Beyond course work: expanding what's valued in computer science degree programs

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Abstract

Purpose – As the field of Computer Science (CS) continues to diversify and expand, the need for undergraduates to explore career possibilities and develop personalized study paths has never been greater. This reality presents a challenge for CS departments. How do the students striving to become competent professionals in an ever-changing field of study? How do they do this efficiently and effectively? This study addresses such questions by introducing RadGrad, an online application combining features of social networks, degree planners and serious games.

Design/methodology/approach – RadGrad application is designed to promote participation in extracurricular activities, value real-world experience and provide guidance for students planning their degrees. What follows is an exploration of how the application was designed, along with an analysis of how students used it in its first year.

Findings – Findings suggest RadGrad helped students to participate in relevant community activities and take an active role in planning their degrees.

Originality/value – The paper describes the features of the application, introducing how the concept of Innovation, Competence and Experience (ICE) scores – rather than a GPAs – were used to motivate undergraduates to participate in extracurricular activities. Initial results suggest RadGrad and the concept ICE scores can be applied to any field where students are encouraged to gain real-world experience as part of their degree program. Lessons learned and future directions are discussed.

Keywords Computer science education, Curriculum, Higher education, Career goals, Diversity, Retention

Paper type Research paper

Introduction

It is no secret that computing and everything it entails has drastically changed our day-to-day lives (code.org). This is one of the reasons computer science is considered a critical field of study, one with fast growth and high paying career paths. Today, 58% of all new STEM (Science, Technology, Engineering and Math) jobs are in computing, and by 2026, the US Department of Labor predicts that there will be an estimated 3.5 million computing-related jobs available in the United States alone (National Center for Women and Information Technology, 2019).

For all of these reasons, the importance of computer science education (CSE) has been emphasized over the years. Evidence of this can be seen in countries who have shifted the focus of their CSE programs from the college level down to primary and secondary schools (K-12) (Hubwieser *et al.*, 2015). Some countries such as Australia, England, South Korea and

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Poland include Computer Science (CS) as a compulsory subject in primary schools. Still other countries like New Zealand, Norway and Sweden introduce computer science as an elective in secondary schools. CS is having an impact on educational institutions around the world.

In the United States, there has been – and continues to be – an extensive push to introduce CS to all students in grades K-12 (Heintz *et al.*, 2016). According to The White House (2014), for example, more than 60 school districts, including the seven largest school districts in the country, made commitments to offer CS courses. Philanthropic contributions of over $20 million have been made to train 25,000 teachers to teach CS. Government agencies such as the National Science Foundation (NSF) have invested in money to support the development of curricula, course materials, pedagogy, scalable models of teacher preparation and approaches to sustainable, ongoing teacher support (The White House, 2014).

As efforts to integrate computer science into the K-12 curriculum have spread, enrollment of CSE in US undergraduate programs has increased. According to Camp *et al.* (2017), the average number of undergraduate CS majors is larger today than at any previous time. For example, the Taulbee survey report by Zweben and Bizot (2018) shows the average enrollment per US CS department has increased over 360 from 2006 to 2018. This same survey predicts increased enrollment will continue based on the fact that the number of new undergraduate computing majors has increased for the eleventh consecutive year. However, despite the increase in enrollment and the growing number of CS programs, the Bureau of Labor Statistics projects that by 2020 there will be 1.4 million CS-related jobs available and only 400,000 CS graduates with the skills to apply for those jobs (The White House, 2014). Consequently, undergraduate CS majors have faced some challenges.

Retention in CS programs

Along with increased student enrollment, institutions have reported difficulties in managing the increased number of students (Zweben and Bizot, 2018). Common challenges faced by institutions include managing resources, providing appropriate provisions and support for students and updating curricular and teaching facilities – especially within a discipline that changes rapidly (Gordon, 2016, p. 5). These challenges are critical since they are directly connected to the retention of students in CS programs.

In many colleges and universities, student success and retention in CS is an ongoing concern (Stewart-Gardiner, 2011, Haungs *et al.*, 2012). Previous studies have reported attrition rates as high as 30%–40% during, or between, the freshman and sophomore years (Beaubouef and Mason 2005; Ohland *et al.*, 2008). More recently, Woodfield (2014, p. 8) reported that CS had a lower retention rate (91%) compared to other disciplines (94%). The authors found that only 56% achieve a degree, with a notably higher proportion of students (38%) leaving without their award because of academic failure.

Recognizing these issues, researchers have investigated the factors that may impact student attrition in CS programs. Some of the factors that have been studied include self-efficacy, social support, career orientation, cultural issues, learning experiences and poor advising and motivation (Beaubouef and Mason, 2005; Giannakos *et al.*, 2017; Kinnunen and Malmi, 2006; Rosson *et al.*, 2011). In particular, Biggers *et al.* (2008, p. 406) found that students who leave CS as a major have an "overwhelming perception that CS is an asocial, coding-only field with little connection to the outside world." The authors went on to conclude that the combination of feeling inadequately prepared and not knowing what career options are available with a CS degree make students less confident and contributed to their leaving their program. Similarly, Rosson *et al.* (2011, p. 17) claimed negative beliefs about CS professions may disincline some students from seeking computer-based education and careers. For example, Carter (2006, p. 30) found students often see computer science as programming or advanced computer use, requiring them to sit in front of a computer all day instead of a profession with more human interaction. Lewis *et al.* (2016, p. 23) described students' stereotypes about computer scientists as individuals who are asocial, competitive, obsessed with CS to the extent of excluding other interests and males considered innately more talented in CS than women. Similarly, numerous studies have discussed CS stereotypes as being male, technologically oriented and socially awkward (Cheryan *et al.*, 2013, 2015; Diekman *et al.*, 2010; Fisher and Margolis, 2002). Taken together, these studies show students may lack a realistic understanding of CS as a profession and hold on to misconceptions about people working in CS.

