Mixed Methods Study of How Computer Science Students Make Technical Elective Course Choices

Mounika Abbineni

Thesis submitted to the Faculty of the

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

Master of Science

in

Computer Science and Applications

Sara Hooshangi, Chair

Brandi A. Weiss

Jin-Hee Cho

May 6, 2025

Blacksburg, Virginia

Keywords: Elective Course, Thematic Analysis, Survey Analysis, Mixed-Methods Study.

Mixed Methods Study of How Computer Science Students Make Technical Elective Course Choices

Mounika Abbineni

(ABSTRACT)

Elective course selection is an important part of the undergraduate Computer Science learning experience. These courses often shape a student's future career along with teaching them new skills and forming their niche in the vast world of Computer Science. While computer science students in Virginia Tech have a designated checklist along with required courses that they are supposed to take, the curriculum offers them a set of technical electives where they are able to learn topics of interest in the vast field of Computer Science. By the time of graduation most Computer Science students have taken about three or four elective courses, where they are able to explore their interests and strengths in Computer Science.

This mixed-methods study utilized responses from undergraduate, graduate, and recent alumni from Computer Science, Computer Engineering, and Data Analytics majors at Tech. For the qualitative analysis, a thematic analysis was done from 14 student interviews. A quantitative analysis was performed through survey responses. A statistical analysis of survey responses was done in order to analyze the data and make conclusions on the factors that influence student choices of CS electives. It was observed that as students gain more exposure, they approach elective decisions with a focus on the impact of their career and the utility it offers. Students consistently prioritized taking courses that built their skill set and added value to their career goals. The only gender difference found in how students choose electives was in how important course format factors were, like class timing, modality, and grade distribution. Secondly, students in different years of study prioritized the value of

professor-related and course format factors differently in their elective choices. This research aims to help young students find their grounding coming into college so they are aware of how to make better course choices. It also aims to introduce better academic advising strategies and curriculum development such that a students' experiences are better in college with easier transition into a successful and enjoyable work life.

Mixed Methods Study of How Computer Science Students Make Technical Elective Course Choices

Mounika Abbineni

(GENERAL AUDIENCE ABSTRACT)

Taking Computer Science elective courses is part of the degree requirement of Virginia Tech CS students. These electives are specialized courses where students are allowed to choose from a list of approved classes. These electives give a chance for students to explore topics of interest outside of the core curriculum courses they must take. These electives range in a variety of areas such as cybersecurity, human-computer interaction, software engineering, and data analytics. However, many students make these choices based on limited guidance and knowledge. This research aims to bridge this gap such that students are able to make better choices, advisors able to give better guidance, and professors able to design more beneficial courses for a student to gain technical knowledge into industry advancement.

This study utilized a combination of student interviews and survey analysis of undergraduate and alumni students primarily from Virginia Tech in order to understand what factors influence CS students elective course choices. It was found that while students do heed to schedule compatibility and degree requirements, skills offered in electives and career alignment goals were the most important in shaping a student's elective course decisions. Students often consulted their peers for elective recommendations and reviews. They also placed a higher enjoyment level on courses that were taken with peers. Another factor that was important was a student's postgraduate interests, which they formed and tried to be more prepared for through their elective course selections.

Acknowledgments

I would like to sincerely thank my advisor, Dr. Hooshangi, for her invaluable guidance and expertise throughout this process. Her support has been instrumental, and I am deeply grateful for her mentorship.

I would like to thank Dr. Weiss for her support, guidance, and technical expertise in survey design and analysis of quantitative data. It has been a privilege to have her on my committee.

I would like to thank Dr. Cho for her support, guidance, and dedication as a committee member. It has been a privilege to have her on my committee.

I would like to thank the small group of peers I personally contacted who were generous with their time in participating in the interviews and survey.

Last but not least I would like to thank my family for their encouragement, belief, and unwavering support, without whom this journey would not be possible.

Contents

List of Figures

List of Tables

Chapter 1

Introduction

1.1 Motivation

The motivation behind this study includes guiding students to make more informed choices regarding Computer Science elective courses. As an undergraduate student in Computational Modeling and Data Analytics with a minor in Computer Science, like many other students, I came in with little background and knowledge of the CS field. Through the help of my advisors, peers, and professors, I was able to navigate the challenges of the degree along with what courses would be beneficial for me. I remember relying on my advisor's recommendation during the initial two years in order to gain her expertise on what courses were fun, beneficial, and interesting. I also heavily relied on my peers in order to understand what courses to take as well as have company in taking these courses. Through the understanding of how CS students make elective course choices, not only will new CS students gain advice on how to make choices, but it will also help instructors and advisors better understand the challenges that students face with these choices.

