Creating Institutional Homes for Computing: Transforming a Department into a School or College

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This white paper addresses the growing interest and trend in transforming a department of computer science, usually housed within a college of engineering or science, into a school or college of computing. The white paper follows up on a successful panel at the 2016 CRA Conference at Snowbird on Schools and Colleges of Computing and a second panel on transitioning to Colleges of Computing at the 2018 CRA Conference at Snowbird (see Appendix I).

As computing continues to grow by tremendous leaps and bounds and to permeate universities' intellectual landscape, many department chairs are finding their programs have outgrown, or are outgrowing, the confines of their current locations in colleges of engineering or science. Discussions are taking place in many departments about exploring the possibility of expanding to a school or college of computing (or a similar name). We examine the multifold administrative, social, strategic, and economic challenges confronting these departments, discuss strategies for transforming a department into a school or college of computing, cite examples of existing schools and colleges of computing, and provide a growing list of current schools and colleges of computing in North America in Appendix II.

Understanding Organizational Structures

In this report, we use the term "computer science" to refer to the core disciplines concerned with the theory and design of computer systems. Computer science includes such topics as algorithms, programming languages, artificial intelligence, operating systems, networking, databases, distributed systems, and software engineering. We use the term "computing" to include computer science, as well as its broader applications, including robotics, human-computer interaction, graphics, language technology, and information systems. Neither of these terms is intended to be precise in its boundaries—the entire discipline is evolving and expanding at a rapid rate, and the interdisciplinary nature of computing defies categorization.

The locus of computer science in academia varies widely across institutions in the U.S. In some cases, it is housed within a combined electrical engineering and computer science department. In others, it is a standalone department, historically housed in an engineering college or an arts and science college. Similarly, the broader topics that comprise computing are housed in many different academic organizations.

In this white paper, we consider an academic structure that we refer to as a "college of computing," consisting of faculty and students concerned with both core computer science and some of the broader topics in computing, and with an organizational structure run independently from any other college[1]. In its most complete form, a college of computing grants both undergraduate and graduate degrees, and is headed by a dean who reports directly to the university administration (typically, the provost). Given the evolutionary nature of academic organizations, however, many universities have something like a college of computing, but without all the features listed above. Note also that many universities have set up "information schools," mostly by expanding the role of their library science program to include broader topics in collecting, managing, and using information. We consider such schools to be colleges of computing only if they also house the university's computer science program.

Why Become a School or College?

Computing/computer science is different from other departments in colleges of engineering or science.

Historically, computer science departments were formed in a college of engineering, science, or science and liberal arts. Administrators often ask why computing should not remain in the college it is currently housed in.

Computer science is different from science departments:

- A CS BS degree leads to a wide range of high-paying job opportunities immediately related to the course work; students have well-paid internship opportunities. Job opportunities for many other science BS graduates are in less demand (see Figure 1 from the U.S. Bureau of Labor Statistics).
- Faculty (and Ph.D. recipients) have a wide range of opportunities outside academia; in certain areas, faculty are actively recruited by industry.

[1] The uses of the terms "school" and "college" vary widely across institutions. We will use the term "college" to refer to an academic organization headed by a dean.

Nonacademic job opportunities for other science faculty are usually less commonplace.

- Increasingly, MS professional degrees in specialized computing fields (e.g., security and data science) are being created, and with significant enrollment. Other science fields have very limited experience with and need for professional MS degrees.
- Computing and data science are relevant to almost every area and domain outside the sciences.

Computer science departments are different from engineering departments:

- CS departments offer courses taken by undergraduates across all majors; some are service courses satisfying requirements. Engineering typically does not offer service courses.
- Increasingly, nonmajors take more than just introductory CS courses (see CRA Enrollment survey).
- Computing and data science are relevant to almost every area and domain outside (and in) engineering.
- CS departments increasingly offer undergraduate and graduate degrees jointly with nonscience and nonengineering departments. Engineering has limited experience offering joint degrees and programs.
- CS undergraduate curricula increasingly allow more flexibility and choices depending on the students' interests (e.g., tracks, threads, and different degrees). Engineering curricula are historically more rigid.

Computing has become pervasive throughout our universities and colleges. Nearly every discipline needs computing. The case can be made that computing should be its own unit or entity on a campus to manage these needs throughout the campus. With a single school or college located on the campus, the former computer science department can create more impact throughout, and better serve, the university. A college recognizes the role computing plays in all disciplines, in research as well as academic programs, and in job opportunities for computer and non-computer science majors[2]. Creating a college recognizes that computing exists in other departments and units at the university, and that students will be better served by combining these computing efforts throughout campus. A college of computing can allow coordinated growth and reduce duplication. What is combined typically depends on the institution and can include, besides computer science, information sciences, statistics,

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[2] See the Burning Glass reports on workforce: http://burning-glass.com/research/digitalskills-gap/.

computational biology, digital media and art, MIS, information technology, and communication.

