Bite-Sized Experiential Education for Computer and Information Science

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ABSTRACT

Many computer and information science educators wish to incorporate experiential education pedagogies such as study abroad, service learning and internships into their courses because of the profound benefits they can provide for students. However, some experiential approaches come with costs — whether temporal or financial. In this paper, we present the results of a literature review of different experiential pedagogies in computer and information science — service learning, study abroad, educational work experiences, and hackathons. We provide an overview of the benefits and costs of each pedagogy, and investigate what strategies have been used to minimize the costs to both students and faculty. Our analysis uncovers a variety of ways that faculty have experimented with "bite-sized" experiential pedagogies to make them more accessible for both students and faculty. We provide examples of these strategies as inspiration for faculty to sample these high-impact pedagogies, but highlight the gap in empirical evaluation that is needed to fully understand the cost-benefit tradeoffs.

CCS CONCEPTS

• **Social and professional topics → Computer science education**; **Information science education**.

KEYWORDS

Experiential Education, Experiential Learning, Service Learning, Study Abroad, Co-Op, Internship, Hackathon

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1 INTRODUCTION

Experiential education is a philosophy of education that blends hands-on experience with reflection to "increase knowledge, develop skills, clarify values, and develop people's capacity to contribute to their communities" [1]. This progressive educational philosophy can be embodied through a range of pedagogies including service learning, internships, and study abroad [37]. Because students who engage in these pedagogies learn from the hands-on nature of the activities, experiential education may help learners from various backgrounds and with diverse skill sets make their learning more impactful [28].

In computer and information science, researchers who study experiential pedagogies highlight numerous benefits for students' personal, professional, and civic growth. Students' personal growth is benefited through an increased confidence in one's skills and ability to teach that skill to others [29, 36, 42], a deepened understanding of how to collaborate [12, 24, 36, 42], and increased networking opportunities [21, 29]. Benefits that contribute to students' professional growth include a better understanding of the professional knowledge and skills being taught in the course [47, 50], increased preparedness for the job market [16], a more sustained interest in the field [45], a better understanding of the global role of computer and information science [16, 42], and the ability to work on "real-world" problems [7, 24, 36]. Finally, benefits that contribute to students' civic growth include the ability to contribute to social change [12, 18] and a deeper understanding of other cultures [12, 18].

These benefits for students are complemented by corresponding benefits for computing programs. Many benefits of experiential pedagogies align with the requirements for program certification, such as the ABET requirements for students to perform effectively in a professional and collaborative environment; for students to understand, design, and implement computing skills in practice; and for students to make responsible and ethical judgements about computing [2].

Yet, experiential pedagogies are not without costs. For students, some experiential opportunities require a significant financial commitment (e.g., study abroad), which rules out participation for many students. Other pedagogies may demand a time commitment that limits participation by students who work to fund their education or have familial obligations to uphold (e.g., certain time- and labor-intensive classes like service learning or unpaid internships) [35, 49]. These costs affect already-marginalized students disproportionately and can result in them being excluded from these experiential opportunities [38]. For instructors, adopting experiential pedagogies can also be time intensive, sometimes prohibitively so, and the work is frequently under-resourced by institutions of higher education [35, 49, 54]. Also lacking are the knowledge resources for faculty to effectively use experiential pedagogies and to manage external partners and students' non-classroom experiences [26].

Weighing the incredible suite of potential benefits of these high-impact pedagogies against the significant costs — particularly those that render experiential education inaccessible to marginalized students or prohibitive for instructors — we take a pragmatic perspective and ask the following research questions:

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- **RQ1: How have faculty in computer and information science designed experiential educational experiences that reduced the costs for students and faculty?**
- **RQ2: How do the benefits of these reduced-cost experiences compare to the typical, full-cost versions of experiential education?**

In what follows, we summarize the benefits and costs of various experiential pedagogies as experienced by computer and information science (CIS) stakeholders. We then offer examples of ways in which faculty have made experiential education more accessible for both students and faculty via a variety of "bite-sized" versions. We highlight the benefits of these scaled-back versions, but argue that more empirical research is needed to fully understand the cost-benefit tradeoffs of bite-sized experiential education, to more systematically assess these experiences, and to continue exploring the pragmatic accessibility of these pedagogies.