1.2 Objective

The objective of this study involves gaining an understanding of how undergraduate Computer Science students make elective course choices. By understanding this decision-making process, this research aims to provide valuable insights for new CS students navigating

course selection, particularly those with limited background in the field. Additionally, the study seeks to highlight the motivation some courses offer versus others to help professors understand how to better their course structure and teaching methods.

1.3 Research Questions

RQ1. What factors influence CS major's elective choices?

RQ2. Does the CS elective course choice influence interests or future plans?

RQ3. Are there any obvious differences between certain groups of students: female vs male students or different years of study?

Chapter 2

Review of Literature

Research has shown that students in STEM majors make elective course choices based upon market trends, technical skills that are in demand, as well as the course perception in terms of the instructor and difficulty [5, 12]. Still, there is a lot of emphasis given on graduation requirements and course logistics, which makes elective courses all the more important where students are able to take an initiative for their own learning [12, 17, 26, 46]. Historically, there has been a significant under-representation of women in technology-related majors. This disparity is largely influenced by societal perceptions of tech careers and the stereotypes surrounding the professionals in the field. Elective courses play a crucial role in promoting diversity and inclusion within computer science. Colleges that offer specialized electives in areas like ethical computing, human-computer interaction, and social impact applications can attract more women and students who may not be drawn to the highly technical aspects of Computer Science. [4, 32, 36, 38, 44] They can do so by showcasing the broader real-world applications of computer science beyond conventional coding roles.

For this study, a series of existing literature was reviewed to gain a comprehensive understanding of previous studies on elective course choices among CS students. This included examining the methodologies used, the influence of gender, the role of group work in decision making, and the factors affecting students' intention to major in CS. Identifying these aspects helped contextualize this study, refine research questions, and identify relevant theories and methodologies. It also helped identify patterns, gaps, and trends in elective course choices, strengthening the study's significance and guiding its research design.

In "How CS Undergraduates Make Course Choices" 33 interviews are conducted with undergraduate CS students from Georgia Tech, Duke University, and Spelman College [25]. CS undergraduate students make course choices based on three main behaviors that evolve over their time at a four-year college degree. These include "exploration, enjoyment triggers, and long-term goals" [25]. This describes the process that a CS student goes through in their 4-year college degrees. They come in with the intention to explore their interests and with little knowledge about CS. As a result, they take courses in order to learn more about their strengths and weaknesses. The second phase is recognizing enjoyment triggers. As students take more CS courses, they come to understand what topics they enjoy versus what topics they dread. Students then seek to make more informed choices, where they view enjoyment of classes as a useful measure of whether they would take a course or not. Lastly, there is the factor of making educational decisions based on long-term goals. By junior and senior year, students often have an idea of what kind of career they want to build. They base their course choices on what will be most beneficial to their career. This study helped understand our research in terms of how students' learn through CS experiences and what role their career goals play in elective choices.

In "Understanding CS Undergraduate Students' Professional Identity through the Lens of Their Professional Development," 14 semi-structured interviews were conducted to understand how US college CS undergraduate students form their continued interest in Computer Science [29]. Students' professional identity forms in the sophomore and junior years through focused coursework such as electives and through engagement with the "broader CS community" [29]. The broader CS community consists of hackathons, CS groups, and other career development opportunities.

Some students conveyed that coursework was important in understanding their strengths and weaknesses in the CS field, evaluating their ability in a discipline, and career goals [29]. Others stated that coursework either had a limited impact on professional goals or a negative impact, causing them to drop out of CS. A few students expressed that the addition of a CS

introductory course in freshmen year, that introduces students to the different disciplines in CS, would be beneficial.

Additionally, a student's professional network had an impact on their intention to major and on the courses they took. While peers and family encouraged them to major in CS, more focused advice from industry professionals, peers, and advisors pushed them towards specific courses to take [29]. Professional development activities such as hackathons, internships, and research groups enabled students to make informed future career decisions. Another student talked about how a computing conference taught her about the field of human-computer interaction and served as an 'eye-opener' for her [29]. Overall this paper helped explain the impact of college courses and CS exposure on students' careers.

One key area of research has examined the impact of curriculum design and institutional policies on elective course selection. Studies indicate that the structure and availability of electives play a crucial role in students' choices, with limited offerings or prerequisite constraints often shaping their decisions [41]. Additionally, the perception of course difficulty and expected workload has been identified as a determinant of course selection, with students often opting for electives that they perceive as manageable or beneficial to their GPA [54].

