Strategies for Engineering Pedagogy to Improve Peer-based & Autonomous-learning through Technical Student Clubs

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Abstract— As the pace of technology development and its applications for industry increases, the knowledge gap between academic curriculum and industry-readiness of technical school graduates also increases. Since a professor can only focus on a limited number of topics in a classroom environment, peer learning can significantly increase the knowledge covered. We have identified several shortcomings in the traditional paradigm of teaching methodology and propose in this paper a cyclical autonomous learning-based methodology that aims to overcome these shortcomings. Autonomous learning in the context of our research refers to a situation where learners take charge of their learning and are responsible for all the decision-making for the progression of the skill they want to acquire. The proposed methodology is a feedback-based student-industry led model that reviews and rectifies itself based on the present needs and requirements. This study explores this methodology which identifies the vital points required to develop student-based technical clubs and leveraging industry-based student initiatives to boost autonomous learning, which will help its members prepare for their careers and gain industry-relevant knowledge. Upon implementing the same vital points, we found a statistically significant increase of 800% in the gained industry-relevant knowledge of the club members, characterized by the dramatic increase in scholarships given by industry leaders, achieved by the club members. The study also found that the proposed methodology is also more effective and cogent than the traditional methods in engaging the students, which was clearly evinced by an 88.89% increase in average attendance. We also found a marked increase in overall ratings, from 8.6 to 9.2, using the proposed methodology. The study thus offers promising results in decreasing the knowledge gap, based on which institutions may be exhorted to adopt the proposed methodology for preparing industry-ready graduates.

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1. Introduction

The growth of the needs of a human has molded the economy, sciences, and society. These three factors combined contribute to a student's learning curriculum. Industries and conglomerates adjust to the needs of consumers by rapidly diversifying their products using various kinds of technologies.

The applications in industries are made according to the consumer; rapid changes in the tech stack of such applications occur to cater to changing consumer needs and reduce development overhead. Upgrades are performed to meet consumer needs so that rapids changes may cause an increase in the tech stack of a company. An employment aspirant to such companies must stay updated with these tech stacks and concepts. One institution of graduate training has to follow a strict generalized structure of learning that strives to meet the needs of a wide variety of students across all the foundational aspects of the subjects while being mindful about introducing some of the niche aspects.

The inherent goal of the academic curriculum is to be balanced in all aspects, which in itself is an immense effort; Hnich et al. [3] describe the problems and constraints that occur while proposing a solution for modeling a balanced curriculum. Such parameters make it very difficult for the academic curriculum to adapt to the fast-paced growth in industry demands and requirements. Due to differences in the pace of transformation in organization charter, industries and academia will always sustain a gap of application-level knowledge in students.

In this work, we propose a club augmented by peer-learning and autonomous-learning-based flip-classroom model. The club relies upon its rudimentary entities - the domain lead and mentors, to create an atmosphere that inspires upskilling through a series of industry-prescribed sessions for gaining in-depth dexterity and proactive project development mentorship parallelly spanning across multiple domains of emerging technologies. The entity domain lead in this framework is a student with close ties to the industry in student developer ambassador programs like Google Developer Groups, Google ExploreML, Intel Student Innovator, Microsoft student program, Nvidia DLI Ambassador, AWS Educate, etc. having access to industry resources and best practices with the responsibility of advocating them. This entity promotes these among the club members through boot camp-fashioned/styled semester-long seminars and expounds these concepts practically using industry-provided resources to teach the latest practices. The entity mentor here is a peer experienced in project development or research who proactively guides the assigned mentee students in areas of interest. The mentor, through his experience, suggests the mentee in their quests to win hackathons, write research papers, win scholarships and get industry-ready. They also establish an environment that inspires others to gather technical acumen proactively.

