

Work in Progress: Examining the Literature on Virtual Internships for Insights Applicable to Engineers

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Abstract:

Internships are undertaken by roughly half of U.S. engineering students nationally and are widely thought to benefit students in a variety of ways, strengthening students' academic self-concept and increasing their persistence in engineering [1]–[3]. However, the COVID-19 pandemic of 2020 caused an unprecedented shift in the structure of internships, with approximately 83% of employers moving internships into a virtual work space [4]. While literature exists on in-person co-ops and internships [5]–[7], relatively little exists on engineering internships held virtually [8]. This Work-in-Progress paper reviews the literature on virtual internships across disciplines to find effective practices that can be applied to virtual engineering internships. The review sets the stage by a brief summary of research on traditional engineering internships and management of virtual teams before delving into findings on the opportunities and limitations as well as program design recommendations for virtual internships.

Introduction

Establishing quality measures specific to virtual internships has relevance to employers, educators and students alike--especially in the wake of an unprecedented shift to remote work during the COVID-19 pandemic. This literature review is a first step to understand and improve virtual internship experiences for engineering students. It aims to establish a context for further research to understand how virtual engineering internships can best achieve their intended goals, both in terms of advancing individual student careers and learning as well as supporting institutional goals of access and equity in engineering education. The institutional focus emerges within the literature and represents a fundamental commitment, as universities may consider coordination of internships for students a key “structure of opportunity” for retention and access [5]. The paper begins by establishing baselines of knowledge for engineering internships (“Traditional Internships in Engineering”) and effective practices for virtual collaborative work (“Virtual Teams”) before synthesizing the literature that exists on engineering internships conducted virtually (“Virtual Internships”). It concludes by noting significant gaps between these intersecting knowledge bases that deserve further research.

Selection criteria and search method

This study falls into the category of a rapid scoping review. Two members of our team searched two databases (EBSCO and Google Scholar) independently in iterations on key terms “virtual internship” and “engineering” and then compared and combined search results in a working bibliography. We then used a snowball technique, adding relevant cited references to the bibliography and expanding our initial key terms, when it became apparent that researchers use multiple terms to describe remote, online internships (e.g. “e-internships,” “computer-mediated internships”). After reading many sources from the 1990s and 2000s, it became apparent that technological advances in virtual work have made this scanty literature largely irrelevant. Therefore we prioritized sources published since 2010. We also found that researchers use the terms “virtual internships,” “e-internships,” and “computer-mediated internships” to refer both to real work placements and simulated in-class “work” placements conducted remotely. Our

review examines only those findings reported in scholarly and/or peer-reviewed publications in English based on real work placements that are completed by interns remotely. Simulated internships, or experiences coordinated within a university course that assign students hypothetical work projects to complete, whether during an in-person or online course, are not the focus of the body of literature considered in this review.

Traditional internships in engineering

Internships and cooperative education experiences (co-ops) are frequently discussed together, although internships are typically shorter and term-limited while co-ops may alternate periods of work with education [9]. A study by the National Association of Colleges and Employers from 2017 suggests that internships and co-ops are widespread in undergraduate experiences in general, with a participation rate of at least 60% [10]. Other data from the National Survey of Student Engagement suggests that as of the 2017-2018 academic year, 52% of seniors had completed or were in progress of internships or co-ops, with a further 23% of respondents planning to do one [11].

Internships may play a unique role in engineering career paths. According to the National Survey of Student Engagement, engineers were more likely to complete or plan to complete an internship or co-op than most other fields (with 58% of seniors having completed or being in progress of an internship or co-op and another 26% planning to do one in the future) [11]. Do et al 2006 suggests a link between internships and participation in technical societies, and Matusovich et al 2019 points to a perception that internships are integral to graduates being seen as competitive in the job market [12], [13]. This makes it somewhat concerning that Liu et al 2020 identifies ways that internships can perpetuate workplace inequities, raising the possibility that underrepresented or underserved populations of students may be at a disadvantage [9]. Given what we know about digital divides, it is doubtful that moving internships online would improve rather than worsen existing inequities. In Liu et al's review of 30 empirical studies, the authors found only "a couple of studies that reported experiences of visible minority students and students from low socio-economic backgrounds." Additionally, Hora et al's recent investigation of online internships suggests that remote interns are more likely to be upper- or middle-class, and those internships are more likely to be unpaid [14].

