

Society for the Advancement of Information Systems
MBAA Abstract March 27-29, 2019 - Chicago

Author(s):

Brandon Olson, College of St. Scholastica, Duluth, MN
Thomas L. Buck, College of St. Scholastica, Duluth, MN

Title: Computer Science Education at a Liberal Arts College: A Value-Centered Approach to Professional Preparation for Meaningful Work

Abstract

Liberal arts institutions of higher education confront a special challenge in undergraduate technology education, these programs strive to maintain congruence between deep technical knowledge and a rounded education providing students with a broad understanding of the world around them. In an effort to reach this balance, the College of St. Scholastica's Computer Information Systems department has embedded components of a liberal arts education within its curriculum of an applied approach to computer science. The purpose of this paper is to provide a framework for a values-based liberal arts technical degree and the benefits from this integration in preparing students to be successful in the profession.

Introduction

The College of St. Scholastica provides a value-centered liberal arts education that assists in integrating a student's personal interests and professional aims with the broader concepts of meaningful work and a value-centered life. The primary goals of a value-based liberal arts education within realm of computer science is give students the opportunity to build morally and intellectually significant lives and careers, as well as the benefits of developing such skills as effective communication, reading comprehension, cultural literacy, and critical thinking.

In 1968, the Association for Computing Machinery (ACM) published its first comprehensive curricular recommendations, and has since regularly updated those recommendations until most recently in 2017. As computer science has evolved as a discipline, researchers and developers have integrated insights and advances from many related fields. For example, the 2017 ACM Computing Curricula argues that the discipline of computing integrates three fundamental processes:

- Theory: from mathematics,
- Abstraction: based upon the scientific method, and
- Design: from engineering (ACM, 2017)

In contrast, programs in the liberal arts build upon a centuries-old perspective that places an emphasis on concepts, principles, and a breadth of education. Students and faculty strive to bring multiple viewpoints to bear in addressing topics and issues (Stross, 2017). When combined, by their very natures, computer science and the liberal arts fit into these different environments nicely, and dovetailing in at least two ways:

- The liberal arts shapes the study of computer science, as a discipline that inherently draws upon insights and perspectives from many subjects.

- Computer science itself contributes insights and perspectives to an overall liberal arts environment.

Overall, a value-centered liberal arts program emphasizes general knowledge, multiple perspectives, alternative ways of thinking, and significant connections among disciplines. For a computer science program, the value-centered liberal arts provide a framework that encourages strategic choices with a focus on long-term and meaningful careers. Within a computer science program, liberal arts graduates master core ideas, structures, algorithms, and methodologies, as well as considerable experience with writing, oral communication, and ideas from other disciplines. Such a breadth of background provides a strong base for successful professional careers as well as a more dynamic approach to new directions and interdisciplinary challenges.

Liberal Arts Education

Definition. A liberal arts education is different from other types of education, it's not about developing professional or entrepreneurial skills, although it may well promote them, but instead the liberal arts help prepare students for a career by instilling those attributes that employers repeatedly say they want when they hire college graduates - the intellectual skills of critical thinking, analysis of information, and effective expression of ideas. Where vocational students develop professional skills for a specific occupation, a liberal arts education is designed to expand each student's intellectual perspective, providing a broader education that embraces virtually all nonprofessional higher learning, from the natural and social sciences to the humanities and the performing arts (Stross, 2017).

The U.S. Department of Education (2016) lists a liberal arts degree earned over four years of full-time studies as most commonly including courses in the areas of the social sciences (art, literature, philosophy, religion, ethics, foreign languages, music, theater, speech, etc.), the humanities (history, psychology, law, sociology, anthropology, economics, etc.), the natural sciences (astronomy, biology, chemistry, physics, archaeology, etc.), and the formal sciences (mathematics, logic, statistics, etc.).

Ideally, in the American higher education system, a liberal arts education exposes the student to a wide spectrum of knowledge and arts, all the while giving constant attention to the discovery and articulation of unifying ideas, with the goal of developing the imagination and promoting freedom of thought. It seeks to free the learner from the limitations of unexamined opinions, current fashions and inherited prejudices, striving to enable a learner to make intelligent and educated choices concerning the ends and means of both public and private life.

Purpose. Zakaria (2015) stated, one of the primary purposes of a liberal arts education is to equip students with the critical thinking skills necessary to not only become valuable community members, but also problem solvers and lifelong learners. Liberal education helps students cultivate the art of reason and disciplines in analysis, argument, and interpretation. Liberal arts students are taught to understand problems, generate solutions, and communicate those solutions to others. "Whatever else a liberal education is," the philosopher of education Paul H. Hirst writes, "it is not a vocational education, not an exclusively scientific education [and] not a specialist education in any sense." It is rather "an education based fairly and squarely on the nature of knowledge itself" (Barrow & White, 1993).

