Board 155: Computing Faculty Introducing Secondary Students to Differences in Computing Fields (Work in Progress)

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An interdisciplinary research team consisting of five faculty members from computer science (CS), computer engineering (CmpE), information technology (IT), and education (EDU) offered a one-week summer computing camp for high school students on a regional university campus in the midwestern United States. The Summer Computing Camp (SCC) aimed to increase students' understanding of computing-related majors and promote higher education in computing fields. Campers received daily instruction on the core components of CS, CmpE, and IT and practiced the gained knowledge through hands-on laboratories. Specific skills developed include computer programming in Python, basics of electrical circuits, integrating computer hardware and software, computer networking, and cyber security. Campers were introduced to computing careers and majors through presentations and guest speakers during the Lunch and Learn time. At the end of the week, teams of campers applied these skills to an Internet of Things-themed Capstone project, which they presented to their peers and parents.

Pre- and post-surveys, daily reflections, and structured interviews were collected to establish continuous improvements for the program and to further our understanding of how to better prepare high school students to choose disciplines of study. Triangulation of the multiple sources supports the conclusion that, by the end of the program, campers could better articulate the differences between each of the three fields, the anticipated career trajectories for each degree path, and increased students' interest in specific computing majors.

Theory

Since the mid-1960s, the Association for Computing Machinery (ACM) [1] and the Institute of Electrical and Electronic Engineers (IEEE) [2] have worked to identify trends in computing and disseminate curriculum guidelines to the computing community. CC2020, the most recent joint publication of the two [3] identified six distinct computing disciplines: (1) computer science; (2) computer engineering; (3) information systems; (4) software engineering; (5) information technology; and (6) cybersecurity. Curriculum guidelines for a seventh discipline, data science, were published in 2021 [4]. Though separate curriculum recommendations exist for each computing discipline, there is a considerable amount of overlap in course topics between the seven. Many universities, including the host of this study, continue to offer the emergent disciplines (cybersecurity, data science) as concentrations or minors within existing programs.

One challenge the camp curriculum was designed to address was the decision of which undergraduate major to pursue. Prospective computing majors are not likely to understand the differences between the seven computing disciplines [5], and will not likely be able to turn to traditional sources of guidance such as parents [6], teachers [7], guidance counselors [8, 9], or (in some cases) current computing majors [10]. Beyond the simple choice of a major, there is also the issue of making informed decisions about high school coursework to better position them for early success within an undergraduate computing major.

The SCC introduced interested high school youth to three computing fields (CS, CmpE, IT). Four computing faculty delivered the lectures and facilitated hands-on laboratories, providing the

prospective computing majors opportunities for direct interaction. Campers also became familiar with current Master's level students throughout the week, specifically during the laboratories. On Day 1 campers received a general overview of computing and an introduction to programming. Days 2-4 were themed to each of the three computing disciplines, informing them about the coursework and careers before immersing them in the field through hands-on activities. On the fifth and final day, campers applied their knowledge to a Capstone project involving Internet of Things (IoT) within a home. Appendix A summarizes the SCC daily activities.

The research questions for this study include:

> RQ1: How does participation in a summer computing camp influence students' understanding of the differences between computing disciplines?
>
> RQ2: How does participation in a summer computing camp influence students' understanding of potential career trajectories in computing disciplines?
>
> RQ3: Which elements of the camp curriculum influenced students' interest in one or more computing disciplines?

Method

This study used multiple measures, both quantitative and qualitative, to capture the impact of a week-long summer computing camp designed to help high school prospective computing majors explore computer science, computer engineering, and information technology (CS/CmpE/IT).

Thirty high school students were accepted to the Camp program. Of the 26 who completed the camp, 22 identified as male, 4 as female, and none identified otherwise. Two males were unable at the last moment to attend, and two dropped after the second day due to various reasons. Eight were rising seniors, 15 rising juniors, and 3 rising sophomores. Eighteen identified as white, 2 as black or African American, and 6 as of Asian descent. When asked at the start of the camp what undergraduate major they were interested in pursuing, 12 reported computer science, 6 computer engineering, and 4 information technology. The other 6 listed other engineering or computing majors, including cybersecurity.

This study utilized a mixed-method research design that involved the triangulation of qualitative and quantitative data. Two instruments were constructed for the purpose of this study and can be found in Appendix B. The S*ummer Computing Camp Survey (SCCS)* was administered as a pre-survey on Monday morning and a post-survey on Friday afternoon following the Capstone presentation. The *Perceptions of Computing Fields (Perceptions)* was administered prior to the camp as a pre-test and after the camp as a post-test. Pre and post survey and test data were paired for analysis. Microsoft Excel was used to analyze quantitative data, establishing frequencies and percentages. Qualitative data was precoded by the first author and sorted into categories [11].

