Journal of Engineering Education Transformations,
Volume No 36, January 2023, Special issue, eISSN 2394-1707

10.16920/jeet/2023/v36is2/23041

Inculcating Design Thinking Methodology in the Minds of First Year Engineering Students: A Step Towards Entrepreneurial Thinking

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***Abstract*—Every economy needs entrepreneurs to fill gaps and promote innovative products with the necessary expertise and hard work. An entrepreneurial culture hastens a nation's overall development because it promotes nurturing a greater number of venture capitalists which eventually boosts nation's economy. Rajarambapu Institute of Technology (RIT) Rajaramnagar, an Autonomous Institute has adopted choice-based curriculum system (CBCS) in 2017-18 which included Entrepreneurship development (ED) as one of the four tracks with the objective to transform students into entrepreneurs. It was observed that, there is dire need to initiate entrepreneurial thinking course in first year engineering curriculum to acquaint students with problem solving and creative thinking skills, communication skills and teamwork which are very important for an entrepreneur. Hence, the course 'Creativity, Design Thinking and Entrepreneurial Mindset' was commenced as an open elective for first year engineering students from the academic year 2018-19. In this paper, course details are presented along with course outcomes and In-Semester evaluation (ISE) plan. Design thinking methodology is illustrated phase wise with help of students' project case study. Innovative active learning tools and techniques were developed to map the required skills for an entrepreneur. Due to this strategically developed active learning tools, course CO attainment has improved from the year 2018-19 to 2021-22; CO1 has improved by 37.09 %, CO2 increased by 47.54%, CO3 by 40.30 % and CO4 improved by 28.98 %. Moreover, number of prototypes developed by the students were 4 in the year 2018-19, which elevated to 15 (increased by 275 %) in the year 2021-22. Furthermore, there was improvement in final year ED track students of 2021-22 as compared to 2020-21; 25 students entered ED track during the year 2020-21, out of which 6 students (24 % students) converted their ideas into startups, while during the year 2021-22, 28 students opted for ED track, from which 13 (46.4 % students) established their startups. Lastly, ED track mentors survey results are reported for the year 2020-21 and 2021-22, which clearly illustrate that ED track students' entrepreneurial knowledge and abilities, students' attitude towards entrepreneurship as a career option and students' entrepreneurial self-efficacy has improved than the previous years.**

***Keywords*— Design Thinking; Entrepreneurial culture; Startup Ecosystem; Active learning.**

I. INTRODUCTION

Entrepreneurs play a vital role in building nation's economy. They help in solving customers' pain points and thus lead to the development of new product, technology or service which eventually creates an employment. As a result, government place a high priority on promoting entrepreneurial activities because they are correlated with a nation's level of economic growth (Bosma, Hill & Ionescu-Somers, 2020). India, which has the second-highest population in the world and aims to have the third-largest economy by 2030, is making significant efforts to cultivate an entrepreneurial culture in this environment (Hassan, Anwar, Saleem, Islam & Hussain, 2021). However, there are many challenges involved in penetrating this Entrepreneurial culture in the society (Irfan, Rajamallaiah & Ahmad, 2018). The majority of engineering students concentrate primarily on MNC jobs because they believe these positions have a bright future (Lynch, Kamovich, Longva & Steinert, 2021). Therefore, there is a tremendous need to instill an Entrepreneurial culture in students' brains, which will help few of them become successful Startup founders. Rajarambapu Institute of Technology (RIT), Rajaramnagar has implemented choice-based curriculum system (CBCS) since 2017-18. According to this system, final year students can opt for any one choice between Undergraduate research experience (URE), Industry internship and projects (IIP) and Entrepreneurship development (ED) (Suryawanshi, Patil & Kulkarni, 2021). However, it was observed that ED track students are lagging in some prerequisites required for becoming successful startup owners. As a result, we determined which skill sets should be covered in a foundation course during the first year of engineering. Problem solving, creative thinking, communication skills and teamwork are very crucial primary stages of entrepreneurship journey (Jonassen, Strobel & Lee, 2006; Passow & Passow, 2017). Secondly, young entrepreneurs must also comprehend how technology can be successfully commercialized and brought into the market (Barr, Baker, Markham & Kingon, 2009; Bilén, Kisenwether, Rzasa & Wise, 2005). In addition, students have myths about creativity, innovation and feel that creativity is not methodical. Hence there was overall need to develop students' entrepreneurial mindset which gave rise to foundation course entitled

'Creativity, Design Thinking and Entrepreneurial Mindset'. This course is introduced as open elective for the first year Engineering students of all branches emphasizing more on Design thinking methodology.

This paper comprises of three parts as given below:

i) Overview of the course 'Creativity, Design Thinking and Entrepreneurial Mindset'.
ii) Design Thinking Methodology with case study.
iii) Active learning techniques implemented to make the course interactive and experiential.
iv) Impact of course on students' understanding regarding entrepreneurial thinking.

II. METHODOLOGY

A. Course overview

1) Course Details

The course 'Creativity, Design Thinking and Entrepreneurial Mindset' is designed as open elective and hence first year students from any branch can opt for the same. The basic details about the course are tabulated below.