2 METHODS

We conducted a literature review of experiential education in computer and information science. Following the recommendations of Pettricrew and Roberts [41], we identified a set of guiding research questions, narrowed down the search criteria for determining articles to include, identified and screened the articles based on their fit, and reviewed and synthesized the findings from the papers.

Following other literature reviews in the discipline [8, 14, 54], we scoped our literature review to articles retrieved from the ACM Guide to Computing Literature — the "most comprehensive bibliographic database focused exclusively on the field of computing" — as it includes not only ACM publications, but additional computer-focused venues (e.g., International Computer Science Education Research Conference). We omitted other databases such as IEEE Xplore to limit our scope to research about CIS courses rather than other engineering fields (a scoping decision consistent with [54]). While our corpus may not include every published paper about experiential pedagogies used in CIS courses, the ACM Guide to Computing Literature likely includes both a significant percentage and a robust cross section of relevant research; as such, we expect our corpus to highlight the relative popularity of research about different experiential pedagogies as well as suggesting broad themes in the design and study of experiential pedagogies (e.g., experimentation with "bite-sized" pedagogies"). Because of the scope of our corpus, our aggregation of the costs and benefits of experiential pedagogies may include only a subset of those identified in research that is not accessible through the ACM Guide to Computing Literature.

We first searched using the primary pedagogies of experiential education as keywords: "service learning," "study abroad," "co-op," and "internship." We also used the broader search terms "experiential education" and "experiential learning" to identify any articles that offered overviews of the philosophy or to guide us to other less common terms for related pedagogies. After assessing the abstracts and keywords to learn more about the range of experiential education pedagogies discussed, we added the following search terms: "study away," "hackathon," and "practicum."

In our corpus, we include only full papers that have been peer-reviewed (i.e., workshop papers, abstracts, and posters are excluded) and that discuss experiential education in higher education (i.e., papers that discuss experiential education for high school students are excluded). The resulting corpus includes 129 peer-reviewed articles about experiential education in computer or information science:

- 12 papers discuss experiential education broadly or refer to a specific course as embodying principles of experiential education more generally;
- 85 papers discuss service learning (including 84 papers that were also analyzed in a recent — and highly resonant — systematic literature review of service learning conducted by Robledo Yamamoto et al. [54];
- 11 papers discuss study abroad and variants;
- 11 papers discuss educational work experiences such as co-ops or internships; and
- 10 papers discuss hackathons.

3 EXPERIENTIAL EDUCATION IN COMPUTER AND INFORMATION SCIENCE

Multiple pedagogies embodying the philosophy of experiential education have been adopted in higher education computer and information science courses. In what follows, we synthesize our findings about the costs and benefits of these different pedagogies and highlight examples of educational opportunities that work to reduce costs, particularly through offering more bite-sized experiences.

3.1 Service Learning

The most prevalent experiential pedagogy in our corpus is service learning (N=85). Service learning is an educational experience in which students contribute to a service activity while reflecting on the experience to better understand course content and better appreciate their civic responsibility [9]. While we are not aware of any reports about the scope of adoption of service learning in CIS programs, scholarship about service learning in CIS has been appearing annually since 2000, with an average of 4.4 publications per year through 2019 [54].

