India Industry-University Collaboration - A Novel Approach Combining Technology, Innovation, and Entrepreneurship

Prof. Sathya Prasad
Director, Center for Innovation and Entrepreneurship
PES University
Bengaluru, India
sathya.prasad@pes.edu

Raghavendra S Bhat
Principal Engineer
Intel Technology India Pvt. Ltd
Bengaluru, India
raghavendra.bhat@intel.com

***Abstract*—Research in fast-evolving technologies like AI & ML requires the collaborative effort of various stakeholders including industries and universities. In developed economies, industry-university collaboration (IUC) is mature and delivers benefits to both stakeholders. In a developing nation like India, there is relatively less emphasis on IUC and when present, is restricted to a small set of premier institutions. At the undergraduate level, the collaboration between industry and university is very minimal to none. This poses major challenges to industry (insufficient qualified talent pool, higher cost of training fresh recruits, limited choice of external research partners) as well as universities (curriculum lagging latest technology, not reaching full research and innovation potential, source for research funding). This paper summarizes the IUC effort undertaken by Intel Technology India Ltd and the Center for Innovation and Entrepreneurship at PES University to create mutually rewarding outcomes for both partners and describes a new model encompassing technology, innovation, and entrepreneurship in addition to the traditional elements of IUC. We present the IUC considerations and processes adopted to deal with the challenges and share the outcomes and impact at the end of two years of engagement and hope that key aspects of this IUC can be leveraged by other industry and university stakeholders for mutually rewarding outcomes.**

***Index Terms*—Industry-University Collaboration, Higher Education, Technology, Innovation, Research, Entrepreneurship, Artificial Intelligence, Machine Learning, Deep Learning, Advanced Driver Assistance System**

I. Introduction

It is widely accepted that Industry and University collaboration (IUC) is one of the critical drivers of the innovation economy and carries benefits for both the stakeholders [1]. IUC is quite prevalent and put into practice very effectively in developed economies. Traditionally there have been several key driving factors for IUC:

- Companies get access to expensive research infrastructure [1]
- Companies get access to a well-qualified talent pool in the form of students and researchers [2]
- Companies gain access to the state-of-the-art knowledge by engaging with the right faculty [3]
- Universities can monetize the research done through income from patent [3]
- Universities may be recipients of collateral offered by industries in the form of equipment/tools (hardware, software, or both)
- Universities can gain access to additional research funding from industries, which can be significant in some countries [4]

While there are tangible benefits of IUC, there are also challenges as industries and universities have more differences than commonalities – everything from culture, mission and underlying goals (financial vs. knowledge creation and dissemination) [5]. In addition to the general IUC challenges, there are additional challenges for a developing nation like India [6] that have a moderating effect on IUC in India:

- Quality research in India happens in silos and mostly in premier institutes (e.g., Indian Institute of Science, Indian Institute of Technology, etc.). University research leading to innovation is spotty and even more so at the undergraduate (UG) level. This is a missed opportunity for creating and nurturing a research and innovation mindset for students at the UG level is underscored by these statistics - there were only 216 researchers per million population in 2015 [6].
- Funding is a major requirement for research and insufficient funding affects the research output. India's investment in research is just 0.62 percent of GDP [6]. These numbers are well below the global best practices. There were approximately 161,000 students enrolled in Ph.D. programs in 2018. This comprises less than 0.5 percent of the total student enrollment in higher education in the country.
- There is relatively more emphasis on teaching compared to research. Thus, faculty at the UG level don't find sufficient time for quality research and the ability to nurture a research mindset among students.
- Teaching and learning process which still lays emphasis on rote learning and thereby missing out on critical aspects like critical thinking, applying concepts to solve cross-domain challenges, etc. The lack of exposure to

978-1-7281-8478-4/21/$31.00 ©2021 IEEE 21–23 April 2021, Vienna, Austria
2021 IEEE Global Engineering Education Conference (EDUCON)

research culture at UG means, the students joining the industry after graduation have gaps in industry-relevant skills.

To address this gap, universities attempt to engage in collaborative partnerships with Industry. However, the quality of these collaborations is rather lackluster and is usually not attractive to the industry. Even when there are engagements, the collaborations are somewhat ad-hoc (e.g., guest lectures) due to a low-touch, opportunistic engagement model.

This paper describes the initial effort undertaken by *Intel Technology India Ltd* (Intel India) and the *Center for Innovation and Entrepreneurship* (CIE) at PES University, over a two-year period, to promote a research mindset among undergraduate students and attempt to make IUC outcomes more meaningful and impactful for both the university and industry partners.