The benefits of participation in internships or co-ops accrue both to students (in educational outcomes and personal development) and to institutions. Internships help build student capabilities and skills for capstone projects, and provide hands-on experience that may resonate especially well with students who learn best experientially [15], [16]. Additionally, internships may bolster student and mentor motivation, as well as the formation of an engineering identity for participating students and student retention [2], [17]–[19]. Institutions also benefit from internships, as both universities and employers gain insight into each other's needs and goals [16].

For better or for worse, internships affect students' decision making, both about their jobs generally and about whether to continue studying engineering in graduate school or enter the job market [2], [17]. The on-the-job training of engineers in internships may also help students develop their moral imagination as well as engineering competencies [18], [19].

Not all internships, however, function the same way. Maertz et al. identify several ways that internship and co-op experiences may vary, from paid vs. unpaid to full time vs. part-time [20]. These different aspects of internships and co-ops may result in different takeaways for students; the positive results of internships may even be contingent on certain qualities of the experience. For example, Raelin et al 2014 showed that the increase in student self-efficacy in internships depends on students feeling as though they have made an impact on their organization, had the opportunity to work in teams, and were able to apply knowledge from their majors [21]. Informal evaluation and inflexibility in internships may form a barrier to student learning goals, and students are not always fully prepared for their internships [16], [22]. This is particularly a problem since internships may be formally integrated into curricula or even take the place of capstone projects [23], [24].

Yet despite these difficulties, internships enjoy positive perceptions among students, faculty, and employers. They are seen as ways to gain experience without the commitment of traditional full-time employment, and as a stepping stone into the job market [13]. Some consider internships to be part of “how the game is played” in engineering, and they allow students to apply their skills in contexts beyond the classroom [12], [25].

Virtual internships - an uneven distribution of benefits

Research into implementing virtual internships has appeared in education, technology, and management journals prior to 2020, with white papers and guides also published by government agencies. A very small number of researchers have conducted surveys and convened focus groups from participants in past virtual internships to gather student perspectives and insights into what makes these productive experiences. The most notable of these is Hora et al, which used a mixed-methods approach including surveys and interviews to characterize internships [14]. Although the authors are careful to note that their results may not be generalizable to the general population of undergraduate interns, their study nevertheless represents one of the most comprehensive investigations of virtual internships to date, particularly as distinguished from in-person or hybrid internships. As many of the benefits claimed for virtual internships are identical to those claimed for engineering internships in general, e.g. bridging the skills gap between university and work, [26] as well as developing students’ self-confidence and launching careers, this section focuses on insights particular to *virtual* internships.

Several studies offer theoretically-based, qualitative claims as to the specific value of virtual internships, and others frame them as mechanisms for promoting public goods. Scholars have claimed that virtual internships offer greater access for previously excluded groups [27] and spread internship opportunities more equally across geographical and social boundaries, e.g. between European countries [28] and between graduates from colleges at different tiers in international rankings [29]. Bayerlein and Jeske note that virtual internships have potential to address diversity and equality targets of higher education programs, by providing opportunities for students with disabilities, students with caregiving responsibilities, or less financial means [26]. As noted above, however, Hora et al suggests there are limits to this increased access in practice [14]

The European Commission has funded a number of inter-university projects to foster international virtual internships. According to Vriens et al, promoting “virtual work placements”

in higher education supports European goals “to create a European Information Society,” promote student mobility, develop communication technology to drive socially inclusive development [30]. Universities in Europe have a range of practices around implementing virtual internships: including virtual work placements that are integrated into curricula (France, Estonia, the Netherlands) and virtual internships that are required as a degree requirement (Turkey, Spain [28]. For example, the Open University in the Netherlands and Tallinn University in Estonia have developed several arrangements for virtual internships at the undergraduate and graduate student levels [27]. A team at the Open University in the Netherlands has reported on its “didactic” virtual internships, “didactic” in the sense that the work placements are integrated into Environmental Science program requirements at the BSc and Masters level. In real-world internship placements conducted remotely, students “work in teams on authentic research questions on behalf of companies or organisations in the Netherlands and Belgium” [31]. With program data on over 100 past participants, they report both great heterogeneity of experiences with the virtual work as well as diversity of backgrounds among the interns in terms of gender, age, and time available for interning. This supports the hypothesis that virtual internships have potential to create greater access to opportunities in engineering as well.

