Teaching Design Thinking in Engineering and Management Institutes – *a Faculty Perspective*

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Abstract

Design Thinking(DT) has emerged in the corporate world as a silver bullet to drive customer-centric innovation. Consequently, many engineering and management institutes across the globe as well as in India have started teaching DT at the undergraduate and postgraduate level. However, there is a wide variation in the manner in which DT is taught across the colleges. In this paper, an attempt has been made to capture the perspective of the faculty members on Design Thinking education through mixed-method research. Based on the findings, the authors have come out with some broad guidelines on the effective pedagogy for teaching Design Thinking in management and engineering education.

Keywords:design education, design thinking pedagogy, engineering education, professional education, teaching, innovation

Introduction

Innovation is fast becoming the key differentiator for modern business enterprises. It is increasingly taking centerstage in a VUCA business climate(James & Bennett, 2014)where constant disruption is the new normal. This is further accentuated as the world faced ahuge, once-in-a-century disruptive event like the Covid pandemic, whichhad upset many established business models. Post that, the advent of Generative AI is completely changing the rules of the game. In such a scenario all business organizations must “innovate or perish”(Govindarajan & Srivastava, 2017)

During the last decade, “Design Thinking (DT)”has emerged as a “silver bullet” to drive Innovation in corporate firms, large and small, andin government bodies and public sector enterprises. It earned wide recognition from the business press as well as from business consultants for its growing contribution to innovation practices. More recently, it is seen that both governments and private sector companies around the world are adopting design-led methods to address national, social, and environmental challenges (Toshiaki Kurokawa, 2013). Thus, both private and public sector companies need an egalitarian processes of idea generation and implementation for survival and growth, and hence now search less for employees with highly specialized knowledge and more so for the ability to innovate (Armstrong, 2016).

This hascreated interest in "Design Thinking" among the academic community and has paved the way for the introduction of Design Thinking as a subject both at the undergraduate and postgraduate levels in many educational institutes(Matthews & Wrigley, 2017). These colleges realized that to be marketable in today's world, young pupils (especially those who are majoring in engineering streams or business education), need to learn the framework and principles of Design Thinking and get "hands-on" exposure to innovation projects(Wright et al., 2020). Over the last few years, the adoption of Design Thinking in engineering and business education has spread to many institutes across the globe, intending to build a bridge between education and industry in this global age. Following this trend, many engineering and management colleges in India have introduced Design Thinking in their curriculum during the last five-seven years.

With the proliferation of Design Thinking courses in educational institutes, the variation in course objectives, course content and teaching methods have also multiplied manifold(Goldman & Kabayadondo, 2016). There are several anecdotal success stories and case studies published by the business press eulogizing the utility and benefits of teaching Design Thinking in technical ande business education. However, there is also a stark absence of systematic and rigorous academic research on how it shouldbe taught and if there is anideal course content that ensuresoptimumlearning outcomes for the students.

To address this looming gap, the authors have done an extensive literature review of the existing methods of teaching Design Thinking across various technical/ management institutes and tried to decipher the rationale behind such methods. Post the literature review, the authors have used

mixed-method research, which includes both quantitative surveys and qualitative interviews of the faculty, to capture their experience, perceptions and recommendations concerning teaching Design Thinking to students. Based on this secondary (literature review) and primary (sample survey, interview) research, the authors have drawn useful conclusions on the optimum course content and pedagogy of teaching Design Thinking at engineering and management colleges.

Literature Review

What is Design Thinking

In an increasingly globalized economy, where consumers have a plethora of choices, and competition among the existing firms runs supreme, companies must “Innovate or perish”. Many studies have established the rapid acceleration of corporate mortality in recent times (Govindarajan & Srivastava, 2017). This has been further accentuated in the last two years due to the advent of Covid, which changed the very fabric of business and economy. It is now fait accompli for established organizationsto develop in-house systemic innovation capability, in the face of a continuous onslaught from nimble newcomers.

Over the last 10-15 years, “Design Thinking”has steadily gained widespread recognition among corporate circles as well as in government bodies as an approach to drive user-centric innovation and build novel products/ superior services (Brown & Wyatt, 2010). During this period, progressive business organizations, public sector companies, government bodies and educational institutions, have started to adopt Design Thinking as a framework to address the contemporary needs of driving innovation, designing better products/ services, and thereby survive and prosper in a "VUCA" (acronym for Volatile, Uncertain, Complex, and Ambiguous) business environment (James & Bennett, 2014). Nussbaum observed more than a decade back "Design has evolved as a structured method to solve business problems; Its focus on empathizing with the users, its stress on prototyping and iteration, its ability to discover fresh alternatives and its ability to connect to powerful emotions made converts out of tough CEOs" (Rauth et al., 2014)(Nussbaum, 2007).