Results

Multiple data sources were analyzed using the appropriate quantitative and qualitative methodology, then disaggregated by relevance to each of the three research questions. The results section is organized around each question.

Understanding of the Computing Disciplines

Through direct instruction on and immersion in activities related to each of the three computing disciplines, participants were found to have improved *confidence* in their understanding of the differences between CS, CmpE, and IT as well as improved their ability to *distinguish between* skills and tasks relevant to each field.

Item 10b on the *SCCS* pre and post surveys asked students their level of agreement with the statement "I understand the differences between computer science, computer engineering, and information technology." Presurvey agreement was high (8% strongly agree, 56% somewhat agree) but a quarter of the students claimed to "somewhat disagree." On the posttest, no students disagreed with the statement and the number who strongly agreed greatly increased (68% strongly agreed, 28% somewhat agreed, and 4% neither agreed nor disagreed).

An additional *SCCS* post-survey item directly supported the students' claim to understand the differences. Participants were given descriptions of the computing fields taken from page 29 in CC2020 [3] and asked to identity which was CS, CmpE, and IT. Ninety-one percent correctly recognized that computer engineering "focuses on the integration of hardware, software, and signal processing," while 87% correctly recognized computer science "has a strong and specific focus on developing strong conceptual foundations and computational capabilities." The same percentage (87%) reported that information technology "emphasizes building and maintaining organizational computing infrastructure capabilities and user support."

Responses to *Perceptions* Question 3 further supported the students' claims of understanding. Table 1 summarized the correct perceptions by discipline, and two tables in Appendix C reported the results by *item*. Understanding of CS and CmpE was relatively high on the pretest. Understanding of IT was initially relatively low (44%) and almost doubled (81%) on the post.

Table 1. Pre and Post Test of Participants' Perceptions of Computing Skills by Discipline

Discipline(s)	Items	Pre	Post	Change
Computer Science	5	80%	80%	+0%
Computer Engineering	4	85%	98%	+13%
Information Technology	7	44%	81%	+37%
Information Technology and Computer Science	3	93%	100%	+7%
Computer Science and Computer Engineering	1	100%	80%	-20%

Understanding of Potential Career Trajectories

Items 10c, d, and e on the *Summer Computing Camp* pre and post surveys polled student thinking about computing careers. The results are reported in Table 2. A small number of participants (12%) initially reported disagreement that they understood the necessary training for careers in CS, CmpE, and IT and another small number (8%) were neutral. At the end of the camp, all students reported some or strong agreement with the statement, suggesting the camp was impactful on their knowledge of computing careers. Students' beliefs in the value of computing careers, both to the economy in general and in compensation, were initially high but demonstrated some growth.

Table 2. Participants' Beliefs About Computing Careers

	Strongly A		Somewhat A		Neither A nor D		Somewhat D		Strongly D	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
c. I understand the training needed for a future career in computer science, computer engineering, and information technology.	40%	68%	32%	32%	8%	0%	12 %	0%	8%	0%
d. Computing careers are essential to the economy.	80%	84%	16%	16%	4%	0%	0%	0%	0%	0%
e. Computing careers offer high paying jobs.	68%	80%	20%	16%	12%	4%	0%	0%	0%	0%

Student confidence in their knowledge of careers is justified based on the results of *Perceptions* pre and posttests Item 4. Students selected **one** of the three computing degree paths (CS, CmpE, IT) they perceived as the most likely route to one of 26 computing careers. Table 3 summarized the results and two tables in Appendix D reported the results in each discipline by item.

Table 3. Pre and Post Test of Participant's Perceptions of Computing Careers by Discipline

Discipline(s)	Items	Pre	Post	Change
Computer Science	5	66%	74%	+8%
Computer Engineering	10	78%	65%	-13%
Information Technology	3	77%	93%	+17%
Information Technology or Computer Science	6	88%	97%	+8%

Pretest scores were fairly high but not so much so that it prevented any improvement. The decrease in perceptions of computer engineering careers is mostly due to changes in student thinking about careers as testing engineers (90% to 50%) and computer system test engineers (60% to 20%). Those whose perceptions changed ignored the word "engineer" and attributed these fields to information technology, a shift to revisit in future iterations of the curriculum.

Influence on Students' Interest in Specific Computing Disciplines

Multiple questions probed the impact of the camp on participants' interest in CS/CmpE/IT. One *SCCS* post-survey item asked participants to agree or disagree with the statement "This camp helped me to clarify which computing field best suits my interests and skills." No students disagreed, as 71% strongly agreed, and the remaining 29% somewhat agreed. A similar question on the *Perceptions* post-test asked students to agree or disagree with the statement "Participating in this camp increased my interest in majoring in computing." No students disagreed, as 73% strongly agreed, 18% somewhat agreed, and 9% neither agreed nor disagreed.