II. Survey of Best Practices in Industry-University Collaboration

Industry and Academia have more differences than they have in common and this collaboration was no different. Hence, the two partners in this collaboration spent a good 4 months discussing and narrowing down on what we called 'pillars of collaboration' before inking the memorandum of understanding (MoU). It brought to fore the key areas and potential conflicts which were addressed directly in the MoU:

- Legal: The MoU was purposely kept simple with an emphasis on flexibility and agility to get the engagement up and running quickly. The MoU had a provision to add new areas of collaboration that might be identified during the two-year tenure of the MoU.
- Intellectual Property (IP): This is usually a barrier to collaboration between industries and universities. To keep it simple, we set up the engagement to be devoid of any IP given or transferred by Intel India. Example: all the problem statements given by Intel India for the student research and innovation contest were real problem statements but with the IP removed in such a way that the problem still retained the essence and challenge. Innovative solutions to the problems could still be generated through the use of open source technology rather than proprietary and/or company-specific tools/software.
- Financials: Given that this was a first time for a rather different type of collaboration (compared to research and/or equipment grants), the emphasis was less on financial aspects. The MoU did provide for some nominal financial assistance but this was not the primary focus of the collaboration, at least for the first iteration. Example: the cash awards for the student contest was not finalized until the very end of the contest (about 6 months into the MoU).
- Timeline/Duration: Given that this was the first such engagement, we agreed to a two-year horizon for the overall collaboration instead of the usual one-year period. We also agreed to prioritize long-term (6 months or greater) outcomes vs. short-term wins.
- Trust: Both authors realized from the very beginning that trust was a key determinant for the success of this collaboration [7], [8]. The fact that both the authors had worked together in the past greatly helped in starting with a good modicum of trust and goodwill in a new partnership [3].
- Experimental attitude: Given that both collaboration partners had the desire to work towards a long-term collaboration, we decided that we would take small but concrete steps, experiment with a few programs, and based on the learnings decide on the course of activities. This shared understanding that we may add/modify/drop programs to find what really worked, greatly reduced the pressure for both stakeholders.

III. Intel India and PES University Collaboration

Technology, innovation, and entrepreneurship are firmly intertwined [9] and also as evidenced by the high-level of interest evinced globally by governments, industries, and universities. The case is no different in India, the 3rd largest startup ecosystem after the US and China [10]. From a government perspective, there are several key initiatives like Atal Innovation Mission [11] and StartupIndia [12] to encourage and support technology-driven innovation and entrepreneurship in startups and universities. Industries and corporate entities have multiple approaches to engaging with startups in India with the presence of more than 140 unique corporate accelerators [13]. On the university side, there are more than 250 incubators [14].

Bangalore, with the moniker 'Silicon Valley of India', tops the list of the share of startups (23%) by location [13] and has a strong base for research and development with over 400 global and local R&D centers and 60+ biotech companies [15] with one of the highest ratios of engineering colleges to the population [16]. Therefore, it is no coincidence that this industry and university collaboration, between Intel India and CIE at PES University came about in the city of Bangalore.

A. About Intel India

Intel India is a development center of Intel Corporation. It is a critical engineering design and development center for key Intel products across CPUs, GPUs, SoCs, Platforms and Software with strong IT expertise and factory automation. Intel India, within the scope of its charter, engages with leading Academic Institutes across the country on research topics with an added incentive to create a talent pipeline.

B. About CIE, PES University

Recognizing the trend and the growing thrust for entrepreneurship, PES University [17], a top 100 ranked engineering institution [18]), located in Bangalore, India, started the Center for Innovation and Entrepreneurship (CIE) in Nov 2017 [19]. CIE's objective is to serve as a launchpad for university students to combine technology, innovation, and entrepreneurship and create value by solving real-life challenges. CIE focuses on 6 primary areas as shown in Fig 1.

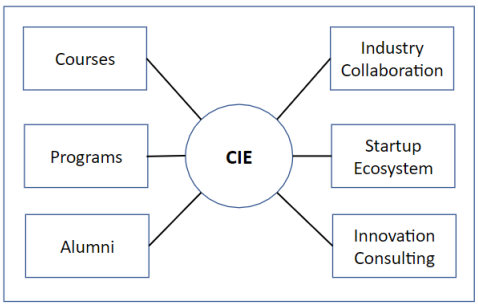

Fig. 1. CIE Focus areas

Industry collaboration is one of the pillars aimed at partnering with industry to promote technology research, innovation and seeks to nurture an entrepreneurial mindset that is increasingly sought after by the industry when hiring talent from campus.

