
Engaging Computer Science Students Through Cooperative Education

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Abstract. Computer science educators continuously seek creative and effective ways of engaging students. The model of cooperative education, in which students systematically combine academic learning with practical work experiences, provides opportunities to deepen student learning, promote student retention, and prepare students for professional life. We discuss ways in which cooperative learning can engage students in the broader discipline of computer science.

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1. COOPERATIVE EDUCATION

Cooperative education is a structured method of combining classroom-based education with practical work experience [16]. The first formal cooperative education college program was founded by Herman Schneider, dean of the University of Cincinnati's engineering school, in 1906 [12]. Schneider had two goals: making traditional part-time employment relevant to students' long-term careers, and providing educational opportunities to students which could not occur in the classroom [9].

Cooperative education is traditionally structured with alternating periods of work and study. Some institutions require all of a student's work experiences to be conducted with the same employer; others allow for multiple employers per student. Some institutions begin work experiences in the first year; others delay them until later. Some institutions conduct work and study at the same time (*e.g.* day/evening programs); others separate work and study into separate periods. Work experiences can be paid or unpaid. Most institutions have an optional cooperative program available; a small number of institutions require cooperative education for selected majors, and a few require it of all majors [5].

Cooperative education is one form of experiential learning: an academic model where students learn by using academic knowledge in practical settings. Several other forms of experiential learning exist. Internships provide students with practical work experiences on a "one-time" basis [8]. Service learning applies academic knowledge to community service [2, 14].

2. BENEFITS FOR STUDENTS

As computer science educators seek to engage students in the discipline, cooperative education presents significant advantages for students. Many of these benefits have been previously noted (*e.g.* [8]); some bear particular relevance to contemporary issues.

2.1 Applicability

Most students need practical examples and exercises to fully learn the principles of a discipline. Employers of cooperative education students ask students to put principles learned in the classroom to practical use, in furtherance of the employer's activities. Moreover, since employers are paying salaries to these students, employers expect students to produce valuable results in return. This high level of expectation provides students with a powerful motivation to apply their skills and perform at a high level.

2.2 Relevancy

Most disciplines struggle with the question of relevancy: ensuring that the concepts taught in the classroom are those valued in the workplace (see *e.g.* [10]). Students want to know how academic coursework will prepare them for a practical career in computer science.

Cooperative education provides direct evidence of the relevancy of classroom education. By entering the workforce early in their academic careers, students see how classroom ideas are put to practical use. While at work, students discover any gaps they may have in their academic training, which can motivate them to apply themselves when they return to the classroom. Students can also use their work experiences to guide future course selections, filling gaps or providing additional depth or breadth.

2.3 Suitability

Negative perceptions about the suitability of computer science as a career field abound; such perceptions are a concern for educators, who want to encourage students to enter the discipline [3]. Cooperative education provides an opportunity to experience employment in the computing industry, unmediated by media images or public perceptions. Completing work experiences can increase student confidence levels, which has been shown as an important factor in retaining students (particularly women) [13]. Students can also discover their own suitability for a computer science career early in their academic careers, increasing their motivation to persevere through their classroom education.

2.4 Employability

Most students seek supplemental income during their college careers; generating income while working at their chosen profession is an obvious bonus. Students who remain with the same employer can receive salary increases, commensurate with experience and performance. Especially for students who struggle to pay for college, well-paid work experiences can be a valuable aid to retention.

Such concerns may seem overly mercenary. But not all students have the resources to pick a career solely for altruistic reasons. Providing tangible may encourage students to study computer science long enough to appreciate both its intrinsic and extrinsic benefits.

2.5 Competitive Advantage

Cooperative employment provides documented work experience, which is valued by most employers when screening job applicants. Depending on the program, cooperative education students can complete the equivalent of 1-3 years of full-time work before graduation. This places graduating students at an advantage during future job searches.

Many employers agree to participate in cooperative education because of the opportunity to evaluate students as potential permanent hires. Students who perform well may secure offers of permanent employment upon graduation; some even receive credit for time served as a cooperative employee towards seniority.

2.6 Interdisciplinary Experience

Computer science educators are interested in preparing students for success in interdisciplinary settings. Simulating an interdisciplinary project within a classroom can be difficult. Cooperative education places students into non-simulated work settings, which are naturally interdisciplinary, and challenges them to succeed. Students are asked to develop computing systems to meet the needs of clients; often, those needs are outside of the world of classical computer science.

3. BENEFITS FOR EDUCATORS

While cooperative education programs provide numerous benefits for students, benefits exist for educators as well. While educators have less contact with cooperative employers than students, those students bring many benefits back into the classroom for their instructors.

3.1 Relevancy

Computer science educators need to remain professionally relevant and aware of industrial developments in order to teach effectively. ABET, for example, requires that faculty in accredited computer science programs be “current and active in the discipline” [1].

Cooperative education provides opportunities for faculty to confirm the relevancy of their materials and methods. Students return to the classroom each semester having seen the tools and techniques in contemporary use. Students can thus comment effectively on the relevancy of classroom ideas, alerting faculty to new ideas and trends.

Cooperative education programs also require periodic contact with participating employers, to ensure that the objectives of both parties are being satisfied. This provides a natural opportunity to hear first-hand accounts of the activities occurring in industrial settings, and the skills that are valued by contemporary employers. This information can be used to ensure the relevancy of their curricula.

3.2 Maturity

Students who participate in cooperative education programs are perceived to mature more rapidly than those in traditional academic programs [5]. Students bring contemporary perspectives and ideas back into the classroom, and are more likely to offer those ideas in classroom discussions [12]. This enriches the classroom setting, facilitating more active and deeper discussions.

