DESIGN THINKING COURSE IMPLEMENTATION IN CDIO BASED UNDERGRADUATE PROGRAMMES

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ABSTRACT

Thiagarajar College of Engineering (TCE), Madurai, India has adapted CDIO curriculum for all undergraduate Engineering programmes in 2018 to address the increasing gap between scientific and practical engineering demand and to meet the global requirements of professional Engineer. In alignment with CDIO syllabus goals and mission of the institute, new courses, namely Engineering Exploration, Lateral Thinking, Design Thinking, Project Management, System Thinking, Engineering Design Project, Capstone Project and major project were introduced in the CDIO curriculum. The objectives of these courses are to improve creativity, critical thinking, collaboration and communication among the millennial learners. The course on 'Design Thinking' offered at third semester aims to provide a conceive-design experience. The course provides an experiential learning to understand the requirements of users, to challenge assumptions, to redefine problems, to create innovative design solutions, to prototype and to test. In this paper, we present the pedagogical framework, evaluation and grading methods developed for the 'Design Thinking' course. The evaluation was carried out based on design quality and the demonstration of the prototype considering both individual cognitive development and collective team effort. From the formal course exit survey and informal interviews with the students, significant students' engagement was observed in the course through teamwork. Students have experienced design-build-test process with a customized design thinking approach through periodical project review and poster presentations in oral and written forms. Performance analysis on course implementation has confirmed significant improvement in technical, personal and interpersonal skills of learners. Inclusion of community projects in project-based learning served as an efficient pedagogical method to promote students' engagement in self-learning.

KEYWORDS

Design Thinking, CDIO Curriculum, Critical Thinking, Collaboration, Communication, Standards 1, 2, 4, 5, 7, 8, 9, 10, 11

INTRODUCTION

The major objective of any engineering program is to produce graduating engineers with ability to conceive-design-implement-operate complex value-added engineering systems in a modern team-based environment (Crawley, 2001). Graduating Engineers should be able to appreciate the process of engineering and contribute to the development of engineering products and systems for the betterment of humanity. However, the recent report on the National Employability Skills Report (Aspiringminds, 2019) reveals that 80% of engineers in India are not employable for any job in the knowledge economy. The employability trends in India have shown no significant change over the past nine years. Annual reviews of Internal Quality Assurance Cell in our institute have revealed that, in the past two decades, 90% of our graduates have been offered placement only in software industries. The percentage of graduates getting employment in core companies is low. Graduates are not able to meet the stringent requirements of core engineering industries such as practical skills and system thinking skills. Quality of the curriculum has a significant impact on employability. Though engineering in an applied discipline, the increasing gap between engineering education and engineering practice has ended up in making engineering education more theoretical. Learners are not sufficiently exposed to design implement experiences during the period of graduation.

As only a few faculty members have industrial experience, adopting industrial practices was restricted to a few academic courses and projects. Though we have been following outcome-based education framework, practical skills, design thinking skills, system thinking skills, personal and interpersonal skills have not been much emphasized in the curriculum. Further, many of the graduate's who have been placed in software industries also want to switch over to core engineering jobs. They come back to the college seeking support for postgraduate studies in their respective disciplines in higher learning institutions. In summary, the challenges namely Poor employability rate in core companies, Insufficient exposure to design implement experiences during graduation, Lack of faculty competence in design and product building skills and Minimal emphasis on personal and interpersonal skills in the curriculum have enforced us to adopt CDIO curriculum framework to bring in systemic changes in the curriculum.

In the earlier curriculum of TCE, 'Engineering Design' and Capstone Courses were offered in fourth and seventh semesters respectively to promote design thinking among the undergraduate students. Only a few faculty members who handled these courses had exposure on design thinking and hence the effectiveness of the courses was not up to the expected levels. Also, identification of real-world complex engineering problems for all the students in the class was difficult. On the other side, learners gave promising and positive feedback that these courses have provided them with a platform to innovate and try something new as an engineer. Hence, a new series of courses with appropriate refinements which includes Engineering Exploration, Lateral Thinking, Design Thinking, Project Management and System Thinking have been introduced in TCE CDIO curriculum since 2018. This article reports an experimental study on the impact analysis of the Design Thinking course offered at TCE in promoting creativity, critical thinking, collaboration and communication. The impact of using community-based projects for Design Thinking for Problem based Learning on student engagement and self-learning is presented. The impact of training programs in enriching faculty competence related to design thinking and product building skills has also been analyzed.