Through extensive experimentation, we establish that our proposed club is a robust framework for colleges bearing tier 2 and lower status that lack computational or industry resources, motivated students, and affiliated to universities whose curriculum cannot keep up with the rapidly changing demands of the industry. In later sections, we shall elaborate more about the gap mentioned above and propound our proposed system as a framework to alleviate it effectively.

2. Identification of issues

2.1 The gap between industries and academia

a) Difference between the pace of progress in Academia and Industry

As a project progresses, the demand of consumers of a company changes. This triggers rapid changes in the skillset of the human resources of the company. To mimic this effect in academia, many factors concerning changes in the curriculum have to decide. Due to the difference in decision-making processes of the industry and academia, the aforementioned 'gap' arises. Sen, Souvik. et al. [4]

b) Development and viability of a technology.

When we study Gartner's Hype Cycle [1][2], by analysis of the difference in cycles for two years, we understand that there is a low chance that the technologies which are currently in the development phase will have a stagnant rate of growth and produce a significant effect in the future.
Upon closer perusal of the same, it can be observed that emerging technologies are highly variable and constantly changing. Thus their adaption to the academic curriculum in real-time is not a practical solution to bridge the gap.

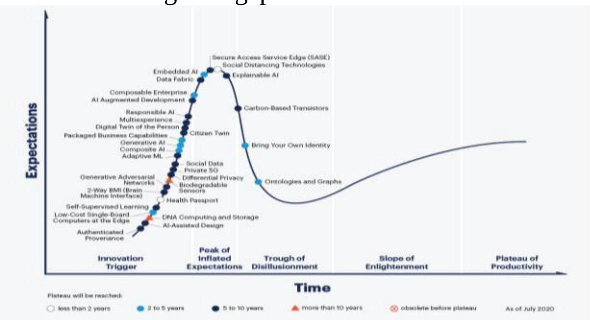

Fig 1. Gartner's Hype Cycle for Emerging Tech 2020 [1]

As an observation, a massive spike in interest in 3D Printing Technology was taken into account at many institutions. The hype chart shows that its impact on the industry was not as expected due to the technology's un-feasibility. Huge losses for institutions saw a fall in admission rate and loss for financial investment. So while doing a careful analysis and waiting for the trend of technology to be stagnant, the institute will miss out on the experience in the trending technology.

c) Large number of technologies to be covered.

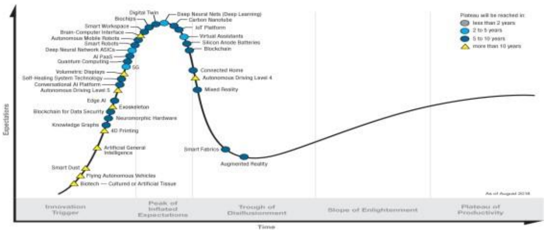

Fig 2. Gartner's Hype Cycle for Emerging Tech 2018 [2]

When we study Gartner's Hype Cycle [1][2], By analysis, we see a large number of technologies that are being developed for a particular field of technology, namely in the Information Technology sector.

Considering an institution has limited financial funding that cannot support investment in many technologies and their dependencies. Many subjects will have to be covered to mitigate this since any academic institution runs on limited funds and human resources. (e.g., only 3 4 students will be present for a specific course). This causes a drift in the knowledge of academic personnel in the ongoing trend of technology.

d) Limited Human Resource

This gap might not only arise from the quality of learning services available to students. The reasons can also be due to the number of technologies covered. Because of innovation and market growth, we see the fast development of emerging technologies. Because of this, a human resource that can teach the emerging technologies will be scarce.

Since the above problems occur, the definition of industry-ready technical graduates gets ambiguous as soon as it is defined.

2.2 Shortcomings of existing solutions

a) Expert Sessions and Workshops

One of the popular solutions employed at multiple institutions is expert sessions to bridge the gap, as mentioned earlier. Expert sessions are where a technical expert, having considerable skill in the requisite field, is invited to instruct/train students on the aforementioned field; Momirski et al. [5]
The industry expert then delivers a session on a particular topic, often only introducing time constraints. However, in our study, we found that such a format is not ideal in improving student skills and bridging the gap. Expert sessions, as mentioned earlier, are often introductory and hence lack depth in their contents to deliver independently any usable value.

