Towards Massively Open Online Virtual Internships in Computing Education

by

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***Abstract*—Student internships are necessary for every student to learn and apply the learning to deliver tangible and relevant outcomes. In-person internship opportunities are less in number and have major challenges in scaling such as lesser number of available projects in relevant technologies, inadequate mentorship during the internship, varying college calendars and others. This paper presents SRIP (Student Remote Internship Program) approach which focuses on the domain of programming in open source technologies and projects for the internships that are relevant to 2nd and 3rd year engineering college students. It aims to overcome the stated challenges and simultaneously make a contribution to the open source community. Virtual Labs is the open source repository that we leveraged to implement SRIP pilot study for interns to contribute and develop programming skills.**

***Index Terms*—Remote Internship, Open source, Programming, Scalability**

I. Introduction

One of the prevalent problems in the world is low employability. There is a fundamental mismatch between market demand and supply of skills. Employers are looking for technical and vocational skills which are lacking in fresh graduates. Internship is one of the solutions to this problem. Today, internships are a part of most curricula of all engineering college and polytechnic students [1]. One of the important reasons for this is that internship programs help students relate their learning to the work and improves their ability to perform well when they join the workforce. Internship programs not only help fresh graduates in gaining professional know-how but also benefit industry to "get fresh perspectives on business issues and discover future business leaders" [1]. Effective internships are a bridge between college education and the competence needs of the industry and employers [2].

With about 1.5 million students coming out of engineering colleges every year, the need for internship programs is critical [3]. In 2019, about 1,00,000 internships were announced by organizations [4] [3] [5] which cover all branches of education - engineering, business management and others, a shortfall of 85.3% internship opportunities for engineering students. There is a need to evolve mechanisms to substantially enhance the availability of these programs so that a reasonable number of students get the opportunity to do internships. There is "no scalable solution to manage the increasing numbers of students seeking technical training for industry jobs" [6]. Also, Tier 2 and 3 colleges need opportunities for internship since internships are adequately available to Tier 1 colleges. Also, Tier 1 colleges are well resourced with highly qualified faculty and have less than 10% of engineering students.

In 2018, AICTE made internship mandatory for engineering and polytechnic students. Most internships available in the market are less in number and are in-person internships. Some of the concerns of existing internships are (a) lack of clear technical deliverables or projects for the interns to do, (b) less involvement by the organization offering internships on mentoring the students to learn, deliver (c) students need for money to travel outstation and stay for longer duration. These major difficulties limit the offers for internships. Internships given by larger organizations such as TCS [7], Wipro [8] and Infosys [9] are focused on students they recruit and are available to only a few students. A major issue that acts as a barrier to internship organizations is the widely differing academic calendar and seating arrangements that must be considered while offering internship programs. Summer vacation time, exam calendars and start/end times differing for colleges across the Indian geography poses a big challenge to schedule in-person internship programs with committed mentors. From the above scenario, it is evident that there is a strong need for internships that are effective while addressing the concern on the availability of adequate internship opportunities. The other challenges that these internship programs present both to the organization providing internship and students who take up these internships are many - such as "Uncooperative Mentors", "Allotment of trivial work", "Issues with Time Management

The Virtual Labs under The National Mission on Education through Information and Communication Technology, MHRD, Government of India

TABLE I
COMPARISON OF TRADITIONAL AND SRIP APPROACH

Internship Feature	Traditional	SRIP
# of projects	Limited	GitHub, GitLab are large source code repositories and growing
# of Interns	Limited by infrastructure	Large number as it is remote
Scalability (reach, #of students)	Limited	Much more scalable
Mentoring of interns	Dependent on availability and interest of Mentors	Continuous online Mentoring
Physical Limitation	Largely 'In office'	Remote- Anywhere Anytime
Time and Duration	Constrained by College calendars and availability	Not a Constraint
Geographical Scope	Interns travel to office locations	No barriers- online

/ Self-Management", "Unnoticed Work" and others . The interns are often hesitant to ask questions as the work environment is excessively grave and professional. In such an environment, interns find it difficult to ask questions for fear of being judged. Communication is often a barrier in such professional internships [10] [11] [12], this leads to reduced interest in students.