The term “Design Thinking” was introduced by Dr Peter Rowe, a professor of architecture from Harvard University, as the title of his book, written in 1987(Rowe Peter G, 1987). Over the next three decades, the theory and understanding of Design Thinking have undergone considerable evolution and have taken on an altogether new, enlarged meaning.

The term “Design” is incidentally both imprecise and nebulous –design engineers as well as fashion designers can rightfully project themselves as design professionals, even thoughtheir focus area and specialization are poles apart (Kuo et al., 2021). It must be recognized that "Design Thinking" is not the same as “Visual Design". Broadly, there are three fundamental dimensions of Design. At the basic level – it is a craft, related to creating artefacts and

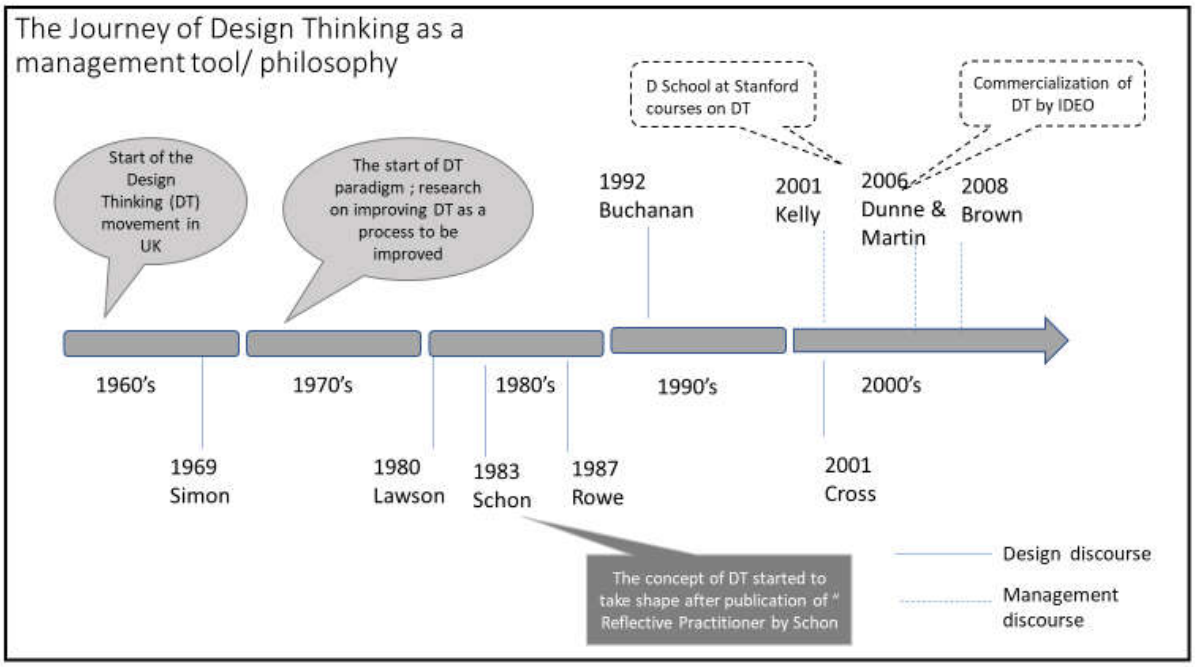
developing an experience for the user. The second is the product/service or can even be a digital experience for the users. The next evolution is "Design Thinking"- a framework used by cross-functional project teams to address difficult-to-solve challenges, often termed “wicked problems” (Buchanan, 1992), and create innovative products/ services. In a nutshell, "Design Thinking" is a customer-centric framework that uses empathy, teamwork and iterative prototyping for developing new products and services and solving customers' problems (Sheppard et al., 2018).

Evolution of Design Thinking – Models and Applications

Over the last five decades, the concept of Design Thinking has been shaped by different thinkers and eventually emerged as a dominant method and philosophy of business innovation. During this metamorphosis, different schools of thought influenced the core concept and positioning of “Design Thinking” underwent a tectonic shift. A section of that journey of Design Thinking is pictorially shown in Fig 01.