Colleges of computing provide excellent opportunities for broad, multidisciplinary coverage and increased research funding.
A college of computing is generally more inclined to make hires of people from a wide range of academic disciplines who are doing research related to computing–including fields related to or in the sciences (e.g., bioinformatics, computational physics), social sciences (e.g., economics, law, anthropology, sociology), and humanities (e.g., philosophy, digital humanities)–than is a CS department. In addition, many funding opportunities build on all areas related to computing. A college of computing will be in a better position to respond to such funding opportunities.

There are great job opportunities for students from all types of colleges of computing.
Job demand is great for both traditional CS students and somewhat less technical but more application-oriented informatics students. Many companies want both types of students, and both fields of study are worthwhile, so students should be encouraged to pursue the choices that best fit them.

Resources are better managed.
As computer science has become a popular major, and the need for computing has reached every college campus, enrollments are booming nationwide[3]. Managing the booming enrollments and the changing needs of computing instruction will require significant resources. Computer science department chairs are not at the necessary level to request these resources. Deans who have computer science departments have other departments that are requesting resources as well. The case for getting additional resources is better made when a university has a dean of computing[4]. A college can bring together relevant groups earlier in the approval process, thereby allowing for better collaboration and communication, and thus streamlining the process.

Colleges of computing provide excellent platforms for external fundraising. The style and inclinations of computing/IT-related people, who generally are the main donor prospects for schools of computing, are quite different from those of donors from engineering or general business careers. Thus, a dean of a school/college of computing

[3] Assessing and Responding to the Growth of Computer Science Undergraduate Enrollments (https://www.nap.edu/catalog/24926/assessing-and-responding-to-thegrowth-of-computer-science-undergraduate-enrollments)

[4] Generation CS: CS Enrollments Surge Since 2006 (http://cra.org/data/generation-cs).

may be considerably more successful in relating to these computing-related donors than a dean of a more general school.

Accreditation is a challenge.
As a member of a specific college, the computer science department will be obligated to serve its home college and will often be defined by the accreditation agency affiliated with that college's discipline, such as ABET, which may not be in the best interest of computer science across campus.

Understanding the Myriad Challenges

It can be difficult to move a computer science department out of its current college.
Colleges of engineering and science may be concerned about the loss of funding, academic synergies, potential harm to industrial relations, and fundraising if computer science leaves. The administration, therefore, needs to be convinced that creating a college is in the best interests of the institution, the students, and other stakeholders.

It may be necessary to form departments once colleges reach a significant faculty size.
Generally, it does not work to have core faculty groups larger than 30-40 people; hence, departments are needed for hiring, faculty evaluation, and so on. It is desirable to keep barriers between departments low to facilitate shared teaching and student supervision across departments within a college. And, of course, facilitating joint research across departments in the college, as well as across colleges, is vital to maintain the interdisciplinary vigor of computing.

Is the "brand" the department or the school/college?
CS faculty members generally tend to have CS as their identity. A college may want the broader school to be the identity that is broadcast. Typically, there needs to be some sense of shared identity.

Success is much easier if resources are tied to productivity, such as increased enrollments, research expenditures, or new government/industry collaborations.
It is easier to be entrepreneurial about attracting more students or starting new programs in a way that benefits the faculty, students, and university when successful efforts lead to additional resources.

Colleges are expected to perform many more functions than a typical department.

It may be difficult in the transition to a college for a department to build up the resources, personnel, and expertise to take on these functions (e.g., development, career planning, student support, and communications) and to do all of them well. Although many departments perform several of these functions, much more is expected at the college level.

The Path to Success: Six Institutional Case Studies

These case studies were compiled in July 2017. Updates to departments may have occurred since the time of submission.

Carnegie Mellon University School of Computer Science

The Carnegie Mellon computer science department housed within the science college made the transition to the School of Computer Science (CMU SCS) in 1988. With the addition of an undergraduate computer science major in 1990, it attained all the attributes listed above for a college of computing. Indeed, Allen Newell, Herb Simon, and Alan Perlis, the founders of computer science at CMU, had an expansive view of computer science that we now associate with the term “computing.” In a 1967 essay in *Science* magazine, they argued for the legitimacy of computer science as an academic discipline. In their essay, they defined computer science as “the theory and design of computers, *as well as* the study of all the phenomena arising from them [italics added.]” That is, they had anticipated the broad and important role computing would have across many disciplines. They themselves embodied this broad perspective with their seminal work on artificial intelligence, human-computer interaction, and cognitive psychology.