C. Intel India - PES University Collaboration Tenets

Intel India and PES University adopted a different approach to kickstart the IUC. In addition to the general IUC challenges, our IUC approach also addresses some of the challenges specific to the Indian context [5]. The approach utilizes new modes of engagement by combining technology, innovation, and entrepreneurship in addition to the traditional elements of IUC.

The key vectors of the approach are (a) student learning-centered approach (b) prioritizing the engagement for long term outcomes over short term wins (c) anchoring the engagement around the latest technology with Industry relevant problem statements with an emphasis on innovation (d) combining the best of mentorship from both faculty and industry and (e) including a competitive element by structuring the engagement as technology innovation contest with the possibility of best ideas being incubated to promote tech-based entrepreneurship.

The approach is based on the hypothesis that a sustained long-term IUC engagement can address the challenges resulting in rewarding outcomes for both industry and university. For the university, students have the opportunity of working on Industry-relevant problems with mentoring by industry experts and guided by faculty resulting in earlier and better exposure to cutting-edge technologies, development of applied-research mindset, and enhanced level of soft-skills (communication, teamwork, problem-solving skills, etc.) thereby increasing the chances for employability in the AI and ML domains. For the industry, this can lead to a bigger talent pool in emerging areas like Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL), where there is a sizeable talent gap.

A survey of global best practices for industry-university collaboration was conducted and critical success factors and challenges were identified [20]. This helped define the key tenets of collaboration that were embodied in the MoU, which was signed and put into action by PES University and Intel India for a period of 2 years (Oct 2018 to 2020). The broad tenets of the collaboration are:

- Strategic context: AI, ML, and DL turned out to be strategically important to both collaboration partners. For PES University, this represents a thrust area for research and academics while for Intel India this is at the heart of current and next-generation of products.
- Shared vision: CIE at PES University has the vision to apply AI and ML for innovation and offer this to undergraduate engineering students spanning different disciplines and not limited to Computer Science students. This matched the vision of Intel which has set up a global program, Intel AI Academy, to foster AI and ML skills in universities.
- Long-term relationships: Both the partners decided that the nominal one-year engagement period would be too short and decided on a two-year duration.
- Empathy for the partner: The principal collaborator (and one of the authors) from PES University had previously worked at Intel (US and India) and both authors have worked in multiple industry roles/functions with linkages to academia (e.g. research partnerships, placement activities, etc.)
- Communication: Strong communication linkage between partners is vital. While the authors are the key points-of-contact on either side of the collaboration, an elaborate communication mechanism was set up to link and keep various stakeholders (students, faculty, industry mentors, PES University leadership, Intel India leadership) connected. In addition to once a month face-to-face meeting, extensive use of digital platforms (Cloud file sharing, email/chat, video conference, online surveys, etc) helped maintain the strong communication link.
- Stakeholder engagement: The MoU targeted good engagement with all the relevant stakeholders on either side of the collaboration. At every major milestone, the progress, status, issues, and key results were shared with respective stakeholders on both sides. For example, CIE featured the outcome of the student research innovation contest prominently in CIE's quarterly newsletter and on the CIE portal while Intel India shared the same through internal employee bulletins. The wider communication beyond the immediate stakeholders helped raise the interest and profile of the engagement on both sides of the collaboration

IV. Collaboration Programs

In this section, we describe the design considerations and the implementation approach of two of the key collaboration areas (henceforth referred to as programs), namely, the *Research and Innovation Contest* and a new course *"Practical Approach to Deep-Learning"*.

A. Research and Innovation Contest

We chose to address the two dimensions of research and innovation for undergraduate engineering students in the form of a Research and Innovation Contest (RIC). The RIC focused

on mutual areas of interest for Intel India and PES University in the AI, ML, and DL domain.

A key consideration for RIC was that the problem statement should be 'fresh' (real-world problem statements, not canned examples) and somewhat open-ended allowing students to explore and be creative in developing their solutions. The problem statements were curated by Intel India engineers and given to students at the beginning of a semester with the final assessment targeted at the end of the semester, giving the students a total duration of about 14 weeks to work on the problem statement. A semester duration ensured students had the necessary time to form a team, conduct a literature survey, design, and implement the solution.

