Peer-Mentoring in Design Projects in Project-Based Learning (PBL) at First-Year Engineering Course

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Abstract-The current wprk in progress paper discusses the peer mentoring program. This program provides dedicated mentoring support for first-year engineering students in Project-Based Learning (PBL) course titled "Engineering Exploration" at KLE Technological University, India. The course focuses both on the process and the output. In this course, students solve interdisciplinary design problems by following an engineering design process. They develop a mechatronic prototype as a solution to the given design problem. During the problem-solving process, the students face several challenges which generally begin during the concept design phase and increase exponentially during the physical implementation phase or prototype building phase.

Students generally work on their team-based projects after college hours in a dedicated prototyping area called the Thinkering lab. More than 275 interdisciplinary projects are done by over 1100 students every year. Fifteen faculty members and three instructors find it extremely challenging to cater to this huge demand, especially during the prototype building phase. Hence, students need a support system in tools and equipment, services, and mentoring to complete their design projects on time while attaining the intended learning outcomes. The peer mentoring program called Mentors In ThinkeRing lAb (MITRA), after conducting a pilot run in a semester, was introduced formally in 2017. In this paper, we present a well-developed, sophisticated, and methodical version of the program, its challenges, evaluation, and results. Here, we describe the peer mentoring program's process: call-for the program, induction, screening, immersive training and deployment of the mentors, program monitoring, and celebration of their success.

The program was evaluated by analyzing its impact on stakeholders: mentors, mentees, and faculty members. Five faculty members each with experience of more than three years in teaching engineering exploration course and seventeen mentors (sophomores, juniors, and seniors) were involved in the study. The data were analyzed using descriptive statistics and thematic analysis.

***Keywords*—peer mentoring, multidisciplinary design projects, thematic analysis.**

I. INTRODUCTION

New teaching pedagogies and recent innovative teaching practices in engineering education demand a change in student and faculty member responsibilities. In developing countries like India, the curriculum innovations pose new challenges in various implementations. These issues pose challenge not only to the administrators but also to its vital stakeholders: mentors, mentees, and faculty members.

Furthermore, if the curriculum innovations are brought in the first-year engineering courses, then there will be many new challenges to faculty members as the students are new to the college environment and may lack the basics required to comprehend the new changes. It is indeed vital to find solutions with the available resources.

The primary objective of engineers is finding solutions to real-world issues. Providing a solution may also include designing something new and innovative. To cater to this primary objective, engineering curriculum must develop the design skills of engineering students. To improve the designing skills and motivate students to explore various areas of engineering, it becomes inevitable to introduce immense changes in higher education and increase the diversity in the education culture [1]. In earlier times, when the curriculum was straightforward and homogenous, academic success and study completion were seen as the students' responsibilities. This generally made students to follow a set curriculum without being innovative. Thus it is important to bring innovative pedagogical practices into engineering course. The modern innovative pedagogical practices introduced in our course motivated students to think out-of-the-box, stay and work beyond college time with the help of faculty members.

A. Intoduction to the course

Engineering Exploration is one such innovative multi-disciplinary course offered for first-year engineering students at KLE Technological University, India. Every year more than 1100 students undergo this course and faculty members from various disciplines teach these students.

The course follows PBL pedagogy, where students are required to build physical prototypes to solve given design problems by following an engineering design process. The physical prototypes have three aspects: mechanical or fabrication, electronics, and programming.

As the course demands interdisciplinary knowledge and skills, it is challenging for faculty members to mentor the students in developing these prototypes. In this course, the content delivery and building the prototypes go hand in hand. This often requires faculty members to spend more time with students, and students will have to spend some extra time after college hours. Furthermore, students will need increased support and handholding during the physical implementation stage of their course project journey.

B. *Context of the study*

Thinkering lab is a dedicated facility in the campus designed for engineering exploration students to build their prototype. The lab is equipped with different tools such as tabletop milling machines, mini lathe machines, laser cutting machines, and tabletop grinding machines. These machines are helpful for mechanical fabrication work during the physical implementation stage. The first-year students do not know how to handle these machines. Thus, it becomes the responsibility of the faculty members to train students to operate these machines.

Generally, faculty members face difficulty in helping first-year students to operate all these machines in a scheduled lab time. Owing to other courses workload, it is also difficult for faculties to spend one-on-one time with every student/project to address every single issue.

Faculty intervention and availability at various stages of project are crucial for completion of project. However, faculty availability beyond college time is the biggest issue. Most of the projects fail because of the unavailability of just-in-time support by faculty which leads to students losing their motivation. Thus, the peer mentoring program, MITRA, was introduced in 2017 to address these issues. In this program, a few of 2nd year (sophomores), 3rd year (juniors), and 4th year (seniors) students are selected to be peer mentors. Moreover, these are students who have successfully completed the Engineering Exploration course.