Moreover, colleges of tier 3 category lack the financial capacity to invite experts all year round to conduct a series of in-depth sessions. The low student participation and their per session rating of these sessions also revealed that a better system is needed.

b) Training the existing staff in the institute

As new technologies are developed, teachers will have to manage their work targets and dedicate much time to learning. This might not be possible for some due to already being under pressure from the existing workload.

3. Literature Survey

Formulation of an efficient study routine will require various kinds of learning practices and tools, and technology.

Student clubs have gained traction over the years and are crucial for any institution as they can radically improve students' motivation to improve on their niche aspects. It has been observed that students who are actively involved in clubs tend to perform more in their future professional careers; Foubert Lauren et al. [6]

Students of an institution who are employed or in a non-residential program have been compelled to have lower attendance. These students also have decreased over time involvement in academic/institutional activities. In these scenarios, when clubs are formed, an increase in student involvement and perseverance was observed; Tinto. et al. [7]

Teamwork, group projects, and collaborative learning encourage students to learn from both the other students and the teacher. Peer learning can include collaborating, communicating, and giving and receiving peer feedback. Additionally, peer learning emphasizes the exchange of knowledge and ideas among students in a mutual partnership; Keppell et al. [8]

Personal development, community establishment, Interdependence, Felicitation, Boundary Management, and resource allocation are considered the most basic peer learning system principles. It also emphasizes the need to have a dedicated goal-driven group of students required to manage the peer system. Hierarchy also works in the group system, given that responsibilities are mutually exclusive and regular audits are conducted; Tosey et al. [9]

In terms of pedagogical practices, the peer learning system indicates a significant positive change in the psychological well-being of its participants, and it also helps in personal growth, environmental mastery, and autonomy; Hanson et al. [10]

Autonomous learning in the context of our research refers to a situation where learners take charge of their learning and are responsible for all the decision-making for the progression of the skill they want to acquire. Here, the resources/facilitation is primarily done by the learner. This kind of system is mainly self-directed and self-assessed.

Autonomous learning skill has been highly correlated with success rate in professional careers.; Cao Y. et al. [11].

Autonomous learning techniques have been able to cope with the fast pace of new trends in the industry. It has also been correlated with an increase in confidence of students (mainly freshman) and overall satisfaction of learning, as the student is independent for his/her pace of learning; Macaskill et al. [12]

Flipped classroom model has been rapidly adopted because of its convenience for teachers and students. One drawback is that though highly motivated and self-learning students are a basic necessity for optimum performance of the system. on the contrary, it is easy to deploy and customize for one's own need will help in better; Bishop et al. [13]

The asynchronous nature of the flipped classroom model helps students accommodate their time for the club and their academic commitments. Holistic education is a widely used technique that emphasizes concentrating the 'wholeness' of a student's learning. Its primary focus is on developing physical, intellectual, emotional, social, spiritual, and aesthetic. These aspects help in boosting the confidence of the students and improve performance in the long run; Mahmoudi et al. [14] Peer-based mentoring systems will help to accommodate the specific needs of students. Peer mentoring systems have been known for increasing communication between students and increasing students' performance. Students show significantly higher results in mentoring activities; Rodger S et al. [15]

4. Proposed System

Our proposed system aims to alleviate these shortcomings mentioned in section 2 by introducing a peer and autonomous learning-based technical student club.

