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Are Engineering & Technology Graduates Ready for R&D Jobs?
Industry-Academia Collaboration Strategies for Training

ABSTRACT

Based on empirical evidence from eleven companies’ collaborations with Indian Engineering &Technology (E&T) Higher Education Institutes (HEIs), this paper discusses how companies use such industry-academia collaborations strategies to prepare fresh E&T graduates for R&D roles (at low cost). We identify that companies use three modes of I-A collaborations to prepare students graduates for R&D and three delivery mechanisms to operationalize the collaboration modes. In the process, we contribute to the literature on I-A collaborations by proposing a new research avenue on industry-academia collaboration in education/teaching and also contribute to the human capital theory.

Keywords: Industry-Academia Collaborations; R&D; Human capital; Education; India

1. Introduction

In the 1990s, multinational corporations (MNCs) from industrialized countries started experiencing difficulties in finding adequate numbers of Engineering and Technology (E&T) graduates in their home and other industrialized economies due to ageing of the population (Economist, 2006), declining birth-rates and declining interest among graduates to study E&T courses (Jacobs et al., 2005). Since a significant fraction of R&D positions in corporations are filled by E&T graduates, scarcity of E&T graduates in developed countries persuaded MNCs to look for destinations to set-up R&D subsidiaries in emerging economies such as Brazil, Russia, China and India (BRIC), where E&T graduates were available in mass numbers (Jacobs et al., 2005). During the period 2000-2009, approximately 6.45 million students enrolled for E&T undergraduate (UG) programs in BRIC nations, 1.8 times more than number of students enrolled for E&T courses in the USA, EU-27, South Korea, Japan and Australia combined in the same time period (Loyalka et al., 2014).

When MNCs established their R&D subsidiaries in emerging countries, while they received access to a considerably larger pool of E&T graduates, one major challenge arose. MNCs found that the majority of E&T graduates in emerging countries were not educated to the same quality level as E&T graduates in their home countries (Loyalka et al., 2014). A McKenzie survey (Farrell et al., 2005) conducted among MNCs’ R&D managers in emerging countries reported only 10% Chinese and 25% Indian E&T graduates to be skilled and qualified enough to be immediately employable for R&D roles. In order to reduce the substantial on-the-job training investments required to train such E&T graduates for R&D in emerging countries, corporations have started to collaborate with universities in education to offer courses, train faculty and establish laboratories (labs) so that E&T graduates could develop the necessary skills needed by industry for R&D roles. Most high-technology corporations such as Cisco, IBM, Huawei, Microsoft, and Texas Instruments etc. are reaching out to academia with titles such as “Cisco Networking Academy”, “IBM academic initiative”, “Huawei ICT Academy”, “Microsoft IT Academy”, and “Texas Instruments University Program” to form collaborations in education. We refer to these collaborations between industry and academia as "education-based industry-academia (I-A) collaboration" that are developed primarily to address the first and foremost mission of universities - teaching and educating students (Laredo, 2007). However, so far, in most studies exploring dynamics of I-A collaborations, research-based and entrepreneurial-based alliances have been the focal topics of discussion (Perkmann et al., 2013), leaving I-A collaborations for teaching tailored to developed skills for R&D jobs largely underexplored. The aim of this paper is to fill this gap and develop better understanding of how such collaborations occur,
identify drivers for universities and corporations to participate in such alliances, and systematize different modes of collaboration.

Based on original empirical evidence from eleven companies’ education-based partnerships with Indian E&T HEIs for developing E&T graduates with skills needed for R&D positions, we identify three distinct modes of education-based I-A collaborations: companies offering training programs to students as a part of the HEIs’ curriculum (Mode-1); companies offering training programs to students outside the HEIs curriculum (Mode-2), and companies setting up new labs/upgrading existing labs at HEIs primarily for teaching purposes (Mode-3). The three modes differ in terms of the type of skills that the company expects the graduates to attain. Mode-1 and Mode-2 collaborations aim to develop graduates with general and industry-specific skills. Mode-3 collaborations allow the collaboration to impart company-specific skills to graduates. They also present different challenges and require different types and size of investment. We find that companies have developed three alternative delivery mechanisms (DM): involving companies’ own employees (DM-1); trained faculty of the partner HEIs (DM-2), and trained third-party organizations (DM-3). We discuss the drivers and challenges for the company and the HEI to operationalize education-based alliance modes through each of the three delivery mechanisms.

We reveal that from corporations’ perspective, the primary driver for education-based collaborations with academia include development of graduates for R&D positions at the company and its clients (at low cost); while academia shows interest in engaging in such education-based industrial collaborations because students and faculty acquire training with industry relevant skills; curriculum and labs are upgraded with industrial inputs; such partnerships may lead to opportunities for future collaborations with the companies.

2. Theoretical background and literature review

2.1 Theoretical background

R&D employees are considered as valuable human resources since their productivity determines the innovation performance of the firm, which is usually considered as the core competency of firms in a technology-driven industry. Besides, they are perceived as unique human resources as they hold knowledge of working with and/or inventing company-specific products and technologies. According to Lepak and Snell’s (1999) HR architecture model, such valuable and unique human resources can only be produced through in-house on-the-job training. This enables companies to offer company-specific human capital to the recruited graduates to enhance their understanding of the companies’ technologies and products, which otherwise would be inaccessible to graduates.

Prior studies outline three types of human capital: general, industry-specific, and company-specific human capital. General human capital refers to the skills that will enhance a graduate’s productivity in most firms in the market, while industry-specific and company-specific human capital aim to enhance the graduate’s productivity in a given industry or at a particular company respectively (Becker 1964; Neal, 1995; Hashimoto, 1981). For instance, for a computer science graduate, an example of general human capital would be basic programming skills such as knowledge of Java programming language. If the graduate aims to work in the information technology industry, knowledge of advanced programming languages for big data analytics such as R and Python could represent the industry-specific human capital. If the graduate is hired by IBM to work on machine learning, the company-specific human capital could be knowledge about IBM Watson.

The standard process for hiring and developing graduates for R&D follows two stages. The first stage is their formal university education, during which graduates are expected to attain adequate general and industry-specific knowledge. In the second stage, companies hire graduates and offer them in-house company-specific on-the-job training (Schultz, 1961; Lam, 1997) on companies’ technologies and products to make them ready to take up R&D activities in the company. This process works well for companies when universities supply graduates with adequate general and industry-specific knowledge. Contrastingly, if the graduates educated by the universities lack such knowledge
and relevant skills, the firms will be required investing in on-the-job training programs. The more time the hired graduates spend in training programs, the later they will start to contribute to R&D activities in the company.

Therefore, companies have strong incentives to develop strategies to eliminate the need for investing in long on-the-job training programs for fresh graduates (Bennett et al., 1999). If universities are unable to develop such skills due to the lack of updated curriculum, equipped labs, and quality faculty (Loyalka et al., 2014), companies can collaborate with universities to form education-based collaborations, so that the curriculum and labs of universities could align with company’s needs, and faculty could be trained to use their labs and teach updated courses (Hemmert, 2017). This will allow firms and universities to jointly develop graduates with adequate general and industry-specific human capital when they are still undergoing their formal education and to share the costs. These graduates, once recruited by the companies, would require on-the-job training only in the form of company-specific skills training, to be R&D-ready. Then, the question arising here is: do such education-based collaborations eliminate the need for companies to offer on-the-job training to graduates recruited to fill R&D positions?