The rest of the paper is organized as follows: Section 2 explores the various pedagogical approaches for design thinking courses reported in the literature. The research questions formulated for the present experimental study are presented in Section 3. Section 4 describes the course structure, content delivery methods and assessment plan adopted for design thinking. Section 5 presents the impact of the course in achieving the desired learning outcomes. Summary of the research findings and the scope for refinements are presented in Section 6.

LITERATURE STUDY

Literature study on the various pedagogical approaches for Design Thinking course practised at various institutions has been conducted. A human-centred design thinking approach has been adapted to a design course at MIT D-Lab (Ranger, 2018). The course aimed at creating prosthetic and assistive devices for human support. The team comprised of learners with diverse background. Problem identification has been done in collaboration with international stakeholders and industry partners who supported with interactive lectures and workshops. The collaborative effort has resulted in long term benefits for projects and has created new career development opportunities. An exploratory analysis of the various dimensions of design thinking has been conducted by Dym et al. (2005). The study confirms that the most favoured pedagogical model for teaching design thinking is Project-Based Learning (PBL). Various sources of data on the assessment of learning skills confirm the success of the PBL approach. The possibility of extending Design Thinking to STEM Education has been investigated by Li et al, (2019). It could be inferred from the reported results that the design thinking approach has resulted in improved creativity and innovation in integrated STEM Education. The impact of design thinking pedagogy on student development specifically for Electrical, Computer and Software Engineering (ECS) students was investigated by Sarah (2019). The impact of the Design Thinking course in shaping the perceptions of what it means to identify as an ECS engineer has also been analyzed. The initial exploratory investigation of design and design thinking in higher education business programs were reported by Matthews et al. (2017). The article also guides potential directions for management education programs. Design thinking can also be extended to organizations in all sectors of the economy. Dunne (2018) conducted a qualitative study which explores the goals of an organization in adopting design thinking, challenges faced and actions taken to address the challenges. It has been reported that legitimacy, cultural resistance, and leadership turnover can compromise the work of design thinking programs.

It could be inferred from the literature that, an appropriate pedagogy for design thinking customized to the learning styles and learning environment results in significant improvement of technical, personal and interpersonal skills of the learners. Learners should not be made to memorize facts and repeat them on demand. They must be provided with opportunities to interact with content, think critically and generate new information. The course on Design Thinking aims to open up the opportunities for collaboration, communication, critical thinking and creativity for the students of TCE.

RESEARCH QUESTIONS

The motivation for the experimental study is supported by the following two Research Questions (RQ):

RQ1: What is the impact of the course on ‘Design Thinking in promoting the 21st century skills namely Creativity, Critical thinking, Collaboration and Communication?

RQ2: Does the inclusion of community-based projects under Project-Based Learning in ‘Design Thinking’ course promote student engagement and self-learning?

DESIGN THINKING COURSE AT TCE

In the view of students' engagement in solving challenging and real-world problems, the Engineering Design course was introduced in our earlier curriculum. With the use of design principles, students developed a prototype addressing a specified theme area like smart city. It was observed that students were enthusiastic and interested in developing innovative ideas. Besides, feedback was also obtained from the course handling faculty members and they expressed their need for training in handling project-based learning courses. As part of institutional capacity building, twenty faculty members have undergone a training programme on the Design Thinking course with the human-centred design approach offered by Purdue University in collaboration with Indo-Universal Collaboration for Engineering Education (IUCEE). Subsequently, our institute has been recognized as a member of the IUCEE-EPICS (IUCEE-Engineering Projects in Community Services) consortium. To improve the students' involvement in community-based projects and addressing technical, personal and interpersonal skills, the previous Engineering Design course was modified as the Design Thinking course with three credits. This course is a customized version of the EPICS design process by adopting the first three of its phases namely problem identification, specification development and conceptual design phases.