CMU SCS was formed partly in response to the scale and prominence of computer science at CMU, relative to other parts of the university. However, CMU SCS also reflected the unique disciplinary foundations of computing. Historically, computing as a discipline drew largely from mathematics and logic for its theoretical underpinnings and from engineering for its concrete realizations, which gave rise to its housing in either an arts (philosophy) and science (mathematics) college or in an engineering college. Indeed, in its early years the challenge of building computers that worked at all justified its strong ties to electrical engineering. As computer technology has become more pervasive and incorporated into the day-to-day lives of people and organizations, however, it has found important foundations in social science. Researchers in human computer interaction, educational technology, and language technology draw heavily on such disciplines as psychology, sociology, and linguistics. CMU SCS provides a home for faculty and students with diverse backgrounds and with a variety of approaches to research and education, drawing equally from natural science, engineering, and social science.

Creating a college of computing within a university can present many challenges, including opposition from faculty and administrators trapped by zero-sum thinking—that this new organization will draw talent and resources away from existing organizations. CMU has demonstrated that a college of computing can provide many benefits for the entire campus. Faculty members within CMU SCS have formed collaborations across the university, as well as with other regional organizations. By embracing a broad perspective on computing, they have been able to form connections to business, social science, and the humanities.

CMU SCS has found that maintaining a robust and healthy college of computing presents its own set of challenges. Faculty and students are concerned with labels and how their colleagues and potential employers at other institutions perceive these labels. For example, some want to be classified as "computer scientists," but others do not. Academic rankings, such as *U.S. News & World Report*, attempt to directly compare computer science programs housed within EECS departments to colleges of computing. Some faculty members have found it difficult to fully embrace the range of research styles and evaluation methods used across the college. CMU SCS manages these challenges by organizing the school into distinct departments, but it keeps the boundaries between the departments very porous. Each department has its own graduate programs and its own process for faculty reappointment and promotion. Every faculty member in SCS, however, is allowed to supervise Ph.D. students in any of the departmental Ph.D. programs. Faculty hiring is done via departmental committees, but with coordination across the entire school. A number of faculty have joint appointments, both across departments within SCS and with departments in the engineering college.

Georgia Institute of Technology College of Computing

In 1987, John Patrick Crecine, who had been instrumental in the formation of the CMU SCS, was named president of Georgia Tech. After less than a year in this new position, he proposed a sweeping reorganization of the academic structure. One of the key parts of this reorganization plan was the creation of a new college that ultimately came to be named the College of Computing.

Prior to this reorganization, computer science was housed in the School (Georgia Tech terminology for a department) of Information and Computer Science (ICS) in the College of Science and Liberal Studies. It was smaller and less prominent than several departments in the College of Engineering, the dominant part of the university. The proposal that ICS, with some minor additions, should be elevated to the status of a College was viewed with considerable skepticism.

During the nine months of debate and consideration of alternative structures that followed, a task force chaired by Peter Denning published a report in *Communications* *of the ACM* entitled “Computing as a Discipline” that presented “a new intellectual framework for the discipline of computing.” Ideas from this report proved to be instrumental in resolving the debate and defining a vision for the College of Computing. The first contribution from the report was the name. “Computer Science” was not construed as broadly at Georgia Tech as at CMU. “Computing” served well to capture a more encompassing vision, especially when coupled with the other key contribution from the report: Namely, the notion that computing incorporates three research paradigms: theory, rooted in mathematics; abstraction (modeling), rooted in science; and design, rooted in engineering. From this perspective, it was possible to argue the advantage of creating a separate college meant to facilitate collaboration in all directions.

The new college was approved in September 1989, but it was not formally established until July 1990, when Peter Freeman joined the faculty of Georgia Tech as the first dean of the College of Computing. Upon his arrival, he was advised by President Crecine that the role of the college was to “lead, not own, computing” at Georgia Tech. The other deans were quick to remind him of the collaborative aspect of the vision of the new college, captured in the phrase “a college without walls.” The College of Computing was designed to be equidistant from all potential collaborators, and the “distance” was meant to be easily spanned.

A 1991 strategic plan authored by Dean Freeman captures the college spirit that he promoted:

- We will strive to achieve our goals by effective programmatic integration with other units.
- Our research activity must push forward the frontiers of basic computer science and selected computing areas in which computer science is a key, but not exclusive, component.
- Our real specialty will be in knowing how to effectively mix computer science and other areas.

This strategic plan provided a very real blueprint for the way the College of Computing has operated. The first key step in this direction was the creation of the interdisciplinary Graphics, Visualization and Usability Center (GVU) in 1991. From its inception, GVU has concretely embodied the broad vision for the college and Freeman’s points from the strategic plan.