Lack of minority and women represented in CS program

Such a lack of understanding combined with misconceptions about the field may contribute to the lack of diversity within CS, such as the gender gap, which has continued to grow despite increased student enrollment. Rather alarming is the fact that CS is the only STEM major to experience a precipitous decline in the representation of women (Beyer, 2014, p. 153). The gender disparities are significant as outlined in a recent NSF report:

> Computer sciences has one of the lowest shares of women degree recipients among the broad fields of science and engineering, despite an increase in the number of women receiving computer sciences degrees over the past two decades. In addition, the share of women receiving bachelor's and doctorate degrees has declined over time. At the bachelor's level, only 19% of the computer science degrees in 2016 were awarded to women, down from 27% in 1997. (NSF, 2019, p. 8)

This issue has caught the attention of researchers who have argued that one of the main reasons for low (and declining) female participation in CS may be a lack of understanding about CS as a field. That is, many women may have strong stereotypes about what it means to study and work in the field of CS. For example, Morton (2005, p. 10) found many girls have images of information technology (IT) that include socially inept programmers who spend their days alone, programming software and maintaining hardware. Related to these stereotypes about who works in CS, some female students believe the field itself is masculine. For example, Lewis *et al.* (2016, p. 29) illustrated how female students come to see CS as male dominated. According to the researchers, females observe the number of male students and teaching assistants in their classes and even begin to believe that men perform better in their classes. As a result of these factors, many studies have shown that women are less confident, tend to have low self-efficacy and may even believe they are naturally or inherently not good in a male-dominated domain such as CS (Beyer and Haller, 2006; Dryburgh, 2002; Hancock *et al.*, 2002; Harrell, 1998; Todman, 2000; Wilson, 2002).

These stereotypes, misconceptions or beliefs are problematic since they have a negative effect on women considering a career in CS. Master *et al.* (2016, p. 424), for example, argued that adolescent girls may avoid CS courses because of prevailing stereotypes, which may signal to them that they do not belong. Cundiff *et al.* (2013, p. 543) found that among women, stronger gender–science stereotypes were associated with weaker science identification and, in turn, weaker science career aspirations. Cheryan *et al.* (2009) described stereotypical cues that impact women's participation in CS. They did this by demonstrating how women were strongly influenced by masculine environments, which impacted their sense of belonging and levels of interest.

Given these issues, it is critical to address how the field of CSE can engage more students in meaningful ways. Fortunately, researchers, educators, policymakers and administrators have continued to make changes in CSE by re-designing curriculum (Sahami *et al.*, 2010), implementing innovative way of teaching (Avery *et al.*, 2010), launching initiatives (The White House, 2014) and supporting research (NSF). What has become clear across these efforts, however, is the need to

(1) provide students with a more holistic understanding of CS, (2) account for students' varied backgrounds, (3) offer helpful collaboration and (4) increase sense of belonging and build a safe learning culture for all (Stephenson *et al.*, 2018). Indeed, studies have shown it is essential to introduce various careers students can pursue with a CS degree rather than allowing students to carry the misconception that everyone is a computer programmer (Rouvrais and Kanellos, 2011). In addition, students must be provided opportunities to learn about and explore those other career paths. Importantly, showing how jobs in CS deal with real-world problems and positively impact communities – locally and globally (Beyer, 2014) – should be another important focus for CS programs. Further still, emphasis must be placed on creating learning environments that are inviting and inclusive to students, regardless of their backgrounds, gender, ethnicity and previous experience. Of course, finding ways to operationalize and maintain these foundational components is an ongoing challenge for CSE programs.

With these priorities in mind, the research team designed and developed an open source application called RadGrad. RadGrad allows students to plan and manage their learning experience, including coursework and extracurricular opportunities, in relation to their individual career goals. The purpose of this study is to describe RadGrad's design in detail and examine how the platform addresses the needs of today's CS undergraduates.

Background

As a means of addressing the challenges described above, a team of interdisciplinary faculty from a large public university in the Pacific region worked together on the project. The team, representing two university departments (Information and Computer Sciences and Learning Design and Technology), developed a new conceptual framework called Degree Experience Plans (DEP). This framework was meant to help CS degree programs ensure they promote individualized student learning plans while emphasizing, and valuing, extracurricular engagement. The framework was based on findings from educational research on diversity and retention. In particular, the framework incorporates ideas related to Individual Learning Plans (ILP) and Communities of Practice (CoP).The following section describes how ILP and CoP influenced the design of DEP framework.

Individualized learning plans

In recent years, ILPs have been implemented in high schools throughout the United States. As strategic planning tools, ILPs help students align course plans with career aspirations and often include the development of postsecondary plans (Solberg *et al.*, 2012). The National Collaboration on Workforce and Disability for Youth (2013) explains ILPs as being both a document and a process that students use to define their postsecondary and career goals. In terms of being a document, an ILP consists of two parts. The first part is for course-taking and postsecondary plans aligned to career goals. The second part is for documenting any college and career readiness skills students have developed. In terms of process, ILPs are designed to enhance the relevance of school and out-of-school learning opportunities so students can explore and plan career development. While there is a range of possibilities when it comes to ILPs, the typical components include an academic plan, identified academic, personal, and career goals, action plan, service learning and career exploration (National Association for College Admission Counseling, 2015). By their nature, *individualized* learning plans are meant to be student-centered. That is, students take an active role in assessing, reflecting on and planning their ILPs based on their needs and goals (Fox, 2013, p. 2). At the same time, ILPs cannot be successful without the collaborative effort of school counselors, teachers and parents. While research studies measuring the impact of ILPs on students' academic success is ongoing, initial indications show that ILPs may be an important method for helping students achieve both college and career readiness. A critical component of success may be helping students perceive school to be more meaningful and useful, ultimately motivating students to pursue more rigorous in-school and out-of-school learning opportunities (Solberg *et al.*, 2014).