Course Design

The expectations of the course are conceived as identification of a societal problem, problem formulation, specification development through the interactions with stakeholders, identification of multiple solutions, selection of best solution with defined measurable criteria, the use of the systematic approach in evolving product architecture using a functional decomposition and development of a conceptual prototype. With these requirements, the Course Outcomes (COs) were formulated for the students' engagement in managing community-based projects. The Course Outcomes (COs) of this course are listed in Table 1. To deliver the course effectively, fourteen faculty members were further trained in the Design Thinking course offered by the IUCEE-EPICS consortium to deliver and mentor the projects of this course. Besides, an industry-experts' led training programme on Product Design was also facilitated to disseminate the industrial practices and tools used in managing the projects.

Table 1. Course Outcomes of Design Thinking Course

CO Number	Course Outcome Statement
On the successful completion of the course, students will be able to	
CO1	Identify a specific social need to be addressed
CO2	Identify stakeholder's requirements for the societal project
CO3	Develop measurable criteria in which design concepts can be evaluated
CO4	Develop prototypes of multiple concepts using user's feedback
CO5	Select the best design solution among the potential solutions with its functional decomposition

Course Content

The content has been evolved from the defined course outcomes. The concept map of this course is shown in Figure 1. Table 2 depicts the relationship established with the TCE proficiency scale and CDIO syllabus version 2.0 (Crawley, 2001).

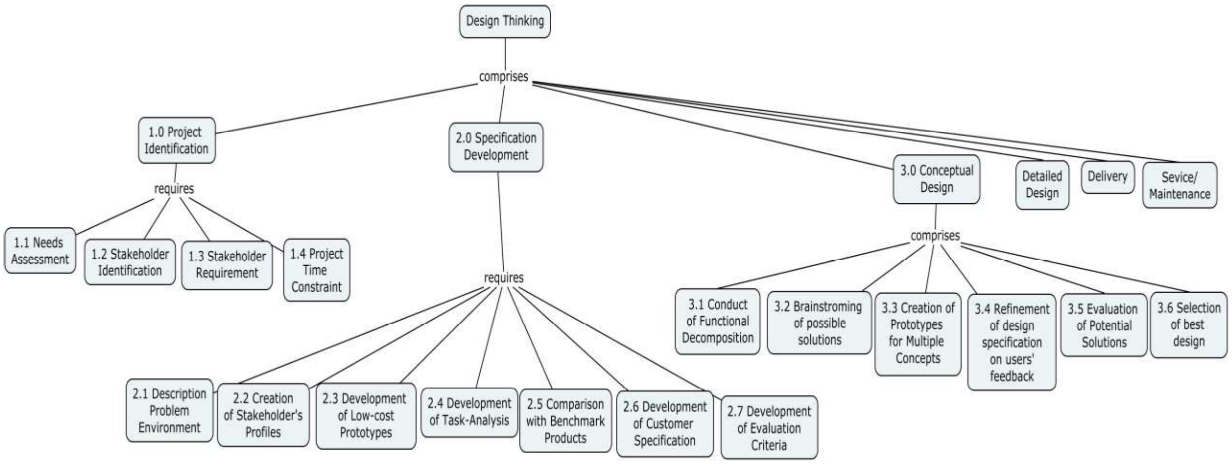

Figure 1. Concept Map of Design Thinking Course

Table 2. CO Mapping with TCE Proficiency scale and CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 3.1.2, 3.2.3, 3.2.6, 4.1.2
CO2	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.2, 2.5.1, 2.5.2, 3.1.2, 3.2.3, 3.2.6, 4.1.2
CO3	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.3, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.3.1
CO4	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.4, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.4.1
CO5	TPS5	Evaluate	Organise	Adaptation	1.1, 1.2, 2.1.5, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.4.1

Assessment Plan

The previous Engineering Design course was designed as a theory-cum-practical course. Based on the feedback received from course handling faculty members and students, the assessment plan of Design Thinking has been defined as a project-based course to enhance the design-build experience to the students. The detailed assessment plan is presented in Table 3.