Both the vision articulated for the college and the name “Computing” mattered in significant ways. The broad, collaborative vision was important in selling the idea of the college to the Georgia Tech community. The fact that the other deans could succinctly describe this vision as “a college without walls” meant that the special nature of the new college was well understood on the campus before it even began operation. The vision was also important in challenging the computer science faculty to see themselves as having a broader role on campus and as part of a more expansive discipline.

The name did make a difference in the external and internal impact of the vision: It reminded everyone that the College of Computing was intended to be about something bigger than computer science. It was particularly instrumental in debates about who should be hired as the faculty of the college expanded in size and scope. It is much harder to say “That isn’t part of computing” than to say the same relative to computer science. It thus became possible to hire a variety of people who might not have been hired by a college of computer science.

The initial push from President Crecine provided a unique set of circumstances behind the creation of the College of Computing. However, the key ideas behind the ultimate success of the college were articulated in the campus discussions leading up to its creation and through the strategic plan cited above. Arguing for the creation of a college based on the growth of demand for computer science is not likely to be successful. Such an approach does not offer anything attractive to the rest of the campus, and it would not challenge the computer science faculty to embrace a broader role. A compelling vision is important in addressing both of these concerns, and the impact of an appropriately chosen name should not be underestimated.

Indiana University School of Informatics, Computing, and Engineering

Indiana University’s (IU’s) School of Informatics, Computing, and Engineering has developed and grown in four distinct stages. In 2000, IU formed the School of Informatics based on a university task force recommendation and approval by the Indiana Commission on Higher Education. The motivation for the new school was to embrace the emerging and highly interdisciplinary aspects of computing, and to foster education, research, and economic development in the state. The new unit did not, at that time, absorb any existing units at IU, including the long-standing Department of Computer Science, or the even longer standing School of Library and Information Science. Instead, it was formulated around a new undergraduate major in informatics, a new Ph.D. in informatics, and MS degrees in a variety of specific areas of informatics, including health informatics, bioinformatics, and human-computer interaction. The informatics BS degree had (and has) the distinction that it is inherently a “computing + X” degree, in that each student takes courses in both computing and a cognate area that can be selected from a wide range of academic disciplines.

The school was formed, and continues to operate, on both the Bloomington and Indianapolis campuses of IU. A faculty was hired over a period of years, mainly from the outside, with a small number of faculty moving over from existing IU faculty positions.

In 2005, the Department of Computer Science at IU-Bloomington moved to the School of Informatics from the College of Arts and Sciences, bringing with it BS, MS, and Ph.D. degrees in computer science and the entire computer science faculty. In 2013, the School of Library and Information Science at both the Bloomington and Indianapolis campuses merged with the School of Informatics, entering as separate Departments of Information and Library Science at Bloomington and Library and Information Science at Indianapolis, and bringing with it MS degrees in library science (both campuses) and information science (Bloomington) as well as a Ph.D. in information science (Bloomington). The merged school was renamed the School of Informatics and Computing. With these moves, the school represents a broad range of computing- and information-related fields, while continuing to collaborate extensively with several other disciplines at the university.

Finally, in 2015, the first engineering program at Indiana University was approved by the Indiana Commission on Higher Education and made part of the School of Informatics and Computing on the Bloomington campus. This forward-looking program focuses on intelligent systems engineering, engineering areas required to advance new technologies such as small-scale, networked, and mobile systems, with special emphases on sensors and nanotechnology. It includes BS and Ph.D. degrees in intelligent systems engineering, including specializations in bioengineering, computing engineering, cyber-physical systems, environmental engineering, molecular and nanoscale engineering, and neuro-engineering. The addition of this specialized sector of engineering rounded out the school to encompass all aspects of computing and information, ranging from theoretical to software to hardware and related areas. In summer 2017, the Bloomington portion of the school was renamed the School of Informatics, Computing, and Engineering, whereas the IUPUI portion retains the previous name.

The school currently consists of departments of computer science, informatics, information and library science, and intelligent systems engineering on the Bloomington campus, and departments of bio-health informatics, human-centered computing, and library and information science on the IUPUI campus. It has grown to be one of the larger schools at IU; the informatics major on the Bloomington campus is the second largest, and the research funding of the Bloomington portion of the school is second only to the very large College of Arts and Science. The school currently has 183 faculty, 131 on the Bloomington campus (111 tenure track, 20 non-tenure track) and 52 on the Indianapolis campus (26 tenure track, 26 non-tenure track).

The school has been viewed as quite successful in three important areas: providing a wide range of computing education and research opportunities to students; collaborating extensively with other units on both campuses; and being a strong asset to economic development in the state and region. Its research strength, impact, and synergies illustrate the benefit of bringing together diverse areas for a broad interdisciplinary view of computing and information technology.