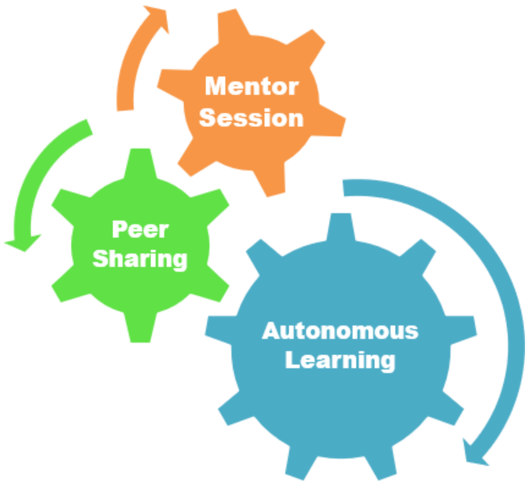

fig. 3 Basic principles of the club

The proposed solution delineates a holistic framework for a club that guides its members toward holistic and better professional careers through active peer learning and a student-centric flipped classroom model.

4.1 Domains of the technical club

The Club will promote core technologies education and provide various learning skills for students in the organization. Students will be given plenty of golden opportunities to realize their talents. Moreover, the club aims to teach them how to appreciate emerging technology and its techniques and help students attain a better mastery of it.

The proposed club is set to be headed by a faculty in charge and divided into domains, where every domain lead can act independently compared to the decisions constrained to their field solely. Domains are decided by current popular realizable emerging technology in the industry and will be highly adaptable as per the changing trends. Domains can be dynamic and changeable at the end of each academic year.

The proposed domains are:

1. Artificial Intelligence / DL / ML
2. Cloud Computing & Distributed Linux Systems
3. App development
4. Web development
5. DSA/ Competitive Coding / CoreCS

Each year new domains (e.g., AR-VR, IoT-i, Robotics) can be added for the year at the discretion of the faculty in charges, and the outgoing domain leads if they were to encounter some meritorious students having mastery in their respective domain and being capable of leading and galvanizing others in the community.

4.2 Hierarchical structure of the club

The rudimentary hierarchy in each domain is proposed to consist of the following, defined subsequently later, entities,

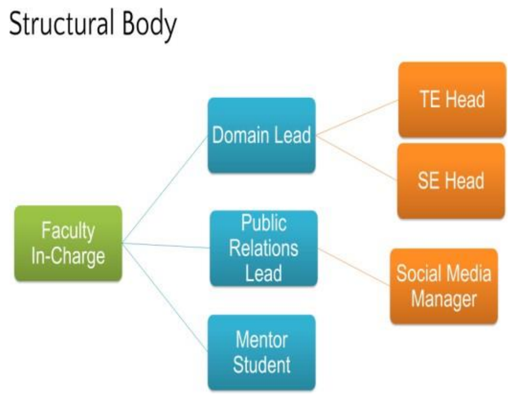

fig.4 Structure of Organizing body of the club

- Domain Lead (1 Position per Domain)
- TE head volunteer (1 Position per domain)
- SE Head volunteer (1 Position per domain)

and other bodies for the club overall:

- Faculty In-Charge (2 Positions)
- Public Relations Team & Creative (2 Positions at Club Level)
- Mentor - Mentees

This structure will be guaranteeing an optimal arrangement that delegates appropriate responsibilities in a manner that keeps the focus on upskilling constantly.

4.3 Key responsibilities in the organising positions

4.3.1 Domain Lead

A domain lead is any student the outgoing leaders and faculty in charge consider to be of proficient skill in their domain while also possessing the ability to teach the student participants the same. A domain lead may be a student of any year whatsoever, and preferential treatment may be given in the appointment of the same to the student ambassadors/ representatives of industry/academia giants leading in the domain, as mentioned earlier. The responsibilities of a domain lead may primarily consist of, but are not restricted to, organizing seminars/workshops/projects/research in the community and disseminating information about other good practices and opportunities in the domain. The activities conducted by the domain lead will be expected to impart fundamental yet in-depth practical knowledge about the domain at the very minimum.