Using ILP as a foundational concept, DEP is designed to implement many of the same features (academic planner, career explorer and action plan) in a manner that is suitable for the undergraduate student context. For example, unlike ILPs, each DEP instance focuses on interests, career goals and academic plans specific to a single disciplinary area, which in this case, is CS. In addition, DEPs implement features to elevate extracurricular activities to first-class status within the degree experience.

Community of practices

Communities of Practice (CoP) are "groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis (Wenger *et al.*, 2002, p. 4)." Based on the argument that learning should be situated within activity, context and culture, Lave and Wenger (1991) introduced the concept of CoPs. Since then, CoPs have been fully developed and extended to "landscapes of practice" (Wenger, 2010, p. 183). How are CoPs different from other communities? Wenger (2010) described three characteristics that are crucial to a CoP: the domain, the community and the practice. A CoP has a shared domain of interest, which requires members to have a commitment to the domain and a shared competence. The members in the community engage in joint activities and discussion help each other and share information. Importantly, the members of the CoP are practitioners, who develop a shared repertoire of resources – experiences, stories, tools and ways of addressing recurring problems – which is known as a shared practice.

Focusing on the development of a shared practice, a growing number of people and organizations in various sectors have established CoPs to improve their performance (Wenger, 2010). For example, the advanced development of information and communication technology (ICT) has offered a virtual space for CoPs to further become a vehicle to facilitate learning via CoPs (Garrison and Kanuka, 2004). For example, Parboosingh (2002, p. 231) explains how CoPs supported by ICT can improve traditional continuing medical education, which often has to be dependent on limited interactions between close colleagues and peers. This is done by providing solutions to common barriers such as limited participation and access to interactions, difficulties in documentation of practices, physicians' busy schedules and various degrees of commitments to lifelong learning. In education, Vavasseur and Kim MacGregor (2008, p. 517) found sharing ideas, discussing issues and making new connections with colleagues through online CoP in teaching, teachers gained curriculum-based knowledge, developed enhanced self-efficacy with respect to implementing technology and collaborated on the development of interdisciplinary curriculum units.

Given the idea of CoPs, it might be assumed that university departments would naturally give rise to such forms of interaction, since departments, by definition, involve groups of people with common interests. Unfortunately, many traditional higher education institutions are built on the assumption that learning is an *individual* process best encouraged by explicit teaching that is, on the whole, separated from social engagement with those outside the university community. This perspective has been challenged by many, who believe learning has to be situated, active, collaborative, connected to real-world problems, beyond the limits of discipline boundaries within a specific university community and beyond the institution into the local community (Hodgkinson-Williams *et al.*, 2008, p. 433).

Because of the known benefits of CoPs, DEP is designed to introduce them to undergraduate students in CS. Students are encouraged to join and participate in CoPs that interests and are relevant to them. More specifically, DEP makes CoPs, which are primarily found within disciplinary-specific extracurricular activities (e.g. clubs, meetups, hackathons, and so forth) visible. Further still, DEP provides *incentives* for students to participate in these communities. It is believed that participating in CoPs will improve undergraduate retention and diversity by guiding students to find a new source for social encouragement, self-perception, academic exposure and career perception.

RadGrad

In order to operationalize DEP, the research team designed and developed a strategic tool called RadGrad. RadGrad is an open source web-based application that allows students to plan and manage their learning experiences. More specifically, RadGrad is designed as a tool for students to use to explore more authentic, diverse, collaborative and engaging learning opportunities within and beyond the school curriculum. To do so, RadGrad mainly consists of the seven entities: Interests, Career Goals, Courses, Opportunities, Degree Plan, Innovation, Competence and Experience (ICE) and Levels.

Interests represent a set of discipline-specific topics relevant to the degree experience. It is critical for students to explore and learn various topics in the field of CS. They also need to identify topics that interest them and are relevant. Since CS is such a broad field, there is a long list of subfields and topics. For instance, the Association for Computing Machinery (ACM) has published the de facto standard classification system for the computing field since 1964. The latest classification system from 2012 includes more than a couple thousand topics. While DEP may not specify and introduce all of those subtopics, it introduces various topics relevant to the degree program and allows students to explore them. Examples of Interests might include "blockchain", "big data" and "Java" (see Figure 1).

Career Goals represent professions a student can pursue through the degree experience. Given the number of topics and subfields within CS, there are various careers students can pursue (see Figure 2). Clearly, coding is not the only thing that CS professions do. Examples of