In the context of industrial PhD programs that are co-developed and supervised by companies and universities, prior studies (D’Este and Patel, 2007; Laredo, 2007) have indicated that company-specific human capital can also be imparted to the participating Ph.D. students by engaging them in the research and development of companies’ products and technologies. Such Ph.D. students become well-versed in the company’s R&D practices during the Ph.D. program and therefore, will barely require additional on-the-job training post-recruitment. However, despite a large proportion of R&D positions in companies being taken by E&T graduates, and not Ph.D. holders, prior studies do not address how graduates can be educated with company-specific skill-sets through collaborations with academia. The next section reviews extant literature on I-A collaborations to articulate to what extent such education-based I-A alliances have been discussed so far.

2.2 Existing literatures on industry-academia collaborations

Industry and academia are two central institutions in a (national) system (Lundvall, 1992). The primary objectives of universities have traditionally been to educate generations and build knowledge stock of a society. However, in recent years, the role of universities has progressively moved towards being described as “knowledge hubs” in conjunction with industries, to not only generate knowledge but also make sure the knowledge is commercialized and disseminated to industry (Perkmann et al., 2013). Scholars have been mainly focused on I-A research collaborations (e.g., Siegel et al., 2003; Gulbrandsen and Smeby, 2005 etc.) and companies spinning out from universities through academic entrepreneurship (e.g., Storey and Tether, 1998; O’shea et al., 2005 etc.). Empirical research has shown that I-A engagements contribute to strengthening research outcome (Gulbrandsen and Smeby, 2005), commercialization of academic know-how (Wright et al., 2008) and assist universities to receive financial benefits in terms of availing private funding (Etzkowitz, 2003; Muscio et al., 2013) through licensing intellectual property invented in the university, contract research, establishing academic-led start-ups and consulting (Storey and Tether, 1998; Perkmann and Walsh, 2008).

However, some innovation policy scholars (e.g., Laredo, 2007) contends that, in most countries, teaching is still the main and sole function of universities and hence I-A collaborations that are targeted towards improving teaching capabilities should be explored more, as the impact of such initiatives on human capital development is likely to be far more significant than research and entrepreneurship-oriented I-A collaborations. Such criticism led to the emergence of a key research avenue that investigates the influence of research-based and entrepreneurial alliances with industry on universities’ teaching activities. Studies exploring this research avenue suggest both positive and negative influences of research and entrepreneurial I-A collaborations on teaching. On one hand, scholars justified industry engagement in research and entrepreneurship stating that such linkages bring additional funding to the universities (Muscio et al., 2013), which can be utilized for enhancing teaching resources; facilitates curriculum inputs and also inward knowledge transfer from industry to
universities through workshops organized by the industrial partners and staff exchange (Acworth, 2008; D’Este and Patel, 2007). On the other hand, studies have argued that high focus on industry engagements may cost a university its original mission, i.e., teaching. Researchers showed an inverted U-shaped relationship (García-Gallego et al., 2012), where teaching performance increases with the degree of research up to a threshold point and declines thereafter. The main argument favoring negative relation between research and teaching is the time factor, time dedicated to research is a time lost to teach (Marsh, 1984). A similar effect has been observed in the case of entrepreneurial initiatives by university professors who disengage from their teaching activities (Rasmussen and Borch, 2010). The literature on I-A collaborations shows limited acknowledgment of education based I-A collaborations, especially where teaching might be considered the primary objective of such collaborations. The Perkmann et al. (2013) review of 20 years of publications on I-A linkages also confirms that education-based I-A alliances is a neglected theme.

Such a long-pending research gap is one of the prime motivations for us to undertake this research on education-based I-A partnerships and to investigate three research questions. First, how do corporations engage with E&T HEIs in education-based I-A collaboration to develop E&T graduates for R&D functions? Second, how do academia and industry benefit from such I-A partnerships in education, beyond enhanced graduates’ employability for R&D functions? Third, what theoretical implications can be drawn from corporations’ engagement with universities in education for enhancing graduates'? And finally, what policy implications can be drawn from such education-based I-A collaborations? In the process of probing these research questions, we contribute towards proposing a new attractive research avenue: I-A collaboration in education, the first and foremost mission of universities.

3. Research Design

3.1 Research Setting

The empirical context for studying I-A teaching collaborations is India, as this country has been identified by companies as an endless pool of E&T skilled workers, when in reality the quality may not be as high to allow immediate utilization of such resource and the newly graduates employed by MNCs may need substantial on-the-job training for R&D activities. Nevertheless it is undisputed that India offers a very large supply of skilled workers and graduates. This is due to a number of government initiatives which took place in the three decades.

Market liberalization in 1991 led to a massive inflow of foreign direct investments (FDI) including FDI in R&D to India (Kumar and Aggarwal, 2005). Prior to market liberalization, India’s E&T education policies focused heavily on the enhancement of quality of selected E&T HEIs (henceforth, whenever we mention the word “HEI”, we mean “E&T HEI”), mostly those with institutes of national importance status, in the country (Saha and Ghosh, 2012). In the 1990s, Indian policymakers realized that India would experience a sustained inward FDI in R&D only if it succeeds in developing a considerably large pool of E&T graduates, which would require the establishment of a large number of new HEIs. Since the government was not in a position to financially support setting-up of such a high number of new HEIs and given the urgent demand, Indian policymakers encouraged private investments in the higher education sector. Such private investments, without possessing proper quality standards, facilitated India to achieve unprecedented growth in the number of graduates (Gereffi et al., 2008) from 678 institutes in the year 2000-01 to 3,346 in 2013-14. Scholars recognized that by early 2008, India’s yearly production of engineering graduates surpassed the USA, but it came “at the cost of declining quality of graduate education at least outside of a handful of elite (high quality) universities” (Ernst, 2006, p. 9). Thus, the push for higher enrolment in E&T education gave rise to a large number of non-elite (low quality) HEIs.

Scholars (Agarwal, 2006; Ernst, 2006; Gereffi et al., 2008; Loyalka et al., 2014) have documented sharp disparity in the quality of E&T education between the elite and non-elite HEIs in India and have cited the following factors as responsible for the low quality of E&T education in non-elite HEIs: low faculty to student ratio; low quality of faculty; enrolling students with little
mathematics and science knowledge; and outdated curriculum and labs. In fact, Agarwal (2006) reported that majority of the non-elite HEIs in India did not have proper accreditation to provide E&T degrees. Reports (Asprining Minds, 2015) presenting survey insights from R&D managers confirm that finding qualified graduates for R&D position is a key challenge facing India, primarily because of the limited number of elite HEIs in the country. Adding that companies face stern competition when recruiting from a very small pool of graduates coming from the elite HEIs. As a result of which, most companies end up recruiting graduates from the non-elite HEIs, who possess severe skill-shortage to engage in R&D related activities at companies. Therefore, in line with our theoretical assumptions, in India, in order to avoid additional on-the-job training costs required to train such low-quality graduates, companies may consider establishing education-based collaboration with Indian HEIs.