Northeastern University College of Computer and Information Science

At the end of the 1970s, an official BS in Computer Science was created at Northeastern under the leadership of the Department of Mathematics in the College of Arts and Sciences and in partnership with the Department of Industrial Engineering and Information Systems in the College of Engineering. In 1980, the university set up a blueribbon panel headed by Joel Moses of MIT to develop a strategy to advance computer science as an emerging field at the university. Initially, there was consideration of housing computer science as a department within either the College of Arts and Sciences or the College of Engineering. Due to significant faculty lobbying, the blueribbon panel eventually recommended the creation of an independent college. The College of Computer Science became official in Fall 1982.

Although the faculty involved in the foundation of the College of Computer Science in 1982 may not have had a fully formed vision of the future, they felt strongly about several tenets of being an independent college rather than a department. The first was that a college would grant them the independence to be creative in curriculum design and research. The next tenet was that to support research, the college would need to develop MS and Ph.D. programs as soon as possible. The third tenet was financial: a college would be able to speak directly to the provost's office about budget and support. The final tenet was to provide a coherent, stable curriculum representing the intellectual knowledge required for computing and not simply courses in a collection of technologies.

Initially, the college offered the BS in computer science. In 1984, the MS was added and in 1987 the Ph.D. The addition of a BS in information science in 2000 offered a second major option to undergraduate students. The year 2000 also marked the introduction of the first three combined majors of computer science: mathematics, physics, and cognitive psychology. In 2004, the college name was changed to the College of Computer and Information Science (CCIS) to reflect the increased focus on information as foundational to the computing discipline and its applications. The activities in the years 1997-2004 represent the beginnings of the long-term strategy for the college to reach beyond traditional computer science to a broader interpretation of the computing field and to a determined effort to foster interdisciplinary efforts.

The college has faced its share of challenges over time, particularly in the early 1990s when it encountered a twofold problem. Northeastern University entered a downturn in freshman enrollment, and at the same time, computer science as a major faced the first of two prolonged declines in national interest, compounding the enrollment issues facing the college. Although each drop in interest was followed by a later surge in enrollments, the college began to focus on creating a long-term strategy to offset such cycles. Over several years, faculty considered how best to contribute as an independent college to the “new Northeastern” while the university rebuilt, reorganized, and expanded. One result of this thinking was the concept of combined majors that was proposed by the college in 1997 and then adopted by the university in 2000 once a template for the creation of such programs was agreed upon. The college faculty also considered how best to achieve national prominence within the computing discipline and began to think about how broadly the notion of “computing disciple” should be interpreted.

Interdisciplinary efforts were key to the college strategy from 2000 onward. Combined majors take computer science and a partner discipline and create a unified degree with an equal amount of coursework in each discipline together with one or more courses that bridge the disciplines. This configuration is now often denoted as CS + X on the national stage. In fall 2017, CCIS offered 27 combined majors in partnership with almost every college at Northeastern. Interdisciplinary graduate programs soon followed the creation of the undergraduate combined majors: MS programs in game science and design, health data analytics, health informatics, and information assurance, and Ph.D. programs in network science, personal health informatics, and information assurance. CCIS has also made a major commitment to joint hires with partner colleges across the university, sharing fiscal and support responsibilities, as well as splitting teaching loads across the disciplines.

Three consequences of the interdisciplinary strategy have been important in the growth of a small college facing significant challenges into a large college with significant partnerships for long-term stability and growth. First, interdisciplinary education programs have helped to diversify the student applicant pool, particularly with the undergraduate combined majors: in 2017, more than half of CCIS’s 1,500 undergraduates were working to complete a combined major, which helps to reduce the potential for a steep decline in enrollment in the event of a future economic downturn. Second, partnering with colleges within the university has made for a stronger position within the university as a whole. Other colleges value these partnerships as a way to help attract top students and recruit faculty to their programs. Third, the strategy has helped CCIS have a scalable platform to work in interdisciplinary application areas, such as network science, health, and security, which are now viewed as critical at the national level, and to be able to add additional areas as they emerge, such as data science.

University of Massachusetts Amherst College of Information and Computer Sciences

Computer science at the University of Massachusetts Amherst was initiated in 1964 and, starting in 1972, was housed in a college of science. This placement turned out to be fortuitous, since CS did not have to fight for resources within a huge college of arts and sciences. Also, CS did not have to try to fit into a college of engineering, with its concerns about matters such as accreditation. The departments in the science college had a strong, shared vision of the centrality of research, along with a strong commitment to education and outreach. Although CS had some cultural differences with many of these departments (e.g., importance of conference publications, few post docs, etc.), over time CS was able to educate its colleagues about these differences and, most importantly, gain their respect and appreciation.