Each student team (minimum 2 and maximum 3, could be from any engineering discipline) was assigned one PES University faculty (from CSE or ECE) for providing overall guidance. Additionally, one Intel India mentor was assigned for each problem statement, to provide context (as the problem statement was by design somewhat open-ended) and deeper technical guidance as needed. The contest was broken into 5 stages: *Problem Definition* (25% completion), *First Prototype* (50% completion), *Final Prototype* (75% completion), and *Final Solution* (100% completion) followed by *Demo-Day* (final assessment). Roughly the top 20% of the teams were picked to present their solution for the *Demo-Day*.

At the end of each stage, Intel India mentors provided detailed feedback to all teams based on their submissions. The feedback and interactions were largely digital (Google Cloud/Drive) with a video conference as a fallback mechanism for tricky problems requiring discussions with students and/or faculty. The *Final Solution* and *Demo Day* presentations were done face-to-face which tested the ability of the students to articulate their final solution in a startup pitch-like format.

The student submissions were rated by only the Intel India mentors without involvement from faculty. The assessment for the contest was divided into two categories with all teams being evaluated for both categories: *Complete Solution* and *Innovative Solution*. The first category emphasized the full solution to the problem statement encouraging students to build the best possible solution in the given time. The second category allowed students to work on a radical design and/or implementation without penalizing them for not delivering a 'full' solution. The *Innovative Solution* category required the students to approach the problem statement in a novel fashion thereby emphasizing the research dimension.

Two editions of the contests have been completed, one each in the 2 years of the collaboration with the details of RIC conducted in 2019 and 2020 described below.

1) RIC 2019: The first contest was held in the first half of 2019 and posed problem statements in the areas of natural language processing (NLP) and advanced driver-assistance systems (ADAS). The students were required to select one challenge from either of the areas. The challenges are listed below:

- Develop an application that uses any (Indian) language-based user interface.
- Develop a Speech transcription engine in the selected (Indian) languages.
- Develop a Question and Answering system in the specified (Indian) language.
- An open-ended problem statement to apply generative adversarial network (GAN) in NLP. The open-ended nature of the challenge required students to define the problem statement which merits usage of GAN.
- Driver Drowsiness detection with a single inward-facing camera.
- Low Light object detection in an outdoor scenario.

Each of the problem statements had a clear communicated evaluation criteria including metrics wherever applicable. As a preparatory step, a session each was organized for the faculty and the students to walk through the problem statements, provide relevant technical pointers and training in some of the key tools likely to be used. The students were asked to form teams (2-3 members per team) and encouraged to spend adequate time conducting a literature survey. The teams were provided with necessary inputs like recommended data sets, access to development cloud-based compute farms, and technical support in the form of faculty and industry mentors. No hard conditions were placed on the datasets or compute infrastructure, the students were required to use. 207 students, the majority from Computer Science and Engineering (CSE) stream, and the rest from Electronics and Communication Engineering (ECE) stream signed up for the contest. 70 teams were formed from this group who were mentored by 11 faculty members. The strong participation is a good indicator that students are willing to invest time in a contest that is technically challenging even if it is for the entire duration of a semester. The key outcomes from the contest are listed below and summarized in Fig. 2.

- Approximately 30% of the teams selected NLP challenges with the remaining 70% opting for the ADAS problem statements.
- From the overall submissions, three submissions were pursued beyond the contest and developed into full project submissions which were released through Git into open source. A good example is a voice-bot implementation based on the Speech Transcription work done by one of the teams. [21].
- A paper based on the contest work was submitted and accepted at the IEEE WIECON 2019 [22]. This is a good indicator that a research mentality in students can be realized through a sustained technical engagement through challenging problem statements.
- Five internships were offered out of which 2 were offered full-time employment at Intel India. These students were handpicked from the pool of contest participants. For the industry, this reduces the risk of bad hiring decisions, smoother onboarding, higher productivity of new hires, and improves the overall talent pipeline.

The RIC 2019 met most of the objectives set. This validated the thought process adopted for the engagement struc-

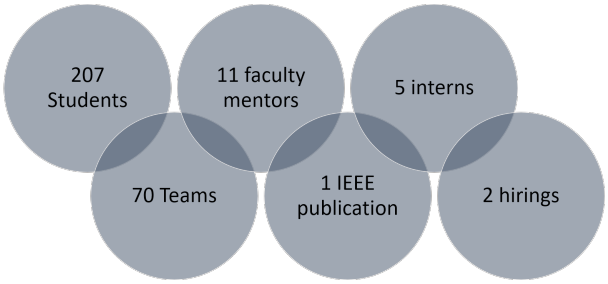

Fig. 2. RIC 2019

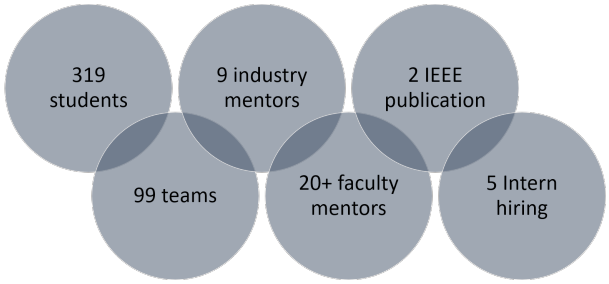

Fig. 3. RIC 2020

ture based on semester-long format, in-depth technical topics backed by strong technical mentorship from faculty and industry experts. This experience justified another shot at a similar contest in 2020.