3.2 Case Selection and Data Collection

This study is based on eleven case studies. Six cases are used as exploratory cases to offer insight into I-A collaborations and the other five are used as confirmatory cases, i.e., to confirm if the findings observed for exploratory cases are valid across companies. Case studies are suitable are used here primarily because they are perceived as appropriate means to answer “how” questions and to address complex and multifaceted issues (Yin, 2003). In addition, since extant literature rarely explains how education-based partnerships occur between industry and academia (Perkmann et al., 2013), an inductive reasoning approach, where the interviews are initiated with “open-ended questions”, is appropriate and adopted here (Turner, 2010). Based on the answers provided by the interviewees, spontaneous questions are asked in order to get finer details. Each company that participates in education-based collaborations with single/multiple HEIs is considered as a separate case. Multiple case studies provide grounds for comparison of results across several cases with consistent or contrasting evidence and thus strengthen the theory building (Eisenhardt and Graebner, 2007). Also, multiple cases are more suitable for our study as we intend to develop a framework that is “more deeply grounded in varied empirical evidence” (Eisenhardt and Graebner, 2007, p.27). We observed that the same company may be driven by different motivations while collaborating with different HEIs in education, which may lead to heterogeneity among collaborating mechanisms adopted by the same company with varied partner HEIs. Therefore, we asked interviewees from each company to offer comparative details on how and why they collaborate with different HEIs with different mechanisms. From the companies, we interviewed managers who are involved in the design and delivery of academic programs. We interviewed 2-4 employees in each company. For confidentiality purposes, the interviewed companies’ and HEIs’ names cannot be disclosed in this paper. The HEIs’ names are referred as HEI-A, HEI-B etc. On the other hand, for referring to companies’ names, we developed a six letter pseudonym for each company. The first four letters refer to the main product/service of the company (COMP- Computers; INFO- Information technology; NETW-Communication networks; SOFT- Software; ELEC-Electricals; CHIP- Chips and microprocessors; AUTO- Automobile). The last two letters represent whether the company is a foreign MNC (F) or a domestic firm (D) and whether the company (or case) is used as exploratory (E) or confirmatory (C) respectively. The companies in the study are the following: COMPFE, INFODE....

I-A collaborations represent a multifaceted arrangement that involves at least two actors- a company and an HEI and occasionally intermediary organizations (Perkmann and Schildt, 2015). Therefore, for each company, we also interviewed a minimum of one HEI (in total, nine HEIs are interviewed) and intermediary organizations (in total, two intermediary organizations are interviewed) to understand the HEIs’ and intermediaries’ perspective on the statements made by the interviewees from the company. Secondary data from company reports and memorandum of understanding signed between the companies and various HEIs pertaining to education-based alliances also offered valuable insights into the scale at which individual companies collaborate in education with HEIs in India and arrangements required for practicing various education-related activities promised under the
collaborations. In total, 47 interviews were conducted during the period from July 2016 to January 2018.

4. Empirical Data

This section presents data received from the exploratory cases. We do not present the five confirmatory cases here as their motivations and mechanisms used for engaging in education-based I-A collaborations are identical to the six exploratory cases.

4.1 COMPFE’s education-based collaborations with Indian HEIs (Case-1)

COMPFE is one of the first major global IT corporations to establish an R&D subsidiary in India. While COMPFE recruits annually over 3,000 E&T graduates, its clients recruit over 6,000 E&T graduates each year. COMPFE needs to ensure that the young Indian E&T graduates are adequately skilled in COMPFE’s tools so that when these graduates are recruited by COMPFE and its clients, they do not need to undergo extensive on-the-job training. For educating the graduates in COMPFE’s tools, by 2017, COMPFE has developed education-based collaborations with more than 150 Indian HEIs, by offering courses to students and faculty, as well as via the setting-up of labs at HEIs in four domains: “big data”, “cloud computing”, “information security” and “mobile computing”.

COMPFE engages with approximately 25 HEIs across India to offer courses to students as a part of the UG curriculum. For example, in the year 2013, COMPFE collaborated with HEI-A, an autonomous HEI located in western India, to introduce a specialization on “big data analytics” within the UG program in Computer Science. This specialization contains seven IT courses (e.g. “Fundamentals of big data with Hadoop using COMPFE software” and “essentials of COMPFE business intelligence administration”) spread across five semesters. Successful completion of all seven courses lead to a certification from COMPFE and the students are awarded a degree called “Bachelor of Technology in Computer Science with COMPFE’s specialization in big data analytics”. Students are required to pay extra for attending courses from COMPFE’s specialization.

In delivering such courses to students at HEIs as part of the curriculum, COMPFE mainly follows two delivery mechanisms: delivering the courses through its own employees or through the HEIs’ faculty. COMPFE sends a group of 2-3 employees from COMPFE’s R&D centers across India who possesses experience in developing or practicing the specific COMPFE tools used in a particular course. Sending own employees to teach at the HEIs on a regular basis, while helping COMPFE to ensure appropriate teaching quality, is rather costly as some of the HEIs are located in geographically remote areas. COMPFE, therefore, considers delivering the courses by the faculty of HEIs to be a preferred mechanism. In order to make faculty familiar with the COMPFE tools and courses, they are offered appropriate training before the start of the courses every year. For example, in the case of COMPFE’s collaboration with HEI-A, since faculty were not familiar with the COMPFE courses, during the first year after the collaboration was announced (academic year: 2013-14), COMPFE delivered almost 100% of the lecture hours, 50% of the lecture hours in 2014-15, and 20% during 2015-16. During the initial three years, faculty gradually developed expertise in COMPFE’s tools/courses through ten-day long faculty training programs organized by COMPFE at its R&D facility located in Bangalore before the start of each academic year and via participation in the COMPFE’s employee-delivered lectures/practical sessions. Apart from co-developing and delivering courses as a part of the curriculum, COMPFE also collaborates with approximately 125 HEIs to deliver courses from the four technological domains that are taught externally to the curriculum. For instance, COMPFE has collaborated with another HEI “HEI-B” located in West India. Initially, HEI-B was interested in offering the COMPFE taught courses as a part of the curriculum similar to the collaboration between COMPFE and HEI-A. However, since HEI-B is not an autonomous institute, it needed permission from the parent university to amend the curriculum. The request for incorporating COMPFE’s courses in the curriculum was rejected by the parent university, which forced COMPFE to offer the courses outside the curriculum. Under this collaboration, COMPFE employees visit HEI-B for 2-3 days in a year and offer one or two courses to students and offer certification to students for
attending the course. Since the courses are completed within 2-3 days, COMPFE prefers to send its own employees to the HEIs’ premises to teach the courses as they can control the quality of teaching the courses. The HEIs are required to pay for allowing COMPFE to offer courses on its premises and the HEIs recover the money from students. The interviewee from HEI-B revealed that student participation in COMPFE taught value-added certification courses is usually 90%. In order to hold practical sessions for all courses that are delivered as a part or external to the curriculum, COMPFE establishes a computing lab, also called “COMPFE Software Centre of Excellence” at each collaborating HEI with necessary resources such as software and access to cloud, which allows the students to receive hands-on training of working on COMPFE tools.

4.2 INFODE’s education-based collaborations with Indian HEIs (Case-2)

INFODE, an Indian IT multinational, started a program in 2004 to collaborate with Indian HEIs to deliver IT courses to the UG students outside the curriculum. Up to 2013, INFODE was able to reach out to 400 Indian HEIs benefitting more than 8,000 faculty and 80,000 graduates across India for development roles. INFODE recruits over 15,000 fresh E&T graduates every year and these programs help INFODE to recruit industry-ready graduates.

Under the Program, INFODE has designed a technical module to roll out to engineering students externally to their formal curriculum. Courses taught under the technical module are: Object Oriented Programming using Java, Relational Database Management Systems, Software Engineering and Introduction to Web Technologies, and Analytics related to Problem Solving techniques. The program starts in the fifth semester for students from all disciplines and ends in the eight semester. On average, each course is delivered in 50 hours, covering both theoretical and practical sessions. Upon successful completion of each course, the students receive a certificate from INFODE. The partner HEIs are not allowed to modify the course content designed by INFODE. The courses are delivered at the partner HEIs by the faculty of the Computer Science Department of the partner HEIs. Since these courses are not a part of the curriculum, they are taught weekly outside the curriculum hours depending upon the availability of faculty. Initially, INFODE offers 72 hours’ training to the faculty at a nodal HEI. A nodal HEI refers to an HEI chosen by a company for using its infrastructure and resources for to deliver training to faculty from nearby HEIs.