Table 3. Detailed Assessment Plan

Phases	**Deliverables**	**Marks**	**Course Outcomes**
Continuous Assessment			
Review 1 – Problem Identification	Technical Report	10	CO1 and CO2
Review 2 – Specification Development	Technical Report	20	CO3
Review 3 -Conceptual Design	Technical Report	20	CO4 and CO5
End-Semester Examination			
Demonstration	Prototype	60	CO1, CO2, CO3, CO4 and CO5
Poster Presentation	Poster	40	

- Reports are to be submitted at each review. The report and presentation will be evaluated based on customized Rubrics for periodic reviews.
- Demonstration and Poster presentation will be evaluated by two faculty members nominated by their respective Head of the Department.

As per the assessment plan, rubrics are developed and implemented in reviewing the progress of students' design thinking projects. Reviews are conducted at the end of Project Identification, Specification Development and Conceptual Design Phases. The rubrics for three phases of evaluation are presented, in Table 4, Table 5 and Table 6 respectively. Further, adherence to the project plan and communication skills are also assessed during the review process.

Table 4. Assessment Rubric for Review-1 (Problem Identification Phase)

Descriptors	**Exemplary (4)**	**Proficient (3)**	**Partially proficient (2)**	**Incomplete (1)**
Need Assessment	Clearly stated the motivation and need of the project with appropriate evidences and data	Clearly stated the motivation and need of the project with enough evidences and data	Stated the motivation and need of the project with minimum evidences and data	Lack of clarity in the statements for the need of the project with no or inappropriate evidence and data
Identification of Stakeholders	All the stakeholders are identified with their roles and responsibilities.	All the stakeholders are identified and the roles and responsibilities are identified for a few stakeholders	All the stakeholders are identified but their roles and responsibilities are not defined.	Few Stakeholders are identified. Roles or responsibilities are not defined.
Definition of basic stakeholder requirements	Excellent and clear understanding of the scope of the problem and its objectives. Identifies and list constraints and able to correlate with the problem	Sufficiently states the scope of the problem and can identify and list the objectives. Identifies and list constraints but unable to correlate with the problem.	Able to identify the scope and objectives with discrepancies. Understands few constraints.	Unable to identify the scope and objectives. Little understanding of the problem constraints
Project Plan	Clearly stated stages of the project with the project charter and appropriate timelines.	Clearly stated stages of the project with appropriate timelines. Project charter is not presented.	Clearly stated stages of the project with inappropriate timelines. Project charter is not presented.	The stages are not identified with timelines.
Presentation Slides	Slides support the presentation, are easy to read and understand, keywords are used effectively.	Slides are easy to read and understand	Slides are easy to read and understand in most of the slides.	Slides are difficult to read and understand spelling/grammar errors evident.

Table 5. Assessment Rubric for Review-2 (Specification Development Phase)

Descriptors	Exemplary (4)	Proficient (3)	Partially proficient (2)	Incomplete (1)
Problem Environment and Stake-holders' profile	Clear specific details of problem environment and stakeholders' profiles with suitable evidences	Adequate details of problem environment and stakeholders' profile with supporting evidences	Adequate Details of problem environment and stakeholders' profile with minimum supporting evidences	Unclear on problem environment and inadequate stakeholder's profile with weak supporting evidences.
Mock-ups or prototypes	Presented low-cost mock-ups or prototypes with revisions based on customer feedback.	Presented low-cost mock-up or prototype with customer feedback but without any further revision.	Presented low-cost mock-up or prototype without any revision or customer feedback	Presented inappropriate mock-up or prototype without any revision or customer feedback
Customer Specifications and Evaluation Criteria	Clearly stated the final specifications and evaluation criteria with consensus from project partner. Presented and recorded the appropriate evidences for the revisions	Clearly stated the revised specifications and evaluation criteria with consensus from project partner. Presented the adequate evidences for the revisions	Clearly stated the specifications and evaluation criteria with minimal feedback from project partner. No evidences of revision of specification with consensus from project partner.	Not clearly stated the specifications and evaluation criteria and no feedback from project partner.
Adherence to Project Plan	Completely executed the individual's role and responsibilities in accordance with the code of conduct Clearly defined appropriate project timelines.	Partially executed the individual's role and responsibilities in accordance with the code of conduct Clearly defined project timelines.	Clearly stated the roles and responsibilities of team members in demand of the project Partially defined project timelines	Inappropriate roles and responsibilities of team members Inappropriate project timelines

Table 6. Assessment Rubric for Review-3 (Conceptual Design Phase)