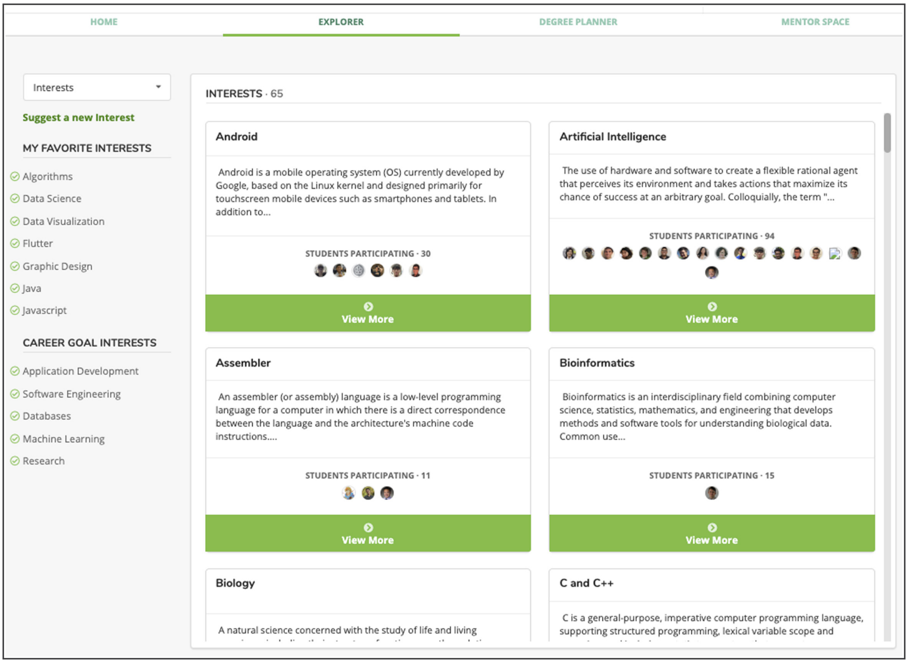

Figure 1.
RadGrad interest page

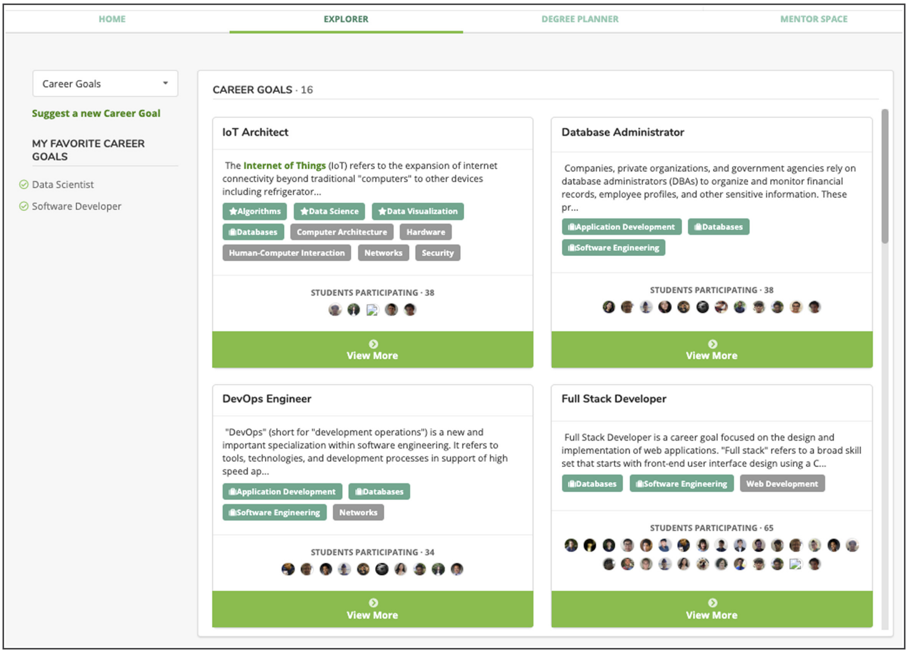

Figure 2. RadGrad career goals page

career goals in CS include starting from "Web Developer" to "Data Scientist", "Augmented Reality Engineer" and "Security Analyst". Importantly, careers and professions in CS are continuously expanding. Job titles, such as Cloud Architect, Search Engine Optimization Analyst, did not exist 15 years ago. Within this fast-growing field, it can be overwhelming or even impossible for students to learn and master every subtopic. Thus, it is important for students to set up their career goals related to their interests. And, they should do this early enough in their degree program, so that they can plan accordingly. In CS, example Career Goals include: Database Administrator, Full Stack Developer, Information Security Analyst, etc.

Courses represent the curricular activities associated with the undergraduate academic unit. For receiving a bachelor's degree, it is required for student to complete their course work within the curriculum. An academic department's curriculum aims to provide students with an in-depth foundation of its field and further guide students to broaden and deepen their understanding. Accordingly, a BS degree at the university provides students with an in-depth foundation in software technology, science of computing and math. Later in the program, students will focus on a specific area of interest in CS, such as theory and algorithms, computer organization and architecture, security and information assurance, software engineering, human–computer interaction, database design, data science, AI and machine learning, etc. (see Figure 3).

Opportunities represent extracurricular activities that help a student progress toward one or more Career Goals and/or learn more about a specific Interest. While a CS academic department continuously updates its curriculum, it is challenging given the rapid revolution and expansion of the field (Sahami *et al.*, 2011). Thus, it is strongly recommended and even necessary for students to expand their experience and learning through extracurricular activities. The set of Opportunities available for a student to add to their DEP are "curated" by faculty members to ensure quality and relevance. Example opportunities include: a local Hackathon, a summer internship at a local hightech company and participation in a faculty

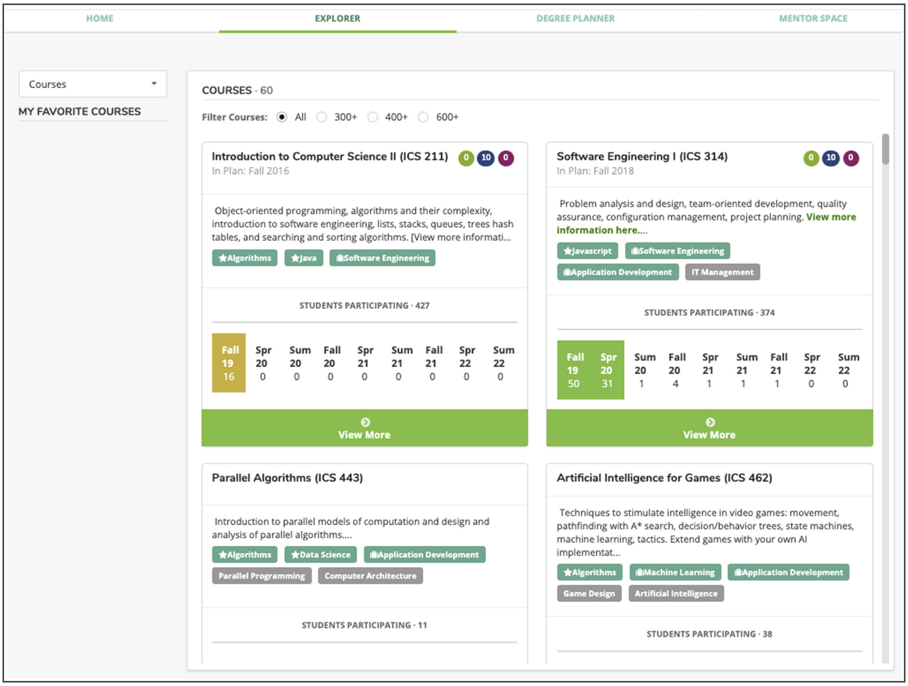

Figure 3.
RadGrad courses page

member's research project. Opportunities can also include online courses available through platforms like Coursera or edX, if faculty have reviewed the offering and found it to be useful and appropriate for students (see Figure 4).