When students participate in service learning, they report increased professional benefits from the experiences, such as increased confidence in their skills and ability to teach those skills to others [31]. They also report having a more sustained interest in CIS [54]. Service learning can also help improve students' personal skills, particularly those that facilitate collaboration with peers and colleagues [42]. Students also note that service learning allows them opportunities to grow their civic-selves and sense of responsibility to their communities [13]. Aside from benefiting students, service learning also benefits the institutions that they are affiliated with. Service learning is the only pedagogy in our corpus for which researchers have noted the relationship between benefits for students and the accreditation requirements of computer science programs. The ABET accreditation, for example, requires students to demonstrate that they are able to "function effectively as a member or leader of a team engaged in activities appropriate to the program's discipline" while also developing professional skills, improving collaboration and communication skills, and understanding best computing practices [2]. Research on service learning has identified positive student outcomes that correspond to both the leadership and collaboration elements of the ABET requirements [42]. The ABET accreditation also has a strong commitment to diversity, equity, and inclusion in CIS fields [6], which service learning can positively influence [10].

While the benefits of service learning can be substantial, this pedagogy is not without costs for many stakeholders. Students and community partners may have differing perspectives and expectations about the technical skills of the students and the goals of the projects, which may lead to tension in the student-community partner relationship and could result in under-delivery of the project [46, 54]. Costs for faculty without institutional support mechanisms can be particularly challenging, including the significant time commitment required to design these courses, recruit community partners, and sustain deliverables over the long term [32, 54]. Additionally, while service learning is defined by mutual benefits for all stakeholders involved, there is relatively little empirical research that has actually demonstrated benefits for more than just students [54].

3.1.1 *Bite-Sized Approaches to Service Learning:*

To minimize time commitments, some faculty have designed service learning opportunities that only last a week. Hsin and Ganzen, for example, took students on a service learning trip to Brazil during the university's spring break [22]. This trip included faculty and students from multiple departments, such as CIS, communication, and business, so that students and instructors could offer a breadth of technical skills to the community in Brazil — introductions to computer literacy and Excel, in particular. Beatty studied the benefits of a similar week-long service learning trip over spring break. The service learning experience included students from a variety of majors across campus, including CIS majors [7]. From pre- and post-trip surveys, they found that the experience positively impacted students' sense of community, improved students' sense of the impact of service, and established students' long-term desire to have a service-related career [7].

There are also examples of service learning that reduce temporal commitments and labor costs by stretching the duration of service learning instead of compressing the experience. In two different courses, faculty [30, 44] designed service learning experiences that spanned multiple semesters. In each of these courses, students finish what they can during the term and then hand off their work to the next semesters' cohort of students to continue where they left off. Though neither of these programs have been studied empirically, they show initial promise in addressing some of the major costs of service learning. Stretching service learning into a longer experience instead of a shorter one reduces costs on faculty — by lessening the workload of finding new community partners and projects every semester — and on students — by allowing for a more realistic scoping of the project so as not to overburden students and to help reinforce positive relationships with community partners.

3.2 Study Abroad

Study abroad programs are educational experiences in which students study in another country, taking classes to support their major or to learn another language [23]. CIS majors are disproportionately underrepresented in study abroad programs despite the importance of cultivating global awareness among students who may be designing technologies that will have an impact globally [27]. While over 5% of students in the U.S. major in CIS, for example, only 2-3% of all U.S. study abroad students are either computer science or math majors [3, 5].

Research reports on many benefits of study abroad for students in CIS. Students report having a deepened understanding of the global role of computer science as a field [16, 42] and being more prepared for working in a global environment [16]. Additionally, studying abroad offers CIS students a better understanding of how other cultures have influenced the field of computer science [18] and students report noticing that they are working on problems that catalyze social change [18]. Professionally, studying abroad helps students have greater confidence in communicating CIS-specific concepts to non-technical audiences [42] and feel more prepared for the job market [16]. CIS students who study abroad also improve their collaboration and communication skills [42].

While the benefits of study abroad programs for CIS students are numerous, there are also a number of barriers to participation. The most widely-cited barrier to study abroad is cost [15, 19]. Students also report having concerns about the language barrier or lack of familiarity with the culture in which they will be studying [11]. For faculty, the additional workload required to develop and run a study abroad program can be daunting and ultimately prohibitive [40]. There are also growing concerns about the difference in curriculum or accreditation of the academic programs that students attend while abroad, along with concerns about credit transferring and mismatches in academic calendars [40].