In the "The Impact of CS for All on College Placement in Computer Science" the CS For All governmental initiative is explored and how giving CS exposure for all students K-12 can affect college students [20] . The paper introduces three students' experiences from high school to college in CS and it mentions how high school CS credit is often taken into consideration for introductory CS courses. This gives students' with prior CS exposure to have an upper hand in terms of being able to take fewer courses or have a preliminary knowledge that makes the learning curve shorter. It was interesting to note that this initiative is expected to lower the historically marginalized group of students, such as females, people of Black ethnicity, and Latinx students, who are overshadowed by the "predominantly white male culture in CS" [31]. A teaching professor from Rutgers talked about how the non-

majors CS courses reflected diversity, CS courses for majors was lagging in this diversity, even more so in secondary level CS courses. It is interesting to see if there is a difference in Elective courses and if topics see more diversity or not.

The impact of peer recommendations is seen in elective course choices [33]. Previous research presents that students consult their friends, classmates, and advisors in order to get a better understanding of a course's difficulty, the content's usefulness, and professor's practices in terms of grading, difficulty, and teaching style [10, 30, 53]. Often times, there isn't much insight into a course just by it's description or syllabus. As a result, students rely on their peers to decide whether to enroll in a course or not [45]. This is first-hand information of a particular course's experience that influences a student's decision to take it or stay away from it [33].

While the influence of family is limited in terms of elective course selection, some research shows how students who have families with strong technical backgrounds in their field do indeed receive guidance on electives based on career advantages it may give [6]. Nevertheless, this advice is used in the preliminary stages of a student's college degree. As students gain more exposure and experience, they take responsibility and autonomy for their own learning and make decisions they think are best for themselves.

The paper "Factors Affecting Selection of Elective Courses: The Use of Multi-Criteria Decision Making Model" [30] aims to provide a mathematical model for student decision-making. Selecting elective courses is a tough decision with many variables for students to consider. Five main criteria, course schedule, teaching staff, course content, course requirements, and friend-environment factor, were identified as essential factors in student elective course selection, along with 12-sub criteria for these main factors [30]. To assess the prioritization of these factors, an online questionnaire was implemented [30]. Overall, the course schedule had the highest priority weight, followed by teaching staff and course content being equal, the friend-environment factor, and the last course requirement.

Transitioning from a high school environment where students may not have elective course selection responsibilities or have a more guided and informed process, college students can make use of this tool for an easier transition. This study shows that graduate students gave the most importance to course schedules and, more specifically, class timing and schedule in their curriculum. Nevertheless, other closely important factors include the professor's teaching style and relationship with the instructor, as well as the application of the course to students' careers.

In "Using Social Cognitive Career Theory to Understand Why Students Choose to Study Computer Science," [1] the authors talk about how there is a rise in demand for CS graduates, highlighting the under-representation of women in the field. The Social Cognitive Career Theory (SCCT) was utilized to understand factors that affect a student's decision to major in CS [1]. The aim of this study is to understand what these influences are and, in turn, to help increase female representation in CS majors. SCCT constitutes of four features: prior experience, social support, self-efficacy, and outcome expectation in order to understand career and academic choices [1]. Through 17 interviews conducted with present students in Scotland universities, this study found that social support of friends, family, peers, and mentors was significant in choosing to pursue CS as a major, particularly for female students [1]. For instance, many CS students stated how immediate or extended family suggested studying CS and explaining its benefits created a positive impact. Another important factor included job prospects after graduating from CS. Students talked about how a degree in CS would help them get a job early on. Students chose to study CS rather than their favorite school subjects because of the promising career it offered. This paper helped understand students' motivations in Computer Science.

Students who choose to major in CS often do so with the intention to pursue successful careers post-graduation [51]. As a result, students want their undergraduate education to prepare them for this step. As a result, they make elective course choices that will give them exposure to technologies and tools that are important for their aspired role. CS is a vast

field with many sub-fields, and it is not necessary that all students have a focused plan as to what they want to do in the field after graduation. Therefore, some students take electives in order to explore their interests and strengths. Taking specific elective courses can influence a student's long-term career interest and guide them towards what they want to do with their college degree [51].

To get a broader understanding of dissatisfaction in CS, "Applying Data Analysis to Identify Early Indicators for Potential Risk of Dropout in CS Students" was read [3]. The researchers studied the performance data of students who either graduated or dropped out of CS from the years 2006-2014 [3]. The dataset included information on students' sociodemographic status, secondary education, and the grades of students from each semester [3]. Patterns were studied among students who dropped out to identify early indicators. After identifying the dropout points of students, specifically what courses played a part, the specific modules and exams of that course were looked into. The findings reveal that early academic struggles, particularly low grades in foundational courses, are strong indicators of potential dropout [3]. Additionally, students with low attendance, missing assignments, and low interaction with learning platforms were more likely to fall behind in the program [3]. The study suggests that universities could use predictive models to identify students at dropout risk early and provide targeted academic support [3]. It was helpful to see how foundational CS courses impacted continued interest in CS.