A domain lead must be proactive enough to plan activities that incrementally increase theoretical and practical knowledge throughout the year. Thus, a domain lead must necessarily be someone of considerable technical expertise in the domain, which may be demonstrated by their GitHub repositories, blogs, articles, publications, LinkedIn profiles, resumes, or video lectures. A domain lead may not be a part of the core team of other institutional committees and organize at least two events a month with in-house or outhouse speakers/experts, not considering the months with IAT, submissions, etc.

4.3.2 TE Head & SE Head

A head volunteer is someone who is a student and member of the club. One each head volunteer is selected from the Second year and Third year, referred to as TE Head and SE Head, studying in the third and second years. The TE head volunteer serves as a point of contact between the committee and the students in the third year for the respective domains. The SE head volunteer serves as a point of contact between the committee and the students in the third year for the separate domains. Responsibilities include, but not limited to, disseminating information about the events of the domain, encouraging participation, help to organize events, helping fellow students understand the materials discussed in the circumstances, ensuring inclusive involvement in events, and other things. Being able to support the domain lead and helping to enrich the domain with valuable and critical inputs

All domain leads will have independent authority over their SE and TE head volunteers but are still expected to help in the events of other domains,

4.3.3. Public Relation & Creative Team

This team will be responsible for all the affairs of the club that includes but is not limited to Graphics Designing, Social Media Management like Instagram, Facebook, Twitter, and publicizing events of the committee.

4.3.4 Mentor and Mentees

The fellow will be a committee member interested and agrees to be responsible for mentoring the inexperienced members/teams of the committee. Being a fellow will be less about privilege and more about responsibility. There will not be a limit on the number of fellows in the program; recruitment will be contingent upon an assignment/test that shall specifically depict an accurate picture equivalent to the fellow's skill. A fellow can then mentor the inexperienced members/mentees in their corresponding domains for research, projects and be specifically responsible for their performance. A mentor can also be a winner of a specific competition or hackathon or some event of considerable prestige to mentor the aspirants of the events above. Fellows program will be the inception of an efficacious and interactive culture where each student can be guided to an innovative mentality and benefit from the experience of others.

4.4 Peer Learning System

The Peer Learning program of the club would also be the one that best represents the motivation behind the club.
Primary goal is promoting self-learning, shared learning, and teaching skills to understand better and apply certain technologies will ultimately lead to better community bonding.

The pillars of the program are the following two roles:

1. Mentor

A mentor will be selected at the discretion of the domain heads. A mentor will be someone who has shown excellence and dexterity in their field. A mentor's primary role would be to guide a selected individual/group of mentees. A mentor must be solely responsible for the progress of the mentees.

2. Mentee

A mentee is a student member of the club who has been selected after a thorough evaluation process. The evaluation process is designed to be such that the mentee student gets involved in project making and skill development from the very start. A mentee is committed deeply to self-improvement and expanding their horizons in the tech industry and academia. A mentee is a dedicated self-learner who participates in various hackathons, makes projects, compete for internships, and strives for positions and events of considerable repute that contribute directly to enriching the mentee's experience and knowledge.

The peer learning program will be an internal activity for the bonafide club members.

4.5. Recruitment Process for the club

In the present world, learning to learn is one of the key skills that one should develop which will help one grow. So, these tasks are designed for them to approach these problems with curiosity to learn and fabricate their skills over these. Version control is important to keep track of changes — and keep every team member working off the latest version. This very thing is the most important evaluating factor for recruiting freshers. This system of completing a variety of tasks and maintaining a report for each along with version control and open sourcing their work will help distinguish and identify candidates with dedication, hard work, and skill

The key takeaways for the recruitment process are:

- Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
- Ability to identify, formulate, research literature and analyze engineering problems reaching substantiated conclusions using open source technologies
- Ability to install and run open-source operating systems. Ability to gather information about Free and Open Source Software projects from software releases and sites on the internet.