3.2.1 *Bite-Sized Approaches to Study Abroad:*

Some CIS programs have reduced the accreditation and credit transfer barriers to study abroad by offering summer study abroad programs that are taught by their own faculty and that earn credit from their home institutions ([18, 19]; see also [51, 53]). Gray et al., for example, designed a course in Digital Civics in which faculty from Purdue University take students studying user experience to England for 10 days to "engage students in a global experience that increase[s] awareness of intercultural capacity and understanding of difference" while expanding student's worldview on design and their future career trajectories [18, p. 74]. Additional bite-sized study abroad experiences include a four-credit course in information science in which students travel abroad for three weeks to explore the role of data in other cultures, [51] and a three-credit course in information systems in which students study abroad for two and a half weeks learning about global startup culture and product development [53]. These study abroad opportunities take less time than a program that requires a full semester or year abroad and are also taught in the language of the home university, not necessitating fluency in an additional language. Despite the reduced costs, these programs can still cost a significant amount of money and still require extensive planning by faculty.

Doyle et al. [15] also developed a variant on study abroad that allows students to explore other cultures within the United States during a short-term visit. They call their experience "study away." During Doyle et al.'s one-credit course titled "Agile in Theory and Practice," faculty led a group of students during spring break to the San Francisco bay area to have hands-on experiences with computer scientists in professional environments. Students read about agile software development; visited four tech companies to see software engineering work practice; and attended cultural immersion events, such as exploring the fishing piers in San Francisco and visiting Alcatraz Island. The reduced expense, shorter time commitment and lack of a secondary language requirement may allow for participation by students with financial, family, or academic constraints. While students may miss out on the global learning experience that studying abroad can offer, there is still the possibility of learning about different cultural and historical contexts domestically that can impact the design or use of data and technology.

3.3 Educational Work Experiences

A variety of educational work experiences embodying principles of experiential education are also used in CIS. Co-ops and internships are the most common forms of educational work experiences in the corpus. They may also be among the most commonly enrolled-in experiential pedagogies by students. One study suggests that over 57% of undergraduates in CIS participate in internships [25].These pedagogies are out-of-classroom professional experiences that expose students to work environments while still integrating in-classroom learning that usually focuses on professional development, career exploration, and connecting theory to practice [37]. Co-op experiences usually last more than one term, and generally alternates with school terms, prolonging the duration of an academic program. Co-op programs are traditionally full-time, paid positions where students can more fully integrate theory and practice [4]. Typically shorter, internships usually last anywhere from several weeks to a semester, can be full or part time, and offer paid or unpaid experiences [4].

Both co-ops and internships offer similar benefits:

- Improve students' collaboration skills [24, 36];
- Help students communicate better with colleagues and peers [24];
- Deepen students' understanding of course content [24];
- Enable students to apply learned skills to "real-world" problems [24, 36, 49]; and
- Improve students' confidence in the job market. [24, 49].

Researchers have identified some benefits of CIS co-ops that are missing from the body of research on CIS internships, such as students' enhanced ability to explain their work and skills to non-technical audiences [20], improved and strengthened connections to their community [20], and preparedness to work in a global environment [16]. Research on CIS internships, on the other hand, reports that the experience helps students feel confident in their skillset and in teaching others that skillset [24, 36], a benefit that did not appear in the scholarship about CIS co-ops.

As with other experiential pedagogies, educational work experiences also have drawbacks for students. While internships can help expose students to the types of environments they want to work in, if students are not placed in the right environments, internships can inhibit learning and even turn students away from the field and discourage them from pursuing other employment opportunities in CIS [24]. Co-ops have the added drawback of prolonging students' undergraduate education [49], which has significant financial implications. Co-ops and internships can also present challenges for faculty and for the host institution that students choose to work with, as the coordination between host institutions and schools can be burdensome and can lead to challenged relationships between faculty and institutions [49].