In "Modeling Women's Elective Choices in Computing," some of the key findings included that courses in human-computer interaction, societal impacts of computing, ethics, professionalism, and mathematical and statistical foundations were more appealing to women [4]. This tells us how courses that had social interaction and less coding-heavy were appealing to women. On the other hand, subjects such as fundamentals of programming languages and parallel and distributed computing had lower enrollment rates, in general, [4]. This study is vital because understanding these preferences can help computer science departments tailor their elective offerings to better meet the interests of women, potentially reducing the gender

gap in computing.

A study was conducted in 2008 about women with STEM degrees who now work in corporate and what their career paths have been like post-graduation [24]. This study was sponsored by 43 companies, such as Cisco, Johnson & Johnson, Microsoft, and Pfizer. This study used four surveys of both men and women ranging from people in Geneva to Hong Kong and New Jersey. The intention was to understand what initiatives could help women in STEM in terms of modifying corporate culture initiatives or ways to help improve career paths for women to ease into the transition from school to corporate careers. Notably, two-thirds of women scientists chose to pursue this career path to contribute to the betterment of society. Nevertheless, it was seen that a little over half of STEM career women quit their corporate jobs because of stressful job environments. Some of the factors that cause these include hostile macho culture, isolation, unstructured career paths, and risk-rewarded systems. It was reported that 63% of women experienced sexual harassment, 45% of women felt like they were missing mentors or people who could guide them, 40% thought that they were at a roadblock in their career, and 35% had difficulty with risk. These hardships caused women to be disheartened at the workplace and contributed to quitting their jobs. These statistics helped companies come up with initiatives that ranged from Cisco's "Executive Talent Insertion Program," which sought to address women's isolation at the workplace, and Johnson & Johnson's "Crossing the Finish Line," which were designed to help young, multicultural women set a path to senior management [24].

These findings were used as a basis to learn of methodologies used in educational research and understand factors that affect CS students' intention to major and their course and career choices. This study combines qualitative insights from interviews with survey-based quantitative data to understand how CS students navigate elective course selection and their broader career plans.

Chapter 3

Methodology

3.1 Mixed Methods

This study employs a mixed-methods research design to explore the factors influencing elective course selection among undergraduate and alumni CS students. The primary data collection method involved semi-structured interviews, complemented by a survey to provide quantitative validation of the identified themes. Conducting qualitative analysis through student interviews provided a deep understanding of the thought process behind student elective course selections, their experiences, and future plans. On the other hand, the quantitative analysis through a survey resulted in generalized findings to a larger population. This method results in triangulation, which enables research findings to have better validation and credibility through the checking of concurrent results from one method to the next.

All research has its set of limitations; however, showcasing multiple research methods can help mitigate those limitations. The qualitative data in this study was used to get an understanding of how students make elective course selections and what their motivations are. Building off the important criteria, a quantitative survey was used in order to understand the sub-criteria of these factors and how they rank against one another. We also observed if the ranking of factors influencing course choices differed based on gender or age group.

3.2 Qualitative Study

3.2.1 Questionnaire

The first form of data collection involved conducting interviews over Zoom that went over student experiences in CS electives. In order to conduct these student interviews, a short questionnaire was designed. This questionnaire consisted of about 12 questions that went over student elective course choices in CS, experiences in the courses, and future plans within CS. Based on each student's path, there were follow up questions asked. This allowed us to get better insight into each student's path and why they made the choices they did.

3.2.2 Procedure and Participants

Participants were recruited through a school-posted flier and peer networks to ensure a diverse range of experiences and perspectives. In order to provide an incentive, a $20 Amazon gift card was promised. The Google Form link was distributed through the creation of a flier, which was posted in Virginia Tech's CS lounge, a space where CS students of all years gather for office hours, study groups, and independent study. Additionally, the flier was included in the weekly CS Newsletter, which is sent to all CS students at VT. Of the 25 students who signed up, 15 were selected for interviews based on a balanced mix of gender, academic year, and diversity in elective course selection. Of these 15 students, there were eight current undergraduate students, five undergraduate alumni, and one graduate student.

3.2.3 Interviews

The study utilized semi-structured interviews, allowing for an in-depth exploration of students' elective course selection experiences. The interview protocol included open-ended questions covering logistical considerations, peer and family influence, course perceptions,

high school experiences, collaborative learning, and post-graduation aspirations. Interviews were conducted via Zoom video conferencing, recorded with participant consent, and transcribed for analysis.