Item **7** on the *SCCS* pre and post surveys asked participants to rank their interest in each of the three computing disciplines on a scale from 1 to 10, with 10 being the highest. Several students (12 of 25) entered the camp with high initial interest in CS (9 or 10), but only 3 had high interest in either CmpE or IT. By the end of the camp, the number reporting a high interest in CmpE increased from 3 to 5 and high interest in IT increased from 3 to 6. Appendix E includes the pre and post results for the 25 who completed both surveys. The post-survey also asked students whether participation in the camp had *changed* their interest in computing (13 yes, 6 maybe, 6 no) and *which parts* of the camp influenced their thinking (Appendix E). Those who responded "yes" offered a variety of responses as to which parts influenced them, but the common theme

was that they learned more about CmpE and IT. Five of the 6 "No" responses finished the camp with the same strong computing interests in with which they entered. Despite their claims that the camp had no influence, one "No" student had a large jump in interest in IT (7 to 10) and two others reported large increases (4) in their interest in CmpE and IT.

Only one reported that they were less interested in computing at the end of the camp. The student explained that the camp helped them realize "why I might not be a good fit for any computing majors." This result, while unfortunate, must be respected as a potential outcome. Better that the student realized this now than after a semester of coursework.

Discussion

Where the camp may have been most impactful was in exposing students to CS and IT, two disciplines that may be less prominent in high school computing course offerings. Camp enrollment was skewed toward participants who completed a high school AP or dual-credit CS course. Those with high interest in CS were not swayed toward IT or CmpE; those who found higher interest in IT and CmpE were from the group less confident in their primary interest.

The combination of direct instruction and hands-on experiences in each discipline led to perceived and evidenced gains in students' understanding of CS, IT, and CmpE and careers associated with each. Previous studies of understanding of differences in disciplines were of undergraduates [10, 12, 13], which means this may be the first published study to focus specifically on high school students' perceptions prior to matriculation. Likewise, previous studies have surveyed computing undergraduates as to what influenced them to choose a particular computing major [5, 14-16], none have surveyed high school students directly prior to their enrollment. Previous researchers surveying high school students instead have been content to survey more broadly about STEM interest [17-20], with the exception of two studies specific to the selection of CS as a major [21, 22].

Limitations

This study is currently limited by its small scope, small population, and single iteration. The project funded for an additional two years; data to be collected in the next two summers will triple the population size. The authors acknowledge this and do not intend to claim that the results are generalizable. The surveys and other instrumentation utilized were constructed specifically for this study and have not yet been validated. Additionally, much of the data collected in this study was self-reported and is thus vulnerable to social acceptability bias and response bias. The authors also acknowledge, as did De Lira [23], those attending the camp elected to participate and thus began with an higher interest in and knowledge of computing.

Conclusions

Preliminary results from the first iteration of this week-long computing camp model support the conclusion that this approach is effective in increasing prospective computing majors' understanding of the computing disciplines and of career trajectories. Evidence also supports the conclusion that this camp model is effective in increasing participants' interest in computer science, computer engineering, and information technology. Future research on the next two iterations of the camp will pursue questions of motivation and student interest in computing.

References

[1] G. Engel, J. Impagliazzo, and P. LaMalva, "A brief history of the computing sciences accreditation board (CSAB) promoting quality education in the computing fields," *ACM Inroads,* vol. 1, no. 2, pp. 62–69, 2010. Available: https://doi.org/10.1145/1805724.1805740.

[2] Commission on Engineering Education, "Computer science in electrical engineering," *IEEE Spectrum,* vol. 5, no. 3, pp. 96-103, 1968.

[3] C. T. Force, *Computing Curricula 2020: Paradigms for Global Computing Education*. New York, NY: Association for Computing Machinery, 2020, p. 205.

[4] A. Danyluk *et al.*, "Computing competencies for undergraduate data science programs: An ACM task force final report," in *Proceedings of the 52nd ACM Technical Symposium on Computer Science Education*, 2021, pp. 1119-1120.

[5] F. Redmond, "With a Rise in Computing Disciplines Comes a Greater Choice of Computing Degrees in Higher Education," presented at the Proceedings of the 22nd Koli Calling International Conference on Computing Education Research, Koli, Finland, 2022. [Online]. Available: https://doi.org/10.1145/3564721.3565946.

[6] E. Anthony, "Computing education in academia: Toward differentiating the disciplines," in *Proceedings of the 4th conference on Information technology curriculum*, 2003, pp. 1-8.

[7] E. R. Banilower, P. S. Smith, K. A. Malzahn, C. L. Plumley, E. M. Gordon, and M. L. Hayes, "Report of the 2018 NSSME+," *Horizon Research, Inc.,* 2018.

