Beyond Code: The Role of Liberal Arts in Shaping Computing Science Education

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Abstract

As artificial intelligence (AI) and emerging technologies reshape society, computing education must go beyond technical proficiency to address ethical, social, and philosophical implications. Ethical considerations should be integrated throughout the development of complex technical systems, yet computing science curricula often lack the structured ethical training required in engineering programs. This gap leaves students unprepared for challenges such as data privacy, algorithmic bias, and the societal impact of AI.

A liberal arts approach can help bridge these gaps by fostering interdisciplinary learning in fields like philosophy, sociology, and political science. By incorporating ethical reasoning into computing education, institutions can cultivate responsible innovators who develop technology with both technical excellence and social responsibility in mind.

CCS Concepts

• **Social and professional topics → Computing education**.

Keywords

Computer science education, curriculum

ACM Reference Format:
Herbert H. Tsang and Andrew J. Park. 2025. Beyond Code: The Role of Liberal Arts in Shaping Computing Science Education. In *The 27th Western Canadian Conference on Computing Education (WCCCE '25), April 28–29, 2025, Calgary, AB, Canada.* 7 pages. https://doi.org/10.60770/1w7c-4f30

1 Introduction

The rapid evolution of technology and its pervasive influence across all sectors of society have fundamentally reshaped the landscape of computing science. Today's computing challenges—ranging from artificial intelligence and machine learning to data privacy, cybersecurity, and human-computer interaction—demand more than technical proficiency. They require a nuanced understanding of human behavior, ethics, communication, and societal impact. Traditional computing science curricula, with their heavy emphasis on technical skills such as programming, algorithms, and systems design, often lack components that foster these broader competencies.

WCCCE '2025, Calgary, Alberta

https://doi.org/10.60770/1w7c-4f30

As technological solutions become increasingly integrated into everyday life, the consequences of their design and deployment extend beyond technical performance to ethical, cultural, and social domains. Issues such as algorithmic bias, misinformation dissemination, and privacy violations underscore the need for technologists who can anticipate and mitigate unintended social consequences. An interdisciplinary approach that incorporates liberal arts perspectives—such as philosophy, sociology, history, and the arts—provides students with the critical thinking skills and ethical frameworks necessary to navigate these complex issues.

Furthermore, interdisciplinary innovation is essential for addressing real-world problems that do not fall neatly within disciplinary boundaries. For instance, breakthroughs in fields like bioinformatics, digital humanities, and computational social science are driven by the convergence of computing with life sciences, literature, and social sciences. These intersections enable the development of technologies that are not only technically robust but also culturally relevant and socially responsible.

The demand for interdisciplinary competencies is also reflected in the technology industry, where employers increasingly seek graduates who possess strong communication skills, ethical reasoning, and creative problem-solving abilities. Tech companies recognize that innovation thrives in diverse teams that bring together technical experts, designers, ethicists, and domain specialists. As a result, computing science education must evolve to produce graduates who can collaborate across disciplines, think holistically, and address the ethical and societal implications of their work.

In light of these developments, there is a pressing need to reimagine computing science curricula through an interdisciplinary lens. Integrating liberal arts education into computing science programs offers a pathway to cultivating well-rounded professionals who are not only adept at building technological solutions but also capable of understanding their broader human context.

2 Purpose and Scope

The purpose of this paper is to examine how the integration of liberal arts education—encompassing disciplines such as philosophy, sociology, literature, history, and the arts—can contribute to a more comprehensive computing science curriculum. By drawing on the analytical, ethical, and creative capacities nurtured by the liberal arts, computing science education can produce graduates equipped to navigate the complex socio-technical landscape of modern technology.

The scope of this exploration includes analyzing the role of liberal arts in fostering interdisciplinary innovation, enhancing ethical practices, and preparing students for industry demands that prioritize holistic problem-solving abilities. We will survey the current curriculum of computing science degree-granting universities in western Canada. Make notes of any gap in the current offerings.