As a faculty, CS had been early and strong advocates for interdisciplinary research. In the early years, topics such as cybernetics, cognitive science, and neuroscience were major research areas. Decades ago, as part of the qualifying exam, CS introduced a synthesis requirement that required students to explore and write a research paper about two distinct areas involving computing. This led to considerable interaction among the faculty in different subareas of computing and to a number of research projects across departments throughout the university. In the late 1990's, CS faculty increased their activities toward establishing a broad educational footprint for computing across campus, including a cross-campus IT minor and the introduction of a BA degree in CS, complementing CS's BS degree. Thus, from both an education and a research standpoint, collaboration across campus was already "part of our DNA."

The strategic planning committee, which consisted of mostly senior faculty, was well aware of the national trends and, starting at least 10 years before CS actually made a request to become an independent college, regularly encouraged faculty meeting discussions about becoming a separate college or moving to a college of engineering. Initially most of the faculty were content with the science-college placement, but a few thought CS might fit more naturally into a college of engineering, and some others were interested in becoming a separate school.

In the context of addressing a tight budget in 2009, a relatively new chancellor decided to reorganize the colleges on campus. Most of the College of Natural Resources and the Environment, which had its roots in the institution's original agriculture-school heritage, was merged with the renamed College of Natural Sciences, making this a much larger college than any of the others on campus. The chancellor also advocated that CS move to the College of Engineering, perhaps as a school within the college. Such a move seemed counter to the trend for computing to separate from engineering schools and become independent colleges. This suggestion, however, invigorated our discussions about becoming a separate college and a unanimous faculty consensus quickly developed supporting such a college.

The CS faculty were well poised to argue that CS should become an independent college of computing that would be a catalyst for interdisciplinary research and education across the university. At this time, the CS department had the largest amount of multi-department research (measured both by number of grants and total grant amounts) on campus, and CS faculty were involved in joint research projects with every other college on campus. The CS proposal described how important computing had become to society and to education and how the university would benefit from having an independent college that could continue to build bridges with a wide range of programs. And of course, the CS faculty promised to develop avenues for new resources, such as expanding its professional MS degree program, growing its BA program, and developing an Informatics Program, which would provide education and career opportunities for a large group of students not served by the existing degrees.

Even though it would remove a significant flow of resources to his college, the dean of the College of Natural Sciences supported our proposal, in large measure because he too recognized the importance of computing across campus. Support from this dean was very important to subsequently winning support from the provost and chancellor.

The provost at this time, however, was hesitant to approve the CS proposal, especially with the turmoil on campus about the recent college restructuring changes and some unpopular pending proposals for additional changes. As a compromise, he agreed to let CS become a School within the College of Natural Sciences. In 2011, the dean of the college, the provost, and CS agreed to a memorandum of understanding that granted significant budgetary control to the School, which, importantly, also gave CS control of the resources freed up by retirements.

The university hired a new chancellor in 2012 and two years later hired a new provost, both of whom were aware of the impact of computing and were appreciative of the role CS played in the university, with the state government, and with industry. The CS faculty discussed with them the benefits of becoming an independent college and, with faculty unanimity and the support of the dean, CS quickly received support from the provost and chancellor. At that point, the proposal moved easily through faculty governance. CS received widespread and unanimous support across campus, partially due to the new, forward leaning, and more transparent upper administration and partially because CS was a leader across campus in governance committees and in cross-college research, education, and outreach efforts. Many of those involved in this process had worked hard over many years to obtain such broad university support, but CS was also fortunate in that the planets aligned, so to speak, with the support of a forward-thinking administration including the dean (whose college stood to suffer financially from CS becoming a college), the provost, and the chancellor.

The transition to being a college has not been without challenges. Instead of breaking up into separate units, CS decided, at least initially, to remain as a single department within the new College, but now had to support two levels of governance. The CS proposal had argued that CS already did many of the functions of a college (e.g., major development and communication efforts, industrial outreach), but CS was perhaps naive about many college obligations. For example, career placement and college level student advising needed a major overhaul. Also, although the dean of the College of Natural Sciences supported the separation and advocated on CS's behalf, the separation of funding did not go as smoothly as envisioned. The interim dean of the College of Information and Computer Sciences, Bruce Croft, had to work hard to obtain a reasonable level of funding and staff support from the administration. Despite these problems, the transition went relatively smoothly, with widespread faculty support in CS and across campus, and with the welcomed arrival of our first permanent dean, Laura Haas, in September 2017.