Hlstory. Liberal arts has a nearly two-thousand-year history, dating to Latin writers of late antiquity, but the underlying questions about mankind, nature, and knowledge go back to the Greeks. Over the past century and a half, America has emerged as a superpower while adhering to a predominantly liberal arts model of higher education. But liberal arts is also a complicated and antiquated term, bringing together two words that don't obviously belong in harness and may not be ideally suited for hauling their intellectual load into the twenty-first century.

Liberal comes from the notion of freeing the mind; there's nothing wrong with that. As classics scholar Katie Billotte (2012) writes, "The Latin *ars liberalis* refers to the skills required of a free man - that is the skills of a citizen." But arts, in the Greek and Roman world, had a different connotation: the Greek term *techne* meant skill or applied knowledge and had nothing to do with aesthetics as we know it.

In the early days of American higher education, liberal arts colleges were typically institutions created for the wealthy upper middle class and social elite. Liberal arts colleges today feature a diverse student body, with some liberal arts colleges even catering to certain demographics which were once considered a minority population in education.

Value of Liberal Arts Education Today

An education in the liberal arts offers great freedom in choice of careers. Evidence indicates that today's college graduates will have multiple careers before they retire, that is, careers that are distinct from each other, complete switches from one to the next. Through the liberal arts education's focus on the intellectual skills of critical thinking, processing information and communication, it allows students to seek a career in a field that they care about, and not limiting them to finding something related to their major.

In addition, there are also vital, life-advancing values in a liberal arts education.

Graduates of liberal arts programs obtain skills valued by employers. Liberal arts programs give such a wide range of experiences that it's easy to tailor a student's abilities to any number of careers. The following is a small sample of the benefits of a liberal arts education.

- Communication Skills - Strong speaking and writing abilities are incredibly important in most every career field. Liberal arts majors spend a large majority of their school time writing and discussing what they're studying, developing skills that can be carried across all careers.
- Reading Comprehension - Reading is another skill that can be carried across all careers. Liberal arts classes usually involve a great deal of reading.
- Cultural Literacy - Students of the liberal arts study people and cultures. They are asked to think about problems in the world and to come up with creative solutions. Liberal arts students understand diversity.
- Analytical Abilities - Critical thinking is one of the cornerstones of a liberal arts education. The ability to assimilate facts, ideas, and conceptual frameworks, and the development of critical minds, are equal parts of a liberal arts education. The vocational and professional skills are obviously important to economic productivity, but so is the entire rainbow of liberal arts learning and the ability to think critically.

Traditional Computer Science Curriculum

Depending on the school, a traditional bachelor's degree programs in Computer Science (CS) will require approximately 120 semester credit hours, resulting in either a Bachelor of Arts (BA) or Bachelor of Science (BS) degree, with a large amount of the course work devoted to programming, operating systems, algorithms, computation and processing, as well as algebraic and discrete mathematics (ACM, 2013).

One of the most widely accepted CS educational accrediting organizations is the Accreditation Board for Engineering and Technology, Inc. (ABET). Among other things, in ABET's criteria for CS program student outcomes, by the time of graduation, the program must enable students to attain an ability to apply knowledge of computing and mathematics appropriate to the program's student outcomes and to the discipline; an ability to analyze a problem, and identify and define the computing requirements appropriate to its solution; an ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs; and, an ability to use current techniques, skills, and tools necessary for computing practice (ABET, 2018).

In general terms, the courses normally cover the basics of human/computer communications, fundamentals of software engineering and both the positive and negative impacts of computers on society. According to the Accreditation Board for Engineering and Technology (ABET, 2018), core courses of a traditional CS major include:

Common CS Major Core Courses		Course Level			
		1st Yr.	2nd Yr.	3rd Yr.	4th Yr.
CS	Principles of Computer Science				
CS	Principles of Information Systems				
CS	Programming: Algorithms/Object-Oriented I				
CS	Programming: Algorithms/Object-Oriented II				
CS	Programming: Assembly Language				
CS	Projects: Design/Testing				
CS	Algorithms/Data Structures				
CS	Computer Architecture				
CS	Software Engineering/Development				
CS	Operating Systems				
CS	Business Computer Applications				
CS	Web Site Development and Design				
CS	Database Management Systems				
MATH	Statistics Theory and Method				
MATH	Calculus				
MATH	Discrete Methods				
MATH	Applied Matrix Algebra				
MATH	Linear Algebra				

Table 1 Common CS Major Core Courses (ABET, 2018)

Once students complete foundational courses in coding and programming, they ~~will~~ decide how they want to specialize. According to ABET (2018), students can then choose between a few options: they might focus on artificial intelligence or big data or they can use their technical skills to navigate other departments or majors, such as using data visualization in an art course.