2) Course Outcomes (COs)

At the end of the course the student should be able to:

CO1_Learn structured approach to creativity, problem identification and problem solving in a new venture context.
CO2_Apply design thinking approach to identify innovation opportunities and develop solutions.
CO3_Identify, validate and define specific innovation opportunities through jobs-to-be-done methodology.
CO4_Develop mindset of a successful entrepreneur.

TABLE I
COURSE DETAILS

Class	F.Y. B.Tech (All Branches)
Number of lectures per week	2 lectures (1 Hour each)
Number of laboratory sessions per week	1 laboratory session of 2 hours
Credits assigned	Theory – 2 Laboratory - 1
In-semester evaluation (ISE)	20 Marks
End semester evaluation	100 Marks

3) In-Semester evaluation (ISE) plan

Semester comprises of 12 weeks and thus ISE modes were planned systematically. Three activities were planned for the ISE evaluation viz; Discussion forum on Modular Object-Oriented Dynamic Learning Environment (MOODLE), Newspaper cutout and preparation of Business model canvas.

TABLE II
ISE PLAN

Sr. No.	Activity	Week in which activity is planned
1	Discussion forum on MOODLE	Throughout semester
2	Newspaper cutout	Throughout semester
3	Preparation of Business Model Canvas	7th Week

B. Design Thinking Methodology

The above course was conducted by giving major emphasis on Design Thinking methodology. Design thinking helps converting problem statements into prototypes in a methodical way. Students were initially taught about the various market domains, which would help them identify societal issues. Certain qualities, such as effective communication, teamwork, creativity, etc., are necessary for having an entrepreneurial mentality and needed to be covered in the course.

Fig. 1. Design Thinking Methodology

Students admitted to this course were divided into interdisciplinary team of 4 members in each group to promote teamwork and team building, which are crucial for entrepreneurship. In the initial phase each team was asked to visit various places in market and find the societal issues. Later they were told to separate all the problems cluster wise.

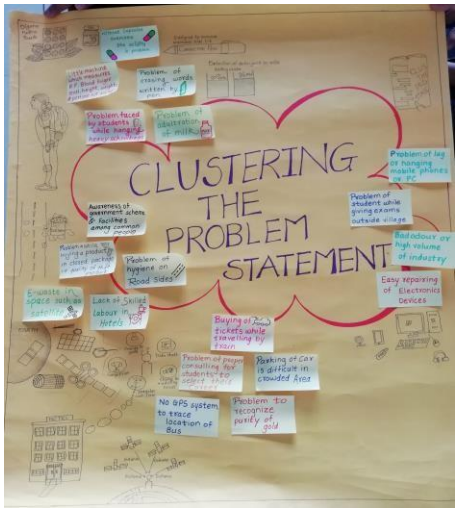


Fig. 2. Clustering the problem statement

Fig. 3. Students working in team

Students were then taught the Design thinking methodology by explaining various successful case studies in market. The

design thinking method is a series of steps that helps people effectively transfer their skills in order to find the best answers to problems (Alok & Saipriya, 2020). Design Thinking is a nonlinear, iterative process which comprises of five phases viz; Empathize, Define, Ideate, Prototype and Test.

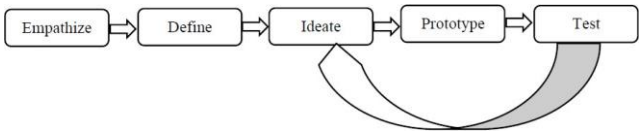


Fig. 4. Nonlinear Design Thinking Process

Prototypes are put to the test, and if they are unsuccessful or need to be amended, the ideate process is repeated and the prototype is changed. The problem statement chosen by one of the teams will be taken into consideration for discussing the Design thinking steps in this paper. The selected problem was from the Civil Engineering construction domain which centered on the fatigue or stress caused to the labors carrying mortar (sand, gravel and cement mixture) on construction sites.

- *Empathize*

User-centric research is the main emphasis of the first stage of the design thinking process. It's important to develop an empathic gain of the issue you're attempting to resolve. Consulting with specialists to learn more about the problem, and making observations to connect with and understanding the users is the core part of this stage. In this stage students were told to interact with users and get the pain points. On field or site visit is very much important for this stage. Customer or user is interviewed formally or informally in this stage.

- *Define*

The information obtained during the Empathize stage must be organized systematically during the Define step. To identify the core problem the team has thus far found, observations are evaluated. It is necessary to define the core problem statement from a human-centered perspective. Fig. 5 depicts the team undergoing define phase.

Fig. 5. Team members in Define phase.

- *Ideate*

Designers are prepared to come up with ideas at the third stage of the design thinking process. In the Empathize stage, they developed an understanding of their users' demands, and in the Define stage, they analyzed their observations to produce a user-centric problem statement. With this strong foundation, the team members can begin considering the problem from various angles and coming up with creative solutions to the problem. Brainstorming technique is very useful at this stage which allows innovators to generate as many ideas as possible at the start of ideation.

Fig. 6. Teams involved in brainstorming session.