4.6

Process Cycle

The existing trend in teaching Traditional teaching methods is followed by most teachers using brick and mortar teaching methods that are outdated. With the availability of online facilities, using the blackboard and chalk method of teaching became obsolete, and the students are not interested in being passive, listening for the whole hour.

When the materials are available online, the students no longer need to take notes in the class. The research facilities and industry-ready teachers are in scarcity, and graduates of both Bachelors and Masters lack industry-required skills. To cope with the industry-level program, we collaborate with the student ambassador programs for the technologies.

Key advantages of the inclusion of ambassador programs are:

- Industry defined curriculum centered around usage and development of their suite of emerging technology
- Collaboration with engineers and leads from Big-Tech for project development and doubt solving
- Big-Tech certifications through student programs are significant incentives for student participation.
- Free credits for otherwise expensive software in boot camps give students hands-on experience to learn industry-ready practices

Also, the traditional teaching-learning methodology is outdated, and the best methods are to be identified and standardized to improve the required skills of the students.

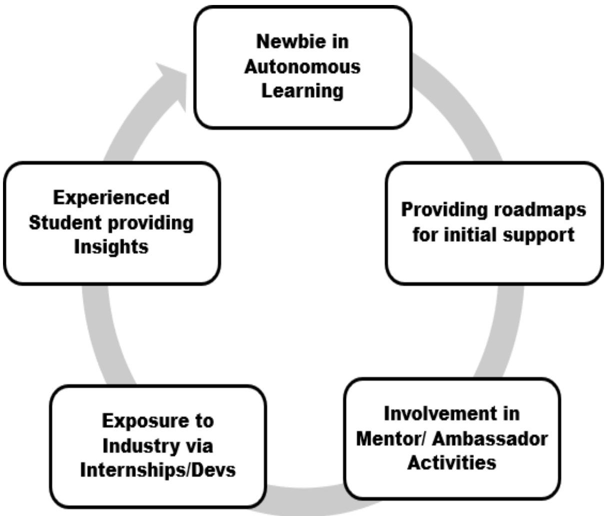

fig. 5. The process cycle for student development in the club

This will now employ an autonomous system which will function on basis of a feedback loop governed by faculties in academia, industry experts via student ambassador programs and Bonafide student club members. This process can be mapped into a cyclic structure which will nourish future members of student-based leadership.

5. Experiments & Implementation

To test our hypothesis, we conducted an array of sessions both in the form of expert sessions and within the proposed club framework.
The proposed model was implemented in the department of computer engineering at Thakur College of Engineering and Technology. Over 26 sessions were conducted, they were spanning around a period of 4 academic semesters or two years.
The average attendance was 85, these were the sessions where an industry-based ambassador student from the club organization body was the instructor. Thus, the average attendance saw an increase of 88.89% from the expert session styled sessions.
The average overall rating of all the sessions was 9.2/10. The total number who participants in these sessions were 400.
We compare our sessions conducted under technically affiliated ambassadors with non-affiliated expert-session styled sessions. We come to find the following observations:

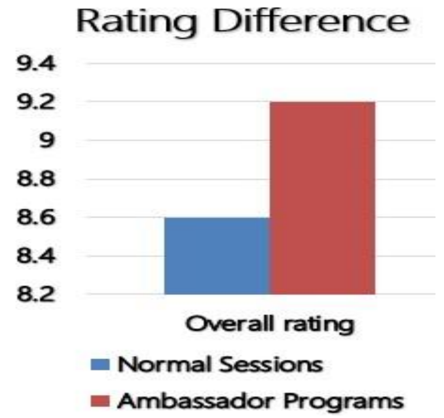

fig.6. Difference in an average rating of company-affiliated sessions and non-affiliated sessions.