Regardless, with the goal of teaching both theory, as well as relevant technical skills for specific tasks, the areas of concentration in a traditional CS curriculum focus on compilers, graphics, and natural language processing (NLP), and often include such things as artificial intelligence, computer systems and networks, security, database systems, human computer interaction, numerical analysis, programming languages, software engineering, bioinformatics and advanced computing concepts.

Knowledge, Skills, and Abilities Alumni Need

A liberal arts education emphasizes developing the student as a person rather than primarily as an employee. As a result, students from liberal arts institutions are exposed to a wide variety of subjects that extend outside of their chosen field of study. This humanistic approach to education not only prepares students for life outside of academia but also prepares these individuals to be valued by potential employers.

Employers need employees who can perform specific roles in the organization and in the IT field, this means graduates must possess the technical skills needed to perform analysis, design systems, and write effective code. While these technical skills are important, they are not among the skills employers value the most. The most important skill employers need is verbal communications followed closely by teamwork, problem-solving, and planning and prioritizing work (NACE, 2016). Analyzing large volumes of data and technical skills are ranked among the most important skills. The top eight skills, summarized in the table below, all fall within the studies offered at liberal arts colleges.

Skill / Quality	Weighted Average Rating
Verbal communicate inside and outside organization	4.63
Work in a team structure	4.62
Decision making and problem-solving	4.49
Plan, organize, and prioritize work	4.41
Obtain and process information	4.34
Analyze quantitative data	4.21
Technical knowledge related to the job	3.99
Software proficiency	3.86

Table 2 Employer skill ratings

The findings from the NACE survey confirm the feedback from our Computer Information Systems advisory board. As part of the department's curriculum review, the department seeks input from an advisory board consisting of a group of alumni and hiring managers. This board identifies the skills our graduates need to be successful in the field. During the most recent advisory board meeting, the board expressed that students can learn the technical skills on the job but they need to possess the critical thinking, communications, problem solving, team skills, and project management abilities. Employers find these non-technical skills are more difficult to develop than technical skills.

CSS Computer Information Systems Degree

The Computer Information Systems (CIS) degree at the College of St. Scholastica is an applied computer science program. In our curriculum, students learn modern technical and analysis skills like Python, Java, SQL, and process and database modeling. Rather than a deeper understanding of theory and why these technologies work, the curriculum enforces how these technologies are applied to solve problems. For instance, rather than learning mathematical logic for database normalization, CIS students learn common normalization techniques and applications. Students are provided case studies of database needs and tasked with designing normalized relational databases to support business needs.

The department recognized the field has many different types of positions and preparation for these types of positions may vary. For instance, skills set needed for a software developer is steep in programming languages and technical platforms while the skill set needed for business analysts is process modeling, business requirements, and the business domain. As a result of these differences, the curriculum, depicted in Appendix A, is designed to provide areas of specialization or concentration. Currently, the curriculum supports concentrations in software development or business analysis to support the most common positions for our graduates. In addition to these two IT-related concentrations, the curriculum also offers concentrations in mathematics and health informatics to support a CIS double major option for our math and health information management students.

Further emphasizing the applied nature of the CIS program, the curriculum also includes a Custom concentration. Using this concentration students in other majors may apply their major courses toward the 24-credit concentration when pursuing a double major with CIS. This Custom concentration allows students, such as Marketing majors, to integrate studies in CIS with their marketing courses. This Marketing/CIS curriculum produces students who are prepared to enter the field of marketing while having the ability to leverage technology to achieve marketing goals.

In addition to supporting double majors, the Custom concentration also provides a pathway into the CIS degree for students transferring from a two-year college. These transfer students, typically graduating with a technical associates degree, can apply their area of expertise toward the custom concentration. For example, a student graduating with an associates degree in computer networking can apply credits from the networking curriculum to the Custom concentration. Using this Custom concentration, the CIS curriculum can be applied to studies inside and outside of the IT field.

Liberal Arts Components of the CIS Program

The applied nature of the CIS curriculum prepares students to leverage their knowledge and skills to solve technical problems. The technical knowledge and abilities are also gained through traditional computer science curriculum as well. However, the CIS curriculum is heavily influenced by the liberal arts education from the college and this influence can be seen in both how CIS courses are taught and the courses students are required to complete. The liberal arts influence on CIS instruction and curriculum align well with the top four skills employers need: communications, teamwork, problem-solving, and planning, organizing, and prioritizing work.

Communication. The importance of verbal and written communications is crucial for graduates in any field and CIS graduates are no exception. In order to prepare students to communicate effectively in their profession, almost each CIS course requires students to formally present their work or research projects to the class. These presentations require students to concisely articulate the problems they try to solve, describe the processes and technical components of their solution, and the explain how the technical solution addresses the problem. Students are commonly evaluated not only on their technical solutions but also their preparation and ability to present their work. In addition to formal presentations, students may also be required to orally provide project status reports summarizing the work completed, work remaining, and any issues they encountered. These formal and informal presentations prepare students to communicate complex and technical ideas in a manner that can be understood by stakeholders in and outside of the project team.