The central thesis of this paper posits that integrating liberal arts into computing science curricula fosters interdisciplinary innovation and ethical practice, both of which are essential for developing technologies that serve diverse societal needs responsibly. By bridging the gap between technical expertise and humanistic inquiry, such integration cultivates computing professionals capable of designing thoughtful, inclusive, and ethically sound technological solutions.

3 Theoretical Foundations

3.1 Liberal Arts Education

Liberal arts education—sometimes referred to as Liberal Arts and Sciences to clarify that it encompasses a broad spectrum of disciplines beyond the fine arts—is a holistic approach to learning that fosters intellectual curiosity, critical thinking, and creativity. Rooted in a tradition that dates back to classical antiquity, this educational model emphasizes a well-rounded foundation across disciplines. This framework is beyond focusing solely on specialized or vocational training. Curriculum under this framework traditionally encompasses the humanities, social sciences, and natural sciences, with the aim of cultivating well-rounded individuals who are equipped with versatile skills applicable in diverse contexts.

This educational framework is designed not only to impart knowledge but also to foster intellectual abilities that enable students to engage thoughtfully with the world around them. Students are encouraged to think critically, not just about how to solve problems but also about which problems are worth solving and why. They will develop the skills to read critically, write persuasively, and think expansively.

One defining characteristic of liberal arts education is its focus on experiential learning and the integration of various disciplines. Seifert et al. highlight that the "overlap and blending" of experiences within liberal arts education creates a seamless learning environment that distinguishes it from other educational practices [18]. This holistic approach is crucial for developing competencies such as creativity and critical thinking, which are essential in today's complex and interconnected world [5]. Furthermore, liberal arts education encourages students to reflect on their learning experiences, which is fundamental for personal and professional growth [14].

In addition to foster intellectual development, liberal arts education plays a significant role in preparing students for civic engagement and leadership. It equips individuals with the skills necessary to navigate societal challenges and contribute positively to their communities. For instance, the liberal arts curriculum is increasingly recognized for its ability to produce graduates who possess the critical thinking and flexible competencies required in the 21st-century knowledge economy [5]. This is particularly relevant in the context of globalization, where the demand for adaptable and innovative thinkers is on the rise [9].

Besides, liberal arts education is not confined to traditional academic settings; it extends to various forms of learning, including extracurricular activities and community engagement. This broader understanding of education aligns with the principles of student-centered pedagogy, which emphasizes the importance of active participation in the learning process [19]. Such an approach not only enhances academic satisfaction but also prepares students for real-world challenges by fostering a sense of responsibility and ethical awareness [7].

In summary, liberal arts education is characterized by its comprehensive approach to learning, integrating diverse disciplines and experiences to cultivate critical thinking, creativity, and civic engagement. It prepares students for a dynamic and interconnected world, emphasizing the importance of adaptability and ethical responsibility in their personal and professional lives.

3.2 Curriculum in Computing Science

In any formal education system in any context, there are three components: a) curriculum, b) pedagogy, and c) assessment. Curriculum defines the course of study to achieve the final learning goals and outcomes. In computer science, the curriculum often includes courses in data structures and algorithms, system design, and software design and architecture. These are the areas students will be traditionally focused on.

In terms of the standard curriculum in CS, the ACM/IEEE computer science curriculum development represents a collaborative effort between the Association for Computing Machinery (ACM) and the Institute of Electrical and Electronics Engineers (IEEE) to establish comprehensive guidelines for computer science education. This initiative has evolved over several decades, with periodic updates to reflect the changing landscape of technology and educational needs. The curriculum development process is characterized by a commitment to inclusivity, adaptability, and alignment with industry standards, ensuring that graduates are well-prepared for the demands of the workforce.