3.2.4 Thematic Analysis

A thematic analysis approach was employed to analyze the interview data. The transcriptions were systematically coded to identify recurring themes and patterns. Codes were iteratively refined through multiple rounds of analysis to ensure accuracy and consistency. The thematic findings were then categorized under 7 key factors, including logistics, peer influence, family influence, course perceptions, high school experiences, collaborative learning, and post-graduation interests/experiences.

3.3 Quantitative Study

Once the themes were identified from the interviews, and a thematic analysis was written, the next step was using the results to design a survey. The survey utilized a Likert-type format to assess the significance of various factors in elective course selection. In order to have better expertise, a survey methodologist was contacted. She was able to contribute to the survey design, questions, and structure such that to ensure a clear, well designed survey. This mixed-methods approach enhanced the validity of findings by combining qualitative insights with quantitative measures.

3.3.1 Motivation

In order to get a better understanding of survey research surrounding student choices and motivations, insights were drawn from existing literature [19, 27]. These studies examined

using survey research in order to study factors that influence student choices when selecting elective courses and when making college decisions. The papers reviewed provided valuable guidance on how surveys are designed, distributed, and utilized to draw conclusions. Lastly, it reinforced the effectiveness of surveys as a tool for capturing nuanced decision-making data.

3.3.2 Procedure

After examining the thematic analysis and findings through the student interviews 4, sets of 10 questions were developed for each theme, resulting in a total of 70 questions. These included both Likert-type and open-ended questions, designed to explore topics course selection logistics, family and peer influence, the impact of group work, high school experiences, and long-term plans in CS. In order to gain feedback on the questions and their relevance, these questions were integrated into QuestionPro and a series of modifications were done based on an exert panel review.

Expert Panel Review

The initial draft of the survey was initially reviewed by two undergraduate CS alumni, currently working full-time, to review and provide feedback. As they had experienced the CS elective course process and were currently working full time, their feedback helped evaluate the relevance and clarity of questions related to CS electives and postgraduate experiences. After incorporating the suggestions they had, a survey analysis and quantitative methodologist was contacted for expert review. Through multiple meetings, the survey was revised to better align with the core objectives of the research. This was an iterative process, where after each round of expert feedback, the survey was updated in QuestionPro and re-evaluated by the two alumni for final suggestions. While the survey started off with 70 questions, many were eliminated and modified in order to ask the most relevant and useful questions

for this research. This process resulted in 29 final questions. This process was integral to the creation of the survey instrument and it took about three months before the survey was ready. Once finalized, the survey was deployed via email to CS graduate and undergraduate students, shared with a CS undergraduate class, and distributed to a selected group of close contacts of CS alumni and undergraduate students.

Participants

A total of 167 responses were collected from the student survey, with 98 complete responses. These 98 students answered all the questions in the survey. Of the 98 responses, 79 were from Virginia Tech students and 19 were from students at other institutions. This broader sampling approach was intended to enhance the applicability and generalizability of the findings, as well as to increase the overall volume of student data. There were about 69 students who partially answered the survey, and responses to questions were still valuable and used for the purpose of the data analysis. Next, checks for duplicate values using QuestionPro's duplicate entry column and based on response ID, IP address, and email address was done. These checks didn't result in any entries being eliminated. There was one student who was not 18 years or older and their response was thus eliminated. At the end, 97 complete responses and 70 partial responses were retained and used for the purpose of the data analysis.

3.3.3 Measures

The survey explored four constructs: Collaborative Learning, Peer Influence, Logistics, and Post-graduation Interests. In the end there were demographic questions and two open-ended questions asked. Each construct consisted of items or survey-questions aimed to delve deeper into student elective choices and future plans in CS.

An important survey question was asked in relation to Logistics: When choosing CS elective courses, how likely are you to consider the following? A set of 16 items were given for this question and students were asked to rate the items on a scale of 1-5 (1=Very Unlikely, 5 Very Likely). A Mann-Whitney U and Kruskal-Wallis test were done on Gender and Year of Study to see its effects on the CS elective course decision-making process.

In the following section a diagram of the survey design process and the survey instrument are displayed.