There are many opensource mentorship programs which provide internship projects to students like those listed under the 'SOC-Programs' [13], prominent among them is the Google Summer of Code program [14]. In most of these programs, the main goal is to get more open source code written and released for the benefit of all and inspire young developers to begin participating in open source development [14]. These programs have an expectation of medium/advanced skill level in coding and a detailed understanding of work requests, etc., a pre-requisite for the student to join the programs. The success of these programs and shortcomings on scalability make a strong case for an internship approach that is open to the larger set of college students who come out of engineering colleges with low or no coding skills.

Virtual internships are more in demand compared to 'in office' ones, virtual internships get three times more applicants than 'in office' [5]. A comparison of our proposed approach vis-a-vis traditional approach is provided in table I. In order to address the above issues, this paper presents a case study on remote internship program. The program is expected to help the setting up and running of internship programs to enhance students' application of knowledge and develop their competence. The approach is applied to engineering college students from various colleges across India with a small presence from overseas students. The rest of the paper describes the challenges, the approach and the case study to validate the approach.

II. Remote Internship Approach

Familiarity with open source software is considered as a primary need for all programmers. Coding in these repositories is necessary and a key capability. Varying calendars and availability of students during this period is also important to get the synergy of the teams supporting the internship programs. Another important consideration is the availability of relevant projects that the students could work on and deliver. An internship approach is tied together with these three cornerstones. The attributes that signify the success of an approach from students and other stakeholders (AICTE, colleges, parents, etc) perspectives are - students' performance in the assigned projects and software components and their exposure to the soft skills such as team working, communication, etc. All the above attributes

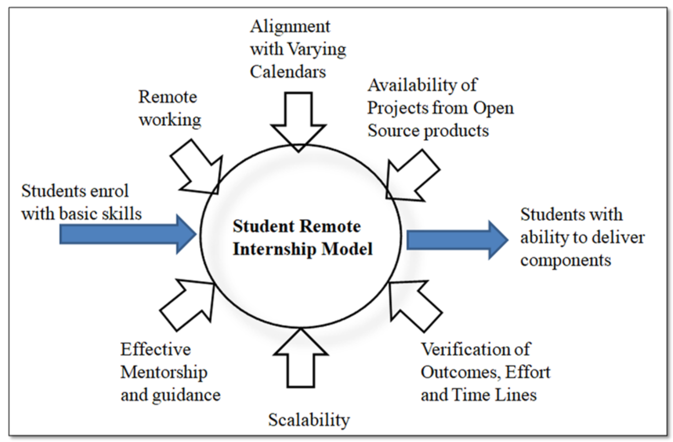

Fig. 1. Student Remote Internship Approach

will need to be met in the specified timelines. Figure 1 depicts the approach from a conceptual perspective. The student remote internship program (SRIP) is based on the support available on open source communities. Contribution of enhanced features and fixes for bugs in existing open source projects that are validated by the community and merged into the main software repository. This provides interns a continuous stream of projects and builds capability in them in open source technologies. They also help students develop competence on troubleshooting and problem solving. The existence of open source software repositories enables scalability in availability of projects. From these software repositories, a pool of projects can be identified and made available for students to work on in the internship.

The SRIP approach envisages that students who join the internship program are imparted 2 days boot camp on basics of programming, coding practices, debugging, GitHub and web technologies. The students are then assigned or allowed to select projects from a pool of identified open source projects. A mentoring arrangement with experienced mentors is made available on collaboration channels through the day. These online collaboration tools support direct and group messaging, file and video sharing, etc. Mentors use collaboration tools to respond to queries from interns. The interns work to meet the preset target of correct delivery and effort estimated based on software estimation guidelines such as Capers, Jones [15]. Interns use open source repositories to understand the issues, analyse features, code and write test cases. Verification of work is done by mentors and the later open source community members.