Degree Plan comprises the set of Courses and Opportunities that a student has completed previously, is currently taking or plans to complete in upcoming semesters. That is, unlike any other resources that may introduce information about available courses or present possible opportunities to students, DEPs guide students to actually plan to do those activities. Among the given courses and opportunities, students can specifically plan out their learning experience within and beyond their curricula. They can do this in on an ongoing and continuous fashion. For example, students can plan which courses they'd like to take in the next two years, and they can also plan to participate in a local Hackathon next month. By explicitly representing and planning curricular and extracurricular activities, DEPs provide a more holistic view of the student's disciplinary experience, not just their classroom activities (see Figure 5).

ICE is a constituent measure of students' progress and success within the degree program. It is made of three components: Innovation, Competency and Experience. In other words, rather than GPA, which simply is a record of how successful or unsuccessful students are within their course work, ICE tracks students' overall learning experiences both within and outside the curricula. For example, typically, a student earns Competency points for completing Courses, and Innovation and Experience points for completing Opportunities such as participating in hackathons, attending a local/national conference or working on a community project. Whenever students participate and complete their course work and participate in various opportunities, students earn points. For Opportunities, students can earn 15 Innovation points for a weekend hackathon, and up to 25 points for a summer-long internship. Advisors and faculty use RadGrad to verify student participation in

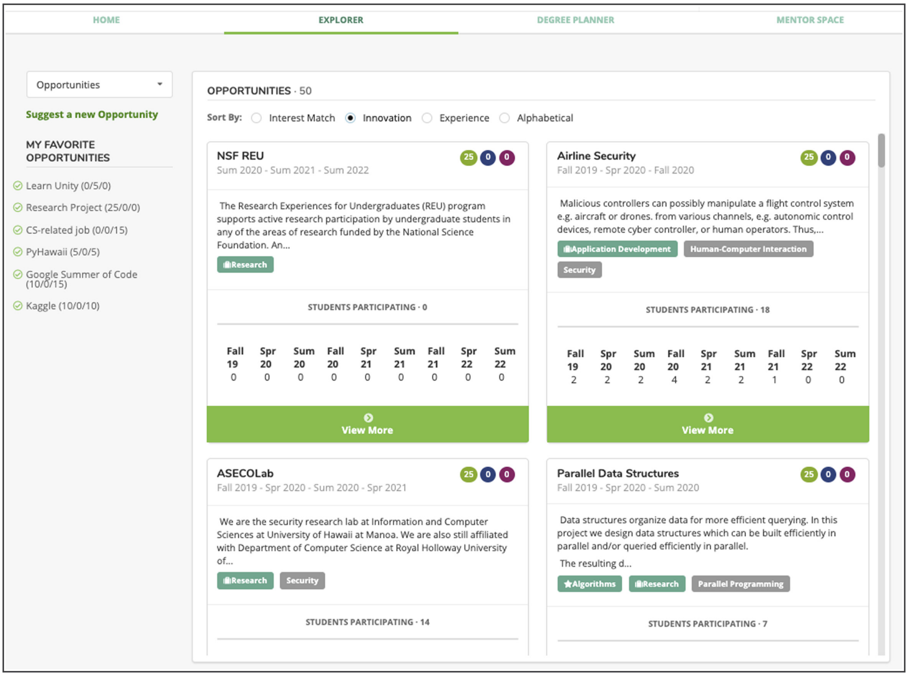

Figure 4. RadGrad opportunities page

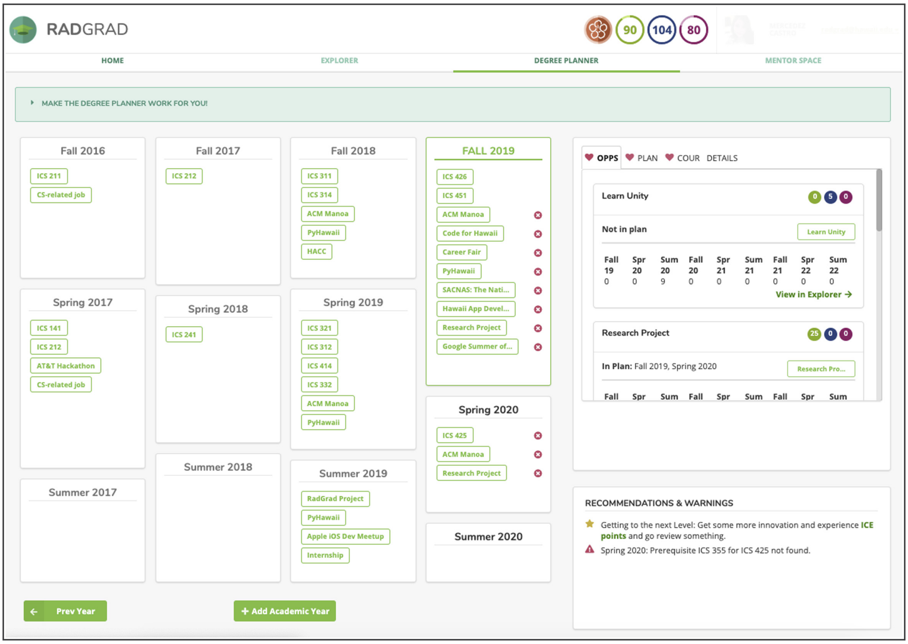

Figure 5. RadGrad degree plan page

extracurricular activities, earning them the specified ICE points for that activity. Coursework is automatically verified in RadGrad by accessing institutional database records. Also, how many points students can earn for each activity is decided by the administrators of RadGrad and an advisor. Students are encouraged to earn 100 points in each of three measures by the end of their program, which is designed to showcase students' active participation and involvement in the field of CS.