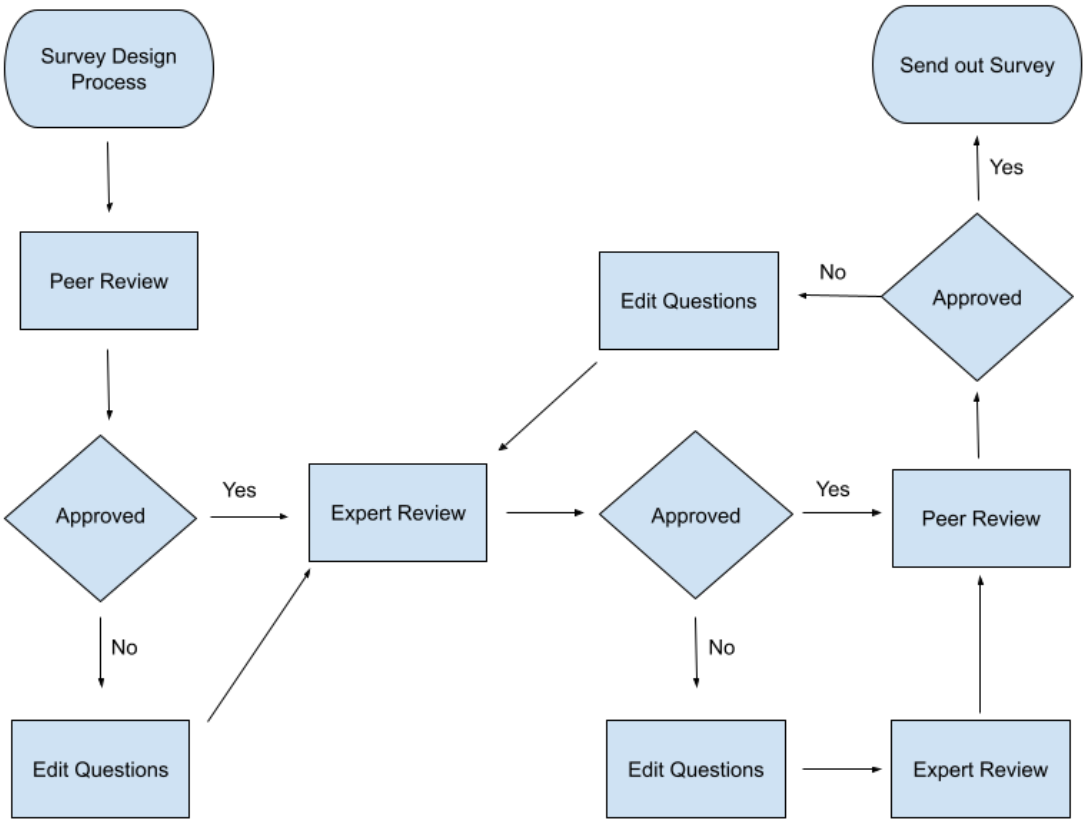

Figure 3.1: Survey Design Flowchart

Hello,
You are invited to participate in our survey to explore students' choice of elective courses and group work. In this study, students will be asked to complete a survey that asks questions about their experiences with group work, elective courses and other related topics. It will take approximately 10 minutes to complete the questionnaire. Your participation in this study is completely voluntary. There are no foreseeable risks associated with this project. However, if you feel uncomfortable answering any questions, you can withdraw from the survey at any point. Your survey responses will be confidential and data from this research will be reported only in the aggregate. If you have questions at any time about the survey or the procedures, you may contact Dr. Sara Hooshangi (shoosh@vt.edu).

You will be placed in a draw for several $15 Amazon gift cards, if you complete the entire survey, provide your email address at the end and submit the survey. This study is under IRB # 23-1060.

If you would like to participate in this survey, and you are currently 18 years of age or older, click YES to begin or NO to exit

- ◯ Yes
- ◯ No

* Thinking about your CS elective courses, how often did/do you participate in group work?

- ◯ Rarely
- ◯ Occasionally
- ◯ Sometimes
- ◯ Often
- ◯ Frequently

---

* When working in a group on coding projects, how often do the following outcomes occur?
(NA=I have never worked in groups on coding projects)

	Rarely	Occasionally	Sometimes	Often	Frequently	NA
Improving coding skills	◯	◯	◯	◯	◯	◯
Learning from peers	◯	◯	◯	◯	◯	◯
Preparing for the workplace	◯	◯	◯	◯	◯	◯

---

*

How beneficial do you find collaborative group work for your academic development?

- ◯ Not beneficial
- ◯ Somewhat beneficial
- ◯ Neutral
- ◯ Quite beneficial
- ◯ Extremely beneficial

---

* How beneficial has group work been in developing skills needed for transitioning into a professional environment (job/internship)?

- ◯ Not beneficial
- ◯ Somewhat beneficial
- ◯ Neutral
- ◯ Quite beneficial
- ◯ Extremely beneficial

* Have you ever had a negative experience during group work that impacted your overall learning? If yes, please describe the situation.

- ◯ Yes
- ◯ No

Please explain:

* When addressing conflicts within your group, how likely are you to utilize each of the following conflict resolution strategies?