Although oral communication is important and prioritized in employable skills (NACE, 2016), CIS students must also prepared to write professionally. The Management Communications course requirement in the CIS curriculum was adopted to provide students with skills in professional writing. These skills are applied in assignments such as email communications and report writing. IT professionals need to communicate through both orally and through written work and the CIS curriculum prepares students with these skills that are not found in traditional computer science programs.

Teamwork and Problem-Solving. Work in the IT field resides predominantly in the project environment where individuals work together to solve problems. Working in teams and solving problems is common across most computer science programs and is certainly emphasized in the CIS classroom. Most courses in the program require a team project where students work together to design and implement a technology solution to a given case study. Through these projects, students gain experience in communicating with other team members, developing solutions to problems, as well as collaboratively troubleshooting problems along the way.

While team-based projects are not unique to the CIS curriculum they are strongly emphasized through both assignments and in-class exercises. In the CIS program, problem-solving and teamwork are further emphasized in the CIS classroom through the active learning teaching methods our faculty adopted. Methods such as inquiry-based learning are applied to project teams requiring student teams to learn through discovery rather than entirely through lecture. In this method, students are given a problem and are asked to work together to apply concepts from the course to solve the problem. Using this method, students have the opportunity to try different concepts and evaluate the results of each. Through team-based activities and assignments as well as the active learning teaching methods, CIS graduates are prepared to work collaboratively in the workplace and excel in problem-solving.

Project-Based Work. The CIS curriculum and the faculty's teaching methods strongly support working in teams and problem-solving. These important skills are further developed along with the NACE (2016) skill of planning, organizing, and prioritizing work through a capstone course. In this capstone course, students teams are assigned a project where they work on a technical solution for a local non-profit organization. Through this experiential learning project, students work as a team to identify current needs, design a solution to these needs, and implement the solution. Through this project experience, students exercise their team skills, use problem-solving

to work through project and client management issues, and their project management skills to plan and execute the project.

Two additional skills the students develop as part of this capstone project are reflection and process improvement. An agile method is adopted in this capstone project where students are required to work across four 2-week sprints. At the end of each sprint, a retrospective is conducted. This retrospective requires the student team to assess their performance on the project, identify strengths and weaknesses, and present to the class their experiences and improvement plan for the next sprint. The final for this course is a reflective lessons learned formal presentation. Between the sprints and the final presentation, students develop the important skills of reflection and process improvement.

Conclusion

Professional computer science programs, such as Computer Information Systems, prepare students with the knowledge and skills needed to succeed in the IT field. A liberal arts education provides students with the insights to understand and engage in the world outside of higher education. When properly integrated, an applied computer science program like the Computer Information Systems curriculum prepares students to solve technical problems using a human-centered approach. Emphasizing problems solving, critical thinking, written and oral communication, and team development, the attributes promoted in a liberal arts education are integrated and further developed through CIS curriculum. This integration results in students who not only possess technical skills but also have the propensity to continue to learn and apply new concepts with the understanding of how technology solutions can improve the lives of others. This value-based education extends beyond the student and contributes to the greater good of our society.

References

- Accreditation Board for Engineering and Technology, Inc. (2018). *Criteria for accrediting computing programs, 2018-2019*. Baltimore, MD: ABET Computing Accreditation Commission.
- Accreditation Board for Engineering Task Force on the Curriculum (2017). *Computing Curricula 2017*. ACM and the IEEE Press, New York.
- Association for Computing Machinery (2013). *Curriculum guidelines for undergraduate programs in computer science*. Retrieved from <https://www.acm.org/education/curricula-recommendations>
- Barrow, R., & White, P. (1993). *Beyond liberal education: Essays in honor of Paul H. Hirst*. New York, NY: Routledge.
- Billotte, K. (2012). *Conservatives killed the liberal arts*. Retrieved from https://www.salon.com/2012/09/14/conservatives_killed_the_liberal_arts/
- National Association of Colleges and Employers (2016). *Employers: Verbal communication most important candidate skill*. Retrieved from <https://www.nacweb.org/career-readiness/competencies/employers-verbal-communication-most-important-candidate-skill/>
- Stross, R. (2017). *A practical education: Why liberal arts majors make great employees*. Stanford, CA: Stanford University Press.
- U.S. Department of Education (2016). *Structure of U.S. education*. Retrieved from <https://www2.ed.gov/about/offices/list/ous/international/usnei/us/edlite-structure-us.html>
- Zakaria, F. (2015). *In defense of a liberal education*. New York, NY: W. W. Norton & Company.

Appendix A – St Scholastica’s Computer Information Systems Degree Curriculum