2) RIC 2020: The 2020 edition of RIC was held in the first half of 2020 and posed challenge statements in the areas of video analytics, Advanced Driver Assistance Systems (ADAS), data handling, and robotics. The students were required to select one challenge from the list. The challenges are listed below:

- Search a video database purely with natural language queries
- Object Detection in twilight or night time conditions. This topic was continued from 2019 contest but with certain additional objectives
- Detecting emotion and behavior of occupants of a car
- Given images captured from a vehicle along with its telematics data, the students were required to come up with novel applications using the data.
- Design fully autonomous "things" leveraging existing robotics platforms coupled with any required AI algorithms. This was an open-ended challenge where the students were allowed to pick specific problem statements for autonomous systems within the boundaries set by this challenge.

The rules of the contest were kept similar to the 2019 edition in terms of team composition, faculty mentorship, introductory sessions for students and faculty, etc. 319 students from CSE and ECE streams signed up for the contest. 99 teams were formed from this group who were mentored by faculty and Intel India experts. The increased participation in 2020 compared to the previous year is an indicator of the acceptance by students of this format of interaction. The key outcomes from the contest are listed below and summarized in Fig. 3.

- Selected teams were asked to write a paper based on their final submissions and submit into premier conferences.
- Two papers were accepted in premier tier-1 conferences like the International Conference on Machine Learning and Applications (ICMLA) 2020 [23] and International Conference on Pattern Recognition (ICPR) 2020 [24].
- A good pool of intern students was identified from the contest interaction. 4 students were already assigned internships at Intel India with the remaining from this pool being considered for the 2021 cycle of the intern and fresher hiring.

The key progress in 2020 was the research focus from the students and their ability to combine core AI algorithms with various applications spanning from video surveillance to Robotics to ADAS. The output of 23 teams was marked for further follow-up.

B. Practical Approach to Deep Learning Course

It is widely known that there is a global shortage of skills in AI, ML, and DL and is prevalent at all levels: starters, skilled, seasoned professionals [25]. In fact, in India, it is no different with several instances of job openings being unfilled [26]. Apart from the opportunity size, the other drivers are better career growth and salary prospects AI-ML [27]. To address this from the government perspective, the Government of India has launched initiatives to reduce the AI, ML skill gaps [28].

As part of this collaboration, we chose to address this challenge by creating a new course on AI, ML at PES University but with some key differences.

The course 'Practical Approach to Deep Learning' (henceforth referred to as PADL) was offered as an elective (2 credits) in January semester 2020 to 44 students in ECE studying in the 6th semester [29]. The objective of the course was to develop a broad understanding of AI and ML frameworks with an emphasis on 'Deep Learning' and to apply this knowledge to tackle real-world use-cases and applications using a hands-on approach.

Unlike most AI and ML courses which are usually first offered to students studying CSE, this course was offered to ECE students. Some of the salient aspects of the PADL course are outlined below:

- The syllabus was created by ECE Department and CIE at PES University with inputs from Intel India engineers. The software tools used in the course did not require the purchase of any new software (downloadable for free over the internet).
- In addition to technical content, exposure was provided to examples of AI, ML, and DL deployments in various industries (automotive, health, retail, industrial, etc.) using real-life examples and cases.
- A guest faculty (CEO of healthcare AI & ML startup) was taken on board as co-instructor.