- *Prototype*

The design team will build a variety of low-cost, scaled-down prototypes of the product (or particular aspects included in the product) to research the primary solutions conceived during the ideation stage. The design team itself, other departments, or a small group of individuals outside the design team can all share and test these prototypes.

Fig. 7. Teams building scale down models

Prototype building is an experimental phase, and its aim is to identify the best possible solution for each of the problems identified during the first three stages. The solutions are implemented within the prototypes and, one by one, they are investigated and then accepted, improved or rejected based on the users' experiences. Fig. 7 depicts the team members

iterating their designs on CATIA and then building small inexpensive prototypes using popsicle sticks.

- *Test*

Using the best solutions found in the Prototype stage, innovators thoroughly evaluate the entire product. Although this is the final stage of Design Thinking, the outcomes are frequently utilized to redefine one or more additional challenges since it is an iterative process. This deeper degree of comprehension might aid innovators in examining usage conditions and consumer attitudes toward the product, and it might even prompt a design thinking process loopback to an earlier stage. The next step for innovators is to perform additional iterations, make adjustments, and perfect their work to rule out best ideas. The main objective is to comprehend the product and its users as thoroughly as possible. Fig. 8 illustrates the testing procedure of prototype.

Fig. 8. Prototype Testing

C. *Use of Active Learning Techniques*

Use of active learning techniques while delivering the course content has become very vital. In addition, Design Thinking methodology is quite critical to inculcate in the minds of students at first year level, thus active learning techniques were designed strategically and communicated during the commencement of semester (refer Table II). Table III represents the list of Active learning strategies conducted and their mapping with Entrepreneurial attributes like creative thinking and problem-solving skills, communication skills, team building etc.

TABLE III
MAPPING OF ACTIVE LEARNING STRATEGIES WITH ENTREPRENEURIAL ATTRIBUTES

Sr. No.	Activity	Creative thinking and problem-solving skills	Communication skills	Team building
1	Discussion forum on MOODLE	√	√	
2	Newspaper cutout		√	
3	Preparation of Business Model Canvas	√		√
4	Storyboard and prototype presentation	√	√	√

Above listed activities are discussed in the upcoming sections.

1) *Discussion forum on MOODLE*

Discussion forums were initiated on MOODLE in which typical statements or questions were uploaded. These questions helped to build cognitive thinking ability of the students. This activity was conducted every week throughout the semester. The discussions were related to the points covered during the lecture. The active participation of students in forums was assessed based on two parameters viz; Cognitive thinking ability which develops problem solving skills and writing skills which impact communication. Fig. 9 shows active participation of students in MOODLE discussion forums.

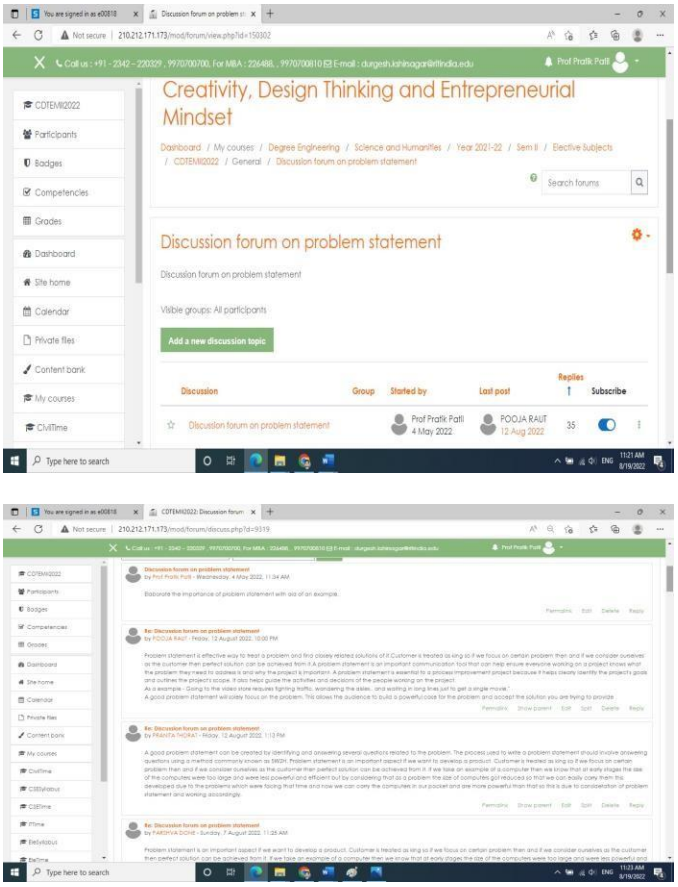


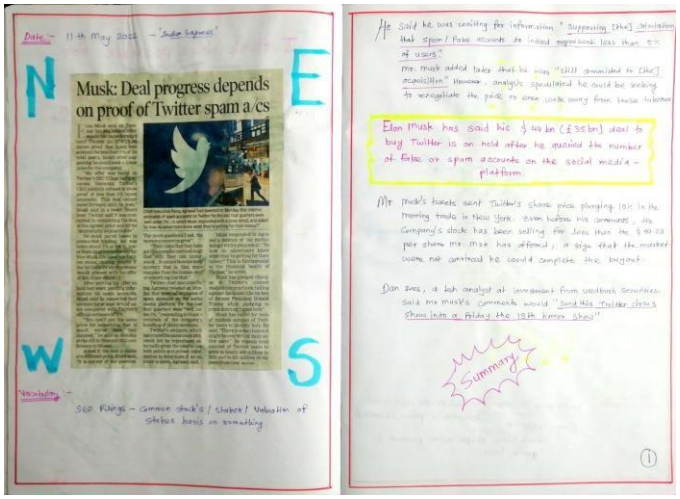
Fig. 9. Students' active participation in MOODLE discussion forums