Historically, the ACM began publishing curriculum recommendations in 1965, with significant milestones including the "Curriculum 68" report, which laid the groundwork for future updates. Subsequent reports, such as "Curriculum 78," "Curriculum 91," "Curriculum 2001," and the most recent "Curriculum 2023," have continued to refine and expand the scope of computer science education [3]. Each iteration has incorporated feedback from educators, industry stakeholders, and academic institutions to ensure relevance and rigor.

The ACM/IEEE curriculum framework encompasses several key components. First, it identifies core knowledge areas that all computer science students should master, including programming, algorithms, data structures, software engineering, and computer architecture. Additionally, it emphasizes the importance of interdisciplinary learning, encouraging students to engage with subjects such as ethics, social issues, and the impact of technology on society [11]. This holistic approach aims to produce not only technically proficient graduates but also responsible citizens who can navigate the ethical implications of their work.

In recent years, the curriculum has increasingly focused on emerging areas of importance, such as cybersecurity, data science, and parallel and distributed computing. For instance, the ACM/IEEE guidelines stress the necessity for all computer science majors to understand parallel and distributed computing, reflecting the growing relevance of these topics in both academia and industry [12].

Furthermore, the integration of sustainability principles into computing curricula has gained traction, as educators recognize the need to prepare students for challenges related to environmental impact and resource management [16].

The development of the curriculum is also informed by the need for accreditation and alignment with industry standards. The Accreditation Board for Engineering and Technology (ABET) plays a crucial role in this process, ensuring that programs meet established quality benchmarks [3]. The ACM/IEEE curriculum guidelines serve as a foundation for institutions seeking accreditation, providing a common framework that facilitates communication between academia and industry regarding expected competencies and learning outcomes [1].

In summary, the ACM/IEEE computer science curriculum development is a dynamic and collaborative process that aims to create a robust educational framework for computer science. By integrating core knowledge areas, emphasizing interdisciplinary learning, and addressing emerging technological trends, the curriculum prepares students for successful careers while fostering ethical and responsible engagement with technology.

CS2023 is the latest version of the computer science curriculum guidelines. Three parties were involved in creating these guidelines: ACM, IEEE-CS, and the Association for the Advancement of Artificial Intelligence (AAAI). Since 2013, the guidelines have shifted from what is taught (a knowledge model) to what is learned (a competency model).

CS2023 has 17 knowledge areas; specifically, one of the areas is Society, Ethics, and the Profession (SEP). In the previous guideline, the SEP was named Social Issues and Professional Practice (SP).

Furthermore, CS2023 recommends that instructors pay attention to SEP issues throughout the curriculum, as these issues are pervasive. As noted in the report: "Given the pervasiveness of computing applications in every walk of life, a curriculum must address issues of society, ethics, and the profession as integrally and widely as possible. Dealing with these issues is integral to the whole solution to a problem that every graduate must be prepared to deliver" [13]. Therefore, whenever the subject matter intersects with SEP topics, they are explicitly listed in the relevant knowledge units.

4 The Role of Liberal Arts in Computing Science Education

As an educator, the central question is: How can we effectively prepare the next generation of computer scientists and technical professionals to meet the evolving demands of the high-tech industry?

Integrating a liberal arts framework as the foundational approach to training computer scientists is not a new concept. In 1986, Gibbs and Tucker already demonstrated a strong and rigorous computer science program [8]. As the nature of computer science evolves, there are other proposed changes that update and enhance the model [21] [20].

The framework of liberal arts education, when applied to computer science education, emphasizes a holistic approach that integrates technical skills with critical thinking, creativity, and ethical considerations. This educational model seeks to prepare students not only for careers in computing, but also for informed citizenship and lifelong learning. The integration of liberal arts principles into computing science programs fosters a well-rounded educational experience that is essential in today's rapidly evolving technological landscape.