[8] L. D. Falco, "The School Counselor and STEM Career Development," *Journal of Career Development,* vol. 44, no. 4, pp. 359-374, 2017. [Online]. Available: https://doi.org/10.1177/0894845316656445.

[9] W. Chi, P. Morreale, and J. Chu, "Increasing School Counselor Awareness of Computer Science," in *Proceedings of the 54th ACM Technical Symposium on Computer Science Education V. 1*, 2023, pp. 1110-1116.

[10] J. Courte and C. Bishop-Clark, "Do students differentiate between computing disciplines?," presented at the Proceedings of the 40th ACM technical symposium on Computer science education, Chattanooga, TN, USA, 2009. [Online]. Available: https://doi.org/10.1145/1508865.1508877.

[11] J. Saldana, *The Coding Manual for Qualitative Researchers*. Sage Publications, 2016.

[12] M. E. Battig and M. Shariq, "A Validation Study of Student Differentiation between Computing Disciplines," *Information Systems Education Journal,* vol. 9, pp. 105-115, 2011.

[13] F.-M. E. Uzoka, R. Connolly, M. Schroeder, N. Khemka, and J. Miller, "Computing is not a rock band: student understanding of the computing disciplines," presented at the Proceedings of the 14th annual ACM SIGITE conference on Information technology education, Orlando, Florida, USA, 2013. [Online]. Available: https://doi.org/10.1145/2512276.2512291.

[14] C. L. Shook, "Choosing Information Systems as a Major: Factors That Influence Selection," Ed.D., University of Arkansas, United States -- Arkansas, 22588813, 2019. [Online]. Available: https://www.proquest.com/docview/2311651910

[15] T. Lenox, G. Jesse, and C. R. Woratschek, "Factors influencing students decisions to major in a computer-related discipline," *Information Systems Education Journal,* vol. 10, no. 6, p. 63, 2012.

[16] M. Säde, R. Suviste, P. Luik, E. Tõnisson, and M. Lepp, "Factors That Influence Students' Motivation and Perception of Studying Computer Science," in *Proceedings of the 50th ACM Technical Symposium on Computer Science Education*, 2019, pp. 873-878.
[17] J. B. Main, T. Dang, B. Johnson, Q. Shi, C. Guariniello, and D. Delaurentis, "Why Students Choose STEM: A Study of High School Factors That Influence College STEM Major Choice," in *2023 ASEE Annual Conference & Exposition*, 2023.
[18] S. L. Ferguson, K. P. Ieva, C. J. Winkler, K. Ash, and T. Cann, "How do you know if this is for you? Exploration and awareness of technical STEM careers," *School Science and Mathematics,* vol. 123, no. 3, pp. 114-124, 2023, doi: https://doi.org/10.1111/ssm.12577.
[19] S. Kaleva, J. Pursiainen, M. Hakola, J. Rusanen, and H. Muukkonen, "Students' reasons for STEM choices and the relationship of mathematics choice to university admission," *International Journal of STEM Education,* vol. 6, pp. 1-12, 2019.
[20] X. Wang, "Why students choose STEM majors: Motivation, high school learning, and postsecondary context of support," *American Educational Research Journal,* vol. 50, no. 5, pp. 1081-1121, 2013.
[21] T. G. Zimmerman, D. Johnson, C. Wambsgans, and A. Fuentes, "Why Latino high school students select computer science as a major: Analysis of a success story," *ACM Transactions on Computing Education (TOCE),* vol. 11, no. 2, pp. 1-17, 2011.
[22] E. Tsagala and M. Kordaki, "Essential factors that affect students' choices to study computer science: Gender differences," *Testing/Assessment,* 2005.
[23] C. de Lira, R. Wong, O. Oje, G. Nketah, O. Adesope, and A. Ghods, "Summer Programming Camps–Exploring Project-Based Informal CS Education in a Rural Community," *International Journal of Computer Science Education in Schools,* vol. 5, no. 4, pp. 20-37, 2022.
[24] P. T. Mitchell, "Undergraduate motivations for choosing a science, technology, engineering, or mathematics (STEM) major," 2016.
[25] T. Urness and E. D. Manley, "Generating interest in computer science through middle-school android summer camps," *Journal of Computing Sciences in Colleges,* vol. 28, no. 5, pp. 211-217, 2013.
[26] M. M. McGill, A. Decker, and A. Settle, "Undergraduate students' perceptions of the impact of pre-college computing activities on choices of major," *ACM Transactions on Computing Education (TOCE),* vol. 16, no. 4, pp. 1-33, 2016.
[27] A. Sahin and H. C. Waxman, "Factors affecting high school students' STEM career interest: Findings from a 4-year study," *Journal of STEM Education: Innovations and Research,* vol. 22, no. 3, 2021.
[28] C. De Lira, R. Wong, and O. Adesope, "A systematic review on the effectiveness of programming camps on middle school students' programming knowledge and attitudes of computing," *Journal of Computing Sciences in Colleges,* vol. 38, no. 1, pp. 89-98, 2022.