2) *Newspaper cutout*

In Entrepreneurship, communication skill is very crucial because entrepreneurs are required to interact with society,

funding agencies, financial institutions, users, customers, employees, workers and many other stakeholders. In this course an attempt was made to help students in building vocabulary and writing skills which may enhance their communication abilities. The activity was assessed on the basis of grammatical correctness and level of interpretation reflected in the summary of news. The details of the activity are explained below:

- Name of the activity: Newspaper cutout
- Instructions:
- Select one news per week from English Newspaper like Business Standard, The Indian Express etc.
- Selected news should be related to economics, business or products/services.
- Read the news carefully, understand the meaning and write the summary of news in your own words.
- Write difficult words and their meaning
- Paste the news cutout on left side of page.
- Weekly one news should be worked out.



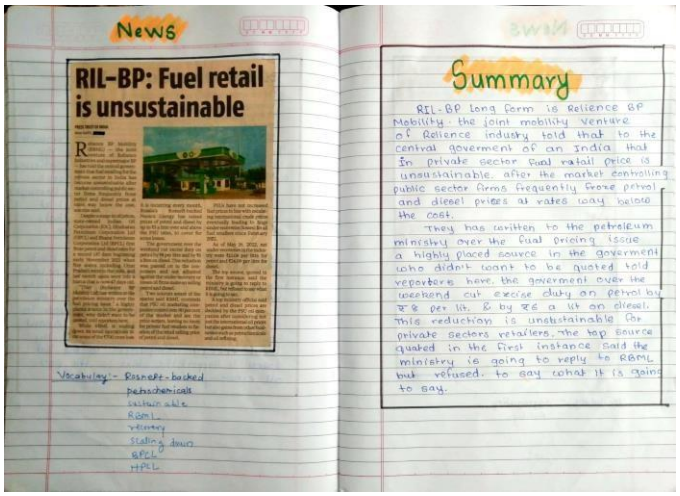
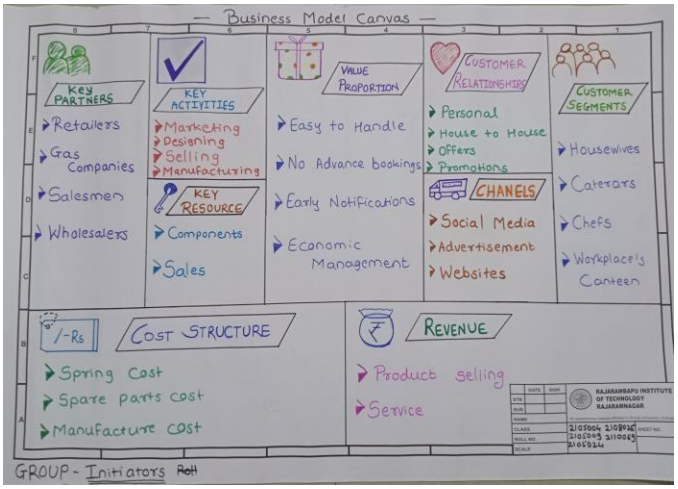


Fig. 10. Photographs of student's activity book representing newspaper cutout and summary.

3) Preparation of Business Model Canvas

A strategic management tool for creating new business models and cataloguing current ones is the business model canvas. It offers a visual chart with elements describing a firm's or product's value proposition, infrastructure, customers, and finances, assisting businesses to align their activities by illustrating potential trade-offs. The nine "building blocks" of the business model design template that came to be called the Business Model Canvas were initially proposed in 2005. This activity was conducted after 7th week, wherein teams were told to prepare canvas of their proposed business as per the standard template. This canvas helped the teams to understand their stakeholders, business revenue models, value propositions etc. This would also help students to improve their family business. The prepared canvases were assessed as a part of ISE. Fig. 11 shows sample photographs of Business model canvas prepared by the students.



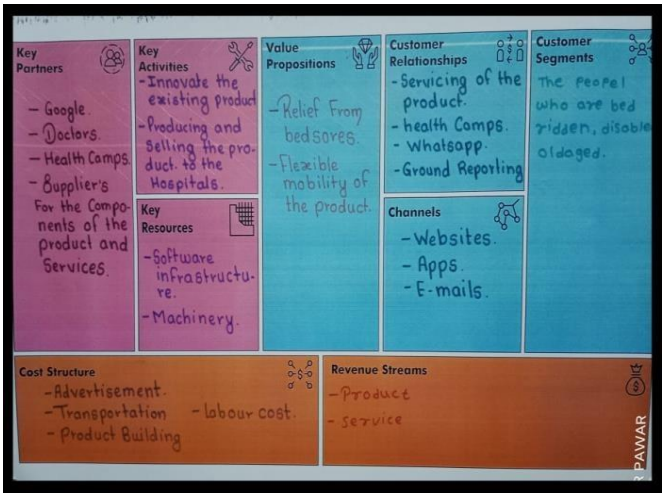


Fig. 11. Business Model Canvas prepared by the teams.