Fig 01

Origin and journey of the concept of Design Thinking (Source: (Hassi & Laakso, 2011)



It may be noted in the above Fig 01, that there are two principal discourses in the evolution of Design Thinking. It first started with Design discourse in the late sixties of the twentieth century. The concept was first propagated by Simon (1969) and further refined by other thinkers such as Lawson (1980), Cross (1982) and Schön (1983). Peter Rowe then came up with a book

on architectural Design and he titled it "Design Thinking" in 1987. From the late 90'showever, it slowly transformed into a management discourse with deep theoretical contributions from Kelly (2001), Cross (2001), Martin (2006) and Brown (2008).

Thus, as the concept of Design Thinking evolved over the years with contributions from various practitioners and academicians, it created two parallel viewpoints - one discourse emanating from the designers (design researchers) and the other from the business managers/ innovation specialists.

Methods

The idea of structuring the creative thinking process into phases was first conceived by Poincaréin 1924. Within a few years, Wallas (1926) came up with four distinct phases of the innovation process such as (a) preparation phase, (b) incubation phase, (c) illumination phase and (d) verification phase (Tschimmel & Santos, 2018). This categorizationstarted the research movements into design creativity, that explored different methods to demystify the iterative phases of the creative problem-solving process.

To make the application of the Design Thinking approach simple and repeatable, the process has been divided into multiple phases and further into multiple activities/tasks under each phase. The objective is to devise an (almost) fool-proof method that will help the team to plan the Design Thinking project and meet the final deliverable (a new product/ service or a solution to a wicked problem) within the defined and agreed timeframe.

Over time, with the adoption of Design Thinking practices by various companies, a gradual increase of interest in Design Thinking in academia, and the proliferation of consulting firms offering Design Thinking consulting services, multiple models, frameworks and methods on how to apply Design Thinking in practice got developed in parallel. Two popular and widely practicedmodels are described below:

(a) Tim Brown's Approach to Design Thinking (2008):

Design consultancy firm IDEO brought the concept of Design Thinking to the business world and Tim Brown was one of the founders of IDEO. He wrote a seminal article in Harvard Business Review (June 2008) where he introduced the fundamental concept of "Design Thinking". He divided Design Thinking projects into three distinct phases. The phases are described briefly below.

Inspiration: In this phase, the objective of the team is to get a complete 360-degree view of the challenges that users experience while using a product or service. The inspiration phase uses ethnographic studies, which involve direct observation of the users in action instead of low-touch mass customer surveys.

Brainstorming: This phase is for the generation, development, and testing of ideas for new products/ services in response to the problem(s) that the users are facing, gathered during the

inspiration phase. In this phase, the team focuses on the users while the multiple prototypes (starting with the simplest Lo-fi version) are developed, tested and refined iteratively. Users usually participate in these multiple test cycles.

Implementation: In this final phase, a definitive prototype is selected and implemented. A business case is established for the final prototype. A communication strategy is also made for this purpose.

While the above three phases are sequential in nature, they are also iterative and interconnected. So, it is quite common for the team to revisit an earlier phase while doing a Design Thinking project.

(b) Stanford Design School's Approach to Design Thinking (2010)

Stage 1: Empathize—Research the Users' Needs

The initial phase starts with deep user research and this phase enables the Design Thinking team to understand the user problem(s) they are trying to address, usually through empathetic observation. Empathy is at the heart of any human-centered design journey as it enables the team to overlook their preconceived notions and gain unfiltered insight into the users and their stated and implied needs.

Stage 2: Define—State the Users' Needs and Problems

In this phase, the team collates and analyses the data and information gleaned in the previous (Empathize) phase. Visualization techniques are used to analyze and make meaning of the observations made in the previous stage. It is then synthesized to clearly define the core problems the users are facing.

Stage 3: Ideate—Challenge Assumptions and generate Ideas

In this phase, the team brainstorms to develop innovative ideas to address the problem observed in Stage 1 and defined in Stage 2. In this stage, the team is expected to do " blue-sky" thinking, challenge the assumptions, explore various alternatives to address the problem and thus bring "out-of-the-box" solutions to the table.

Stage 4: Prototype—Begin to Create Solutions

In this stage, the team aims to zero down to the best possible solution that will address the user's pain points. Usually, the Design Thinking team produces many, scaled-down and inexpensive replicas of the product (a.k.a. Lo-fi prototypes). These prototypes are built so that they can be tested with the intended users to gather useful feedback to further refine the product/ service.

Stage 5: Test—Try the Solutions Out: This is the last and final phase of the Design Thinking process albeit there is always a possibility of iteration in a Design Thinking project when the team can go back to an earlier stage. Here the team meticulously tests the completed final

product with the potential users. As mentioned earlier, the Design Thinking project steps are linear but iterative. So, the results generated even in this final phase can be used to revisit and, if necessary, redefine the original problem statement.