Appendix A

Table A.1: Schedule of themes and activities by day

Day	Theme	Activities	Skills
Monday	Introduction to Computing	• Dean's welcome • Intro to Computing • Intro to Python programming • Computer programming lab	• programs, algorithms, computing • Python programming syntax • conditional expressions • pseudocode • if-elif-else statements • user input
Tuesday	Computer Science	• Intro to Computer Science • Python programming • Software development • Python programming lab	• conditional repetition • while loop • for loop
Wednesday	Information Technology	• Intro to Information Technology • Intro to computer networking • Intro to cybersecurity • Cybersecurity lab	• networking • cybersecurity
Thursday	Computer Engineering	• Intro to Computer Engineering • Electronics 101 • Integrating hardware and software • Raspberry Pi lab	• circuits 101 • Snap Circuits • Raspberry Pi
Friday	Collaborative Computing Capstone Project	• Use Internet of Things (IoT) to design a smart home • Group presentations	• critical thinking • collaboration • cooperation • communication

Other Daily Activities:

(1) **Icebreaker**
Activity at the start of each day to help the campers get to know one another and the staff

(2) **Lunch and Learn**
(Monday – Thursday) guest speakers from industry, sharing about their careers in computing,
(Friday) university admissions counselor, discussing university admissions.

Appendix B

Summer Computing Camp Survey - Pre-Camp | Post-Camp Survey

The *Summer Computing Camp Pre-Survey* and *Post-Survey* were administered on the first and last days of the camp. The pre and post surveys included questions concerning (1) basic demographics, (2) high school coursework, (3) knowledge of computing fields, and (4) thinking about computing careers. The post-survey also included reflective open-ended questions about (1) what they learned about computing, (2) their favorite and least favorite parts of the camp, and (3) what they might recommend be changed about the camp in the next iteration. Questions on this instrument were constructed by the authors based on a literature review of STEM motivations. One question asking participants to identify extracurricular activities was adapted from Mitchell's STEM Motivations Survey [24].

1. Tentative University Major(s): (if considering more than one, list your top three interests)

1b. Tentative University Minor(s) (if considering more than one, list your top three interests)

2. What three factors are most important to you in deciding what major you will pursue in college/university?

3. Which of the following math courses have you taken or are currently taking in high school? (select all that apply)

- ○ Calculus (dual-credit, AP, IB, or other)
- ○ Algebra 2
- ○ Pre-Calculus
- ○ Advanced Math and/or Trigonometry
- ○ Statistics (AP or other)
- ○ Other math beyond Algebra 2 _____

3b. Which math course(s) are you planning to take in school next year? _____

[Post only] Did your answer to this question change as a result of the Summer Computing Camp? **Yes** **No**

4a. Does your high school offer courses in engineering or computing?

- ○ Yes
- ○ No

4b. Have you received any academic advising or guidance from your high school counselors or teachers to help you understand the similarities and differences between computer science (CS), computer engineering (CmpE), and information technology (IT)?

- ○ Yes
- ○ No

5a. Which of the following science/technology/engineering courses have you taken or are currently taking in high school? **(select all that apply)**

- ○ Integrated Chemistry and Physics
- ○ Project Lead the Way (PLTW) computer science
- ○ Physics (general, honors, or AP)
- ○ Project Lead the Way (PLTW) engineering
- ○ Chemistry (general, honors, or AP)
- ○ Computer applications
- ○ Dual-credit computer science
- ○ Computer hardware repair
- ○ AP Computer Science (any)
- ○ Other _____

5b. Which science, technology, or engineering course(s) are you planning to take in school next year? _____

[Post only] Did your answer to this question change as a result of the Summer Computing Camp? **Yes No**

[Post only] Is/Are there a mathematics, science, technology, or engineering course(s) you would take next year but cannot because your school does not offer it? If yes, list it in the space below.

6. Are you currently or have you in the past participated in any of the following STEM-related activities in high school? (STEM is science, technology, engineering, mathematics)

- ○ Science competition (science fair, robotics competition, etc.)
  Please list their names in the box provided. _____
- ○ Research internship or fellowship
- ○ Attend a career presentation by a computing guest speaker
- ○ University visit (department specific presentation, engineering day, etc.)
- ○ Company visit (company outreach programs, engineering consulting firms, etc.)
- ○ Computing-related enrichment camp
- ○ Other STEM-based enrichment camp (space camp, science camp, etc.)
- ○ Job shadowing/internship in computing-related field
- ○ Self-paced online courses in computing
- ○ Other _____

7. On a scale of 1-10, with 10 being the highest, what is your interest in studying the following fields in college?

Computer Science	0	1	2	3	4	5	6	7	8	9	10
Computer Engineering	0	1	2	3	4	5	6	7	8	9	10
Information Technology	0	1	2	3	4	5	6	7	8	9	10

[Post only] Did your answer to this question change as a result of the Summer Computing Camp? **Yes Maybe No**

[Post only] If your answer to this question changed, please share about what parts of the Camp influenced your thinking.