In this initiative, mentors were recruited through initial screening and interviews. The recruited students are called MITRAs, and they mentor engineering exploration students during the prototype building phase (physical implementation phase) of the course project. They bring back their disciplinary knowledge and they have skills required to convert ideas into prototypes.

The course project has multi-dimensional aspects. Hence, mentoring also has multiple elements: Firstly to assist mentees to operate tools and machines, providing appropriate suggestion in selection of material required for the project, fabrication support, and testing and debugging support during the prototyping building phase. Most importantly, from this MITRA initiative mentees are getting timely help. The MITRA initiative directly brings about reciprocal relationship [4] where both mentees and mentors get benefited in the course duration.

II. MITRA PROCESS

The MITRA initiative has the following objectives: (1) To increase the feasibility of concepts during the concept design phase. (2) To utilize the disciplinary knowledge and skills of mentors during the physical implementation phase. (3) To ensure that first-year students follow standard operating procedures. (4) To provide just-in-time support in troubleshooting and debugging.

The process started with floating the flyer on social media platforms in the second week of the semester. Once students register for the MITRA program, a group of engineering exploration faculty members conduct an orientation program to convey the expectations out of MITRAs. It was then followed by interviews, where the final set of mentors are selected. Finally, the training session was organized for recruited students.

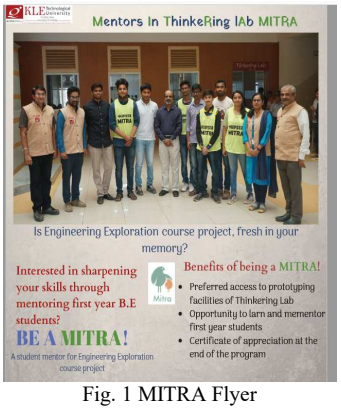

Fig. 1 MITRA Flyer

The recruited students are then called as MITRAs and work as mentors for first-year students for six weeks. Generally, 20 to 30 MITRAs are recruited for one semester. They assist first-year students by spending time in thinkering lab after the college timings between 5.30pm to 8.30pm. During their mentoring journey, MITRAs have to follow a set of rules and regulations. They are expected to do: (1) Observe safety and security of first-year students (mentees) in operating tools and equipment. (2) Help mentees in fabrication part. (3) Provide their support in operating tools, equipment, and machines. (4) Help mentees in error debugging. (5) Avoid involvement in mentees assessments.

MITRAs are required to attend the sessions regularly, report to work 10 minutes before, and stay until the end of the session. They have to be courteous to junior students and maintain respectable distance while mentoring. They are different from teaching assistants. At the end of the program, MITRAs are rewarded with a letter of appreciation and access to Thinkering lab facilities for their course project.

III. LITERATURE SURVEY

The literature review focuses on understanding mentoring and mentoring relationships, mentoring elements, and peer mentoring concepts.

A. *Mentoring and peer-mentoring*

Mentoring is a complex, interpersonal relationship in which a mentee seeks guidance, knowledge, thoughtful reflection, encouragement, and experiential counsel from a mentor. In mentoring, first-year students get to connect with their peers or seniors very quickly [2]. There are several definitions available. Mentorship professionals work together to support each other in personal and professional growth, development, and success by providing career and psychosocial support [9].

Peer mentoring is a helping or supporting relationship in which two individuals of a similar age group experience come together in achieving a common goal or fulfilling their requirements by helping each other, either informally or through formal mentoring programs[10].

There are theories and theoretical frameworks for mentorship. The traditional mentoring model allows peers to mentor people of less experience and cross-aged groups to complete tasks and solve task-related problems. Mentors are older than mentees in such mentoring models and have experienced the same phenomena by performing similar tasks [10].

Across the world, universities follow different strategies to assist students when they are new to the campus, especially for international students. Some universities follow the social mentoring programs that involve social organizations where senior students volunteer to help their juniors, making new students' early life in university easy, and help them adjust to the new place and new academic culture [2].

First-year students face a steep learning curve in their first two semesters as they are new to the campus and they are in a transition phase from their high school environment to the college environment [5]. New teachers, new atmosphere, new friends, an increased demand for self-learning, and whole new responsibilities bring stress.