TABLE I. PADL Course Highlights

Artificial Intelligence(AI) – Deep Learning(DL) Domain
Syllabus created with Industry inputs
Use of latest AI, ML and DL framework/tools
Target students from non Computer Science
Hardware and Software focus
Application-oriented with 70:30 Practical:Theory
Lab-in-Class' with hands-on experience in every class

TABLE II. Summary of Collaboration Outcomes

520+ Students (Intel Contest)
44 Students (Intel AI Univ based Course)
1st Intel OpenVino AI/ML Course for UG
3 International Conference papers
3 Full Time Hire, 9 Internships
Award Purse of Rs 350,000
Hardware Grant worth Rs 600,000

- A 'Lab-in-Class' approach, where students had the opportunity to work on problem statements in the class on their laptops, with roughly 50-50 time split between lecture and lab.
- Instead of a final examination, a final project (done over 6 weeks) was adopted. The final project involved analyzing and detecting tumors from real brain scan/images.
- The assessment and grading criteria for the final project went beyond a working solution and focused on the methodology/approach adopted, understanding the design and implementation trade-offs, and presenting all of this in a 'pitch' style format.
- The final project was judged by a panel of Intel India engineers in addition to guest faculty and ECE faculty.

V. Collaboration Outcome

The impact of the *Research and Innovation Contest* and the course *Practical Approach to Deep Learning* is summarized in the table and further described in subsections.

A. Research and Innovation Contest (RIC) Impact

We would like to summarize the net impact of the RIC as exceeding the expectations. The listed points provide the rationale and relevant metrics to support the assertion.

1) Promote research mindset: The 2019 edition of the contest confirmed the potential in the students which led to mandating paper submissions in the 2020 edition resulting in a total of 3 international publications.
2) It is still early to provide a metric on the quality of the papers although the indicators are positive based on the 2020 trend where two papers were accepted in prestigious international conferences. There is a noticeable second-order positive impact in terms of the number of research papers submitted by the contest participants as a result of their learning's from writing technical papers as part of RIC.
3) State of the art technology problem statement to promote industry relevance for the engagement: One consistent feedback received from the participating students, after the contest, was the motivation due to the relevance of the problem statements. In the 2019 contest, students were using state-of-the-art AI models like BERT from Google while in 2020, the students were combining Audio and Video models towards intelligent indexing of video and using Graph Neural Networks to make sense of telematics and road image data. It was also seen that the quality of innovation significantly improved with the quality of the literature survey.
4) Spread the net wide and catch-them-young: The RICs helped widen the student base by having students from different semesters and different streams. Compared to 2019, the participation increased by 54% which is an affirmation of the heightened interest in students for the contest-format.
5) Faculty as a force-multiplier: The experience of two rounds of contests confirm the key role played by the faculty in ensuring the overall quality of the submissions. Across the two editions, it was observed that the best team submissions had strong support and mentoring from the respective faculty.
6) A heartening trend observed is the strong participation of girls in the contest. The ratio of girls to boys was 1 : 3 for both editions of the contest.

B. Practical Approach to Deep-Learning Course Impact

The introduction of the PADL course, a contemporary hands-on, application-oriented course targeting a non-traditional student section (i.e., not from Computer Science and Engineering) with a different pedagogy and implementation was an ambitious goal taken under this collaboration. Below impact is based on the feedback from students (administered through a survey) and anecdotal feedback from faculty and industry stakeholders. The impact can be assessed along three dimensions: student, department, and industry.

For the student, this meant exposure to the latest AI and ML industry software tools/framework and hardware accelerators and the opportunity to apply this to solve real-world problems rather than just theoretical learning. PADL introduced the students to a team approach to developing a solution and implementing an end-to-end workflow that mimicked what they otherwise would have experienced after graduation. The course also offered a chance for the students to interact with industry experts as part of the course and hear from them directly about the most recent advances in AI and ML. Further, 50% of the students were girls which ensures strong diversity in new technology like AI and ML which will help address technology issues like bias in AI algorithms. The ECE students also reported increased confidence in being able to present themselves and their work for the upcoming placement interviews for recruitment by deep-tech companies.

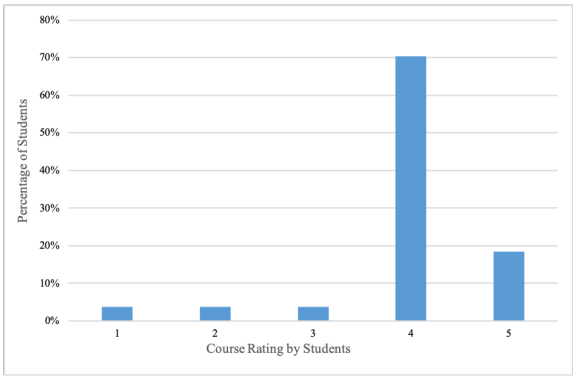

Fig. 4. Student Feedback on PADL Course

The student feedback for this course has been positive as shown in Fig. 4.