As stated earlier, the above two are only two of the many methods developed concurrently by Design Thinking consultants and practitioners for executing a Design Thinking project. The authors have studied most of these methods and found that there is a striking similarity among these methods. The table below maps the steps of different models to one or more generic phases of innovation lifecycle.

Table 1
Mapping of Design Thinking models to generic phases of DT (Source: Authors)

Generic Phases	**Describe the (wicked) problem**	**Observe Users**	**Define the need**	**Generate alternative solutions**	**Build prototypes**	**Test**	**Refine and implement (launch)**
Dunne & Martin (2006)	Generalize			Generate ideas	Predict consequences		Test
Tim Brown (2008)	Inspiration				Ideation		Implement
Stanford D School (2010)	Empathize		Define	ideate	Prototype		Test
Liedtka & Ogilvie's Approach (2011)	What is?			What if?	What wows?	What works?	
SAP Design Thinking approach	Scoping	360-degree research	Synthesis	Ideation	Prototyping	test	validation
St . Gallen's Design Thinking approach	Define the problem	Need finding		Brainstorm	Prototype	test	
Kelley & Littmann (2016)	Understand	Observe		Visualize	Evaluate &Refine		Implement

TISDD Service Design Framework (2018)	Research	Ideation	Prototype	Implementation

Why Design Thinking is relevant in technical and management education

It is a generally accepted fact that the world is undergoing massive and unprecedented changes in the way humans work and live. With the advent of Generative AI, we witness thatrobots and "Thinking Machines" are becoming all pervasive and are fundamentally changing the nature of most of the tasks traditionally performed by human beings. Thus, it can be assumed that the skills that are needed in the workplace will soon be very different from what is required today.

As per the "The Future of Jobs Report" published by the World Economic Forum in April 2023, analytical thinking and creative thinking have emerged as the most important skills in the workplace. As per the survey, the ability to think analytically and creatively is seen as the mostimportant skill for the future.In the report, Creative thinking, a cognitive skill, ranked second, ahead of three other self-efficacy skills – (a) resilience, flexibility and agility; (b) motivation and self-awareness; and (c) curiosity and lifelong learning. These self-efficacy skills underscore the importance of workers' ability to adapt todisrupted workplaces. The core skills are complemented by empathy – the ability to understand and share the feelings of others – a skill, that, as per the report, will become increasingly important in the future workplace.

It is quite revealing in the report that various soft skills will become more important in the future workplace than the critical skill of "technologicalskills". Yet the diminishing exposure to and pursuit of humanities courses, which usually help to develop these skills, has transferred the pressure on business schools to fill the gap (Spivack, 2019).It is also well established that many of these soft skills such as innovation, complex problem solving, critical thinking, creativity, ideation and leadership etc. can be inculcated/ enhanced among the students by training in Design Thinking.

It is found that learning Design Thinking stimulates three key traits in students. These are: (1) able to collaboratively solve complex problems, (2) to think critically and creatively and (3) to communicate effectively. These traits are needed to be successful in today's workplace and will be more critical in the future (Seidel et al., 2020). In addition, it is generally accepted that Design thinking is a method that enhances the endurance and engagement of the students; it teaches them to work effectively in inter-disciplinary teams and helps to enact positive, design-led change in the world (Luka, 2014).

The Covid pandemic has accelerated the adoption of digital technologies toan unimaginable level in every human endeavor and has created unprecedented changes in the business environment. In parallel, many (wicked) problems have mushroomed in human society that warrants a humane solution. In such a scenario, learning and practicing the principles of Design thinking such as empathy, ideation, prototyping etc. havebecome more and more important in the current times. Thus, the engineers and management graduates , who are entrusted with creating products and processes to meet 21st-century needs must learn and apply the basics of Design Thinking in a structured manner during their formative years in college.

Research objective

Design is considered a core activity across most engineering disciplines(Simon, 1996). Thus, it is quite natural to expect that engineering education should teach budding engineers the necessary skills to design futuristic products/ services, fit for 21st-century consumers.

Design Thinking represents the intricate processes of learning through inquiry that designers undertake in the context of a system, making important decisions as they proceed, mostly working on teams in a social process, and "speaking" several languages with each other (and also to themselves). (Dym et al., 2005).

However, all Design Thinking courses are not the same and there is a very wide variation in the course content and pedagogy across the engineering and management institutes.