HEI-B is INFODE’s education-based partner. For students interested in enrolling for INFODE’s courses at HEI-B, before participation in each course, a pre-test is organized at HEI-B to understand the students’ prior understanding of the course and where the actual knowledge gap exists. The results of pre-test are also shared with INFODE so that INFODE could revise the content of these courses for future years in order to bridge the knowledge gap. However, the pre-test is not used as a selection criterion for students to enroll in the specific course. At the end of each course, assessment is conducted by faculty, which is again approved by INFODE. The results of the final tests are compared with the pre-test results to observe how many students have improved and what the improvement level was. Again these statistics are shared with INFODE. The partner HEIs are not required to purchase any lab resources from INFODE for offering the courses to students, but they can use any of their existing labs for the practical sessions of the INFODE courses as long as the labs possess necessary resources such as computers, internet and necessary software. However, before the start of the program, partner HEIs are required to consider INFODE’s comments on whether or not to upgrade/purchase any license of software to match the needs of their courses.

4.3 NETWFE’s education-based collaborations with Indian HEIs (Case-3)

NETWFE is a leading US MNC specializing in ICT business and has its second headquarter located in India outside the USA. In 2000, NETWFE started forming education-based alliances with Indian HEIs to offer courses to UG/PG students on basic programming, network design and security and IoT outside the curriculum. By 2013, this program penetrated 450 HEIs and trained over 60,000 students in India. While NETWFE does not hire fresh Indian E&T graduates in mass numbers, some of its clients do. Therefore, enhancing skills of graduates through education-based alliances with
HEIs help NETWFE in developing a talent pipeline for its clients. The interviewee mentioned that 12 months’ on-the-job training is required to train graduates, who lack necessary skills to work in the industry. However, by offering courses, NETWFE is able to reduce the period of on-the-job training from 12 months to 2 months, which has resulted in huge savings in training costs for NETWFE.

NETWFE offers a number of popular courses outside the traditional curriculum of HEIs, which include cyber security and IoT. The duration of the courses ranges from 20 hours to 140 hours and involves mostly blended learning, i.e., a part of each course is delivered as instructor-led training and remaining part is delivered through online-led training. The instructors could be either the HEIs’ faculty or third-party organizations (TPOs), who are trained by NETWFE to deliver the courses to students. The introductory courses are mostly delivered online. The students need to go through materials prescribed by NETWFE and attend virtual classrooms for such basic courses. For the advanced courses, NETWFE requires instructors to teach the theory section as well. Students can also use the e-learning platforms to access NETWFE approved curriculum, and books, to engage in community discussions, and for mock tests.

NETWFE follows a hub-spoke distribution paradigm to train the faculty of HEIs. First, in a particular region, NETWFE collaborates with an HEI to establish a “regional academy” and to train faculty of the HEI. The regional academy has two responsibilities. First, it has to train the students of the HEI, where the regional academy is set up. Second, it needs to train faculty of the surrounding HEIs so that those faculty can go and set up “local academies” in their respective HEI to offer NETWFE’s courses to students. One regional academy manages up to 10 local academies. In India, NETWFE has over 400 local academies and 50 regional academies. In order to establish a regional or local academy, the respective HEIs need to have a basic infrastructure such as a dedicated classroom, internet, server and computers as well as it needs to purchase lab equipment from NETWFE such as routers and software. The faculty is trained on theoretical aspects of the courses, how to set up the labs and after the training, it is mandatory that faculty go and set up the labs at their respective HEIs’ without any external help. The trainer certificates offered to faculty have a validity of 2-5 years depending upon the how often the content of these courses are updated by NETWFE, after which the faculty and TPOs need to undergo training and assessment again to renew the certificates. NETWFE offers flexibility to the HEI on when they plan to offer the courses to students.

4.4 SOFTF’s education-based collaborations with Indian HEIs (Case-4)

SOFTF, a US multinational firm specialized in the development of customer-facing applications, has developed education-based collaboration with over 20 HEIs and HEI-B is one of them. In such collaborations, SOFTF offers projects to UG students on Android platforms outside the HEIs’ curriculum. SOFTF is a regular recruiter of HEI-B’s engineering graduates. In 2017, SOFTF recruited 13 graduates from HEI-B for the Android Developer roles. The graduates who have already completed a project using Android platforms under the education-based collaboration between SOFTF and HEI-B receive preference in job interviews, because such graduates require less additional on-the-job training compared to graduates who have no prior experience in working with Android platforms.

At the start of every academic year, SOFTF employees visit HEI-B to organize workshops for students explaining how students can take advantage of the education-based alliance between SOFTF and HEI-B to gain experience in working with Android platforms and the possible utilities of doing practical projects on Android platforms in the real job market. The faculty from Computer Science department is responsible for supervising the projects. The interested students are divided into groups of 2-4 students and are required to work on a project for an entire academic year similar to a thesis project under faculty’s guidance. Since such projects are not part of the curriculum, HEI-B has recognized that supervision of multiple projects may increase the teaching load of faculty, which may affect their research and regular teaching activities. Hence, HEI-B only allows maximum 10 teams i.e., 40 students to undertake the Android projects. Total five faculty members are involved in the supervision of the projects and no faculty can supervise more than two projects.
Before the start of the academic year, HEI-B shares a list of faculty, who will be supervising the projects, with SOFTF. SOFTF then trains the faculty through own employees on application development using Android technologies. The faculty then offers seven days’ classroom training at HEI-B to students to impart them with the requisite knowledge for initiating the projects. Once the students have submitted their ideas to the faculty on what sort of application they intend to develop, the faculty then forwards these ideas to SOFTF staff based in Noida (U.P., India) to explore if the ideas are implementable. Additionally, SOFTF visits HEI-B if it feels a face to face explanation is necessary to address particular issues in the projects. HEI-B covers the travel costs if faculty visits SOFTF’s office for training and SOFTF pays for their own travel while visiting HEI-B. SOFTF does not offer certifications for participating in such application development projects; rather they organize an exhibition among all collaborating HEIs annually where the students showcase their apps and the best team is awarded certificates and prizes.

4.5 ELECDE’s education-based collaborations with Indian HEIs (Case-5)

ELECDE is a domestic firm specializing in electrical equipment manufacturing. In 2015, it entered into an education-based collaboration with HEI-C, a private autonomous HEI located in Delhi NCR to jointly design and offer an UG program in Electrical Engineering with a specialization in Power Electronics. ELECDE considers this collaboration as a pilot and intends to extend it to other HEIs provided the pilot results in solving their problems in finding employable graduates in the power electronics domain. ELECDE has promised that post completion of the UG program, the graduates will be employed by ELECDE.

Before the collaboration with ELECDE, HEI-C had a UG program in Electrical Engineering without any specialization. ELECDE made several changes to the UG curriculum in Electrical Engineering. Firstly, it introduced a new specialization in Power Electronics by replacing some of the generic courses with three new courses from Power Electronic domain such as “Applications of Power Electronics in Power Systems”, “Advanced Control Theory”, and “Programmable Logic Controllers & SCADA”. Also, ELECDE suggested changes to the contents of two existing courses. Secondly, ELECDE asked HEI-C to keep no courses in the eighth semester of the UG program and instead, make it mandatory for the UG students to undergo 20 weeks training at ELECDE in this semester. In order to organize the practical sessions, ELECDE has set-up a lab at HEI-C’s premise. ELECDE also placed an engineer permanently at the lab for conducting the practical sessions pertaining to the courses while the theory classes are run by faculty. Faculty receives five days training before the start of each academic year from ELECDE. HEI-C has also placed one faculty member from the Department of Electrical Engineering permanently at the lab so that faculty member can assist the engineer from ELECDE in conducting lab classes and acquire the necessary skill-sets in operating ELECDE’s tools in the lab. This lab is not only used to teach courses jointly developed by ELECDE and HEI-C, but also to teach other relevant courses, and students from other disciplines are also allowed to use the lab resources for their UG thesis project. However, this lab houses basic facilities that are not adequate to develop advanced technical skills for ELECDE’s workplace machineries. Therefore, from time to time, ELECDE’s engineers take the students for day-long practical training at the nearest manufacturing facilities. Also, graduates are required to undergo 20 weeks training at ELECDE in the final semester of their UG program.