For the ECE department, this allowed extending beyond the theoretical AI and ML courses offered and developing a contemporary syllabus leveraging industries' insights in a relatively short time (1 quarter). The faculty also got dedicated exposure to cutting edge AI and ML tools and key practical aspects through targeted faculty development program (FDP) sessions.

For Intel, creating and launching this new AI & ML course represents another step in the objective to bring the latest technology to universities and help create engineers beyond the rigidly defined 'hardware' or 'software' engineers. While this one course cannot address the talent gap, this instance has given several valuable learnings to scale up efforts in this direction which may over the long run help the talent challenges highlighted earlier.

VI. Summary

Intel India – PES University engagement started with the hypothesis that improving the IUC experience in a developing country like India and improving the overall research mindset among the undergraduate students is possible with a well thought out methodology. The methodology was anchored in a long-term partnership, student-first approach, real-world application challenges, technology-based innovation contest with a goal of maximizing the outcomes for both the IUC partners. The results and impact achieved by RIC and the new PADL course is highly encouraging and validates our initial hypothesis and gives us confidence to invest more efforts in this direction. We believe that in addition to the direct impact of these two programs under the collaboration, the "trickle-down" benefits (example, scaling innovation within a university as well as across universities) will make this even more attractive for both partners as well as the ecosystem. The key results of this collaboration can be summarized as:

1) A strong trend towards paper publications was seen beyond the direct submissions from RIC. About 20 paper submissions are underway following the 2020 contest with two papers already accepted at tier-1 conferences like ICMLA 2020 and ICPR 2020. Further, students who participated in the contest are seen spending more time on research topics as evidenced by the increased paper submissions. The research innovation contest helped break the real and perceived barriers and put more students on the research track.
2) As a result of the contest and the new course, about 600 students have been exposed to the latest in deep technology with ample exposure to AI, ML, and DL frameworks, tools, and associated hardware/systems. Proof of the progress was also seen in the contest output where the students had referenced the latest state-of-the-art (SOTA) publications which enhanced the overall quality of submissions in the second round of the research innovation contest.
3) The PADL course survey underlines the importance of direct industry-university engagement as a means to introduce the latest technology to students. The impact is measured by the highly positive feedback and the quality of interns hired into Intel India in this timeframe with a few of them converted to permanent hires.

VII. Future Work (2020-2022)

The positive impact of the 2018 - 2020 MoU has given both the sponsoring institutions enough motivation to extend the MoU by another two years until 2022. We plan to deepen the collaboration for higher impact in the next two years and includes the following:

- Combine cross-domain skills in the next edition of RIC. The contest will require the participating teams to combine students from different engineering streams. For example, Computer Science and Electronics Engineering together to tackle problem statements requiring both hardware and software knowledge and skills. scope.
- Tapping into the entrepreneurship element of CIE, we plan to catalyze the entrepreneurial spirit by providing a path to launch start-ups based on the output of the RIC. Exploration with various industry incubator programs is in progress to provide the necessary support for this endeavor. This will additionally bring in other departments at PES University like the Department of Management Studies and Faculty of Architecture and Design into the mix.
- The PADL course will be extended to also cover the hardware aspects of accelerating AI, ML, and DL applications. A new FPGA based course is in the planning stage to provide Electronics and Communication Engineering students an end-to-end view of AI covering both hardware and software aspects

References

[1] S. Ankrah and O. AL-Tabbaa, "Universities-industry collaboration: A systematic Review," Scandinavian J. of Manage, vol. 31, no. 3, p. 387, 2015.

[2] Y. Myoken, "The role of geographical proximity in university and industry collaboration: case study of Japanese companies in the UK," Int. J. Technol. Transf. Commer., vol. 12, no. 1/2/3, p. 43, 2013.