Typical liberal arts-based computer science curricula emphasize several key themes:

(A) Critical Thinking and Problem-Solving: How philosophy and logic enhance algorithmic reasoning.
(B) Communication and Collaboration: The impact of rhetoric, writing, and language studies on teamwork and technical communication.
(C) Ethical and Social Responsibility: Insights from ethics, sociology, and history in addressing technological impacts on society.
(D) Creativity and Innovation: How arts, literature, and design thinking contribute to user-centered software development and HCI.

4.1 Interdisciplinary Learning

One of the core aspects of a liberal arts education in computing science is the emphasis on interdisciplinary learning. Programs such as the Computing in the Arts (CITA) curriculum exemplify this integration by combining computer science with artistic creativity, allowing students to explore the intersection of technology and the arts [15]. This approach encourages students to think critically about the implications of technology in society and to develop innovative solutions that are both functional and aesthetically pleasing.

Moreover, liberal arts universities often provide a unique environment for computer science education by promoting a broad-based curriculum that includes courses in humanities and social sciences alongside technical subjects. This breadth of study is crucial for developing well-rounded graduates who can navigate complex social issues related to technology. For instance, Baldwin et al. highlight how liberal arts institutions can successfully implement computer science programs that emphasize both depth and breadth, ensuring that students are equipped with the necessary skills to tackle real-world challenges [2]. This is particularly important in addressing social and ethical issues in computing, as discussed by Davis and Walker, who advocate for incorporating social issues into computing curricula [6].

Interdisciplinary integration matters in the 21st-century digital age. The computer scientists and engineers of the next generation need to be able to bridge the disciplinary gap in order to create and survive the next innovation. There are many examples of successful integrations: Digital humanities projects, interactive media and computational arts, bioinformatics and computational biology as interdisciplinary case studies, to name a few.

4.2 Soft Skills Development

Furthermore, the liberal arts framework also encourages the development of soft skills, such as communication, collaboration, and critical thinking, which are essential for success in the computing field. Sarkar and Johnson emphasize the importance of these competencies in preparing students for the demands of the modern workforce, particularly in areas such as artificial intelligence and data science [17]. By fostering these skills, liberal arts education in computing science helps students become adaptable professionals who can thrive in various roles and industries.

Furthermore, the historical context of liberal arts education provides a foundation for understanding the role of computing science within this framework. The Liberal Arts Computer Science Consortium (LACS) has been instrumental in developing model curricula that align with liberal arts principles, ensuring that computer science education remains relevant and impactful [4]. This collaborative effort underscores the importance of maintaining high-quality computer science programs that are informed by liberal arts values.

In conclusion, the liberal arts education framework applied to computing science education promotes an interdisciplinary, holistic approach that prepares students for both technical proficiency and ethical engagement with technology. By integrating diverse disciplines and emphasizing critical thinking and soft skills, this educational model equips graduates to navigate the complexities of the modern world and contribute positively to society.

5 The Current Ethical Education in Computer Science Curriculum

With the rapid proliferation of artificial intelligence, society has begun to recognize the transformative power of technology and its profound impact on individuals and communities.

When developing complex technical systems, ethical considerations must be integrated at every stage, from design to maintenance. Teaching computer ethics in computing curricula is not merely an optional enhancement, it is essential.

Unlike engineering programs, which require a dedicated course in professional ethics, computing science curricula often lack such a requirement. As a result, critical areas necessary for addressing contemporary technological challenges are frequently overlooked.

As we confront pressing issues such as data privacy, algorithmic bias, and the societal implications of AI, it is imperative that both engineers and computing scientists possess the skills to analyze complex problems, evaluate diverse solutions, and think creatively — an essential component of innovation and user-centered design.

5.1 Survey of Western Canada Universities

In this section, we report our attempt to survey universities in western Canada (in the provinces of British Columbia (BC) and Alberta (AB)) in their curriculum for offering a class in Social and Professional issues in Computing (SP).

There are 31 post-secondary institutions in BC and AB offering computing science courses (21 in BC, and 10 in AB). Of these 31, only 13 offer a Bachelor of Science (BSc) in Computing Science degree (8 in BC and 5 in AB). We will be focusing our discussion to these 13 institutions.