8. What are three things you are most interested in learning more about in computing?

9. What are three concerns you have about taking university courses in computing?

10. For the following statements, please choose the option that represents your best answer:

Strongly agree | Somewhat agree | Neither agree nor disagree | Somewhat disagree | Strongly disagree

a. I am knowledgeable of career options in computer science, computer engineering, and information technology.

b. I understand the differences between computer science, computer engineering, and information technology.

c. I understand the training needed for a future career in computer science, computer engineering, and information technology.

d. Careers in computing are essential to the economy.

e. Careers in computing offer high paying jobs.

[Post Test only]

Q: What are the three most important things you learned about computing throughout this week of camp?

Q: Each of the following statements best describes one of the three computing disciplines presented in this week in the Summer Computing Camp. Choose the best possible answer for each.

a. Focuses on the integration of hardware, software, and signal processing

○ Computer Science ○ Computer Engineering ○ Information Technology

b. Has a strong and specific focus on developing strong conceptual foundations and computational capabilities

○ Computer Science ○ Computer Engineering ○ Information Technology

c. Emphasizes building and maintaining organizational computing infrastructure capabilities and user support

○ Computer Science ○ Computer Engineering ○ Information Technology

Q: For the following statements, please choose the option that best represents your thinking

a. This camp helped me to clarify which computing field best suits my interests and skills.

○ Strongly agree ○ Somewhat agree ○ Neither agree nor disagree ○ Somewhat disagree ○ Strongly disagree

b. This camp helped me better understand how computer science, computer engineering, and information technology collaborate to solve real world problems.

○ Strongly agree ○ Somewhat agree ○ Neither agree nor disagree ○ Somewhat disagree ○ Strongly disagree

c. I would recommend this camp to a friend.

○ Strongly agree ○ Somewhat agree ○ Neither agree nor disagree ○ Somewhat disagree ○ Strongly disagree

Q: What was your favorite part of the camp?

Q: What did you like least about the camp?

Q: What would you change about the camp for next year?

Perceptions of Computing Fields Pre-Test | Post-Test

The *Perceptions of Computing Fields* was written by the authors and administered before and after the camp as a pre and post test to gauge participants understanding of the differences between three principal computing fields (CS, CmpE, IT) and the connection between these fields and prospective career paths. Similar to but developed independent of earlier surveys probing understanding of the differences between computing disciplines [10, 12, 25], participants were asked to discern which of the three fields was most likely to use each of 21 computing skills. Then participants were asked which one of the three computing majors would be the most likely route to one of 26 computing careers. Other questions included in this instrument probed participants' interest in computing, including one question that asked participants to rank twelve factors by personal importance to their decision on a computing major. Construction of this instrument was informed by the literature on student interest in computing [15, 19-21, 26-28]

I. Interest in Computing

The following questions are designed to measure your interest in the computing disciplines

[Pretest only]

1: Which factors are the most important to you in deciding on a computing major?
Rank in order from most important to least important.

Encouragement from teachers	Outlook for future employment / Future
Encouragement from parents	My joy/passion for learning about computing
Salary & Pay	My aptitude/skills in the subject
Job security	Current opportunities for employment
My interest in the subject	Flexibility
Stability and security of employment	Outlet for creativity and problem solving

[Posttest only]

1. Agree or disagree: participating in this camp increased my interest in majoring in computing.

○ Strongly agree ○ Somewhat agree ○ Neither agree nor disagree ○ Somewhat disagree ○ Strongly disagree

2. My participation in the Summer Computing Camp increased my understanding of the three computing fields.

○ Strongly agree ○ Somewhat agree ○ Neither agree nor disagree ○ Somewhat disagree ○ Strongly disagree

II. Careers in Computing

The following questions are designed to measure how you perceive the differences between these computing disciplines.

3. Which of the three computing career paths is most likely to use each of the following skills?
Select the best answer for each of the skills listed below.

Choose from *Computer Science*, *Computer Engineering*, or *Information Technology*

A. Develop hardware and firmware

B. Develop algorithms to solve problems

C. Configure and maintain operating systems

D. Test software

E. Work with cloud-based applications

F. Develop electronic products

G. Design and prototype microchips and circuits

H. Query databases & analyze data

I. Software design and development

J. Administrate computer networks

K. Design and develop robotic prototypes

L. Troubleshoot computers and networks

M. Design databases

N. Install and maintain computer systems

O. Design hardware and software interfaces

P. Design and build computer networks

Q. Secure networks

R. Provide technical support

S. Develop operating systems

T. Analyze computer systems

U. Develop web-based applications

4. Which of the three computing degree paths do you perceive as the most likely route to each of the following careers? Select the best answer from the three.