Across the globe, new initiatives are taking place to support first-year students in this phase of their professional course journey. The drop out rate at the early stage of university life is very high [6][7]. Retaining students to continue their higher education studies is a challenge that has received attention from educational researchers in more recent times. Universities find new ways to help first-year students by providing supplementary instructions, peer mentoring, and social media platforms for offering help. In this phase, first-year students get connected with their peers or seniors quickly and hence peer mentoring helps achieve this goal [8][9].

The new innovative project-based learning pedagogies address the current 21st-century educational demands. In the engineering exploration course, such new innovative project-based learning pedagogies were implemented. It also demands extra commitments from faculty members; practically, it is challenging to cater to all such demands for such a large number of students. Thus, mentoring models address such issues.

B. Mentoring benfits to mentors and mentees

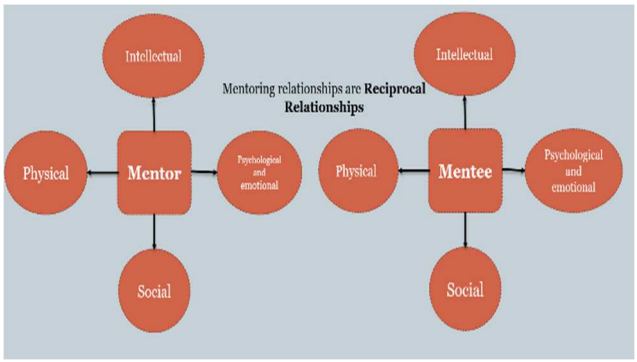

Fig. 2 Mentors and mentees benefits in different aspects[11]

The Fig. 2 summarizes the benefits of mentors and mentees in the mentoring process. The following are the benefits to mentors: 1) Increased self-esteem and confidence. 2) An increased set of technical knowledge and skills (an academic perspective). 3) Good social network inside and outside the campus. 4) Improved self-esteem by sharing appropriate knowledge with another peer 5) Better opportunities to interact with other peers. 6) Improved social competencies. In the same way, the mentees have benefits too:1) They have better opportunities for practicing new skills. 2) They have better interactions with experienced individuals of different background. 3) Development of emotional support and friendship by learning new skills with a trusted friend/peer [11].

IV. METHODOLOGY

The MITRA initiative has brought a lot of benefits to mentors, mentees, faculty members, and to the course itself. This new innovative practice has opened different dimensions of thinking.

A. Sampling and Data collection

The evaluation of the study is still going on. The current paper gives light on the new innovative practice carried in a project-based multi-disciplinary course. In this paper, we provide insights into the impacts on one of the crucial stakeholder - mentees.

Table. 1 Journey of MIRA initiative

Year	No. of MITRAs	Disciplines
2017-18 Odd (pilot run)	5	CS, EC and Mechanical
2017-18 Even	17	CS, EC, Civil and Mechanical
2018-19 Odd	15	CS, EC, Civil and Mechanical
2018-19 Even	28	CS, EC, Civil and Mechanical
2019-20 Odd	28	CS, EC, Civil and Mechanical

Table 1 shows the count of mentors from its pilot run. The initiative started from the 2017 fall semester (even semester) to the 2019 summer semester (odd semester). The mentors and mentees have maximum interaction during the mentoring process. The survey data regarding the quality and experience of MITRA initiative were collected from mentors and mentees for data analysis during this period.

The qualitative and quantitative research methods were followed for data analysis. For mentors and faculty members, a qualitative research method was followed. The quantitative research method was followed for mentees. The Focus Group Discussion (FGD) was conducted after every semester for MITRAs. After every session, MITRAs post their experiences. These posts were consolidated and discussed during the FGD.

More than 20 MITRAs participated in the FGD every semester. For mentees, a survey was conducted using Google forms. Out of over a 1100 students, 550 first-year students (mentees) responded to it. The responses so collected are analysed and discussed in this paper in brief. The feedback from mentees and mentors helped in improvising the MITRA program.

The purposive sampling was done to select mentors for interviews. *Mentors* having experience mentoring at least for two semesters were selected for interviews to study the advantages of peer mentoring programs in-depth. The data collected from mentors in the interview was used in thematic analysis. The results and outcome of the analysis will be presented in a comprehensive study.

V. RESULTS AND DISCUSSION

This section discusses on mentees perspectives. The survey was conducted for the mentees. And following graphs show mentees' feedback on mentoring in the physical implementation phase of their course project. Figure 3 shows 93% of mentors were available and helped mentees.

They were willing to take help from mentors to complete their course projects, fig. 4 shows 98% of mentees were aware of the MITRA initiative.