Descriptors	**Exemplary (4)**	**Proficient (3)**	**Partially proficient (2)**	**Incomplete (1)**
Functional Decomposition	Identified all the functions of the proposed product and presented in a clear visual representation	Identified all the functions of the proposed product with adequate visual representation	Identified only few significant functions of the proposed product with inadequate visual representation	Few significant functions are not identified. No visual representation of functions
Alternate solutions and their evaluation	Identified potential alternate solutions and adopted a systematic procedure in evaluating the best solution	Identified potential alternate solutions and adopted a procedure in evaluating the best solution	Identified potential alternate solutions and not adopted any procedure in evaluating the best solution	Identified few alternate solutions and not adopted any procedure in evaluating the best solution
Prototype	Demonstrated a working prototype and its functions	Demonstrated a prototype/model with few of its functions	Presented a visual representation of product with few of its functions	Presented an inappropriate model/sketch of the product
Adherence to Project Plan	Completely executed the individual's role and responsibilities in accordance with the code of conduct Clearly defined appropriate project timelines.	Partially executed the individual's role and responsibilities in accordance with the code of conduct Clearly defined project timelines.	Clearly stated the roles and responsibilities of team members in demand of the project Partially defined project timelines	Inappropriate roles and responsibilities of team members Inappropriate project timelines
Communication Skill	Effectively and creatively delivers the information while staying on the topic and considering the audience, uses voice variations, seems confident and delightful ending on time.	Adequately delivers the information while staying on the topic, considers the audience, speaks clearly and ends on time	Delivers the information while staying on the topic, considers the audience, speaks somewhat clearly, trying to end on time	Demonstrates inconsistent command of the English language

Course Delivery Plan

Students were identified location-specific community problems and were mapped with one of UN Sustainable Development Goals (SDG). The students were instructed to follow the steps in the human-centric approach which is delineated in Figure 2. The course outcomes, assessment plan, assessment rubrics and course delivery plan were obtained approval in the academic council. The scheduled activities for each phase of design thinking are given below.

PROJECT IDENTIFICATION PHASE

- Team Formation and Roles Assigned
    - Roles such as Project Manager, Project Partner Liason, Project Archivist, Financial Officer, WebMaster
- Brainstorming/ Focus Group Discussion
    - Requirements - 5W-1H technique, Photos, Videos and Report prepared
- Code of Cooperation Discussion
- Stakeholders Interview Question and Survey Question Preparation
- Voice of Customer Report
- Requirements identified with priorities

PROJECT SPECIFICATION DEVELOPMENT PHASE

- Low – Cost – Model Preparation: Materials identification, Stakeholder Profile and Model Preparation Phase
- Low-cost model demo – video
- Opportunities identified to showcase the idea
    - All teams are presented their models in Intra department Association Event
- Received Feedback in the models and requirements from stakeholders, experts etc.

PROJECT CONCEPTUAL DESIGN PHASE

- Functional Decomposition
    - 10 important functions are identified in each team
- 5 possible ideas for each function
- Preparation of idea evaluation parameters
- Best Idea identification – Document submission
- Demonstration of working project/ product video submission