Choose from *Computer Science*, *Computer Engineering*, or *Information Technology*

A. Software developer/engineering

B. Information research & data scientist

C. Software architect

D Electronical engineer

E. Firmware engineer

F. Computer network & systems administrator

G. Information systems manager

H. Game designer & developer

I. Computer hardware engineer

J. Computer support specialist

K. Quality Assurance/Testing

L. Testing engineer

M. Automation systems engineer

N. Security/Identity analyst

O. Robotics engineer

P. Cloud architect

Q. Business analyst

R. Cybersecurity & computer security analyst

S. Database administrator & architect

T. Forensic computer analyst

U. Industrial Control Engineer

V. Embedded Develop Engineer

W. Computer System Test Engineer

X. Computer System Analyst

Y. Web developer and designer

Z. System Engineer

5. My participation in the Summer Computing Camp increased my understanding of how experts in the three computing fields collaborate to accomplish real world tasks.

○ Strongly agree ○ Somewhat agree ○ Neither agree nor disagree ○ Somewhat disagree ○ Strongly disagree

Appendix C

Table C.1. Pre and posttest of participants' perceptions of computing skills by discipline

Computer Science

	B. Develop algorithms to solve problems		D. Test software		I. Software design and development		S. Develop operating systems		U. Develop web-based applications	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
CS	8	10	7	5	9	10	8	7	8	8
CmpE	0	0	0	0	0	0	1	2	1	0
IT	2	0	3	5	1	0	1	1	1	2
% correct	80%	100%	70%	50%	90%	100%	80%	70%	80%	80%

Computer Engineering

	A. Develop hardware and firmware		F. Develop electronic products		G. Design and prototype microchips and circuits		K. Design and develop robotic prototypes	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
CS	0	0	0	1	1	0	0	0
CmpE	9	10	8	9	8	10	9	10
IT	1	0	2	0	1	0	1	0
% correct	90%	100%	80%	90%	80%	100%	90%	100%

Information Technology

	C. Configure and maintain operating systems		L. Troubleshoot computers and networks		N. Install and maintain computer systems		P. Design and build computer networks		Q. Secure networks		R. Provide technical support		J. Administrate computer networks	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
CS	4	1	5	1	2	2	3	0	4	0	0	0	2	0
CmpE	2	2	0	1	5	2	6	4	2	0	2	0	2	0
IT	4	7	5	8	3	6	1	6	4	10	8	10	6	10
% correct	40%	70%	50%	80%	30%	60%	10%	60%	40%	100%	80%	100%	60%	100%

Table C.2. Pre and posttest of participants' perceptions of computing skills shared by two or more disciplines

Computer Science and Information Technology

	E. Work with cloud-based applications		H. Query databases & analyze data		M. Design databases	
	Pre	Post	Pre	Post	Pre	Post
CS	6	2	0	2	3	2
CmpE	0	0	1	0	1	0
IT	4	8	9	8	6	8
% correct	100%	100%	90%	100%	90%	100%

Computer Science & Computer Engineering

	O. Design hardware and software interfaces	
	Pre	Post
CS	4	2
CmpE	6	6
IT	0	2
% correct	100%	80%

Computer Science, Computer Engineering, & Information Technology

	T. Analyze computer systems	
	Pre	Post
CS	3	3
CmpE	4	2
IT	3	5
% correct	100%	100%

Appendix D

Table D.1. Pre and posttest of participant's perceptions of computing career paths

	CS		CmpE		IT		% Correct	
Computer Science	Pre	Post	Pre	Post	Pre	Post	Pre	Post
A. Software developer/engineering	9	9	1	1	0	0	90%	90%
B. Information research & data scientist	1	2	0	0	9	8	10%	20%
C. Software architect	5	8	4	1	1	1	50%	80%
H. Game designer & developer	9	10	0	0	1	0	90%	100%
Y. Web developer and designer	9	8	0	0	1	2	90%	80%
Overall							**66%**	**74%**

	CS		CmpE		IT		% Correct	
Computer Engineering	Pre	Post	Pre	Post	Pre	Post	Pre	Post
D. Electronical engineer	0	0	9	10	1	0	90%	100%
E. Firmware engineer	3	4	6	6	1	0	60%	60%
I. Computer hardware engineer	0	0	10	10	0	0	100%	100%
L. Testing engineer	1	2	9	5	0	3	90%	50%
M. Automation systems engineer	2	3	8	7	0	0	80%	70%
O. Robotics engineer	0	0	9	10	1	0	90%	100%
U. Industrial Control Engineer	1	1	9	6	0	3	90%	60%
V. Embedded Develop Engineer	5	5	5	4	0	1	50%	40%
W. Computer System Test Engineer	3	5	6	2	1	3	60%	20%
Z. System Engineer	3	4	7	5	0	1	70%	50%
Overall							**78%**	**65%**