In this research study, the authors have attempted:

1. To understand the key elements of a Design Thinking course and their relative importance in the curriculum from the faculty perspective.
2. Capture the faculty perspective on the optimum pedagogy that will ensure all-rounded learning for the students

These findings will help in tweaking the approach of teaching Design Thinking as necessary and help in making policy recommendations related to Design Thinking in engineering and management education.

Research Methodology

Any course has two elements – (a) the course content (what should be taught) and (b) the pedagogy (how it should be taught). The faculty members are in the best position to comment on both these aspects.

To capture the faculty perspective, the authors have used a mixed method approach which includes an online survey followed by a one-on-one personal interview that provides qualitative data.

To identify the areas (elements) to emphasize for optimized learning outcomes, the authors conducted an online survey of 18 faculty members from various engineering and management colleges in India who are teaching the subject. (a total of 30 faculty members were approached, and 18 responses were finally received).

To understand the preference for a pedagogical approach to teaching Design Thinking, an online survey may be inadequate. It is important to have in-depth discussions/ freewheeling chats with the faculty through one-on-one interviews in a relaxed atmosphere. What works in an interview method is that it allows the researchers to get a peek into the thought process of the faculty.

Thurstone scaling techniques (specifically the Method of Equal-Appearing Intervals) is used to map the most important criteria for a Design Thinking course offering from faculty perspectives provides a methodologically rigorous way to establish an interval-level scale of importance. This method moves beyond simple ranking or rating to quantify the attitudes of the faculty panel.

Thematic analysis , an excellent qualitative research method, is used to understand faculty perspectives on a new Design Thinking (DT) course in a bachelor's program, as it allows for the identification, analysis, and interpretation of patterned meaning (themes) within textual data, such as interview transcripts or open-ended survey responses.

Research findings

Findings from Quantitative Survey

The authors first identified the top 5 elements/ focus areas of a Design Thinking course as taught across various universities through Literature review as well as interaction with the faculty , students and other stakeholders. These five elements are:

1. Learning tools and techniques of Design Thinking
2. Opportunity for iterative prototyping with the product/ service idea as part of the DT project
3. Executing a DT Project as part of the course
4. Working in a cross functional team (CFT) during coursework and project work
5. Making a presentation on the completed project to the panel as part of the assessment

The researchers then asked the faculty members (all of whom have taught one or more batches of students in Design Thinking) to put their preferences based on the perceived level of usefulness of each of these elements to the desired learning outcome. Using the response sheet of the faculty members, the following bi-variate frequency table was prepared.

Table 02
Faculty perception of the usefulness of various elements of the DT course

	Which Component of the DT course is more important				
Other Component Y ↓	Preferred Component X				
	Learning tools and techniques	Iterative prototyping	Doing a DT Project	Working in CFT	Making a presentation on the project to the panel
Learning tools and techniques		15	14	15	14
Iterative prototyping	3		8	5	7
Doing a DT Project	4	10		6	6
Working in CFT	3	13	12		9
Making a presentation on the project to the panel	4	11	12	9	

Table 03
Observed frequencies (in the bracket) and proportions of preferences of choice of the elements of DT courses (Faculty perspective)

	Which Component of the DT course is more important				
Other Component Y ↓	Preferred Component X				
	Learning tools and techniques	Iterative prototyping	Doing a DT Project	Working in CFT	Making a presentation on the project to the panel
Learning tools and techniques		15(0.833)	14(0.78)	15(0.833)	14(0.78)
Iterative prototyping	3(0.167)		8(0.45)	5(0.28)	7 (0.39)
Doing a DT Project	4(0.22)	10(0.55)		6(0.33)	6(0.33)
Working in CFT	3(0.167)	13(0.72)	12(0.67)		9(0.5)

Making a presentation on the project to the panel	4(0.22)	11(0.61)	12(0.67)	9(0.5)	

Table 04

Measure of distance from one design Thinking course component (X) with others (Y)

	Which Component of the DT course is more important				
Other Component Y ↓	Preferred Component X				
	Learning tools and techniques	Iterative prototyping	Doing a DT Project	Working in CFT	Making a presentation on the project to the panel
Learning tools and techniques	0.00	0.96	0.78	0.96	0.78
Iterative prototyping	-0.96	0.00	-0.13	-0.58	-0.28
Doing a DT Project	-0.78	0.13	0.00	-0.44	-0.44
Six Thinking Hats	-0.96	0.58	0.44	0.00	0.00
Business Value Canvas	-0.78	0.28	0.44	0.00	0.00
Total	-3.48	1.95	1.53	-0.06	0.06
Average	-0.696	0.39	0.306	-0.012	0.012
Average- Min	0	1.086	1.002	0.684	0.708
R*: Thurstone Scale Value= (Average-min/Max-min)	0.00	1.00	0.922	0.63	0.651
Representative Rank	**5**	**1**	**2**	**4**	**3**