Upon surveying the academic catalog for these institutions, we noted in their SP course offering that there are three possibilities:

- a) SP course is not offered,
- b) SP course is offered but not required for the credential, and
- c) SP course is offered and required for the credential.

We recognize that, even though a specific course on SP is not offered, content related to the ethics and technology of society can still be addressed at various points throughout other courses in the curriculum. However, this approach often leaves it up to individual professors to decide whether to include this additional content. Without a concerted effort, it is reasonable to assume that there is a possibility that the content may be overlooked.

Tables 1 and 2 summarized the degree granting institutions in BC and AB, respectively, and their SP course offering (if any).

We note that not all CS degree-granting institutions offer a course in SP (5 out of 7 in BC and 2 out of 5 in AB). Although the course is offered, some institutions do not require this course for their credentials.

In British Columbia, the universities that offer an SP course as a degree requirement are Simon Fraser University (SFU), Trinity Western University, the University of Fraser Valley, and the University of Northern British Columbia.

Simon Fraser University (SFU) previously offered a course on the social implications of technology (CMPT 320), which explored various ethical issues related to technology. However, since 2016, this course has been removed from the degree requirements and is now offered as an elective. Instead, the content has been integrated into the syllabi of two other courses, CMPT 125 - Introduction to Computing Science and Programming II and CMPT 376W - Professional Responsibility and Technical Writing.

According to the university Senate document (March 4, 2016), 'Social and Professional issues in Computing (SP) are considered important for our curriculum so are to be added to the syllabus of two other courses, CMPT 125 and CMPT 376W.' CMPT 376W is a required course for the B.Sc. credential. However, upon reviewing the course descriptions, it appears that CMPT 105W now covers some of the content that was previously taught in CMPT 320, rather than CMPT 125. It is important to note that while CMPT 320 once dedicated the entire course to topics related to SP, CMPT 376W is now also responsible for teaching technical writing. Additionally, SFU cited difficulty in finding staff to teach CMPT 320 as one of the reasons for its removal from the curriculum.

5.2 Ethical Practice in Computing

There are many technological inventions that come with ramification in the ethics area. For example: algorithmic bias and fairness, data privacy and surveillance ethics, and AI and autonomous systems: moral and philosophical considerations. There is a need for system designers to understand the frameworks for Ethical Decision-Making so that they are not just the producers of programming source code, but they are also able to incorporate ethical theories and methodologies into technical problems.

5.3 Survey on Computing Science Education at a Liberal Arts University

A survey on computing science education at a liberal arts university was conducted with 24 students, mostly computing science majors and a few pre-engineering and mathematics majors. The survey results show that most students consider ethics an important subject in computing science (46% extremely important; 42% very important) (Figures 1). About 63% of the students think that a

Table 1: Institutions in British Columbia that offer BSc degree in computing science and their offering of SP courses.

Institutions	Offer SP course	Required SP course	Course number
Simon Fraser University	Y	Y	CMPT 376W
Thompson Rivers University	N	N	
Trinity Western University	Y	Y	NATS 483 Christian Perspectives in the Sciences: Computing Science
University of British Columbia	Y	N	CPSC 430 Computers and Society
University of Fraser Valley	Y	Y	COMP 420 Computers and Society
University of Northern British Columbia	Y	Y	CPSC 260 - Ethics in Computing Science
University of Victoria	N	N	

Table 2: Institutions in Alberta that offer BSc degree in computing science and their offering of SP courses.