Each intern is assigned a mentor to maintain continuity and personal connect to facilitate communication. On collaboration channels, the open interaction between interns and mentors on technical problems, debugging and other clarifications help other interns as well and builds into a knowledge repository. Options for private online communication is also provided to enable any specific issues to be resolved and also help students that are conservative in their communication. The interns receive certificates on completion of predefined delivery and effort. Figure 2 depicts the SRIP process of the internship.

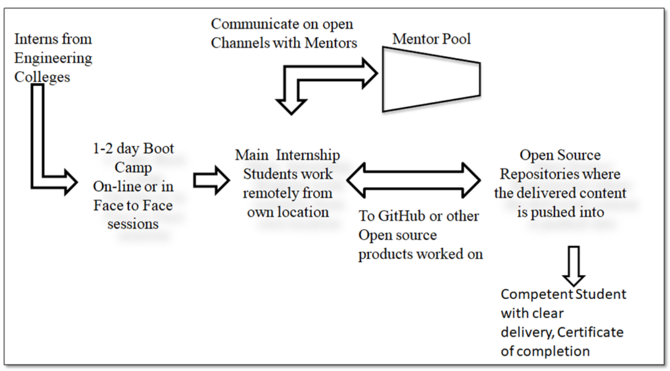

Fig. 2. Indicative Process of Internship

III. Implementation Approach and Results

The approach described above was implemented as a pilot case with Virtual Labs. Virtual Labs is an initiative of MHRD [16], Government of India which consists of 114 virtual labs across 9 engineering disciplines. These labs were developed with the support from 11 top engineering institutes of India. The student remote internship program [17] received over 600 application and those registered formally were 130 students.

A boot camp was run for 2 days and the technologies relevant to the projects such as HTML, CSS and Javascript. Some basic commands on Ubuntu ver 16.04 (operating system) and GitHub (software repository) were also covered as part of boot camp. A team of 11 mentors were constantly mentoring the students. The 130 students were split into 2 batches with 55 in the first batch and 75 in the second batch. The batches were spaced to accommodate the student constraints or exam dates, travel constraints etc. Each mentor was assigned a lab with 10 experiments, and students working on the experiments. An escalation mechanism, with developers from the Virtual Labs Community provided a second level support for coding work and for verification of committed deliverables. Frequently, issues beyond coding such as approach to problem solving, students trying to give up due to their inability to move forward were tracked on the communication channel by the 2 levels of mentors and by the management of the program. The deliverables were - (i) completion of the projects or tasks assigned, (ii) verified quality and correct code. A regularly updated scoreboard kept the students informed about the progress on effort that is based on standard software estimation procedures. The targets were delivery of projects with quality code, and a total effort of 240 hours, for which the elapsed time allowed was 10 weeks. This aligns with the AICTE mandate of 6 weeks of internship effort. Mentoring on an online communication channel was provided by an adequate number of mentors, to ensure that all questions and difficulties articulated by the interns were resolved and they could complete the prescribed targets. Feedback on the internship and mentorship was sought from the interns every three weeks. About 62% of them rated the mentor assistance at 80% while 31% rated their mentor assistance at 100%. About 31% of the interns stated that mentors responded in less than 1 hour while 23% felt they had to wait for 2-3 hours after their raising a query. 31% mentioned that all their questions were answered while 54% of the interns mentioned that there were instances that 1 or 2 questions were unanswered and they had to put effort to learn on their own. The commits on GitHub of Virtual Labs and survey feedback confirms that interns appeared to be reasonably ready.