Virtual internships may confer greater benefits to students in certain fields in engineering, in particular to computer science students wishing to enter careers in software development that can be completed in distanced work environments [32]. Indeed, a great number of virtual internships are offered in software startups and information technology firms [33]. Many opportunities are available for coding project work, including in virtual internships that have become prevalent around the world and become popular with non-profit organizations and small and medium-sized companies alike [34], [35]. At a larger scale, the Government of India sponsored a remote internship program for open source coding, run through its national Virtual Labs program in order to address the enormous gap between the number of engineering graduates each year (1.5 million) and available internships (1 million for *all* fields of study) [29]. The U.S. government also operates a virtual internship program, the Virtual Student Federal Service (VSFS, <https://vsfs.state.gov/about>), which hires unpaid student interns from many fields, including those hired to perform data collection and analysis for open source projects [36]. Relatively few opportunities advertised in the VSFS are specifically for engineering students. It is worthwhile remembering, then, that the expansion of virtual internships is expanding access to certain fields, e.g. software design, IT, and marketing, but this process is far from universal. Moreover, expanding access reflects shifting economic conditions within and across engineering professions that lower the cost of labor for a private company, which no longer has to provide office space or equipment for newly virtual interns [33]. Remote work has been effective in software design and IT, but incorporating virtual interns into real projects in aerospace, civil engineering, and other fields could be less feasible.

Making virtual internships work - better practices

When it comes to practical lessons for how to make virtual internships more effective for students, it is generally agreed that communication, planning, organization, and clear expectations between student interns, employers, and higher education sponsors are even more important when internships go online and remote [8], [33], [37], [38]. Limited studies based on interviews with students themselves confirm the particular importance of communication [28], [38] and having previous experience working autonomously with a high level of responsibility

[33]. One analysis of the nature of employee-supervisor relationships in virtual internships has unpacked the specific dimensions of communication involved in producing higher quality experiences in terms of psychological contract types, ranging from weak “transactional” ties to “balanced” relationships. More frequent communication, using thoughtful and appropriate modes of technology, and greater perception among interns of their supervisors’ investment correlated with more balanced psychological “contracts,” and ultimately more satisfaction reported by the virtual interns in the study [8]. Having a mentor was correlated with self-reported skill gains in another survey of virtual interns--and mentoring was not linked to the duration of internships in the study [39].

A large and interdisciplinary literature on successful practices for working in virtual workplaces, stemming from human resource and business journals as well as technical and engineering communications, provides useful insights applicable to the successful management of virtual internships [40]–[42]. Much like virtual internships, virtual teams are defined as distributed work teams whose members predominantly communicate and coordinate their work via electronic media as opposed to working face-to-face [40]. Due to their ability to cross boundaries of space, culture, time, organizations and hierarchies, virtual teams enable organizations to assemble teams that are best suited to a task [43]. This literature provides useful insights into how to work effectively when working remotely and points to overlapping themes and success factors. These include: trust among team members; intercultural communication; effective virtual management practices, including work planning, meetings, and goal-setting; and the impacts of specific technological tools and choices on work outcomes, including for diverse global teams [40]–[42].

Working remotely poses a number of challenges that apply directly to virtual internships. Gaining trust, engaging in effective communication, establishing shared interpretations of language and expectations of technology, negotiating time zones and perception of time, and identifying hierarchies and clear leadership roles are all challenges that interns and their supervisors face when working remotely [43]. As such, it is critical that efficient communication and collaboration processes are carefully implemented to prevent misunderstandings and mitigate conflict due to reduced communication cues and the increased abstraction of virtual workplaces [40]. Effective virtual workplace communication indicates the importance of planning (including discussing differences), implementing face-to-face meetings when team members are co-located, social communication, using mixed media, and learning to navigate nonverbal communication [43].

Even with these management techniques in place, however, navigating cultural differences, especially in a globally dispersed team, can be challenging. In one study by Brewer et al, forty-five percent of engineering professionals attribute some of the miscommunication they experience in virtual team communication directly to international communication [43]. In another study by Liu et al which examined 30 study design teams, locally distributed teams self-reported higher team effectiveness on average across 11 measures in comparison to globally distributed teams working remotely, although the effectiveness ratings varied greatly across the global teams [44]. While global virtual teams can provide meaningful cross-cultural experiences for engineering students [45], the modes for building trust are conditioned by whether team members share common language abilities [46]. Where they do, the free exchange of ideas, questions, and comments with fellow team members can provide a strong model for building

trust and sharing information among team members. However, where they do not share a common language, trust is built on team members' ability to complete assigned tasks on time [46]. Virtual teams with cultural diversity can choose communication technologies that mitigate the negative impacts of that diversity - namely the potential for miscommunication and misunderstanding - while supporting its positive impacts, which can include improved outcomes for decision-making and performance [47].