As it is evident from the table 4, the top two elements in a Design Thinking course are (a) executing a Design Thinking project and (b) doing iterative prototyping (starting with a Lo-fi prototype). Thurstone scaling method, used in the present research study, provides a quantifiable, interval-level measure of the faculty's collective attitude toward the course offering criteria,

allowing researchers to precisely map and prioritize the most significant elements. These insights will be useful while designing the course on Design Thinking. This also reiterates the need for Project-based Learning (PBL) as the overarching pedagogy for teaching Design Thinking in professional education(Murielle& Hiba, 2023).

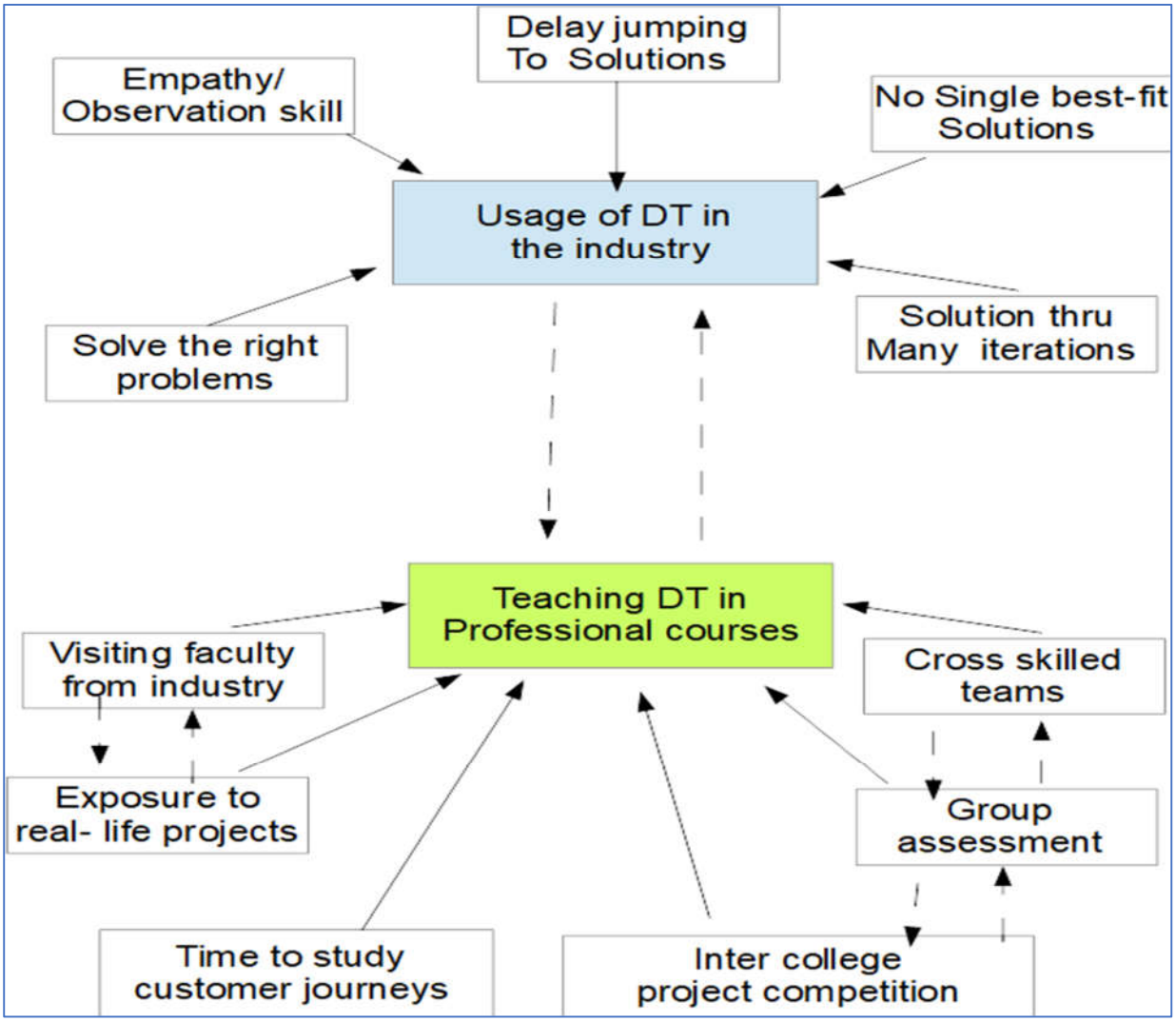
Findings from the Qualitative Survey/ Case Study Method