Montana State University Gianforte School of Computing

Unlike the previous case studies, this case study discusses creating a broader School of Computing that still resides within a College of Engineering. Creating such structures can be a step toward becoming a college.

In 2010, the CS faculty realized that expanding the footprint of Montana State University's Department of Computer Science would position it to better serve students, the Montana State University research enterprise, the computing profession, and Montana's high-tech economy. As part of this strategy, the CS faculty believed a new name could help the department better convey the pervasive, interdisciplinary nature of computing. Although CS's ultimate goal is to become a College of Computing, the size of the organization in fall semester 2010 (220 students and 10 faculty members) meant that becoming a School of Computing would be a more realistic intermediate goal.

To communicate CS's aspirations, the faculty invested time and money to create a business plan. Creating this plan sent a clear signal to upper administrators that CS was serious about the name change, and simultaneously generated excitement and buy-in. In addition, the plan helped CS articulate the compelling benefits that a School of Computing could offer Montana State University. One benefit is to provide a natural home for crosscutting degrees such as a computer science bachelor of arts or a data science minor. Another benefit, as greater numbers of new professors join MSU with computational backgrounds in other disciplines, is to provide a willing partner for future joint hires. A third benefit is to attract and graduate more, and more diverse, students who are in great demand by high-tech companies throughout Montana and the world.

To make CS's argument more compelling, the faculty proactively undertook various initiatives to accelerate student interest in computer science. High school initiatives included outreach presentations to 30,000-plus students and the creation of two dual enrollment courses with accompanying summer teacher-training workshops. University initiatives included remodeling the CS student spaces into collaborative, aesthetic areas, revamping entry courses, creating a tutoring center, and sponsoring student cohorts to travel for professional development opportunities (e.g., the Grace Hopper Conference, the oSTEM conference, and a Spring Break Tech Road Trip). The university initiatives helped not only with the recruitment of new students, but also with the retention of existing students due to community-building aspects. Coupled with the growing interest in computer science nationwide, these initiatives helped expand the population of computer science students from 220 in 2010 to 539 in fall semester 2017.

The progress toward becoming a School of Computing took a big step forward in March 2015 when a long-time supporter provided a $1,000,000 gift and specified that one release condition of the gift would be for CS to become a School of Computing. Once the university approved the gift, CS moved the name change paperwork through the approval process, culminating with approval by the Board of Regents in March 2016. After the name change was approved, Greg and Susan Gianforte stepped forward with a generous naming gift, and in August 2016 CS became the Gianforte School of Computing. Becoming a School of Computing has already yielded benefits: The school has received two new tenure-track lines and one new nontenure-track line from the university. In addition, the CS BA proposal goes before the Board of Regents in September and, if approved, becomes available to students in 2018.

For organizations contemplating a name change, the following tips might be helpful. First, seek broad buy-in and solicit input from key stakeholders. Second, be proactive and become more investment-worthy. Whether it is high-level administrators or donors, positive developments seem more likely when a unit is an exciting place to invest resources. Third, plan for road bumps. The provost was ready to delay the School of Computing proposal just weeks before its Board of Regents' hearing. However, when the provost was reminded of the release condition for the $1,000,000 gift, the delay was averted. Fourth, be patient and stay focused. The CS faculty thought they had compelling arguments to become a School of Computing. However, the process took longer than anticipated. It was important to celebrate short-term wins to maintain high morale. Fifth, think big. Big ideas inspire external and internal stakeholders.