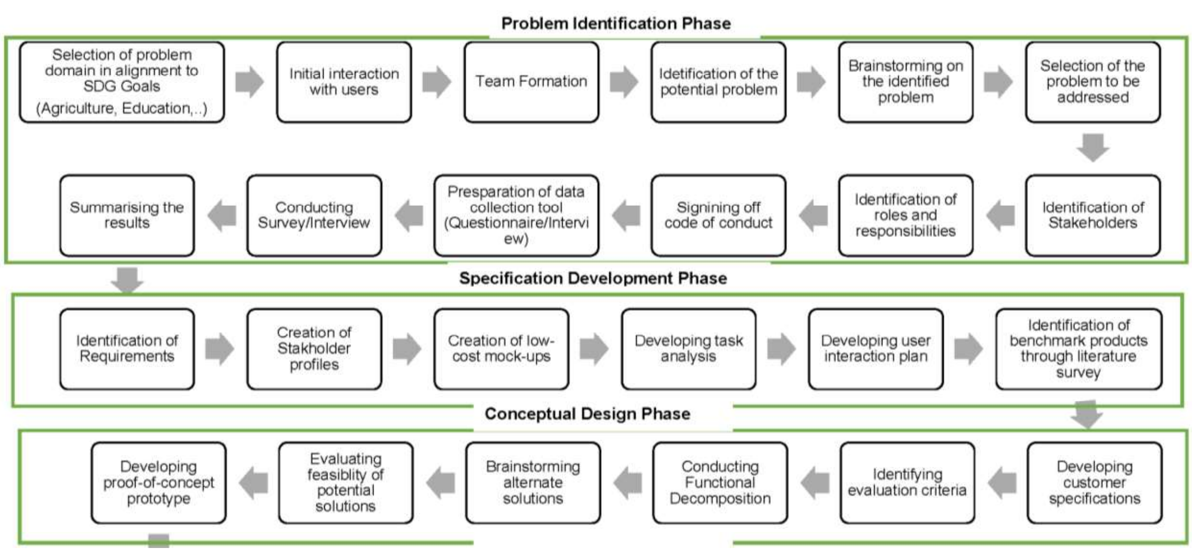

Figure 2. Steps involved three phases of Design Thinking course

IMPACT ANALYSIS

The Design Thinking course was first offered to 880 undergraduate students belong to civil, mechanical, electrical and electronics, electronics and communication, computer science and engineering, information technology and mechatronics programmes. A study was conducted to analyze the students' engagement in this course and in addressing community-based projects influences their perceptions on learning experiences and professional skills of 21st century learning skills (creativity, critical thinking, collaboration, and communication).

An institutional survey with a 4-point Likert scale has been conducted to determine the effectiveness of the course. Students' learning experiences in the Design Thinking process, team experience, professional communication and assessment were performance measures of this online survey. 530 (out of 880) responses were received The distribution of the responses according to the programmes is presented in Figure 3.

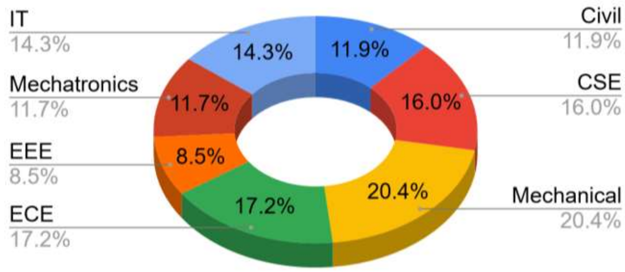

Figure 3. Distribution of students' responses in percentage

The students' responses on overall experience on the course, and opportunities in addressing creativity, critical thinking, collaboration and communication are presented in Figure 4 (a-e) respectively. Photographs taken during brainstorming sessions, exhibition of low-cost prototypes, project reviews are shown in Figure 5 (a-d). The performance measures are consolidated in Table 7.