Institutions	Offer SP course	Required SP course	Course number
MacEwan University	N	N	
Mount Royal University	N	N	
University of Alberta	Y	N	CMPUT 200 Ethics in Data Science and AI and CMPUT 300 Computers and Society
University of Calgary	Y	N	CPSC 409 History of Computation.
University of Lethbridge	N	N	

liberal arts university helps them develop critical thinking about the social implications and ethics of technological advances (Figure 2). 62.5% of the students agree that they learn an interdisciplinary approach to the problems in liberal arts education (Figure 3). About 71% believe that ethics-related courses will help them make the right decisions in their future workplace (Figure 4). Half of the students are satisfied with their computing education at a liberal arts university, and 37.5% responded neutrally (Figure 5).

These survey results are encouraging, as students perceive the liberal arts as playing an important role in their computing science education. They understand the benefits of a liberal arts curriculum for their future career by learning ethics and interdisciplinary approaches to problems in addition to technical skills.

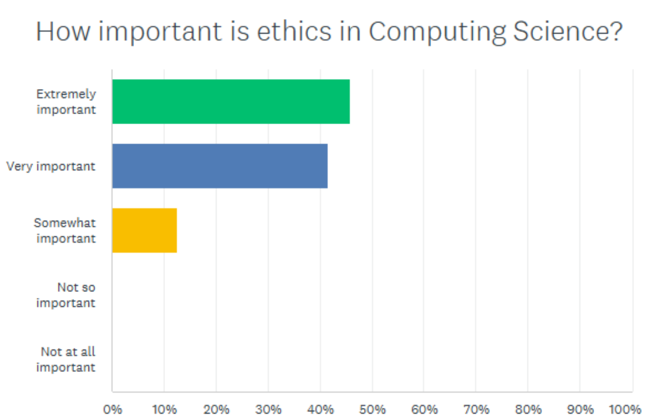

Figure 1: Survey question 1 and results.

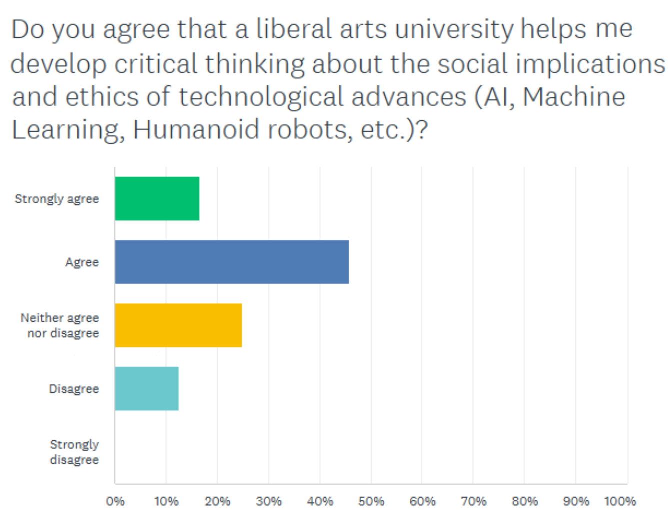

Figure 2: Survey question 2 and results.

6 Recommendation to Curriculum Design for a Comprehensive Educational Paradigm

We strongly recommend that all computer science curricula incorporate two key components: a) a dedicated focus on ethics, and b) opportunities for students to engage in interdisciplinary coursework, similar to the liberal arts education model.

By integrating these approaches, we believe it is possible to foster a culture of interdisciplinary innovation that addresses gaps in the current educational model.

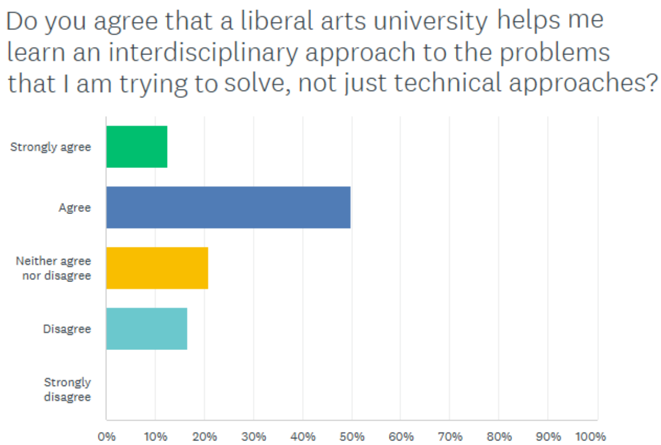

Figure 3: Survey question 3 and results.