Universities have incorporated many principles of successful virtual teams into the design and management of existing virtual internship programs. For example, several programs deploy a wrap around design with pre- and post- training on the academic side and a relevant work placement, accompanied by guided student reflection and employer evaluation, sandwiched in between [30], [32]. Learning management systems to track student progress have been implemented in several virtual internship programs managed by universities [31]. The use of student self-monitoring and reflection with e-portfolios in an LMS during a virtual internship hints at where research on online education converges with designing effective virtual internship programs. Despite a high-level of planning and involvement in their virtual internship program design, Roy and Sykes describe their model as "self-regulated," referring to the extent to which students are asked to monitor and track their own learning as they intern [48]. They are not alone in consciously patterning their virtual internship program on the self-directed learning model of online education.

Roy and Sykes also raise a question of whether the benefits in terms of skills development may differ for a virtual internship for in-person students versus online students. We do not know the extent to which prior preparation in self-regulated learning would favor online students' success in virtual internships. An international survey of 158 people who had completed a virtual internship between 2011 and 2015 found that the majority reported gaining interpersonal and communication skills as well as skills relevant to their career development and strategic thinking, supporting the hypothesis that virtual interns gain skills similarly to traditional interns [39]. Bayerlein and Jeske have also explored the extent to which virtual interns may gain less affective and skill-based learning, based on a conceptual framework in which affective learning is "the result of the extent to which interns experience and internalise the feeling of being part of the workplace [38]." It seems plausible that virtual internships offer greater access and convenience with quality trade-offs for learning that must be addressed with intentional practices and socially-responsive technology choices. In this vein, Ruggiero and Boehm have built on a community of inquiry educational framework to elaborate a "Virtual Attachment Theory [32]," which represents one analytical tool to explain why different virtual internships are more or less successful in terms of psychological attachment to the work. A next step is to test this theory with additional virtual internship programs. Findings could in turn be applied to develop strategies that mitigate the costs of interning remotely, e.g. by fostering better affective learning with appropriate practices with communication technologies.

Opportunities for further research

This literature review reveals significant opportunities for future research into the qualitative differences between virtual and traditional internships, their impact on student learning and career outcomes, and their impact on institutional goals of access and equity in engineering education. These areas include the importance of internships and virtual team strategies by

discipline (i.e., specific to engineering and within engineering) and whether better practices in these areas vary by discipline. A common claim in engineering is that internships form the first step of an engineering student's transition into the workplace, yet little peer-reviewed evidence (quantitative or qualitative) characterizes the impact of internships on career paths at a large scale, let alone how these career trajectories might differ for students doing virtual internships. Additionally, researchers might evaluate differences, whether in design or outcomes, between internships planned as virtual from the start and those that were designed in-person but became virtual due to extraordinary circumstances (i.e. COVID-19). Repeat surveys might indicate what impact the pivot to remote internships might have had on recruitment for engineering firms.

Greater attention could be paid to how educational and economic goals may diverge for virtual internships. Universities have an interest in making "every project...an exceptional learning experience [33]," but what about employers? It is an open question whether employers will view virtual internships as "valid work experience [38]." Their interests are frequently invoked in discussions of virtual internships, but scantily represented in the literature. Similarly rare are efforts to trace out the impacts of virtual internships on students' subsequent career paths. One suggestive finding in surveys and focus groups with over 100 interns in a European program found that the "virtual interns [were] less likely to benefit from corporate recruitment [27]." More research should explore whether virtual internships benefit students' career advancement comparably to traditional internships. For example, researchers might look at the impact of virtual internships by borrowing methods used to study the comparative impact of internships, as for example between paid and unpaid internships [49]. Ideally, virtual internships would be tracked as part of national first destination data to give a clearer picture of their relative value for student career paths. As Jeske and Linehan have observed, additional research is needed to reveal the extent of virtual internships across national boundaries as well as the complex impact of cross-cultural differences on the learning and work experiences themselves [39].

Finally, researchers should explore equity and access to internship experiences and test the optimistic hypothesis that virtual internships increase access and thereby make education more equitable. The COVID-19 pandemic has deepened digital divides in education that exacerbate inequalities in access and preparation for engineering studies. Claims that virtual internships expand access and equity should be empirically tested, given the existing disparities in access to traditional internships. Focus groups and surveys of employers as well as quantitative research (including wage analyses) could illuminate issues of access and equity that may become less visible when internships go virtual. Achieving solutions for students, employers, and universities will require a fuller accounting for virtual internships.

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