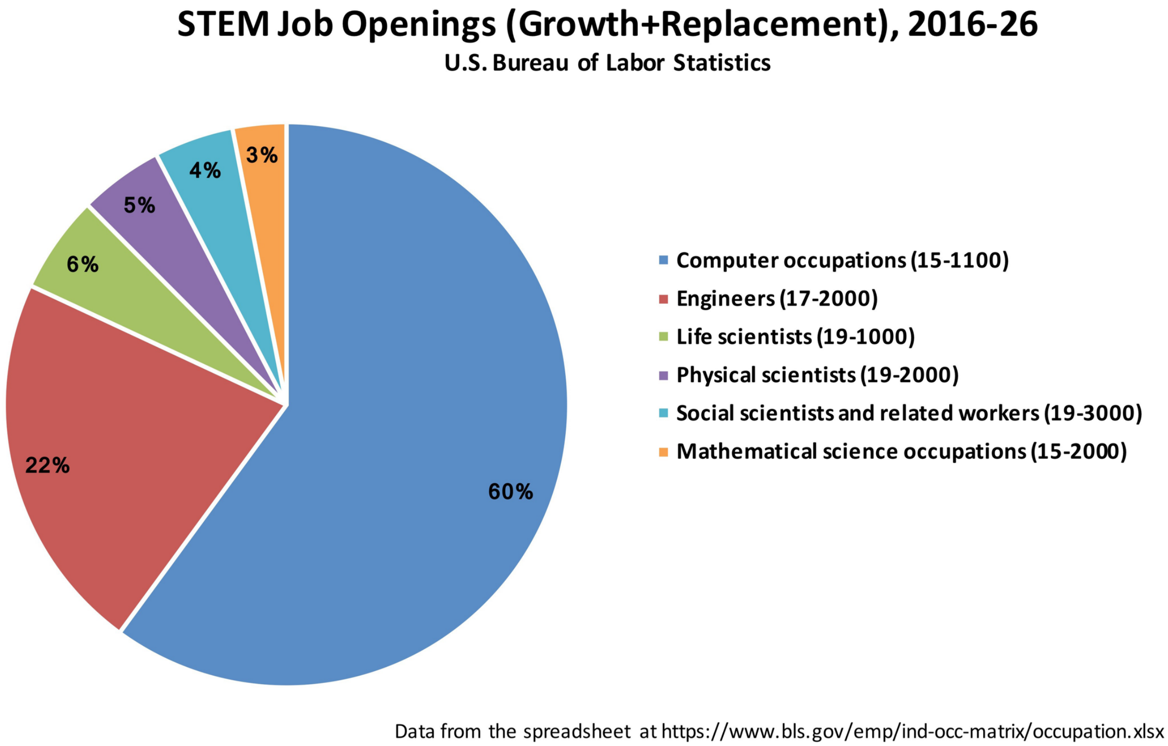

Figure 1. STEM job openings 2016-2026

Appendix I

Panel on Schools and Colleges of Computing
CRA Conference at Snowbird 2016, July 17-19, Snowbird, Utah
http://cra.org/events/snowbird-2016

Panelists' slides are available by clicking on the hyperlinks below.

Chair and Moderator: Chris Johnson, University of Utah

Speakers: Randy Bryant, Carnegie Mellon University; Richard LeBlanc, Georgia Tech and Seattle University; John Paxton, Montana State University; and Bobby Schnabel, ACM and Indiana University

Panel on Colleges of Computing
CRA Conference at Snowbird 2018, July 16-18, Snowbird, Utah
https://cra.org/events/2018-cra-conference-snowbird/

Chair: Chris Johnson, University of Utah

Speakers: Farnam Jahanian, Carnegie Mellon University, Katherine Newman, University of Massachusetts Amherst, and Carla Brodley, Northeastern University

Appendix II

Schools and Colleges of Computing as of April 18, 2019

Arizona State University School of Computing, Informatics, and Decision Systems Engineering - http://cidse.engineering.asu.edu

Clemson School of Computing - http://www.clemson.edu/cecas

Cornell University Computing and Information Sciences - http://www.cis.cornell.edu/

Carnegie Mellon University School of Computer Science - https://www.cs.cmu.edu

DePaul University College of Computing and Digital Media - https://www.cdm.depaul.edu

Drexel University College of Computing and Informatics - http://drexel.edu/cci

Georgia Institute of Technology College of Computing - http://www.cc.gatech.edu/

Indiana University School of Informatics and Computing - http://www.soic.indiana.edu

Long Island University College of Information & Computer Science - http://www2.liu.edu/CWIS/cwp/cics/cics2.html

MIT Stephen A. Schwarzman College of Computing - http://news.mit.edu/school/mitschwarzman-college-computing

Montana State University, Gianforte School of Computing - https://www.cs.montana.edu/

New Jersey Institute of Technology College of Computing - http://ccs.njit.edu

Northeastern University Khoury College of Computer Sciences https://www.khoury.northeastern.edu

Pace University Seidenberg School of Computer Science and Information Systems - http://www.pace.edu/seidenberg/

Penn State University College of Information Sciences and Technology - https://ist.psu.edu

Rochester Institute of Technology College of Computing and Information Sciences https://www.rit.edu/gccis

SUNY Albany College of Computing & Information - http://www.albany.edu/ceas/

UC Irvine School of Information and Computer Sciences - http://www.ics.uci.edu/

University of Maine School of Computing and Information Science https://umaine.edu/scis/

University of Massachusetts Amherst College of Information and Computer Sciences https://www.cics.umass.edu/

University of Nebraska at Omaha College of Information Science & Technology - http://www.unomaha.edu/college-of-information-science-and-technology/

UNC Charlotte College of Computing and Informatics - http://cci.uncc.edu

University of Pittsburgh School of Computing and Information - https://sci.pitt.edu

University of South Alabama School of Computing - http://www.cis.usouthal.edu

University of Washington Paul G. Allen School of Computer Science and Engineering - https://www.cs.washington.edu