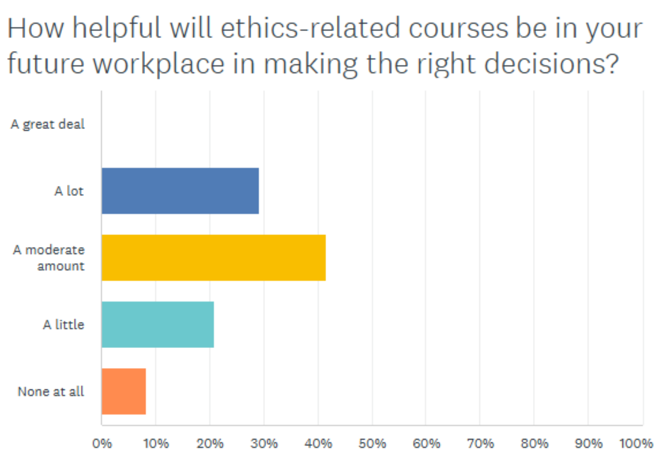

Figure 4: Survey question 4 and results.

Rather than confining discussions of ethics to a single course, there is a growing effort to embed ethical considerations throughout the curriculum. One notable example is Harvard University's Embedded EthiCS program, in which faculty develop ethics modules that are seamlessly integrated into existing computer science courses [10]. This approach ensures that students encounter ethical reasoning in context, reinforcing its importance across diverse technical domains.

By adopting similar initiatives, computer science programs can better prepare students to navigate the complex ethical challenges of modern technology while fostering a more holistic and socially responsible approach to computing.

7 Conclusion

To effectively educate our students and prepare them for success in the workforce or graduate studies, we must take the following steps:

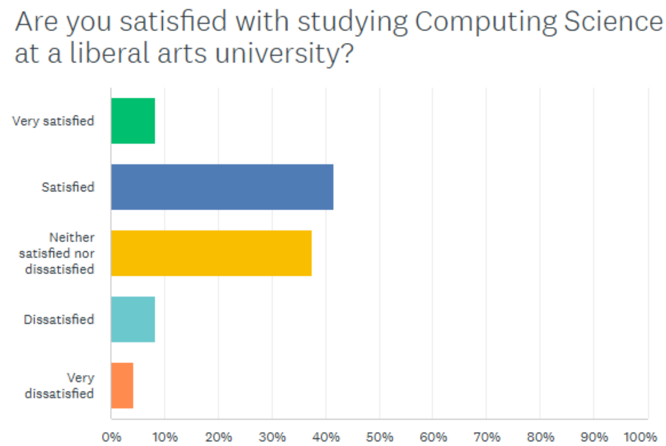

Figure 5: Survey question 5 and results.

- Emphasize the importance of project-based learning. As class sizes continue to grow due to economic and budgetary constraints, educators must find new pedagogical approaches that enable project-based learning in larger classrooms.
- The next breakthrough in technology will likely stem from interdisciplinary collaborations. Our students need the necessary skills and training to succeed in such environments.
- Computer science students must be equipped with essential ethical reasoning tools, as they will be required to make ethical decisions in areas ranging from software and system design to the recycling of computer hardware.
- Both academia and industry urgently need more individuals who are well-versed in the intersection of ethics and technology. In an increasingly digital world, it is crucial to have professionals who understand the ethical implications of technological advancements. Only with a larger pool of individuals equipped with these skills can we foster intelligent, meaningful debates on the critical issues shaping our future. These discussions are essential to ensuring that technology serves society in a responsible, equitable, and sustainable manner.

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Received 4 March 2025; accepted 10 Apr 2025