ELECDE’s CEO was inducted to the Board of Studies of HEI-C after they started collaborating to jointly develop and deliver courses in Power Electronics. Such involvement served two purposes for the HEI. First, it helped HEI-C to lay the foundation for a stronger and long-term connection with ELECDE. Second, engagement of ELECDE’s CEO helped HEI-C to receive industry inputs on how to improve the curriculum, labs, skills of students and faculty. Also, the HEI-C was able to use ELECDE’s CEO’s connections to contact other companies for forming education-based collaborations to enhance skills of graduates in other engineering disciplines as well.
CHIPFE’s education-based collaborations with Indian HEIs (Case-6)

CHIPFE established its R&D center in Bangalore in 1998 and this is now home to over 5,000 R&D employees. By 2013, CHIPFE partnered with 35 HEIs in India to train 155 faculty and established labs on Embedded Systems; through which, 3,354 students have been trained. CHIPFE’s embedded labs include resources such as microprocessors, circuits, switches and software etc., access to CHIPFE’s cloud that contain free/subsidized teaching materials including textbooks, user manuals for its product, and lab exercises. While the primary motivation is to produce graduates that are well-versed in using CHIPFE’s hardware and software, which becomes beneficial when either CHIPFE or CHIPFE’s clients look for potential graduates to recruit, CHIPFE also consider selling lab tools as a revenue generating stream. CHIPFE does not use these labs to offer any courses to students. Rather, CHIPFE expects that the HEI will integrate the labs into their existing curriculum by conducting the practice sessions pertaining to the curriculum courses in the CHIPFE’s lab.

In order to promote CHIPFE’s lab tools, CHIPFE annually organizes information sharing workshops at nodal HEIs in different regions across India, where CHIPFE educates the faculty from surrounding HEIs on CHIPFE’s advanced lab tools and embedded system technologies. If CHIPFE receives a request from HEIs for establishing labs, it sends its own employees to set-up the labs at HEIs. Post setting up of labs, CHIPFE organizes 2-3 days faculty training program at the HEIs. The program comprises of both theory and lab sessions. In the lab sessions, faculty is given hands-on training on how to operate the tools installed in the lab and how this lab can be used for conducting practical sessions for students pertaining to the relevant courses in their respective HEIs. Additionally, the theoretical sessions show faculty how they can integrate the lab equipment to existing UG/PG curriculum. CHIPFE has also partnered with Indian Institute of Science, Bangalore, India’s top-ranked HEI in QS World University ranking, to develop an advanced curriculum on embedded systems around the use of CHIPFE lab equipment. In the theoretical sessions of the workshop, this curriculum is shared with faculty and they are taught on how to use the curriculum to either develop new courses or integrate to existing courses in embedded systems.

CHIPFE also collaborates with TPOs to: promote CHIPFE’s lab tools; and carry out financial negotiations with HEIs and set-up labs. Such TPOs are trained by CHIPFE’s employees on how to install, maintain and teach courses using the tools. These TPOs are responsible for conducting workshops at HEIs that currently do not hold a CHIPFE lab and to inform them about utilities of CHIPFE labs and how existing courses can be taught by using the lab equipment. TPOs offer initial training to faculty on how to operate the equipment once a new lab is installed and offer maintenance whenever required. The TPOs are also required to interact regularly with the HEIs by organizing workshops, where there already exists an CHIPFE lab, to inform them about new CHIPFE technologies so that the existing CHIPFE lab can be upgraded with advanced tools. The TPOs receive a consulting fee for fulfilling their responsibilities. Appointment of TPOs helps CHIPFE in forming education-based alliances with remote HEIs. While such labs are mostly used for teaching purpose, CHIPFE also encourages students and faculty to use the labs for developing innovative technologies/products that could be commercialized. Every year, CHIPFE organizes a rapid prototype camp among partner HEIs, where students are encouraged to showcase their prototypes. In most occasions, when a lab is set up, most tools have to be purchased by the partner HEI. The constraint for HEIs to engage with CHIPFE is, therefore, lack of funds. HEIs cannot charge from students because CHIPFE does not offer any course to students.

5. Cross-case Analysis

According to interviewees, a majority of the fresh Indian E&T graduates particularly from non-elite HEIs lack necessary technical skills to work in R&D functions. When such graduates are hired, companies must usually invest in offering approximately 12 months on-the-job training in order to make these graduates R&D ready. During the on-the-job training period, the graduates are also paid salary, yet their contribution to revenue generation is minimal. However, if the company trains graduates when they are still undergoing their formal university education through education-based
collaborations with HEIs and then recruits such graduates, the company receives graduates with the required level and type of R&D skills. In this scenario, the company may only need to organize 1.5-2 months additional on-the-job training for the recruited graduates to make them ready to take up R&D positions at the company. Thus, through education-based collaborations with HEIs, companies are able to reduce on-the-job training costs and also, graduates should be able to start contributing to revenue generation for the firm after two months.

5.1 Three modes to realize I-A collaborations in education

From the case studies, we identify three distinct modes of education-based I-A collaborations, which are: companies offering training programs to students as a part of the HEI’s curriculum (Mode-1); companies offering training programs to students outside the HEI’s curriculum (Mode-2); and companies setting-up new labs/upgrading existing labs at HEIs primarily for teaching (Mode-3). The three modes distinguish from one another in terms of the type of skills that the company expects the graduates to develop over time. While Mode-1 and Mode-2 collaborations aim to develop graduates with mainly general and industry-specific technical skills; Mode-3 collaborations allow the collaboration to impart company-specific technical skills to the graduates. Mode-1 and Mode-2 further differ in terms of challenges they carry for the company. Also, there exists heterogeneity across the drivers for HEIs to engage in the three collaboration modes. In Mode-1 collaborations, companies engage with academia to develop curriculum and train students with the updated curriculum, while, in Mode-2 collaborations, the foci remain on training students without affecting the curriculum. Through Mode-3 collaborations, companies contribute to the HEIs’ labs development.

Mode-1 - Companies engage with academia to offer training programs to students as part of the curriculum

In Mode-1, companies are involved in designing single/multiple courses as part of the UG/PG curriculum at HEIs and offering these courses to students. COMPFE’s collaboration with HEI-A and ELECDE’s collaboration with HEI-C are examples of Mode-1 I-A collaboration in education. In both cases, the companies developed a specialization within the existing curriculum by introducing several new courses. The contents of these courses are usually jointly developed by the faculty and companies. At the end of the program, on successful completion of all courses pertaining to the specialization, the students receive a degree, where the undertaken specialization is clearly mentioned. The students need to pay an additional fee to undertake courses from the company specializations, but on completion, they are more likely to be offered a job at the company. Students are likely to show more seriousness in taking such courses possibly due to the sense of “compulsion” that comes with a course that is a part of the curriculum. However, there exists a serious challenge that restricts companies to engage in Mode-2 collaboration with HEIs, which is lack of academic autonomy of the HEIs to change curriculum suggested by their parent (government) universities. Therefore, corporations are likely to enter into Mode-1 collaboration only with autonomous HEIs which have full independence to create or modify existing curriculum. Even within autonomous HEIs, in order to change existing curriculum or to insert a new curriculum at an HEI companies need to engage in intensive communication with the HEIs over a long period of time to ensure that the suggestions of the HEI are also taken into consideration while designing the courses to be taught to students. It, therefore, suggests that a long processing time period is needed to start collaborations in Mode-1. Further, in this process, the company may lose control over the content of the courses to be taught to students. The benefits for HEIs to participate in Mode-1 collaboration come in the form of training students in industry-relevant courses and development of curriculum in line with industrial needs.