Levels is a symbolic representation of what progress students have made. That is, based on the ICE points students earn, the levels will be determined. There is currently a six-level progression from zero ICE points to 300 points across all three categories. When students move up to each level, students earn actual laptop stickers with different colors, which seems to be an appealing and useful way for students to form communities around their degree experience plans. Each student's level is also displayed in their navbar to the left of their ICE points once they login into *RadGrad*. Incorporating the idea of "gamification", which the application of game-design elements and game principles in non-game contexts (Robson *et al.*, 2015), the Levels allow students to see who is making what progress, compare their own progress with the others and challenge and motivate themselves to earn higher levels. The sample illustrated in Figure 6 is at Level 5 (Brown).

Ultimately, RadGrad uses these seven entities to (1) introduce the CS field properly through Interests, Careers, Courses, (2) guide students to plan their experiences through degree plan and opportunities and (3) encourage them to actively plan, participate, broaden and also deepen their learning by incorporating ICE score system and Levels.

Development of RadGrad began in 2015 with the design of paper mockups and usability tests by and for computer science majors. RadGrad is now a functional web-based application using the Meteor framework, implemented in approximately 30,000 lines of Javascript and 7,000 lines of HTML. RadGrad has extensive design and development documentation, which is included in the RadGrad Manual (see https://radgrad.gitbooks.io/radgrad-manual/ for more information), unit and integration tests and implements continuous integration. Instances can be deployed locally or using the Galaxy platform-as-a-service. Figure 7 illustrates a hypothetical user's home page after logging into the system. Over the past two years, the development of RadGrad went through an iterative process of design and testing. When the beta version of RadGrad was ready, we tested the system with approximately 50 undergraduates enrolled in the university's CS program. Beta testing has helped us refine our training approach and verified that the system is functional and ready for broader dissemination.

Implementation and evaluation

After finalizing development, RadGrad was launched and became available for all of the students enrolled in the university's CS program. We introduced RadGrad in the course, Introduction to Computer Science and students were encouraged to sign up for RadGrad and

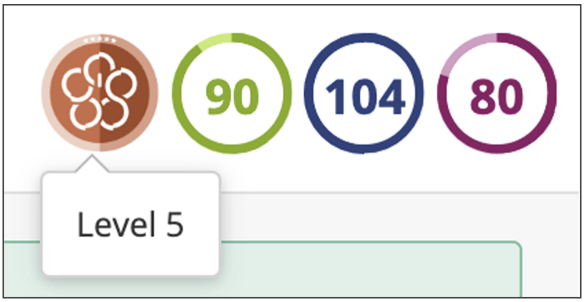

Figure 6.
UI for student level and ICE points

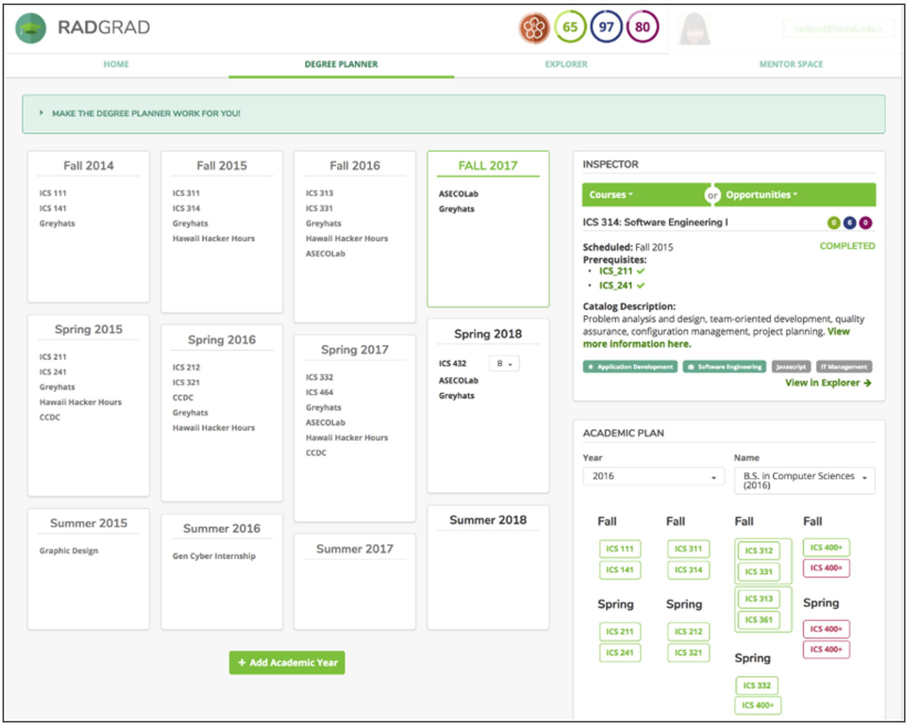

Figure 7.
User's home page

start planning their degree program using the system. Importantly, we introduced RadGrad to an academic advisor as a tool for to be used during advising sessions. The CS program expects students to meet with an advisor once a semester to discuss their upcoming course selection and progress toward graduation. RadGrad provides features to simplify that aspect of advising in order to enable discussion of the larger degree experience such as students' interests and career goals and planning for complementary extracurricular activities over the remaining semesters of their program. Accordingly, we expect students to consult RadGrad consistently but infrequently: once or twice per semester. During these sessions, students are expected to update their Degree Experience Plan with new or different interests and career goals, modify future plans for curricular and extracurricular activities, obtain verification for activities they participated in previously and receive their next Level laptop sticker (if achieved).