The quantitative survey was supplemented by a qualitative survey as part of the mixed method research design. As part of the qualitative survey, a total of 9 faculty members were interviewed (a sample of 10 were approached out of which, one declined) to understand their preference for the pedagogical approach for teaching Design Thinking. The interviews were semi-structured in nature – a set of questions to be asked were prepared in advance, but many of the questions were modified during the interview, depending on the flow of conversation and interest level demonstrated by the interviewee. Unstructured interviews are very effective to discuss the topic in-depth and allow the interviewer to "find out what's really happening?"(Saunders et al., 2012).

The interviews were audiotaped and transcribed. The data from the interviews were segregated using thematic analysis and studied in detail. Thematic analysis is a methodical practice to decipher patterns in unstructured qualitative data. It looks for recurring themes within the data set and leverages these themes to summarize the data sets(Dennis Howitt, 2010). The themes initially identified were broken into sub-themes and/or by modifying them into new themes. The following thematic network (Fig. 01) emerged from this exercise:

Fig 02

Thematic Network on Design Thinking in industry and education



The Thematic Network Diagram shown above has two sections – the upper section shows the relevance and usage of Design Thinking in the industry – while the lower part demonstrates the recommendation to teach this subject as part of professional courses in general and engineering in particular. The diagram was drawn solely based on the interview with the faculty members involved in teaching Design Thinking.

Various measures were applied to check the descriptive, interpretive and theoretical validity of the research findings. For example, to confirm the descriptive validity, the audio-recoded versions/ transcripts were checked by the researcher with the research notes jotted down during the interviews(Braun & Clarke, 2006). Finally, the themes were tested against the interview

transcript/ notes during the data analysis process to ensure the generalization of the themes across multiple interview transcripts (Johnson & Onwuegbuzie, 2004).

Some emerging themes from the interviews are summarized below:

1. **Faculty Profile and project types:** Design Thinking is a purely practical-oriented subject with heavy application in industry. So, the Design Thinking practitioners from the industry who are using the concepts day intheir day to day work, are the best people to teach it. In the words of interviewee I1:

"Bring faculty from Industry, to get a closer look at the real problems. Do not rely fully on the college professors who may end up with only theoretical concepts".

Closely related to this are the projects that students do as part of the Design Thinking course. Instead of asking students to pick up any project – many of the interviewees felt that the projects should closely resemble actual real-life projects from industry. This can be enabled through the participation of industry professionals as visiting professors who can suggest and even guide some of the projects taken up by the students.

2. **Empathy and observational skills**: Having empathy and observational skill is a key trait/ skill of a successful Design Thinker. This is also an OFI (opportunity for improvement) area for most young professionals. Hence adequate time must be given during the course to develop this critical skill. In the word of Interviewee I6:

"Often the Design Thinking projects are rushed in the industry. As a result, the team does not spend enough time understanding the customer or mapping the customer'sjourney. While teaching Design Thinking, it must be ensured that students get sufficient time to study the user(s) and map the customer journey. This is the most critical skill they must learn."

Therefore, teachers must ensure that the students understand the subtle but important difference between sympathy and empathy(Melvin Ilyas Barth, 2021) and also develop deep observational skills which is the hallmark of a good Design Thinker.

3. Projects by interdisciplinary teams: The team composition, while learning Design Thinking is very important both in and off the classroom. As per interviewee I3:

"*Ideally, Design Thinking could be an elective topic and the students from different disciplines (such as Mechanical Engineering, Computer Science, Electrical Engineering, Electronics, Architecture etc.) can opt for this elective course."*

This will ensure that not only the class composition but also the project teams have interdisciplinary representation. The diversity in the teams will lead to better cross-learning, enhanced collaboration and optimize learning outcomes for the students.

Many faculty members feel that since Design Thinking is being taught in many engineering and management schools now, there should be inter-college competitions among various Design Thinking teams. This will surely motivate the students to have more innovative projects as part of the course which will lead to enhanced learning. In the words of one interviewee:

"There may be inter-college competitions on the ideas which have come up as an outcome of internal projects and assignments. The winners of these competitions must be given seed money or incubation support so that it could lead to the successful creation of startups".