Mode-2: Companies engage with academia to offer training programs to students outside the curriculum

In Mode-2, companies collaborate with HEIs to offer training programs that are delivered outside the curriculum hours. Depending upon the agreements made between the HEIs and the company, the training programs can be covered over a semester if offered for 2-3 hours weekly or can
be completed within 3-4 days with highly intense training. Since courses/projects taught in Mode-2 are offered outside the curriculum; they need not be approved by the HEIs’ parent universities and therefore, companies may prefer engaging in Mode-2 with HEIs that do not possess adequate autonomy to include company’s training programs in their curriculum. Again, companies are not required to involve the HEI in designing the courses/projects to be offered in Mode-2. This ensures that the company retains control over the contents of the training programs being offered to students in Mode-2 and the collaboration can be started with lesser processing time. However since completion of the training programs offered in Mode-2 is not obligatory for the students to receive their degree, students may show low interest in participating in these programs. This might restrict the companies to reach out to a large number of students through Mode-2. HEIs benefit from Mode-2 collaborations in terms of training of students in skills and competencies that are needed at workplaces. However, one discouragement for HEIs to engage in Mode-2 collaboration with companies is their inability to control the content of the training programs offered by the companies.

Mode-3: Companies engage with academia to set-up new labs or upgrade existing labs

In Mode-3, companies establish labs at HEIs or upgrades existing labs with the intention to educate the students in company-specific products/technologies, which helps the company to develop the graduates for R&D position at the company and also at other companies (e.g., clients) that use the companies’ products/technologies. This factor aids the company in marketing its products and technologies. Mode-3 collaboration contributes to laboratory development of HEIs. While the primary function of these labs is to ensure that students receive adequate practical knowledge during their formal university education, these labs could also be used for research and entrepreneurship purpose. The HEIs may experience challenges in integrating the technology and products from the lab to the regular curriculum as faculty may not hold expertise in the operation of the labs. Therefore, at the time of setting-up the labs, the companies (e.g., CHIPFE) offer training to faculty on how to integrate the labs into the HEIs’ regular curriculum for conducting the practice sessions pertaining to the courses from the regular curriculum.

Mode-3 collaborations are often practiced alongside Mode-1 and Mode-2 collaborations, as in cases of COMPFE, ELECDE, and NETWFE, to conduct practice sessions pertaining to the training programs offered by the companies in Mode-1 and Mode-2. Offering Mode-3 alongside Mode-1 or Mode-2 helps companies to design and offer courses to graduates that aim to impart the graduates with general, industry-specific and company-specific skills. For instance, the course titled “foundation in business analytics using COMPFE software”, offered in Mode-1 by COMPFE at HEI-A aims to enhance not only the competencies of the graduates on big data analytics, which is an industry-specific skill-set, but also on COMPFE’s software used for processing and managing big data. Similarly, communication networking courses from NETWFE (offered in Mode-2) require graduates to learn to configure communication networks using NETWFE’s routers and switches. HEIs are required to pay for procuring lab set-ups from companies in Mode-3 and therefore, funding becomes a challenge for HEIs. However, in cases where Mode-3 collaboration is practiced alongside Mode-1 and Mode-2 collaboration, this challenge can be avoided by including the prices of the lab tools in the fee to be paid by the students for attending the training offered in Mode-1 and Mode-2.

Table 1 summarizes the drivers and challenges for companies and HEIs to engage in the three modes of education-based I-A collaborations.
Table 1 Drivers and challenges for companies and HEIs to engage in the three modes of education-based I-A collaborations

<table>
<thead>
<tr>
<th>Modes</th>
<th>Drivers for companies</th>
<th>Drivers for HEI</th>
<th>Challenges for companies</th>
<th>Challenges for HEIs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode-1</td>
<td>Developing graduates with mainly general and industry-specific skills for R&amp;D</td>
<td>Curriculum development in line with industrial needs</td>
<td>Longer processing time needed to start the collaboration</td>
<td>Lack of autonomy of HEIs to alter curriculum</td>
</tr>
<tr>
<td></td>
<td>Reaching out to high number of students</td>
<td>Student becomes employable for R&amp;D in the industry</td>
<td>Risk of losing control over the content of the training programs to be taught to students</td>
<td></td>
</tr>
<tr>
<td>Mode-2</td>
<td>Developing graduates with mainly general and industry-specific skills for R&amp;D</td>
<td>Graduates becomes employable for R&amp;D in the industry</td>
<td>Difficulty in reaching out to high number of students</td>
<td>Lack of honesty and interest from students to undertake the training programs</td>
</tr>
<tr>
<td></td>
<td>Control over the content of the training programs to be taught to students</td>
<td>Lesser processing time needed to start the collaboration</td>
<td></td>
<td>Limited control over the content of the training programs to be taught to students</td>
</tr>
<tr>
<td>Mode-3</td>
<td>Developing graduates with company-specific skills for R&amp;D</td>
<td>Lab development</td>
<td>Funds to buy lab tools from the company</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Compliment Mode-1 and Mode-2 collaborations</td>
<td>Graduates becomes employable for R&amp;D at the company and company’s clients</td>
<td>Integrating the labs to the regular curriculum</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Marketing tools</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.2 Three delivery mechanisms to realize the three modes of I-A collaborations in education

In order to operationalize the three modes of education-based I-A collaborations at partner HEIs, companies may choose three delivery mechanisms (DM) by involving three actors in the mode-specific activity delivery process: companies’ own employees (DM-1), trained faculty of the partner HEIs (DM-2) and TPOs (DM-3). Figure 1 illustrates how the three collaboration modes are operationalized using the three delivery mechanisms.
Delivery Mechanism-1: Training students and setting up labs at partner HEIs through company’s own employees

Companies may send own employees from R&D functions, usually experts in respective disciplines and experienced in using specific tools to train students in courses/project from the same discipline (Mode-1 and Mode-2) or to set-up labs (Mode-3) at the partner HEIs. In terms of training students in Mode-1 and Mode-2, by company’s own employees, the company is able to control the quality of delivery of the training programs. Also, the company is able to maintain direct contact with the students of partner HEIs. Such direct communication with the students could help the companies in identifying talents for possible recruitments. However, engaging its employees in the physical delivery of courses to students at HEIs increases the operating costs of teaching courses at HEIs, particularly when the HEIs are located in remote areas. Also, companies may not possess the adequate number of human resources to deliver the training programs and set-up labs directly at HEIs, particularly when the company has a number of education-based collaborations with different HEIs going on in parallel.

Delivery Mechanism-2: Training students and setting-up labs at partner HEIs through trained faculty

High operating costs involved for companies to send own employees to train students (Mode-1 and Mode-2) and/or to set-up labs (Mode-3) at HEIs particularly when the partner HEI is located in remote areas, the companies may choose to implement the activities pertaining to the three collaboration modes through the partner HEIs’ faculty. In this delivery mechanism, the company first trains the faculty in the training modules to be offered to students (for Mode-1 and Mode-2) and lab tools to be installed and used at HEIs (for Mode-3); whereby the faculty can then train the students and set-up labs at HEIs. The company can either train the faculty through its own employees (DM-2a) or through trained TPOs (DM-2b). When the training of faculty is conducted by companies’ own employees, direct communication between the companies own employees and faculty of the partner
HEIs may lay the foundation for research and entrepreneurial collaborations between the collaborating faculty and the company’s employees. However, such a benefit cannot be availed when the training is offered to faculty through trained TPOs. The faculty receives a “trainer certificate” post completion of the training. In some cases, in order to get the “trainer” certificate, faculty needs to undergo an assessment process, which not only examines faculty’s knowledge on the topics to be delivered to students but also assesses faculty’s teaching approach. This certificate is offered at no cost by the companies.