III. RESULTS AND DISCUSSIONS

The above course has been implemented in the curriculum since the academic year 2018-19 for the first year Engineering students. As stated in the Introduction section, CBCS was implemented in the year 2017-18, however final year ED track students were having some lacunas which were addressed in this course. A storyboard and prototype presentation event was organized during the semester end and was evaluated for 100 marks on the basis of rubrics presented in Fig. 13. Some sample prototypes and storyboards are depicted in Fig. 12. A storyboard is a graphic tool that comprises of pictures or

photographs displayed in sequence for the purpose of pre-visualizing a particular process. Teams were taught to prepare the storyboard representing the whole process right from problem selection to prototype building and were informed to present the same during prototype presentation program.

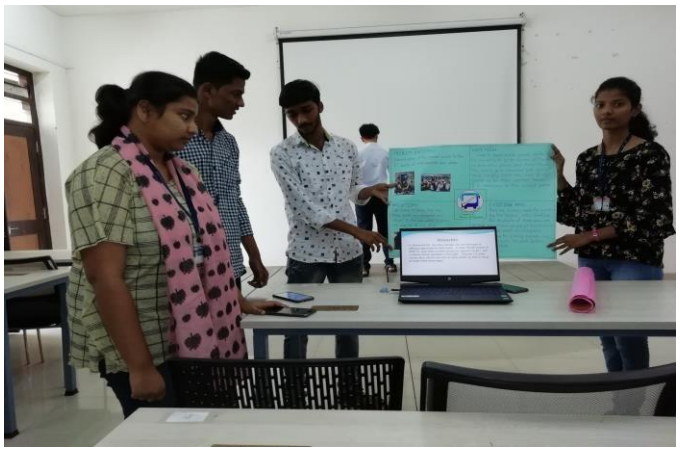


Fig. 12. a. Team Presentation
b. Prototype demonstration
c. Storyboard presentation

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Prototype Evaluation Rubrics

Name of Student: _____ PRN: _____ Branch: _____

Project Title: _____

	Criteria	Excellent	Good	Fair	Poor
		4	3	2	1
A	**Identification of Product Application Relevant cases**	Suggestions have made good quality and can be widely applied	The quality is appropriate but relevant in specific cases.	It is relevant in specific cases.	Suggestions have not been forth coming.
B	**Evaluating the real-life scenario where new method crops up**	A broad evaluation has been carried out to high detail level	Number of evaluations is carried out to appropriate level	A brief assessment is carried out at low level	It has not been evaluated
C	**Creativity**	Meets or Exceeds Highest Expectations Completed after this product	Above Expectations Completed business plan but didn't add any advertisement.	Meets Expectations met most requirements of product without advertisement.	Does not meet expectations
D	**Marketing Analysis**	Meets or Exceeds Highest Expectations	Above Expectations	Meets Expectations Missing most content	Does not need expectations
	Identify Market Segments Customer and Competitor Analysis	Completed all content for this area.	Completed most content.		Missed entire page
E	**Marketing Plan Product, Price, Place, Promotion**	Meets or Exceeds Highest Expectations Completed all content for this area.	Above Expectations Completed most content.	Meets Expectations Missing most content	Does not meet expectations Missed entire page.
F	**Financial Plan Start-up Costs Estimated Sales & Profits**	Meets or Exceeds Highest Expectations Completed all content for this area.	Above Expectations Completed most content.	Meets Expectations Missing most content	Does not meet expectations Missed entire page.
G	**Report Mechanics Clear, concise with logical sequence of**	Met all requirements of report mechanics.	Met most requirements of report mechanics	Did not meet most of requirements of report mechanics	Did not meet any requirements of report mechanics.
H	**Information. Check spelling, grammar, capitalization, punctuation and sentence structure.**	Met all requirements of report mechanics.	Met most requirements of report mechanics	Did not meet most of requirements of report mechanics	Did not meet any requirements of report mechanics.
I	**Oral Presentation**	Interesting, well- rehearsed with smooth delivery that holds audience attention.	Relatively interesting, rehearsed with a fairly smooth delivery that usually holds audience attention.	Delivery not smooth, but able to hold audience attention most of the time.	Delivery not smooth and audience attention lost.