Targeted users – students in CS

In the first year of full implementation, 206 students voluntarily signed up for RadGrad. Out of those students, 121 responded to a survey asking about their perceptions of and experiences with the CS program *prior* to their use of RadGrad. Since few students had seen or used RadGrad previously, 114 students reported no prior use of RadGrad. Out of 114 students, 24 (21%) were female and 11 (9.6%) were Native Hawaiian.

Students were asked how they evaluate their progress through their degree program. In this portion of the survey, participants were able to select multiple responses (i.e. all that apply). Eighty-three students (73%) indicated they had a clear academic plan for graduation. Seventy-five participants (66%) indicated they looked at their GPA and 67 participants (59%) selected having a clear career goal. While the top three responses were somewhat predictable, it was surprising to learn that more students chose having an academic plan for graduation than looking at their GPA as progress. Other indicators of progress selected by participants included attending internships, learning to code, understanding course materials and meeting with an advisor.

The survey also asked participants about the activities they thought were important for being a successful computer science or computer engineering graduate. The top three responses were (1) doing an internship (83%), (2) participating in professional organizations (e.g. Association for Computing Machinery, Cyber Hui) (66%) and (3) taking workshops (43%). These results are encouraging since they show students are aware of and value extracurricular activities related to CS. One notable finding was the fact that 16 participants (14%) responded by selecting "I do not know." This result suggests that some students need more guidance or support in terms of knowing about certain activities and how to engage in them during their CS program and/or profession.

The survey also attempted to capture factors that might prevent students from participating in extracurricular activities. Not surprisingly, a lack of time was the top response selected by 103 participants (90%). Another factor indicated by 51% of participants was a lack of information about existing opportunities. Fifty percent of participants indicated a lack of direction/advice from the program as a factor.

In contrast, different factors emerged when participants were asked about the factors that helped influence them to stay in the CS program. For example, 77% of participants chose learning about possible career goals as one factor. Similarly, 77% indicated being able to pursue specific Computer Science/Computer Engineering interests and 66% indicated having a clear academic plan for graduation as important factors. In addition, 61% of participants suggested having more varied course offerings, 58% indicated access to mentors and 47% suggested participating/learning about extracurricular activities.

As these results suggest, the findings from the survey are not new. The results are consistent with what the field has known for some time. That said, it was valuable to have students identify the factors they feel are important when it comes to continuing and ultimately completing a CS program. In short, the student responses illustrated the fact that many students in CS see value in having clear academic plans and a career goal. In addition, it seems the majority of students are looking for extracurricular opportunities. Accordingly, the program might want to work on providing students more information and guidance when it comes to identifying and participating in activities beyond the normal curriculum.

DEP/RadGrad was developed to serve such needs: to support and guide students' academic plans, to inform extracurricular activities beyond course work, to provide opportunities to work on real-world problems, to encourage students to explore various career goals and to let them have access to their alumni and mentors. Thus, a critical question is whether or not DEP/RadGrad served its stated purpose. While this question cannot be answered in full after a single semester, the following section begins to address this question by describing how students used DEP/RadGrad in its first year of implementation.

Student use of RadGrad

At the end of the Spring semester, the research team looked at how students used the RadGrad system. As mentioned, out of a total of 425 students in CS, 206 (48%) registered for and actively used the system. Out of those 206 students, 133(64%) were male and 37(18%) were female. The gender of 36 (17%) students was not available.

The total number of RadGrad logins was 272 in the Spring semester, which resulted in an average of 1.32 logins per student. Closer analysis found that two students logged in 12 times each, and more than 50 students logged in more than two separate times. In other words, approximately 48% of CS students voluntarily registered for RadGrad, logged into the system at least once and explored and planned their degree program. Since students typically do not “manage” their degree program regularly throughout a single semester, the average number of logins of 1.32 per student, is about what was expected in terms of system access.

As a matter of fact, a single login might be sufficient for many students. Accordingly, the fact that the average number of logins was over one is promising since first-year implementation focused on introducing the system to students, who used RadGrad was completely voluntary.

Importantly, we also looked at the pages students visited within the system. As described, RadGrad is composed of seven entities: Interests, Career Goals, Courses, Opportunities, Degree Plan, ICE and Levels. Once logged in, students were free to explore these entities and their subpages freely. Based on usage statistics, students visited the ICE page the most. The ICE page was where students could track their curricular and extracurricular activities. In total, there are 980 visits to the ICE page across all students. This suggests that most all other students checked their ICE scores at least once. The next most visited page after ICE was the Opportunities page. There were 857 visits to this page. Students also visited the Interests, Career Goals, Levels, Courses and Degree Plans pages (see Table 2 for detail). Overall, these numbers suggest students actively explored their career goals and interests within the RadGrad system. In addition, they used the pages of the system to learn about courses, plan their degree program, search for opportunities, participate in them and earn ICE points. These were encouraging results for the first year and align with expectations as to how students would use the RadGrad system.

The next step in the analysis was to examine the subcategories of each entity that students viewed. For example, within the Career Goal entity, the most viewed career goal was “Information Security Analyst”, which was visited 22 times. The career goal of “Full Stack

RadGrad users	*N*	%
Female	37	18
Male	133	65
Not identified	36	17
Total	206	100

Table 1. Gender distribution of RadGrad users

Page		Number of visits
ICE		980
Opportunities		857
	ACM–Manoa	85
	Google summer of code	75
	RadGrad project	61
	ACM ICPC	53
Interests		390
	Artificial intelligence	12
	Algorithms	12
	Bioinformatics	11
	Software engineering	11
Career goals		387
	Information security analyst	22
	Full stack developer	20
	Software developer	18
	Game developer	18
Levels		342
Courses		277
Degree plan		198

Table 2. Number of visits per RadGrad sections

Developer" garnered 20 visits, whereas "Game Developer" and "Software Developer" both had 18 visits. In addition, students visited other career goals such as Data Scientist, Mobile App Developer and DevOps-Engineer. In terms of interests, the pages for algorithms and artificial intelligence were visited the most. Taken together, over 50 interest topics were viewed by students including Application Development, Bioinformatics, Computer Architecture and Software Engineering. As shown in the table below, there was no page or topic that was visited by a majority of students. This highlights the range of interests and career paths students bring to their program when majoring in CS. Further, it reinforces the need for academic departments to provide more diverse experiences for students along with proper guidance.