While the involvement of faculty in the offering of training and setting-up of labs at partner HEIs help companies to reduce operating costs in realizing the three modes of collaboration, HEIs benefit from the fact that their staff receive free applied training and remain up to date with some key technological advancements. Although this delivery mechanism might look like an attractive proposition for both companies and HEIs, there exist several key challenges in pursuing this delivery mechanism. Firstly, faculty may show limited interest to participate in offering the training to students and set-up labs because: a) involvement in such activities requires significant time investments from faculty, yet, they appear to receive no incentive for their participation; b) public HEIs may restrict regular faculty members from engaging in training students outside curriculum (in Mode-2) considering such engagement as a “conflict of interest”. Secondly, particularly for delivering activities of the three modes via faculty, few weeks’ of training might not be sufficient to educate the faculty to a level that they become able to train students with the expected quality. This problem, however, can be solved by engaging in the slow and long-term training of faculty as seen in the collaboration between COMPFE and HEI-A. Also, companies could employ strict monitoring to ensure appropriate delivery of the training to students. For instance, as observed from INFODE’s partnership with HEI-B, the company may ask the faculty to report regularly about the schedule, batch size, the progress of the students, examination questions and examination scores to the company so that it can keep track of the progress of the course delivery. Thirdly, the involvement of faculty in the delivery of activities pertaining to the three collaboration modes results in loss of direct communication between the company’s own employees and students, which may negatively moderate the company’s ability to identify graduates for possible recruitments.

**Delivery Mechanism-3: Training students and setting-up labs at partner HEIs through trained third-party organizations (TPOs)**

Shortage of faculty or lack of interest among faculty at partner HEIs to pursue activities pertaining to the three collaboration modes may drive the HEI to receive the student training programs and lab set-ups from the companies through trained-TPOs. These TPOs are required to undergo train-the-trainer program directly at the firm similar to the delivery mechanism DM-2a. Delivery of activities pertaining to the three collaboration modes through trained TPOs result in lack of direct communication between the firm and students and faculty. It limits the firms’ ability to identify students for possible recruitment and students’ ability to identify job opportunities with the company. While the lack of direct interactions between faculty and the company may also restrict opportunities to identify each other’s expertise for developing research and entrepreneurial linkages. Due to the involvement of TPOs, the company loses control over the delivery of the final mode-specific activities i.e., training students and setting-up labs. Also, the involvement of TPOs is likely to result in high operating costs for the company as TPOs charge a fee for their services.

Table 2 summarises the drivers and challenges for companies and HEIs to collaborate in education through the three delivery mechanisms.
Table 2: Drivers and challenges for companies and HEIs to collaborate in education through the three delivery mechanisms

<table>
<thead>
<tr>
<th>DM</th>
<th>Drivers for company</th>
<th>Drivers for HEI</th>
<th>Challenges for the company</th>
<th>Challenges for the HEI</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM-1</td>
<td>Direct interaction with students*</td>
<td>Direct interaction of students with the company**</td>
<td>Unavailability of employees to involve</td>
<td>Limited access to remote HEIs</td>
</tr>
<tr>
<td></td>
<td>Control over the delivery of final activities</td>
<td></td>
<td>Limited high operating cost</td>
<td>Limited faculty training</td>
</tr>
<tr>
<td>DM-2</td>
<td>Unavailability of employees to involve</td>
<td>Direct interaction of faculty with the company***</td>
<td>Lack of control over the delivery of final activities</td>
<td>Lack of direct interaction of students with the company**</td>
</tr>
<tr>
<td></td>
<td>Direct interaction with faculty***</td>
<td>Faculty training</td>
<td>Conflict of interest over faculty’s involvement</td>
<td>Faculty turnover</td>
</tr>
<tr>
<td></td>
<td>Access to remote HEIs</td>
<td>Low operating cost</td>
<td>High teaching load on faculty</td>
<td></td>
</tr>
<tr>
<td>DM-3</td>
<td>Unavailability of employees to involve</td>
<td>Lack of interest from faculty to involve</td>
<td>Lack of control over the delivery of final activities</td>
<td>Lack of direct interaction of students** and faculty*** with the company</td>
</tr>
<tr>
<td></td>
<td>Access to remote HEIs</td>
<td>Avoid conflict of interest over faculty’s involvement</td>
<td>Lack of direct interaction with faculty*** and students*</td>
<td>High operating cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shortage of faculty to involve</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*to identify graduates for recruitment  
**to identify job opportunities at the company  
***to identify potential research and entrepreneurial opportunities

Table 3 shows the positioning of the eleven cases (both exploratory and confirmatory) against the three modes of education-based I-A collaborations and three delivery mechanisms.

Table 3: Positioning of the eleven cases against the three modes of collaborations and three delivery mechanisms

<table>
<thead>
<tr>
<th>Modes</th>
<th>Delivery Mechanism (DM)</th>
<th>Exploratory cases</th>
<th>Confirmatory cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode 1</td>
<td>DM-1</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>DM-2</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>DM-3</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Mode 2</td>
<td>DM-1</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>DM-2</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>DM-3</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
6. Discussions

6.1 Education-based I-A collaborations: benefits for companies and theoretical implications?

Our findings indicate that most Indian E&T graduates are unable to acquire required general and industry-specific human capital during their university education. In order to develop such graduates for R&D, the companies are required to first make them industry-ready by offering additional on-the-job training before the company could focus on making them R&D-ready by offering on-the-job training to develop company-specific human capital in the graduates. We suggest that the formation of education-based alliances with academia and the training of students with general and industry-specific human capital will allow the companies to receive industry-ready graduates at minimal costs as students pay for such training. Surprisingly, we observed that firms further exploit these education-based I-A collaborations to develop R&D-ready graduates by integrating company-specific training to both general and industry-specific training modules. For instance, the courses that NETWFE offers at partner HEIs require graduates to learn to configure NETWFE’s routers in labs. Particularly, the labs are established in Mode-3 to reinforce a “company-specific” learning component into the training offered under Mode-1 and Mode-2. Therefore graduates can directly engage in R&D tasks without having to undergo extensive on-the-job training at the company post recruitment.

This finding leads us to make two key theoretical contributions to human capital theory. Firstly, scholars (Barron et al., 1999) suggest that employers mostly pay for the company-specific training to employees as it is unlikely to raise the employees’ productivity outside the company (Becker 1964; Neal, 1995; Hashimoto, 1981). However, in contrast with this viewpoint, we argue that by forming education-based alliances with academia, companies are able to develop company-specific human-capital among graduates (future employees) without paying for it, provided companies choose to deliver the training through faculty or third-party organizations. Secondly, in the context of hiring graduates for R&D, we propose modifications to Lepak and Snell’s (1999) HR architecture model. The HR architecture model based on the value and uniqueness of human capital (HC), proposed that hiring employees and offering them company-specific on-the-job training is “the only” employment mode that helps a company to develop highly valuable and unique human capital such as R&D employees. We argue that in the case of hiring graduates for unique and valuable job functions e.g., R&D, the employment mode suggested by Lepak and Snell (1999) is costly, particularly when the fresh graduates coming out of the universities are not industry-ready. In such a context, we show that companies should follow an alternative strategy, in which, they should collaborate with academia in education to offer company-specific training alongside general and industry-specific training to graduates when they are still undergoing university education. Hiring such graduates once they complete university education will enable companies to recruit highly valuable human capital, but at a lower cost, since these graduates require minimal on-the-job training. Also a major part of the investments made for development and operationalization of education-based I-A alliances is extracted from students as fees for participating in the training programs.