	CS		CmpE		IT		% Correct	
Information Technology	Pre	Post	Pre	Post	Pre	Post	Pre	Post
G. Information systems manager	0	0	0	0	10	10	100%	100%
J. Computer support specialist	2	0	1	1	7	9	70%	90%
N. Security/Identity analyst	4	1	0	0	6	9	60%	90%
Overall							**77%**	**93%**

Table D.2. Pre and posttest of participant's perceptions of shared computing career paths

	CS		CmpE		IT		% Correct	
IT or CS	Pre	Post	Pre	Post	Pre	Post	Pre	Post
F. Computer network & systems administrator	2	0	2	0	6	10	80%	100%
P. Cloud architect	7	4	0	0	3	6	100%	100%
Q. Business analyst	2	2	0	0	8	8	100%	100%
R. Cybersecurity & computer security analyst	6	2	1	0	3	8	90%	100%
S. Database administrator & architect	2	2	2	1	6	7	80%	90%
T. Forensic computer analyst	4	4	2	1	4	5	80%	90%
Overall							**88%**	**97%**

	CS		CmpE		IT		% Correct	
CS or CmpE	Pre	Post	Pre	Post	Pre	Post	Pre	Post
K. Quality Assurance/Testing	5	3	3	3	5	5	80%	80%

	CS		CmpE		IT		% Correct	
CS, CmpE, or IT	Pre	Post	Pre	Post	Pre	Post	Pre	Post
X. Computer System Analyst	5	2	2	1	6	8	*	*

Appendix E

Table E.1. Interest in computing by discipline pre and post survey responses

		CS			CmpE			IT		
Interest	Rank	Pre	Post	ΔCS	Pre	Post	ΔCmpE	Pre	Post	ΔIT
High	10	5	7	+2	2	2	-	0	3	+3
	9	7	5	-2	1	3	+2	3	3	-
Strong	7-8	11	7	-4	9	12	+3	7	5	-2
Moderate	4-6	2	4	+2	11	5	-6	8	9	+1
Low	2-3	0	1	+1	1	3	+2	3	4	+1
	1	0	1	+1	1	0	-1	4	1	-3

Table E.2. Perceived change in interest in computing as a result of the camp

	Yes	Maybe	No
b. Did your answer to Question 2 change as a result of the Summer Computing Camp?	13	6	6

Table E.3. Paired pre and post survey responses of participants who reported "No Change" in interest in computing as a result of participating in the camp

	CS			CmpE			IT		
Respondent	Pre	Post	ΔCS	Pre	Post	ΔCmpE	Pre	Post	ΔIT
1	10	10	0	4	8	4	6	6	0
2	8	8	0	5	6	1	1	5	4
3	10	-	n/a	10	10	0	1	-	n/a
4	8	8	0	7	7	0	6	6	0
5	8	8	0	7	7	0	7	10	3
6	10	10	0	3	2	-1	3	2	-1

KEY: Gold highlights highest possible interest in a field. Green highlights increased interest, while red highlights decreased interest.

Table E.4. Parts of the Camp that influenced interest in computing fields (*SCCS* Q7) by response to answer changing as a result of the Camp

Yes

IT

I am more fascinated by IT and computer engineering

Learned about IT more

I discovered that it would be a fun and easy job because at school I already help my friends with computer issues and I set up stuff in my house from outlets with USBs to servers

CmpE

Working with Raspberry Pis and doing cryptographic activities vastly increased my interest in those subjects because of how cool they are to experiment with.

I really like the hands-on stuff and computer engineering seems really fun

I didn't think about the scope of technology that computer engineers work on before this camp.

All of the hands-on activities were fun and enjoyable and the activities really increased my interest in the engineering field.

CS

I didn't know the other areas had some CS within them. CS is what I'm interested in and I learned it's apart of other things.

I didn’t really enjoy programming that much

Impact on Major

I understand the different majors better now and am considering a minor in one of the majors I was previously not interested in

Learning more about what they all are influenced my choice of major a lot.

Just made me want to join all of the fields more than before

Pretty much everything about the camp was educational about why I might not be a good fit for any computing majors.

Maybe

The camp simply made me even more interested in the fields of computer science through the time spent Python programming and listening to valuable information in each of the presentations.

The computer engineering part really made me more interested in the subject

It helps distinguish the difference between the subjects

Being able to learn the specifics of the different career opportunities

No

After learning about different types of computer engineering, I have decided to go for embedded systems engineering