IV. Results and Analysis

SRIP internship implemented on 130 students has met all the requirements of the program envisaged in the approach namely- interns deliver quality output, get exposure to the soft aspects such as teamwork, communication and met effort requirements and timelines. The unit of measure was effort-hours. An effort hour is the size of the deliverable (code) that can be delivered in 1 hour as estimated by Caper Jones. About 100 effort-hours of validated deliverable was considered the minimum to qualify for the internship certificate. In the present internship, 34% of the interns qualified, 44% did not meet the requirements of 100 effort hours. 23% did not participate after registering. Based on the % effort-hours completed over the prescribed 240 hours of effort, 12% scored over 85% and 2% exceed the target of 240 hours. We analyzed that some students were finding it difficult to program and some of them did not find the work interesting as the reasons for lesser contribution. The other important outcomes were - contributions they made to the open source software repository - Virtual Labs in the form of coding for experiment simulation and the related quizzes. About 88% of the interns have improved their coding skills as against their skill level prior to internship. Figure 3 shows the distribution of quality effort-hours delivered by the interns, the coefficient of variance reduced from 155% in the 6^{th} week to 76% in the 8^{th} week, signifying that the process has stabilized and that results are repeatable in future programs. The communication needs are addressed with

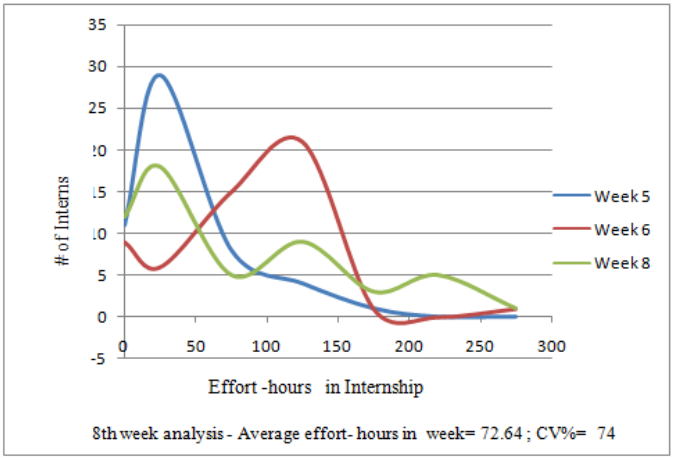

Fig. 3. Distribution of Effort Hours vs Number of Interns

Slack collaboration tool that is used by 8 million people world-wide. The Slack channel was available to the interns throughout the day, the average rate of communication per person was 13-14 slack messages per day or 1,204 messages for a channel per day. This gave mentors adequate time to respond to the satisfaction of the students and reduced fragment time for the mentors. This corroborates the interactions between mentors and intern students. Students feedback on mentors was largely positive, with feedback such as "It's just great. My mentor has helped out in every difficult situation I have been". Similarly, mentors too went worked closely with the mentees making in depth assessments like "he is trying to work, has implemented Github authentication, and a html page where notes are saved ...". It is noteworthy that this exercise has contributed to Virtual Labs some 70 new experiment simulations and corresponding 50,000+ lines of code. The results validated the veracity of the approach and the implementation process. Being remote and online the approach is scalable with proportionate mentor strength.

V. Conclusion and Future Work

The remote internship program developed to meet the requirements of engineering college students with a focus on programming skills was piloted on a batch of 130 students. This was designed to be able to scale to a large number of students and to overcome the limitations of the traditional 'In office' internship programs. Improved communication coupled with effective learning, availability of adequate projects from open source products, which in this case was "Virtual Labs", contribution to the Open source communities by way of bug fixes and enhancements were some of the takeaways. About 34% of the students delivered quality code and simulations for Virtual Lab experiments. Based on the results from the pilot implementation, we propose to extend the approach to more number of students, with newer open source communities and different complexity levels. We also plan to involve colleges faculty as part of internship teams to facilitate greater acceptance. The simplicity of the approach is such that it can be replicated not just by universities alone, but by any skill development program, in any domain, in any part of the world. The need for infrastructure and cost to execute is minimal. We also plan to record the boot camp programs and integrate it with collaboration tools to make it online. The SRIP approach discussed in the paper can effectively scale and increase global student employability and productivity as students commits are visible on GitHub. We also propose to use better estimation methods other than Caper Jones.

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