One goal the RadGrad/DEP system attempted to achieve was introducing students to career goals and related CS interests. The point was to challenge and encourage students to actively look for opportunities to participate in CS-related extracurricular activities. This was operationalized through the ICE scores and Levels system. Accordingly, students were encouraged to find interesting activities related to the CS program outside of their classroom and participate in them. What opportunities were students interested in besides taking courses? At the end of the Spring semester, there were 57 different opportunities viewed by students. These opportunities included participating in internships, hackathons, conferences, meet-ups and career fairs. Among them, the most viewed opportunity page was ACM-Mānoa, which was dedicated to a local student chapter of the Association for Computing Machinery. In total, this page was visited 85 times. Students also explored various internship opportunities, research opportunities, social meetup opportunities, code challenging opportunities. Of course, once students learned about these opportunities, they had to plan to participate in them. As described earlier, when their participation was confirmed by an advisor or faculty, students were able to earn ICE points based on the type of activity they completed. For these extracurricular activities, students earned points for Innovation and Experience.

ICE score

When the RadGrad/DEP was introduced to students, they were encouraged to earn 100 points in each of the three measures of ICE by the end of their program. By the end of the first year, all 206 students earned ICE scores, which ranged from 6 to 522. Sixty-two students did not participate in any extra curriculars but earned ICE scores for Competence by taking courses. The remaining 146 students (69%) participated in extracurricular activities in addition to engaging with their course work.

The average ICE score of the 206 participating students was 197.69 (SD = 143.26). This total combined score was then broken down into its three components. The average score for Innovation was 58.62 (SD = 59.74). The average score for Competency was 84.29 (SD = 43.95). The average score for Experiences was 54.78 (SD = 54.52). These averages were higher than expected in the first year considering there were students who did not participate in any activities for Innovation or Experiences. For comparison purposes, if the students who did not earn any points for Innovation and Experiences are excluded from the analysis, the average ICE scores shift dramatically. For example, the average Innovation score increases to 83.85 points (SD = 54.63) and the average Experiences score jumps to 78.37 (SD = 48.99). It was also interesting to examine the extreme ICE scores. The highest ICE score was 809 points and the

Table 3. Minimum, maximum, mean and standard deviation of ICE points

	Min	Max	*M*	*SD*
Innovation	5	285	58.62	59.74
Competence	6	224	84.29	43.95
Experience	5	300	54.78	54.52
Total ICE	6	809	197.69	143.26

lowest was 44 points. While it is worth noting this wide range of scores, it is also worth mentioning that 79 (38%) students earned over 300 points and 44 (21%) students earned over 100 points. Taken together, the analysis of the ICE score confirms that the majority of students participated in extracurricular activities and logged/tracked them via the RadGrad system.

Conclusions, limitations and future research

The primary goal of this project was to design and develop a tool to support CS students in successfully completing their degree program. Given the challenge of being a broad and fast-growing field, it is clear that simply taking academic courses in Computer Science isn't enough for students to be successful in their degree program. For that reason, it is critical for them to explore their interests and career goals, participate in various activities within the CS community and plan their experiences in the degree program based on their own needs. Accordingly, a web-based application called RadGrad, which can facilitate students' Degree Experience Plans (DEP), was designed, developed and implemented by the research team. After three years' development, RadGrad was implemented in the university's CS program. At the end of the first year, the research team examined how students used RadGrad by tracking the number of times students visited each page within the system. The results showed that over 200 (64%) students registered to RadGrad and explored, searched and learned about topics and career goals in the CS field. Further, approximately 70% of the students took opportunities to participate in diverse activities in the CS communities and earned their ICE scores. A total of 79 (38%) students achieved over 300 ICE points, which was initially presented as a challenge to students. The results are promising since this was the first year of implementation. RadGrad was new to students and using RadGrad was completely voluntary. This work provides preliminary evidence that RadGrad is being used to help students plan their degree program and, importantly, encourage and promote them to participate and value extracurricular activities within the greater CS community.

We recognize, however, that these findings have some limitations. First, half of the students did not register for RadGrad. Did they not know about RadGrad? Or Did they choose not to register? If they chose not to, it is critical to find out why to improve the implementation of RadGrad. Did they face any issues or difficulties registering for the system? Did they not value joining RadGrad? Second, the results discussed herein are based on the frequency of student visits and ICE records in the system. While interesting data for analysis, this information does not allow the researchers to reach any conclusions about the impact of RadGrad on student success in the CS program. Further research is needed to examine *how* students plan their degree programs and the impact RadGrad has on this process. Does this system actually motivate students in a way that ultimately impacts their academic performance? The answer to this question is still open. However, it is worth mentioning that this research is ongoing. More specifically, a survey regarding student perceptions of using RadGrad and the focus group interviews continue. It is our goal to collect both qualitative and quantitative data to understand how students use RadGrad and, in turn, measure its impact on student successes in the CS program over the next two years. We believe aggregated data from three years of RadGrad implementation will show how RadGrad facilitates the process of navigating their career goals and planning their degree programs. Ultimately, it is our hope to see a web-based tool like RadGrad be a valuable resource for students to enrich their learning experiences in the degree program and further help them to feel confident and connected in the CS field.

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