Discussions

The quantitative and qualitative survey of the faculty members teaching Design Thinking had thrown up quite a few interesting insights related to Design Thinking education at engineering and management colleges. This primary research along with an extensive literature review has enabled the authors to draw some broad implications on how Design Thinking should be taught as part of engineering and management education. Some of these insights are summarized below:

a)Usefulness of Design Thinking as a subject in engineering and management schools. There is near unanimity among the faculty members that Design Thinking as a subject is a need of the hour and it should be compulsorily taught as part of engineering and management education. This is even though it is a new topic to many faculty members, and as a result, they sometimes struggle to teach this rather unconventional subject (Foster, 2019). As per the faculty, learning Design Thinking helps students to improve their creativity, team working skills, ability to decode customer (user) voice and even improves presentation skills. While there is agreement on the benefits of the course, the faculty is somewhat divided when it comes to the content and pedagogy to achieve an optimized learning outcome.

b) Course Content & Pedagogy: As per the faculty, it is important to teach the tools and techniques, but it is more important to create opportunities for the students to apply them in a project setting without which the learning will remain incomplete. So, in addition to teaching the tools and techniques of DT, it is important to create an atmosphere so that the students inculcate the philosophy, values and mindset of Design Thinking. So, the content should balance the focus to teach the tools and the philosophy of Design Thinking. Many faculty members also spoke about incorporating multiple mini projects in the course to create opportunities for applications of different tools/ techniques. Facultymembers prefer group assessment but donot prescribe completely doing away with the practice of individual assessment.However, most of the faculty

members opined that the individual assessment can be in the form of viva -voce and not necessarily a written examination.

c)Integration of Design Thinking tools and principles with current curriculum: Before introducing an altogether new subject "Design Thinking" in the engineering/ management curriculum, it is necessary to first do an in-depth study of theexisting level of integration of the Design Thinking tools and principles in the current curriculum of the various subjects being taught in the engineering and business schools.However, it is evident from the literature review, multiple surveys and interviews that the level of integration today is low and less than desired. The faculty members strongly feel that learning Design Thinking tools/ principles can help the students in their careers, but the rigidness of the current curriculum and pedagogy makes it somewhat difficult to intertwine the concept of Design Thinking with other subjects. For example, there are hardly any interdisciplinary team projects (although enough possibilities exist across disciplines) and all assessments are done through individual tests/ quizzes and not through any group evaluation.

The faculty expects that the content, pedagogy and assessment methods of various should change, aligned to meet the 21st-century skill requirements. Unfortunately, it has not happened so far in the Indian context.

d) Course Duration: The faculty strongly felt that it is almost impossible to cram so much course content and achieve desired learning outcome through a single credit course of 40-50 hours, to be taught in a single semester. The suggestions they have on this are twofold – (a) there could be two courses on Design Thinking (DT I and DT II) in two consecutive semesters, or(b) integrate the tools and principles of Design Thinking in other relevant courses on engineering and management. This will result in better absorption of Design Thinking knowledge and skills among the students.

Conclusion

The relevance of teaching Design Thinking in engineering and management education has been well established. However, it is necessary to identify some best practices on how to teach Design Thinking effectively as part of education. In this paper, the authors have attemptedto capture the perspective of the faculty members concerning Design Thinking education in the engineering curriculum. What has become evident through the survey and the interaction with the facultyis that the subject needssomewhat different treatment as compared to many other subjects taught in the engineering degree / management diploma program. The difference includes more emphasis on action learning/ project-based learning as against rote learning, a combination of formative and summative assessment, and proliferation of Design Thinking concepts and tools across other subjects of the curriculum. The authors strongly believe that some of these insights, gleaned

from the faculty with first-hand experience of teaching Design Thinking will prove to be very useful in redesigning the course content and pedagogy.

However, the relevance of Design Thinking is not limited to engineering/ management students alone but extends to a wide variety of disciplines. A more in-depth survey can be conducted drawing from the insights of the faculty members involved in teaching Design Thinking across other professional courses. The research and the survey can extend beyond the faculty feedback and include feedback from other stakeholders such as students and industry professionals. Comprehensiveresearch involving a wider range of stakeholders across various professional disciplines will provide a more holistic perspective of Design Thinking education at the academic level. This can lead to the development of a fewmeaningful hypotheses based on the perspectives of all stakeholders gathered through these surveys and focus group discussions. These hypotheses can then be tested through randomized experiments to the extent feasible in various academic settings. This will help in designing an effective Design Thinking course and pedagogy for engineering and management education.

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