We suggest that companies can reduce investments made on education-based I-A alliances by choosing the appropriate delivery mechanisms. Adoption of DM-1 incurs high costs to the company. Therefore, conducting such training through the HEIs’ faculty (DM-2) and TPOs (DM-3) could help the companies to reduce the cost involved in offering training to students and setting-up labs at HEIs. Such education-based alliances also bring additional benefits to the companies. In particular, by educating graduates in company-specific products allows companies to develop a graduate pipeline for the existing and potential clients of their products/technologies. This could bolster the companies’ marketing drives for their products and technologies. Firms can also use education-based collaborations to help them better understand the competencies of faculty staff, for instance, evaluating whether some faculty might be utilized for future research and consultancy engagements (Perkmann et al., 2011).
6.2 Education-based I-A collaborations: benefits for academia

In this paper, we identify three modes of education-based I-A collaborations. Previous literature (Plewa et al., 2015), while not in detail, did recognize the existence of “curriculum co-development” (similar to our Mode-1) between industry and academia. Co-development of curriculum for training graduates for R&D work in industry was mainly concentrated to discussions on research-led “triangular doctoral allocations” degree programs, i.e. doctoral programs in conjunction with industry, where firms jointly supervise PhD students in conjunction with universities (Laredo, 2007). However, we argue that, not only PhD students join R&D departments of firms; a large number of graduates without a PhD join R&D functions. In fact, Jacobs et al. (2005) in the context of Netherlands observed more than 40% of E&T graduates to be joining R&D positions in industry. Existing literature does not appear to address how corporations engage with HEIs to co-develop and deliver curriculum within the UG/PG education. By exploring three mechanisms to engage in Mode-1 education-based I-A collaboration, we attempt to fill this research void. Regarding the other modes of collaboration, especially companies setting up labs at HEIs, previous scholars (See Appold, 2004) have contended that labs are established by companies at HEIs predominantly for research purposes. However, we maintain that it is highly likely that such labs are primarily established for teaching purposes (Mode-3), but might also be used for research purposes. We also add to the literature explaining how these labs are established and how faculty and students are trained to use these labs. To the best of our knowledge, Mode-2 collaboration, i.e., the offering of training programs by companies to students of partner HEIs outside the HEIs’ curriculum has been largely overlooked by the preceding studies. We also reveal that, in addition to students, faculty greatly benefit from education-based I-A collaborations as three modes of collaboration are often realized through the faculty (DM-2) and faculty acquire training in general, industry-specific and company-specific skills in the process. Although not explicitly proposed, few scholars (Acworth, 2008; D’Este and Patel, 2007; Woolgar, 2007) have indicated that companies can train faculty in new technologies by engaging in an employee exchange program. However, these studies do not discuss how faculty transfers the knowledge back to the students. Our paper highlights through the discussions on DM-2, not only how faculty offer the training programs of companies to students at HEIs, but also the potential benefits and challenges that come along with the involvement of faculty in the delivery mechanism of the training programs. In terms of benefits for academia to participate in such education-based I-A collaborations, while we concur with Plewa et al. (2015) that association of industry in education provides students exposure to “real-world problems”, we maintain that benefits for academia differs greatly across the three modes of I-A collaboration and different modes chosen to realize the individual modes.

6.3 Policy implications

Appropriate policy reforms can eliminate the challenges pertaining to the three modes of education-based I-A collaboration. In line with earlier studies (Gereffi et al., 2008; Loyalka et al., 2013), this paper reports that most Indian HEIs, particularly non-elite ones still follow an outdated curriculum. By participating in the co-development and delivery of curriculum with HEIs (Mode-1 collaborations), firms can educate the students with the type of skills required by industry. However, the lack of autonomy of Indian HEIs is a challenge for industry to modify the HEIs’ curriculum. In fact, approximately 90% of Indian HEIs do not have adequate autonomy to modify curriculum (AICTE, 2017). Therefore, Indian policymakers could encourage more academic autonomy for HEIs. In this respect, we suggest companies to approach government universities instead of HEIs for inclusion of the training programs in the university curriculum. As the curriculum prescribed by a government university is followed by hundreds of its affiliated HEIs; by engaging in curriculum co-development with the universities, wide-spread effect can be achieved.

We found that faculty involvement in delivery training programs to students and setting-up labs at HEIs could benefit both the company and the HEI. However, in order to encourage faculty to be trained in company-taught courses and lab tools, appropriate incentive mechanisms should be
designed. Especially for Mode-2 collaborations, where training programs are offered outside curriculum and participation is voluntary for faculty. Also, time spent in facilitating activities pertaining to education-based alliances is a time lost to research and entrepreneurial activities. The time that faculty spend in attending training from companies and offering such training to students, could be utilized to write applications to federal grants, offer research consultancy to firms, patenting, developing publications and practicing entrepreneurship, which could assure sound financial returns (Muscio et al., 2016; Owen-Smith and Powell, 2001), help academic to build academic reputation and recognition (Bruneel et al., 2010), and could thus facilitate required inputs for sustained career growth (Debackere and Veugelers, 2005). However, it seems that present practices for promoting faculty’s involvement in delivering training programs particularly in Mode-2 collaboration, which is sponsoring of a trainer certificate, is therefore, relying on academics' intrinsic motivations (Stern, 2004) to learn industrial technologies. Prior research (e.g., Debackere and Veugelers, 2005; Owen-Smith and Powell, 2001) has empirically observed positive association between presence of a formal incentive mechanism and academics’ propensity to engage with industry for joint research and entrepreneurship. Similarly, to encourage better participation from faculty in education-based alliances, companies could consider offering monetary incentives for delivering these courses to students.

7. Conclusion and future research directions

By introducing a typology of education-based I-A collaborations and proposing three different yet mutually inclusive collaborative modes which use different delivery mechanisms, this paper not only fills a long-pending literature void on industry-academia collaborations in education and teaching, but also opens up a potentially strong research avenue for the future. By exploring I-A alliances with respect to hiring graduates for R&D, we also contribute to human capital theory. We conclude that through education-based I-A collaborations, companies are able to impart general, industry-specific and company-specific human capital to graduates, which eliminates, to a large extent, the need to offer on-the-job training to graduates to make them ready to take up R&D positions at companies.

One limitation of the study is that our data is based on one country - India. However, we believe that our findings are relevant to other emerging countries, where employability of E&T graduates for R&D functions is a concern (Farell et al., 2005), as well as potentially developed countries which have been experiencing shortage of E&T graduates. As mentioned before, Oracle has already made education-based collaborations with 737 HEIs in China, 123 HEIs in Brazil and 71 Russian HEIs (Oracle, 2016); while EMC has made similar collaborations with 487 HEIs in China, 164 HEIs in Brazil and 84 HEIs in Russia (Emc2, 2015). Such secondary evidence also highlights the need and relevance for exploring the dynamics of education-based I-A collaborations in other emerging countries. This study is also relevant for some developed economies in the context of emerging technologies, where companies often complained about HEIs not producing relevantly skilled graduates. Another limitation of this paper is that we have limited our investigation of education-based collaborations to E&T HEIs only. Future research could study the occurrence of such I-A partnerships in the broader STEM disciplines. Future research could also use large scale data to examine academia-level factors e.g., HEIs’ autonomy, location, ownership, and faculty size etc. that in our understanding could influence the occurrence of each type of education-based I-A collaboration in order to inform HEIs, policymakers, and corporations on how to develop a favorable environment for implementing each collaboration mode. Finally, future research could examine to what extent, each of the collaboration modes actually improves quality of graduates.

8. References


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