[3] T. Barnes, I. Pashby, and A. Gibbons, “Effective University – Indus- try Interaction:: A Multi-case Evaluation of Collaborative R&D Projects,” Eur. Manag. J., vol. 20, no. 3, pp. 272–285, Jun. 2002, doi: 10.1016/S0263-2373(02)00044-0.
[4] “OECD Science, Technology and Industry Scoreboard 2015,” OECD, 2015. [Online]. Available: https://www.oecd-ilibrary.org/content/publication/sti scoreboard-2015-en.
[5] “Working Together ,Creating Knowledge: The University-Industry Research Collaboration Initiative,” Business-Higher Education Forum, 2001. [Online]. Available: https://www.bhef.com/publications/working-together-creating-knowledge-university-industry-research-collaboration.
[6] ”Improving research in India: Introducing undergraduate research in higher education,” Observer Research Foundation, Feb. 1, 2020 [Online]. Available: https://www.orfonline.org/research/improving-research-in-india-introducing-undergraduate-research-in-higher-education-47713.
[7] A. I. Canhoto, S. Quinton, P. Jackson, and S. Dibb, “The co- production of value in digital, university–industry R&D collabo- rative projects,” Ind. Mark. Manag., vol. 56, pp. 86–96, Jul. 2016.
[8] A. M. Attia, “National innovation systems in developing countries: Barriers to university–industry collaboration in Egypt,” Int. J. Technol. Manag. Sustain. Dev., vol. 14, no. 2, pp. 113–124, Jun. 2015.
[9] T. Bailetti, “Technology Entrepreneurship: Overview, Definition, and Distinctive Aspects,” Technology Innovation Management Review, Feb. 2012.
[10] “India emerges 3rd largest ecosystems for successful startups,” Economic Times, https://economictimes.indiatimes.com/small-biz/startups/newsbuzz/india-emerges-3rd-largest-ecosystems-for-successful-startups/articleshow/71636451.cms?from=mdr. (accessed Dec. 14, 2020).
[11] https://aim.gov.in
[12] https://www.startupindia.gov.in
[13] NASSCOM, “Indian Tech Start-up Ecosystem - Leading Tech in the 20s,” NASSCOM, Noida, India, 2019.
[14] S. Sharma, N. Vohra, “Incubation in India – A Multilevel Analysis,” W. P. No. 2020-03-01, IIM Ahmedabad, Mar 2020.
[15] C. Assisi, A. Raghava, and N. Ramnath, “The rise of the Indian start-up ecosystem,” Commun. ACM, vol. 62, no. 11, pp. 82–87, Oct. 2019.
[16] Startup Vision Group, “Bengaluru Innovation Report,” Startup Vision Group, Karnataka, 2019.
[17] https://www.pes.edu
[18] National Institutional Ranking Framework (NIRF). [Online]. Available: https://www.nirfindia.org/2020/UniversityRanking.html.
[19] https://cie.pes.edu
[20] J. A. Pertuze, E. S. Calder, E. M. Greitzer, and W. A. Lucas, “Best Practices for Industry- University Collaboration,” MIT Sloan Management Review, Summer 2010.
[21] QA Voicebot Application ”git hub link” https://github.com/madhavmk/QA VoiceBot Desktop Application
[22] S. Mohanty, S. V. Hegde, S. Prasad and J. Manikandan, ”Design of Real-time Drowsiness Detection System using Dlib,” 2019 IEEE International WIE Conference on Electrical and Computer Engineering (WIECON-ECE), Bangalore, India, 2019, pp. 1-4, doi: 10.1109/WIECON-ECE48653.2019.9019910.
[23] S. Chandar, M. Mansoor, A. Reddy, and S. Jamadagni, “Road Accident Proneness Indicator Based on Time, Weather and Location Specificity Using Graph Neural Networks” Available: https://www.icmla-conference.org/icmla20/ICMLA 2020 Program.docx
[24] V. Malaika, N. V. Nandagopal, N. Maanvi; N. Subramanyam, ”Real-Time Driver Drowsiness Detection Using Facial Action Units” Available: https://www.micc.unifi.it/icpr2020/index.php/papers-and-authors/
[25] “Assessment of opportunities for skills Development for the artificial intelligence Driven age,” Electronics Sector Skills Council of India, Jun. 30, 2020 [Online]. Available: https://www.essc-india.org/report-on-artificial-intelligence-hardware.
[26] “Over 4,000 artificial intelligence job roles vacant on talent shortage: Report,” The Economic Times, https://economictimes.indiatimes.com/jobs/over-4000-artificial-intelligence-job-roles-vacant-on-talent-shortage-report/articleshow/67131803.cms?from=mdr. (accessed: Dec. 14, 2020).
[27] “Artificial Intelligence Salary in India: For Beginners and Experienced,” UpGrad, https://www.upgrad.com/blog/artificial-intelligence-salary-india-beginners-experienced. (accessed Dec. 14, 2020).
[28] B. Marr. “The AI Skills Crisis And How To Close The Gap,” Forbes, https://www.forbes.com/sites/bernardmarr/2018/06/25/the-ai-skills-crisis-and-how-to-close-the-gap/?sh=2798025031f3. (accessed Dec. 14, 2020).
[29] “Practical Approach to Deep Learning”. cie.pes.edu. https://cie.pes.edu/cie-practical-approach-to-deep-learning (accessed Dec. 14, 2020).