Fig. 13. Prototype Evaluation Rubrics

Fig. 14 illustrates the statistics of number of prototypes developed since 2018-19. Initially during the year 2018-19, the number of prototypes developed was minimal since active learning techniques were not implemented effectively. Moreover, during the later years design thinking methodology was explained based on real life case studies which helped students a lot. Then the number of prototypes increased by 75.0 % and thus 7 prototypes were developed in the year 2019-20. Further in 2020-21, the number rose to 12 i.e was increased by by 71.4 %. Last academic year ended with 15 prototypes; thus, the number was increased by 25%. In a nutshell, there was constant rise in number of prototypes (increased by 275 % from 2018-19 to 2021-22) which clearly illustrates progress in students understanding level since 2018-19.

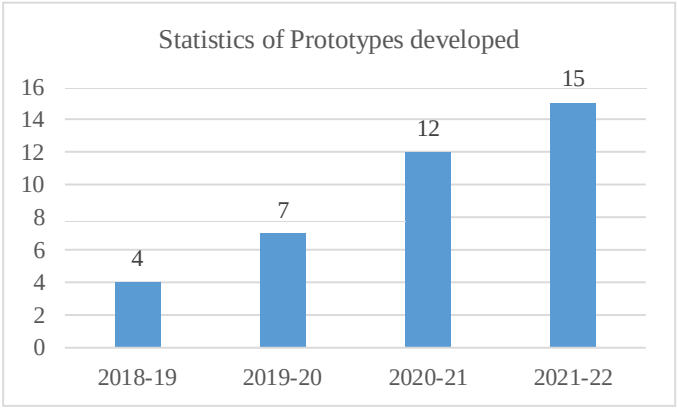

Fig. 14. Statistics of prototypes developed from the year 2018-19 to 2021-22.

The above implemented course consists of four CO's which were analyzed and attainment was calculated with the help of commercial software IONCUDOS. Year wise (2018-19 to 2021-22) CO attainment is depicted in the statistics shown in fig. 15. It implies that, CO1 was attained at the level of 62 % during 2018-19 and has increased to 69.5 in 2019-20, 75.5 % in 2020-21 and 85 % in the year 2021-22. There was rise of 37.09 % in the attainment level of CO1 during the years which can be attributed to discussion forums created on MOODLE, Business model canvas and prototype development and presentation. CO2 attainment level was 61 % in 2018-19, which gradually increased to 71 % in 2019-20, 75.5 % in 2020-21 and 90 % in the latest year. Hence it clearly indicates rise of 47.54 % in the attainment level of CO2 which was due to Design Thinking cases discussed during the course and implementation of design thinking methodology for student's project. CO3 attainment level was 67 % in 2018-19, which gradually increased to 73 % in 2019-20, 76 % in 2020-21 and 94 % in 2021-22. It plainly shows growth of 40.30 % in the attainment level of CO3 which may be due to understanding the market need from various case studies and prototype development. CO4 attainment level was 69 % in 2018-19, which gradually increased to 75 % in 2019-20, 77 % in 2020-21 and 89 % in 2021-22. It purely exhibits progress of 28.98 % in the attainment level of CO4 which can be ascribed to all the activities like MOODLE discussions, newspaper cutout, business model canvas and prototype presentation which contributed in developing entrepreneurial mindset of students. Therefore, it can be concluded that over the years each CO attainment has improved due to the implementation of Design thinking methodology and use of active learning tools and techniques during the course delivery.

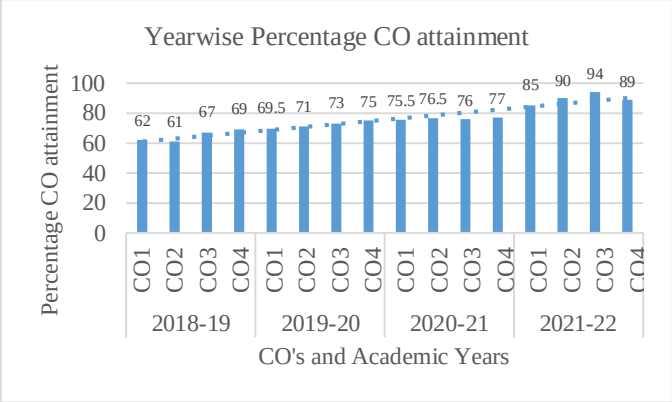

Fig. 15. Year wise Percentage CO Attainment

As stated earlier, this course was implemented for the first time in the year 2018-19, thus 2021-22 final year ED track students were the first who have undergone this course during their first year in 2018-19. Therefore, we found it very relevant to compare the statistics of final year ED track of academic years 2020-21 and 2021-22. Fig. 16 represents total number of final year students admitted to the ED track and the number of startups established during the years 2020-21 and 2021-22. It can be seen that 25 students entered ED track during the year 2020-21, out of which 6 students (24 % students) converted their ideas into startups, while during the year 2021-22, 28 students opted for ED track, from which 13 (46.4 % students) established their startups. Thus, it can be resolved that conversion of idea into startups has been increased from 24 % to 46.4 % during the year 2021-22, which must be attributed to the implementation of experiential learning based first year foundation course Creativity, Design Thinking and Entrepreneurial Mindset.