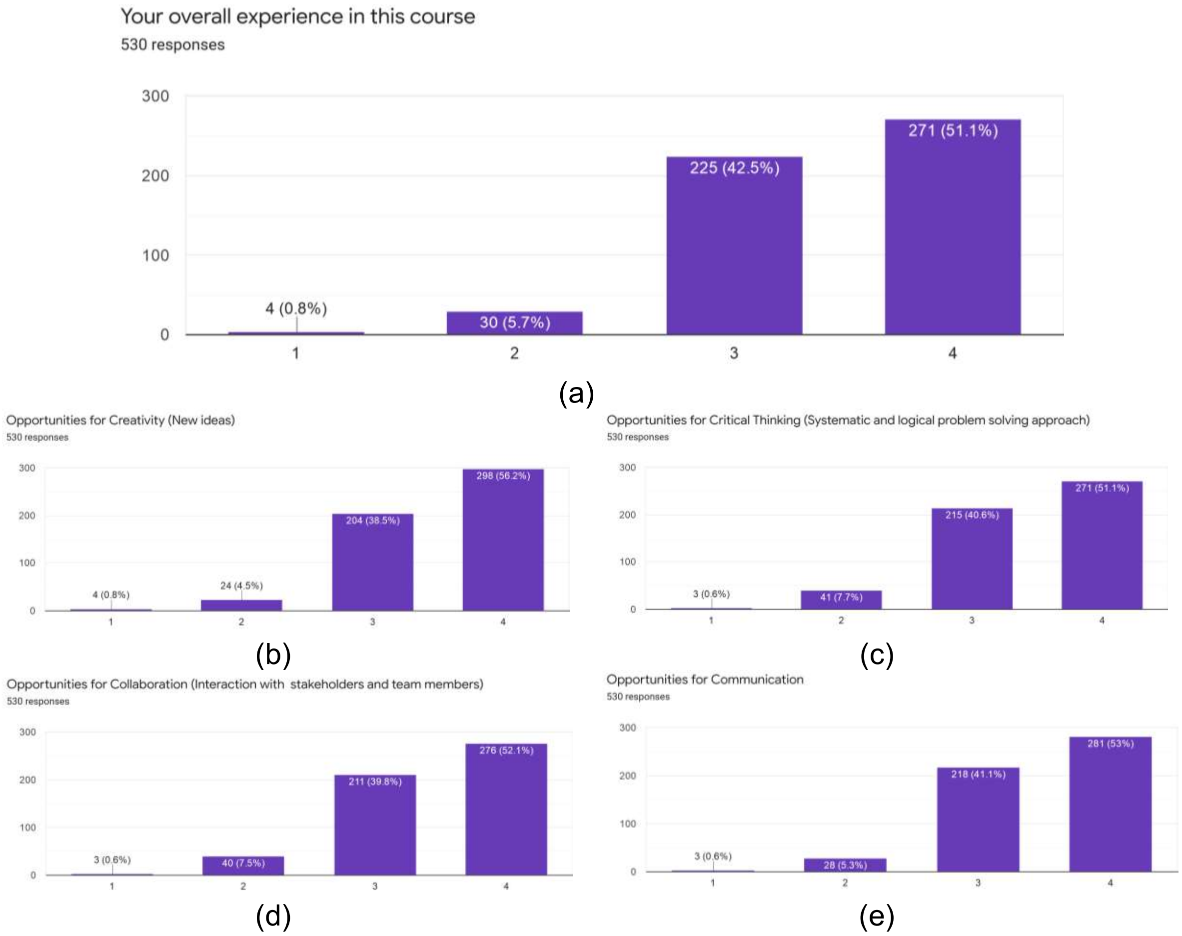

Figure 4. Students' Satisfaction Level on 21st century learning skills

(a) Brain-storming Session

(b) Low-cost prototype Preparation

(c) Inter-departmental open house

(d) Periodic Project Review

Figure 5. Sample Photographs of Students' Activities

Table 7. Students' Response on Institutional Survey
**Values are in percentage*

Description \ Response Scale	4 (Excellent)	3	2	1 (Fair)
1.0 Learning Experience on Design Thinking Process				
1.1 Identification of Societal Problem	44.7	48.5	6.4	0.4
1.2 Formulation of the problem	39.1	51.9	9.1	0
1.3 Literature Review (Research Articles, Patents, Existing products, etc)	35.7	48.9	14	1.5
1.4 Identification of Stakeholders of your project	50.8	41.3	7.4	0.6
1.5 Identification of Stakeholders' specification	48.1	42.8	8.5	0.6
1.6 Specification Development process	39.4	50.8	9.4	0.4
1.7 Functional Decomposition	39.2	47.9	12.3	0.6
1.8 Prototype Development	47.4	44	8.3	0.4
2.0 Team Experience				
2.1 Roles and responsibilities assigned	48.9	39.8	9.6	1.7
2.2 Opportunities to contribute individually	49.8	39.4	7.9	2.8
2.3 Contribution of other members	46.6	35.8	14	3.6
3.0 Experience in professional communication				
3.1 Oral Presentation	48.1	42.3	8.5	1.1
3.2 Report writing experience	43.6	46	9.1	1.3
3.3 Poster Preparation and Presentation	56.4	35.8	6.6	1.1
3.4 Drawings/sketches in idea generation and communication	55.7	36.4	7.2	0.8
4.0 Assessment				
4.1 Guidance of Assessment rubrics in the execution of the project	41.9	46.8	9.6	1.7
4.2 Satisfaction level in assessment	42.5	46.8	9.1	1.7
4.3 Periodic Reviews - Continuous Assessment	47.2	42.8	8.7	1.3
4.4 Poster presentation - Terminal Examination	52.8	39.1	7.2	0.9
4.5 Confidence in the presentation in common forum like an open house, hackathon	52.6	40.2	6.4	0.8