While some internships strive to reduce costs in terms of time required compared to co-ops, they may introduce other costs. Internships are highly competitive and research has found that the decision making process for who secures internships is inequitable and influenced by race and gender [34]. Other research has found that the largest determining factor in who participates in internships is socioeconomic status; students who come from a higher socioeconomic bracket are more likely to intern [25].

3.3.1 ***Bite-Sized Approaches to Educational Work Experiences:*** One way faculty have reduced the costs of educational work experiences is by building authentic work experience into their classrooms via participation in open source software development. Marmorstein [33], for example, used the working environment of the open source community to help students understand the software development process in a real-world environment and offer a better understanding of collaboration with other developers and colleagues.

3.4 Hackathons

Hackathons are a site for experiential learning that are unique to computer science. In these events, students collaborate around a shared challenge or problem; they work together to ideate, design, and develop a solution within a highly constrained period of time [12].

The benefits that students derive from hackathons have been well-documented. Students report personal growth in improved collaboration skills [12, 21, 45]. Students also reap many professional benefits from hackathons:

- More sustained interest in the discipline [45];
- Increased confidence in teaching technical skills to others [12, 29, 52];
- Ability to apply learned skills to "real-world" problems [36, 49, 52]; and
- Better preparation for the job market and a broadened sense of available careers [21, 29].

Additionally, research reports on civic benefits for students who participate in hackathons, including a better understanding of how to affect social change with their career [12, 21, 43] and a greater appreciation for cultural differences [12]. External collaborators to hackathons, such as community partners also report benefiting from their participation in hackathons: expanding their social networks, learning more about technology, and receiving systems that meet their needs [17, 43].

Despite the benefits of hackathons, researchers have found that individuals from marginalized groups are still underrepresented in these events and are hesitant to participate [12, 21, 29, 39, 45] because of the often-competitive culture, the male-dominated demographic, and the time commitment [21, 39, 45, 52].

3.4.1 ***Bite-Sized Approaches to Hackathons:*** To reduce some of the temporal and competitive drawbacks of hackathons, Skirpan and Yeh [48] designed a weekly, in-class hackathon. Students

	Service Learning		Study Abroad		Edu. Work Experience		Hackathons	
Personal Benefits	**Bite-Sized**	**Full Scale**	**Bite-Sized**	**Full Scale**	**Bite-Sized**	**Full Scale**	**Bite-Sized**	**Full Scale**
Improved Collaboration Skills		[42]		[42]	[33]	[24, 36]		[12, 21, 45]
Professional Benefits	**Bite-Sized**	**Full Scale**	**Bite-Sized**	**Full Scale**	**Bite-Sized**	**Full Scale**	**Bite-Sized**	**Full Scale**
More sustained interest in the discipline		[31, 54]						[45]
Increased confidence in teaching skills to others		[31, 54]		[42]		[24, 34, 36]		[12, 29, 52]
Application of skills to authentic problems	[7]				[33]	[24, 36, 49]		[52]
Preparedness for the job market and broadened sense of available careers	[7]		[16]			[24, 34, 49]		[21, 29]
Understanding of the global role of CIS			[16]	[42]				
Civic Benefits	**Bite-Sized**	**Full Scale**	**Bite-Sized**	**Full Scale**	**Bite-Sized**	**Full Scale**	**Bite-Sized**	**Full Scale**
Ability to affect social change	[7]	[13]	[18]					[12, 21]
Preparation for working in a global environment			[16]					
Greater appreciation for cultural differences			[18]					[12]

Table 1: Overview of benefits for students in empirical studies of CIS experiential pedagogies.

completed a tutorial for homework that helped them learn a new skill; throughout the week, students worked on a hackathon project relevant to the material covered in the tutorial. These hackathons stretched over three class periods, totalling 150 minutes. Kirpan and Yeh [48] found their class to have a high attendance rate (92%) and argue that the skills learned in the class were authentic and applicable to real-world situations.