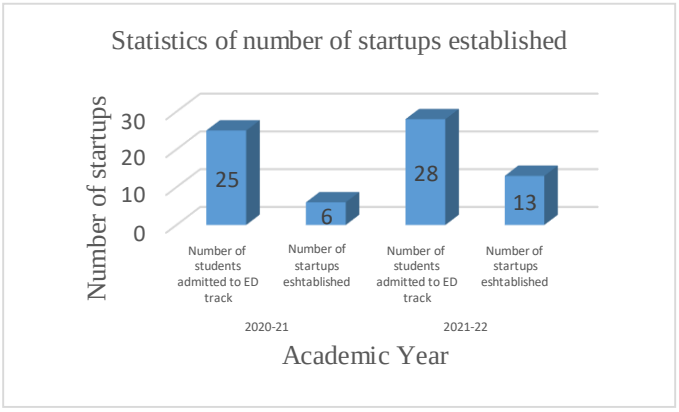

Fig. 16. Statistics of number of startups established

A survey of final year ED track mentors was performed for the two consecutive years i.e 2020-21 and 2021-22 to gather information about students' entrepreneurial knowledge and abilities, attitudes toward entrepreneurship as a career option, and student's entrepreneurial self-efficacy (Duval-Couetil, Reed-Rhoads & Haghighi, 2010). Table IV presents the survey question contents for each survey parameter. Survey responses given by the ED track mentors after examining students are presented in Fig. 17 to 22.

TABLE IV
SURVEY DETAILS

Sr. No.	Survey parameter	Survey content
1	Students' entrepreneurial knowledge and abilities	Creative thinking and problem-solving skills, Marketing skills, technical ability etc.
2	Students' attitudes toward entrepreneurship as a career option	Moto behind starting a business
3	Student's entrepreneurial self-efficacy	Confidence level in starting own venture, self-finance, family support etc.

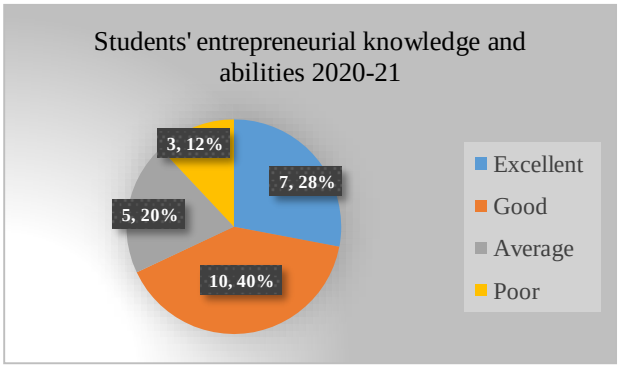

Fig. 17. Students' entrepreneurial knowledge and abilities 2020-21.

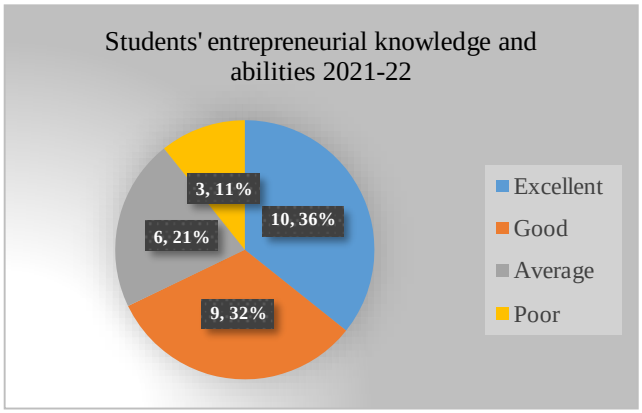

Fig. 18. Students' entrepreneurial knowledge and abilities 2021-22.

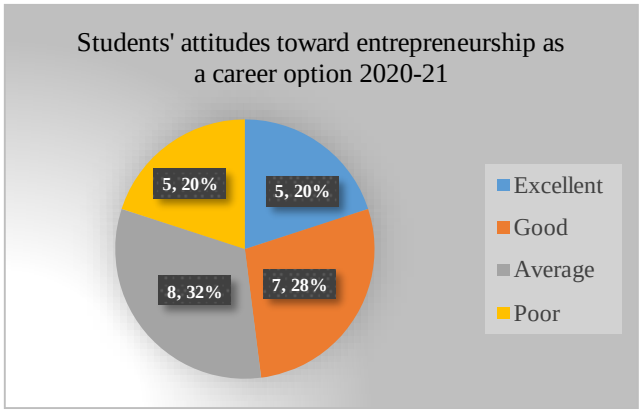

Fig. 19. Students' attitudes toward entrepreneurship as a career option 2020-21.

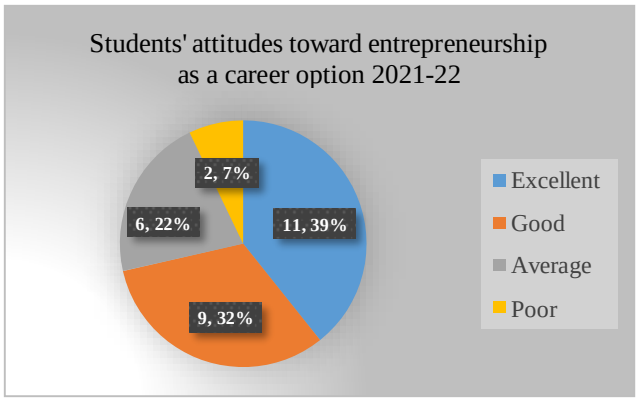

Fig. 20. Students' attitudes toward entrepreneurship as a career option 2021-22.