	Very Unlikely	Unlikely	Neutral	Likely	Very Likely
Ignoring the conflict	◯	◯	◯	◯	◯
Communicating openly	◯	◯	◯	◯	◯
Dividing tasks	◯	◯	◯	◯	◯
Allowing peers to take the lead	◯	◯	◯	◯	◯
Taking the lead yourself	◯	◯	◯	◯	◯
Talking to the professor	◯	◯	◯	◯	◯

* When given the option, how likely are you to work in groups with friends?

- Very Unlikely
- Unlikely
- Neutral
- Likely
- Very Likely

* When working with friends, how often have you found that course group work strained your relationships?

- Rarely
- Occasionally
- Sometimes
- Often
- Frequently

* When choosing elective courses, how likely are you to consider peer input for each of the following?

	Very Unlikely,	Unlikely	Neutral	Likely	Very Likely
Taking a specific course					
Content difficulty level					
Professor difficulty level					
Quality of instruction					
Course workload					
Peers are also taking it					

* To what extent do you rely on peers' recommendations versus your own

preferences when selecting courses?

- ◯ Rely primarily on others
- ◯ Equal balance between peers' and personal preferences
- ◯ Rely primarily on personal preferences

---

* Do you think your friends' success or struggles in a course impact your decision to enroll in that course?

- ◯ Yes, significantly
- ◯ Somewhat
- ◯ Not really

* Do you believe taking a course with friends improves your performance or enjoyment in the class? Why or why not?

- ◯ Yes
- ◯ No

Please explain briefly

Please explain briefly

* When choosing CS elective courses, how likely are you to consider the following?

	Very Unlikely	Unlikely	Neutral	Likely	Very Likely

Professor likeability	○	○	○	○	○
Professor stature (reputation, fame,etc)	○	○	○	○	○
Professor's style of teaching	○	○	○	○	○
Availability of resources for the course (e.g., professor's flexibility of office hours or TA support)	○	○	○	○	○
Personal passion or curiosity about the content	○	○	○	○	○
Content aligns with your career goals	○	○	○	○	○
Content includes specific skills you want to acquire	○	○	○	○	○
Content contributes to the breadth of your CS toolbox	○	○	○	○	○
The timing of the course fits into your schedule	○	○	○	○	○
Course modality (online, F2F, hybrid)	○	○	○	○	○
	Very Unlikely	Unlikely	Neutral	Likely	Very Likely
Class size (small or large)	○	○	○	○	○
Format (e.g., lecture, discussion-based, hands-on, labs)	○	○	○	○	○
Course assessments/structure (e.g., you hate tests, so you take a course because it has projects instead of tests)	○	○	○	○	○
The course provides exposure to industry or external entities	○	○	○	○	○
Fulfills a core elective requirement	○	○	○	○	○
Prerequisite for another course	○	○	○	○	○
Grade distribution of previous offerings of the course	○	○	○	○	○

* What are your current plans after graduation?

- [ ] Enter the workforce
- [ ] Pursue a graduate degree (e.g. Masters, PhD)
- [ ] Freelance
- [ ] Other

* If you plan to enter the workforce immediately after graduation, do you plan to pursue further studies (e.g., grad school) later in your career?

- ◯ Yes
- ◯ No
- ◯ Maybe

* Do you prefer gaining industry experience before pursuing further academic studies? Why or why not?

- ◯ Yes
- ◯ No
- ◯ Maybe

Please explain briefly

Please explain briefly

Please explain briefly

* On a scale of 1-5, to what extent has your college experience (courses, internships, etc.) influenced your post-graduation goals?

- ○ Not at all
- ○ To a small extent
- ○ To some extent
- ○ To a great extent
- ○ To a very great extent

* Which industry sectors are you most interested in working in after graduation?

- ☐ Technology (e.g., software, data science, AI, cyber)
- ☐ Finance
- ☐ Healthcare/Biotech
- ☐ Consulting
- ☐ Other

* If staying in the tech field, which area of study or career do you plan to focus on post-graduation?

- ☐ Data Science
- ☐ AI/Machine Learning
- ☐ Software Engineering
- ☐ Cybersecurity
- ☐ I plan to leave the tech field
- ☐ Other

* How beneficial do you believe each of the following skills or experiences will be for your future career?

	Not beneficial	Somewhat beneficial,	Neutral	Quite beneficial	Extremely beneficial
Technical skills (e.g., coding, AI, data science)	◯	◯	◯	◯	◯
Soft skills (e.g., communication, teamwork)	◯	◯	◯	◯	◯
Industry exposure (e.g., internships, capstone projects)	◯	◯	◯	◯	◯

* How do you plan to stay adaptable and navigate potential career changes in the future?