4 DISCUSSION

The CIS research community has published far more experience reports than empirical research on experiential pedagogies (see also [54]), so we currently have more examples of the pedagogies-in-action from which to garner inspiration than empirical findings to inform our next steps. While there are ample studies detailing the range of benefits of these pedagogies in the broader research literature, our empirical understanding of the benefits for CIS education and stakeholders, in particular, is limited (see Table 1). Surprisingly, while there are fewer publications about hackathons in our corpus, there are just as many empirical studies of hackathons as most other experiential pedagogies, perhaps because of its uniqueness to CIS.

More of the existing empirical research focuses its analytic attention on full-scale versions of the pedagogies than on bite-sized versions. While additional research about any forms of experiential pedagogies would be welcome, more empirical studies of the benefits of these bite-size versions would be particularly valuable as initial evidence of their benefits are promising. For example, there is initial empirical evidence that bite-sized service learning, study abroad, and work experiences provide multiple classes of benefits to students — personal, professional and/or civic benefits. More systematic research comparing the benefits of full-scale and bite-sized versions of these experiential pedagogies would help us more strategically imagine how to reduce costs while maximizing benefits.

Finally, we note that empirical studies of experiential pedagogies have identified more benefits for students' professional growth than for students' personal or civic growth. While these benefits may be foregrounded in evaluation because of the learning objectives of the associated courses, it is important not to overlook personal and civic benefits in evaluation plans. We encourage researchers who are studying experiential pedagogies to explore the fullest possible range of benefits in their assessment and evaluation. Foregrounding these other classes of student growth (i.e, via learning objectives in syllabi or through reflection activities) legitimizes them for students and validates their importance for the whole learner.

Our ultimate goal in this research is to identify tractable and accessible ways for faculty to begin to take advantage of the extraordinary benefits of this suite of high-impact pedagogies. In addition to the published strategies highlighted above, faculty might...

- **Bite-Sized Service Learning:**
  - ⋆ Invite representatives of nonprofit organizations to a "volunteer fair" in which they present their ideas for ways in which students might be able to use their CIS skills in volunteering for the organizations.
- **Bite-Sized Study Abroad:**
  - ⋆ Design a one-credit hour course to take students to the city that serves as the capital for technology policy development in your country or state.
  - ⋆ Combine service learning with bite-sized study abroad by working on a service project for a culturally-different community within driving distance to your campus (i.e., an under-resourced rural community or an ethnic community center in a nearby city).
- **Bite-Sized Work Experience:**
  - ⋆ Invite computing employees who work for a variety of different institutions—large corporations, small startups, nonprofits, or government agencies— to contribute to a panel during your class.
  - ⋆ Take your students on tours of companies with different corporate cultures in your town or in a nearby town.
  - ⋆ Design a one-credit hour course for spring break or the first week of summer vacation and ask local companies to let students "shadow" an employee for a week.
- **Bite-Sized Hackathons:**
  - ⋆ Try a small, in-class hackathon as a culminating project at the end of a unit or as the final project for the course.
  - ⋆ Pick an open source project and have students work on it hackathon-style during class.

5 CONCLUSION

In this paper, we have contributed a synthesis of the benefits and costs of four key experiential pedagogies in computer and information science: service learning, study abroad, educational work experiences, and hackathons. We have provided concrete examples of ways in which faculty have experimented with reducing the costs of these high-impact pedagogies, often by offering "bite-sized" versions. Initial evidence of the benefits of these bite-sized experiential pedagogies are promising and we hope our work serves as inspiration for faculty to experiment with integrating bite-sized versions of these pedagogies in their own courses. Further, there is a dearth of evaluation of experiential education in CIS, in general, and in these "bite-sized" versions, more specifically. More research is needed to enable a comparison of what benefits carry over from full-scale versions of experiential pedagogies to the more accessible bite-sized versions and we hope that faculty who adopt these pedagogies will help contribute to building up a more robust body of research on this topic.

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