CONCLUSION

A significant outcome of the design thinking course includes 164 conceptual prototypes of real-world location-specific community problems. Satisfaction index of the students is improved mainly because of experiential learning. Use of the rubrics for periodic reviews served as an effective instrument for assessing personal and interpersonal skills of the students. Opportunities provided for promoting 21st-century skills namely creativity, critical thinking, collaboration and communication have motivated the students to take up the prototypes to the next level of its implementation. Many of our students have extended their projects of design thinking and exhibited their implementations in a national level contest like Smart India Hackathon and IUCEE-EPICS Design contest and received good recognition and rewards. The training programs on Design Thinking have enriched the faculty competence in mentoring the students with a human-centred approach to solve real community problems. The outcome of this training resulted in faculty awards for their posters in Design Thinking training programme. The course coordinator has been rewarded with the IUCEE- Transformational award for the year 2019 under the category of Leadership in Community Project-Based

Learning (CPBL). Based on the feedback from faculty and students and as a part of continual improvement, few refinements in the pedagogy of Design Thinking course are in progress. Based on the experience gained in its initial attempt and the feedback from the faculty & students, the implementation process for managing an interdisciplinary team is under development.

LIST OF ABBREVIATIONS

Abbreviation	Expansion	Abbreviation	Expansion
CO	Course Outcome	PBL	Project-Based Learning
CPBL	Community Project-Based Learning	SDG	Sustainable Development Goals
ECS	Electrical, Computer and Software Engineering	STEM	Science Technology Engineering and Mathematics
EPICS	Engineering Projects in Community Services	TCE	Thiagarajar College of Engineering
IUCEE	Indo-Universal Collaboration for Engineering Education	TPS	TCE Proficiency Scale

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BIOGRAPHICAL INFORMATION

Thiruvengadam.S.J. holds a Doctoral Degree in the field of Signal Processing for Communications. He carried out postdoctoral studies at Stanford University, USA in the area of MIMO Wireless Communications. He has completed many sponsored research projects in the area of Signal Processing for Defence Laboratories and Industries. 11 students were awarded a Doctoral Degree under his guidance. He has completed the IUCEE Engineering Education Certification Programme with Distinction and got IUCEE Engineering Educators Award for the year 2017 and IUCEE Institutional Leadership Award for the year 2019.

Saravana Perumaal S. holds a Doctoral Degree in the field of Robot Trajectory Planning Algorithms. He has obtained the IUCEE Engineering Education Certification Programme with Distinction and got IUCEE – SCALE Mentor Award for the year 2017 and IUCEE Transformational Award - Leadership in Community Project-Based Learning (CPBL) for the year 2019. He is also completed Design Thinking course with distinction offered by Purdue University in collaboration with IUCEE.

Baskar Subramanian holds a Doctoral Degree in the field of Hybrid Genetic Algorithms. He has carried out postdoctoral studies at Nanyang Technological University, Singapore in the area of Evolutionary Computation under BOYSCAST Fellowship, DST, India. He has completed three research projects in the area of Sensors and Evolutionary Computation. 16 students were awarded a Doctoral Degree under his supervision. He has completed the IUCEE Engineering Education Certification Programme with Distinction.

Jeyamala Chandrasekaran holds a Doctoral Degree in the area of Information Security from Anna University, Chennai in the year 2018. She has been part of the teaching fraternity since 2005 guiding Undergraduate and Postgraduate Information Technology Students. Her teaching interests include Cryptography, Artificial intelligence, Network security and Information Systems. She has undergone various pedagogical training programmes and has a keen interest in using different teaching and learning methodologies. She has obtained IUCEE IIEECP certificate with Distinction.

Abhaikumar.V. holds a Doctoral Degree in the field of Microwave Engineering. He has completed many sponsored research projects in the area of RF, Microwaves, Wireless and Antennas for Defence Laboratories and Industries. 13 students were awarded Doctoral Degree under his guidance. He has obtained US patents in the field of Base Station Antenna.

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