3.3 Countering Boom/Bust Job Myths

During the employment boom of the late 1990s, many universities reported a surge in enrollments in computer science. Some professionals speculated that universities might not be able to hire enough instructional faculty [6]. Anecdotally, some students were being encouraged to leave school before graduation, in order to take on immediate job opportunities at high salaries. (The oft-told story of Bill Gates dropping out of Harvard to found Microsoft [7] may have encouraged students to undervalue a completed degree.) Years later, a sagging job market left some with neither a job nor a degree.

Several years later, the perception of the market had changed dramatically. With the advent of offshoring, the perception among students was of fewer jobs in computer science. Academics debated how to compensate for the effect of offshoring [4], or more generally the myth of a declining discipline [3], in order to increase enrollment.

Cooperative education can counteract both myths by placing students in the academic and professional world simultaneously. When the myth of plentiful jobs prevails,

students experience the world of work without permanently abandoning their education, seeing the added value that formal education brings. When the myth of scarce jobs prevails, students see that good jobs are still available for those with the proper education. In either situation, cooperative education gives students a realistic look at employment prospects in industry, in ways that lectures or media reports cannot.

3.4 Assessment

Contemporary computer science programs must engage in periodic assessment. For example, ABET requires ongoing assessment of program educational objectives and program outcomes to foster continuous improvement [1]. Many recent papers have considered how to effectively assess of computer science programs (e.g. [15], [17]).

Cooperative education provides a unique opportunity for program assessment. ABET defines program outcomes as “statements that describe what students are expected to know and be able to do by the time of graduation” [1]. Cooperative employers are uniquely positioned to assess the practical skills of their graduating students. Such employers can offer valuable commentary on how well their students have developed the skills outlined as program outcomes.

ABET defines program educational objectives as “broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve” [1]. Many cooperative employers continue to employ their students after graduation; this gives employers the opportunity to comment on how well graduates achieve those long-term objectives over time.

4. CHALLENGES

Cooperative education programs present special challenges for students, faculty, and employers. A conscious acknowledgement of these challenges is a necessary prerequisite to resolving them.

4.1 Managing Relationships

Every cooperative education experience is a relationship between three parties: the student, the employer, and the academic institution. Time and effort is required to manage these relationships. Students and employers must be brought together, and opportunities created for both sides to enter into an agreement. Periodic evaluations from all participants must be conducted; results of those evaluations must be analyzed and used to foster improvements. Problems arising from any of the participants must be resolved. And as more employers become involved with a program, the number of communication paths to be managed increases dramatically. All of the above require dedicated university personnel to manage these relationships.

4.2 Micro-Market Forces

Currently, there is substantial demand for graduates with computer science skills [11]. Nevertheless, such demand can be frustratingly regional; a given region may experience unusual economic distress, making jobs less plentiful. And any given employer may experience economic problems, regardless of national or regional conditions.

All of these factors can contribute to difficulty in securing cooperative employment. Even once secured, cooperative employment may not continue perpetually. When layoffs occur, cooperative education students, having the least seniority, are often the first affected. Consequently, developing leads for future employers is a perpetual task.

4.3 Employer Expectations

Employers participate in cooperative programs because of the benefits they receive. While altruistic satisfaction can be one of those benefits, the employer’s investment in paying the salaries of such students should result in tangible returns.

Employer expectations of the cooperative education experience are often independent of those of the academic institution. Employers may desire that students receive training in specific technologies; institutions may wish to emphasize broader concepts. Employers may expect students to remain continuously employed with the company; students may want the opportunity to explore the job market. Employers may expect complete control over student job responsibilities; institutions may want students to have job responsibilities closely related to their academic development. Frequent communication between employers and academic institutions is needed to ensure that the expectations of all parties are clearly understood.

4.4 Student Expectations

Students who choose a cooperative education program do so because of the unique benefits they expect to receive. As with employers, those expectations may not always coincide with those of their academic institution.

Students may look at cooperative employment as a right; institutions may want students to qualify for the privilege of employment through interviewing. Students may want the opportunity to change employers frequently; institutions may want students to persevere with one employer. Students may enter cooperative employment with unreasonable expectations regarding work, lacking the initial maturity needed for success in the workplace. As with employers, frequent communication between students and their institutions is required to resolve conflicts.

4.5 Geography

Most college students have two geographic loci: their hometown and their academic institution. Cooperative education students have a third locus: the site of their employer. This third locus may or may not coincide with

the other loci; either situation presents benefits and challenges.

If a student's employer is located near the student's hometown or academic institution, students generally need to move less often. If living at home, students can save money on living expenses. But restricting consideration of employers to particular geographic locations can reduce job opportunities, and make students more susceptible to regional economic disruptions.

4.6 Calendar

Cooperative education programs usually take longer to complete than traditional educational programs. The extra time spent in the work force does not eliminate the need to complete the requisite number of hours of classroom instruction.

As a result, the calendar of a cooperative education student looks significantly different than that of a traditional student. Cooperative education students may have to take courses during non-traditional terms, or in a non-traditional sequence; consequently, student course selection can become more difficult. Students may be at work when certain calendar-bound activities occur (e.g. homecoming, spring break, study abroad); this can lead to feelings of isolation. Campuses can provide alternative

community structures for cooperative education students that take advantage of their unusual calendars.

5. CONCLUSION

Cooperative education programs provide numerous opportunities to engage students with a practical understanding of the discipline. Students apply their academic skills to real problems; in the process, they discover how those skills are relevant, and how well-suited (and employable) they are as a computer scientist. Educators benefit through frequent contact with the discipline at large, and through the maturity developed by their students while working. Academic programs benefit by receiving frequent external validation of the relevance of their curricula and the abilities of their students upon graduation. While significant challenges exist in running a successful program, the benefits received by students, employers, and academic institutions can make such programs worthwhile for all participants.

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