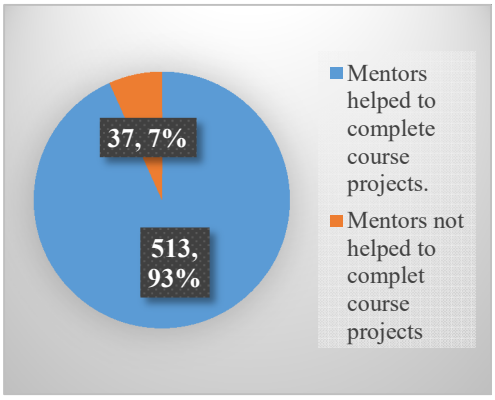

Fig. 3 Mentees response on mentors' help

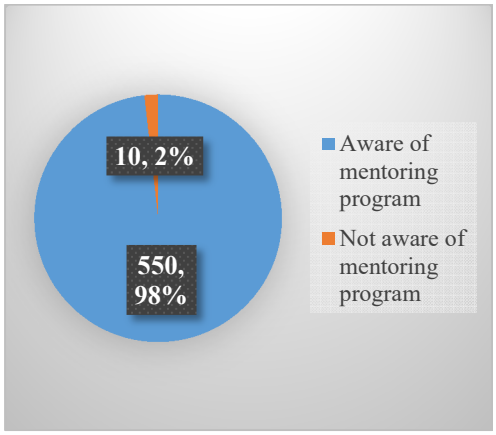

Fig. 4 Mentees' awareness on the mentoring program

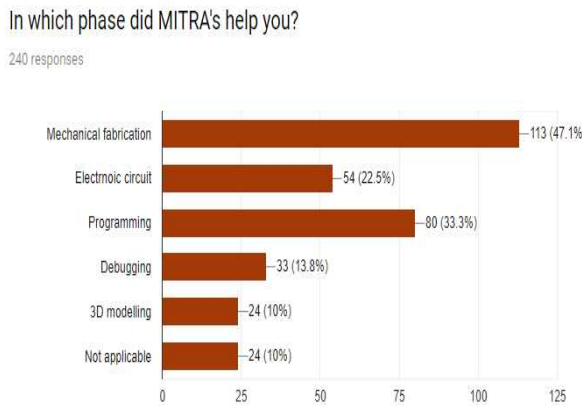

Fig. 5 Mentees response on type of support offered by mentors

Fig. 5, 6 and 7 shows mentors were helping first-year students in mechanical fabrication work. Physical prototyping is very challenging for mentees as they are first-year students, the exposure to such machines is minimal. As mentors bring their disciplinary knowledge during the mentoring process. It addresses most of the mentee's issues like operating machines, programming, and debugging errors.

The insight from the analysis of figure 5, 6 and 7 is that all the teams may not need help in all the phases, that is the reason we have some surprising result, around 10% of students have said they didnt take any help, around 14% of students have had debuggin and 3D modelling support from figure 5, similarly around 25% rated between 0-2 scale from figure 6.To study the in depth understanding of benefits to mentees, a mixed methodology of qualitative followed by quantitative will be used to arrive at the results.

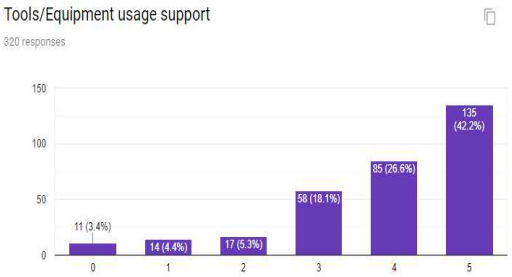

Fig. 6 Mentees rating on the scale of 5 for tools and equipment usage support

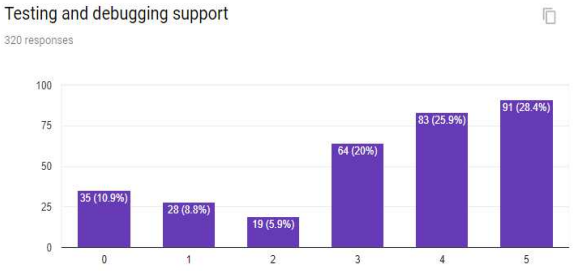

Fig.7 Mentees rating on the scale of 5, in testing and debugging support.

CONCLUSION

Mentoring Process enables learning in both mentors and mentees; mentors learn new mechanisms, which could be helpful for their higher semester projects. They understand how to work with different tools and equipment and discover new electrical and mechanical components. The mentoring process builds a better rapport between mentors and mentees. The current paper focuses more on benefits for mentees and in terms of course project. Apart from a technical perspective, there are many more intellectual benefits that mentors can acquire in mentoring.The further study of the same. emphasizes understanding mentors' benefits in terms of emotional intelligence and leadership skills development.

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