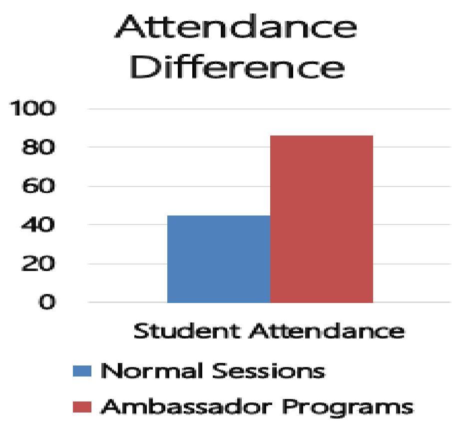

fig. 7 Difference in student attendance in normal sessions and ambassador sessions

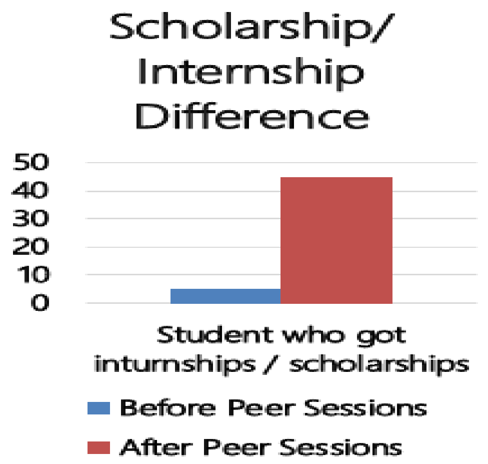

fig. 8 Difference in internship opportunities in normal sessions and ambassador sessions

We can clearly see that the results of the sessions conducted within the proposed framework, measured by no of internships and scholarships begotten by the attendees, is remarkably greater than the results of expert session styled sessions. Thus, it can be conclusively said that our proposed framework did conclusively better in raising the overall acumen of the attendees and the attendees thus trained were relatively much more valuable to the industry .

6. Results and Discussions

Thus we found through thorough experimentation using our proposed framework, that following the aforementioned framework increases the quality of overall technical understanding of students.

The proposed framework appropriately allocates responsibility to ensure an optimal learning environment fostered by sessions and mentoring, which bolsters peer and autonomous learning. We observed that we could gain a transparent performance boost in our ratings by adopting a structured industry-prescribed curriculum through industry-affiliated domain leads than we could by adopting an expert session series format.
We attribute the same to the more in-depth and hands-on characteristics of our session curriculums which covers a variety of topics and is semester-long as well as the peer learning systems. Clear

assignment of roles and responsibilities and confinement of the same to only emerging technology-based technical roles for only technical events led to a setup focused solely on student skill development. Our proposed framework fared better in terms of participation and rating performance than institute clubs where both technical and non-technical events are held.

The peer learning system of the framework boosts the pace of growth of students decisively. In the system, the mentor takes an active responsibility for the mentee and mentors the mentee proactively for various activities. In comparison to other frameworks and clubs in the institutes, our peer learning and autonomous learning-based framework were the only ones whose participants secured scholarships directly consequential of the framework. With good monitoring and quality assurance, the program can be extended to collaborations with other institutions, which extends the framework to a wider diverse audience.

Academic incentives to the organizing committee & club members will encourage students to become more active.

Cultivated industry contacts give easy access to other programs, employment opportunities, and the latest trends.

7. Conclusion

Thus, in this work our contributions include identifying the gaps prevalent in industry necessities and academic education which hinders a student from performing in the industry to the best of their ability and proposed as well as tested a solution. The solution, club as a robust framework, augmented by peer learning and autonomous learning provided a definitive and significant boost in overall rating metrics, participation and deliverable performance, in the form of scholarships and internships, of the students. This proposed model leverages the power of peer learning and autonomous learning in the most efficient way with minimal changes in the hierarchical structure of any institution. It will also minimize the load of institutional management for covering every niche topic of industrial relevance and set up a thoroughly proactive process where adaptability to latest industry trends, in depth, is a feature of the overall structure itself. This will thus perpetually work to reduce the gap between Industry requirements and academic curriculum and is an efficient solution for institutes heavily constrained by human and computational resources.

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