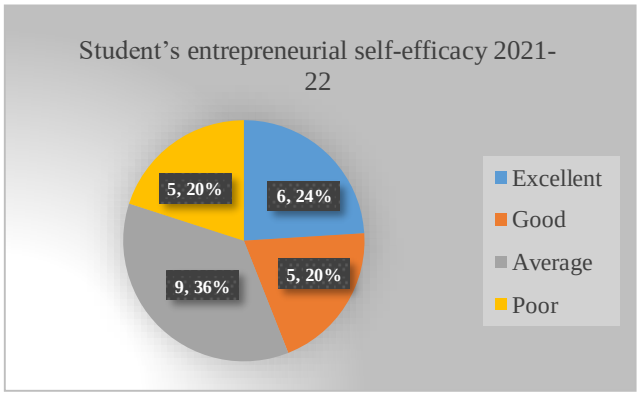

Fig. 21. Student's entrepreneurial self-efficacy 2020-21.

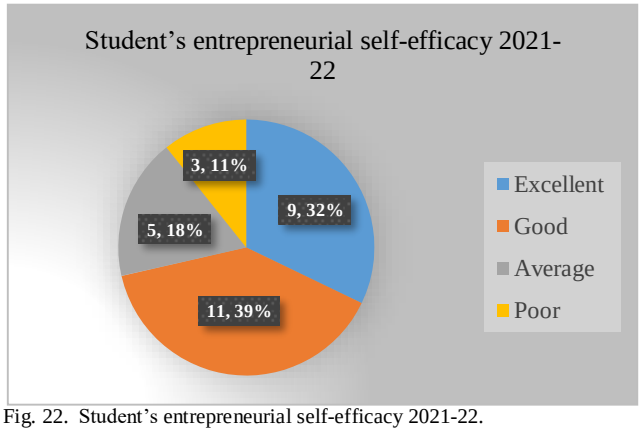

Fig. 22. Student's entrepreneurial self-efficacy 2021-22.

In the year 2020-21, regarding entrepreneurial knowledge and abilities, 28 % students were in the excellent category which has increased to 36 % in 2021-22. Thus, it is clear that introduction of aforementioned course in first year has improved students' problem solving and creative thinking abilities. In addition, it has contributed in improving entrepreneurial skills required for the students. From the fig. 19 and 20 it is clear that, students' attitude towards starting entrepreneurship has been changed and thus the statistics reveals that number of students in excellent category has moved from 20 % to 39 %. Students are more precisely focusing on the pain points of the user or customer and thus they are engaged in societal problems which seems that they are interested to choose entrepreneurship as the career option. Similarly, students' entrepreneurial efficacy has been improved, percentage of students from excellent category has been shifted from 24 % to 32 %. ED track students seemed to be more confident in taking decision about new venture development, fund raising etc.

IV. CONCLUSION

RIT Rajaramnagar has implemented choice-based curriculum system (CBCS) since 2017-18. It was observed that final year ED track students were facing some hurdles in achieving the ultimate objective of the track i.e., to establish a startup. This laid to the formation of foundation course for first year students 'Creativity, Design Thinking and Entrepreneurial Mindset'. The course majorly focuses on Design Thinking methodology which is very crucial part of entrepreneurship. Course delivery was systematically and strategically planned along with ISE modes and active learning techniques. MOODLE discussion forum, newspaper cutout activity, preparation of business model canvas, storyboard and prototype preparation and their presentation were the prominent experiential learning activities conducted to make the course hands-on. The active learning tools and techniques implemented in this course have improved CO attainment significantly from 2018-19 to 2021-22. In addition, number of startups developed by the first-year students have increased by 275 % through the years 2018-19 to 2021-22. Moreover, this course has significantly benefitted the final year ED track students of 2021-22 batch in terms of

following:

- In 2020-21, 25 students opted for final year ED track, from which 6 students (24 %) established their startup. Whereas in 2021-22, 13 startups (46.4 %) were formed out of 28 students.
- ED track mentors survey was conducted for the years 2020-21 and 2021-22 on the selected survey parameters namely; Students' entrepreneurial knowledge and abilities, Students' attitudes toward entrepreneurship as a career option and Students' entrepreneurial self-efficacy.
- According to the survey results, in 2020-21 the percentage of students in excellent category for the parameter Students' entrepreneurial knowledge and abilities was 28%, which has grown to 36 % in 2021-22.
- Students' attitudes towards entrepreneurship as a career option was elevated in 2021-22 which resulted into 39 % students in excellent category as compared to 20 % in 2020-21.
- Similarly, student's entrepreneurial efficacy was assessed, which showed 24 % students were in excellent category in 2020-21 which rose to 32 % in 2021-22.

ACKNOWLEDGMENT

We would like to express sincere thanks to management and faculties of RIT for their continuous support and motivation.

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