor
Session 2: Flow Control Conditions Power Point Presentation
Session 3: Flow Control Loops File
Session 4: Arrays File
Session 5: Strings
Session 6: Functions File
Session 7: Recursion File

Java 1 - Workshop Mode
Section 1: Introduction to Java
Section 2: Session 2 - Data Types & Operators
Section 3: Conditions and Control Statements
Section 4: Tasks
Section 5: Java Data Structures Session III
Section 6: Java Objects and Classes
Section 7: Encapsulation and packages
Section 8: File abstraction and polymorphism
Section 9: Exception Handling
Section 10: File IO

OOPS2 - Workshop Mode
Section 1: Concurrent Programming
Section 2: GUI using Swings
Section 3: Socket Programming
Section 4: JDBC
Section 5: Collections
Screenshot from CIT Course using Butterfly Model *Playground*

Data Structures - Build a web calculator
Screenshots from Courses using Butterfly Model in CS and ECE
Screenshots from Courses using Butterfly Model in CS and ECE (contd.)
Screenshots from Courses using Butterfly Model in CS and ECE (contd.)
This dissertation is a reflection of an intervention - EnhanceEdu - designed to improve Information Technology education in South India, training over 500 teachers who in-turn trained over 6000 students. This study developed new models for content development, teacher change, stakeholder interaction and empowerment, and a novel pragmatic framework called Design Story. Research based on design science research, with wider implications in India and other developing countries with similar context.