- ☐ Continuous learning
- ☐ Networking with professionals
- ☐ Attending conferences or workshops
- ☐ Other

Explain

* Please select your gender

- ◯ Male
- ◯ Female
- ◯ Other
- ◯ Prefer not to say

* What is your year of study?

- ◯ Freshman
- ◯ Sophomore
- ◯ Junior
- ◯ Senior
- ◯ Grad Student
- ◯ Alumni
- ◯ Prefer not to say

* What is your student status?

- ◯ Full-time
- ◯ Part-time
- ◯ Graduated
- ◯ Other

* What is your major?

- ◯ Computer Science
- ◯ Computer Engineering
- ◯ Computational Modeling and Data Analytics
- ◯ Data Science
- ◯ Other

* How do you pay for college?

- ○ Self
- ○ Parents/Family
- ○ Scholarship
- ○ Combination
- ○ Prefer not to say

If you would like to participate in our several draws to win a $15 Amazon Gift card, please enter your email below

Which CS electives have provided the most valuable experiences, and why?

What changes would you suggest to improve experiences in your CS elective courses?

Chapter 4

Qualitative Results and Discussion

In this chapter, we explore a detailed explanation of the themes identified from the interviews. The first step of this process was the coding of the interviews. This involved looking at the interview transcripts and breaking them down into smaller parts so as to assign sentences or smaller sections into a "code" or label. The open coding method was utilized, where chunks of data were assigned codes without predefined categories. After refining the codes two or three times, when patterns were found, they were grouped into themes. as the first step. Through this process seven distinct themes were identified from the interviews.

A short thematic analysis was done of open ended questions that students were asked regarding electives they found valuable at Virginia Tech and suggestions they had to improve their overall CS experiences in elective courses.

4.1 Theme 1: Logistics

Selecting elective course choices depends on a range of factors, from interest to professors to peers. In this also lies the practicality of taking a course which involves the credit requirements, fitting it into a schedule, and course difficulty level. Some students chose streamlined paths within CS which which enabled their electives to be chosen for them. For instance Student 1 made the decision to choose the HCI path, which made most of their elective course choices pertain to this area without much choice to explore other electives.

"I didn't have much of a choice. I was on the HCI path and that decides almost

all of your electives for you. When you're in the human computer interaction track, you have to take intra HCI for the minor to get into the capstone, you have to take GUI. It literally only left me a 4,000 level elective, and I was already involved in research. For me, I didn't make a single decision in regards to my electives, it was basically decided for me." - Student 1

Many students were not as aware in terms of what their specific interests in CS were. In this case they relied on other factors such as the grade distribution, course difficulty, or fitting courses into their schedule. Students understood that their interest in a course was important but also understood the value of a well balanced schedule. This would help them perform better and enjoy their classes.

"The time the class was offered was important because I wanted to make sure that it fit in my schedule properly without me having to stress out if it's too close to [the next] class." -Student 13

4.2 Theme 2: Peer Influence

The majority of interactions a student has is with their friends. Consequently, students consulted their peers in order to get a better picture of whether a course would be of interest to them. This peer network consisted of friends, seniors, alumini, and advisors.

[friends] can give me first hand experience and insights on how the classes [are] because sometimes classes might not be super high in the GPA distribution, but that could just be that the content is difficult, but the overall instruction is okay."
-Student 6

Similarly, if a student heard negative reviews from peers about a professor, they avoided taking the section of a course with that professor. Websites like Reddit and *RateMyProfessor*

were used in order to see other student's anonymous reviews and scaled ratings of professors and courses from their university.

Taking courses with friends was seen to be influential for students in terms of doing well and enjoying it.

> *"I like to take courses along with friends as it becomes fun and approachable." -Student 8*

Nevertheless, students mentioned how while they did value taking peer recommendations for courses and having peers in their classes, it wasn't the most important factor. Students were still focused on taking courses that were of interest to them and ones that would benefit their career goals.

> *"Friends recommendation is important but not to a very great extent. I'm not going to change courses based on friends being in them." -Student 12*

This sentiment of enjoying working alongside peers was resonated by other students who voiced out the importance of group work in terms of collaborating on homework assignments as well as working on projects. In some cases students adjusted their schedules to match thier friends'. However, some students voiced out that they preferred not to work with friends on projects for a grade. They mentioned how it was tricky to manage the friendship and work as they felt obligated to be nicer or less direct when a group member wasn't working according to expectation. This would complicate the dynamic, and students were working harder to save their friendship. These students said that while they liked to take courses with friends, they preferred working in groups with classmates they didn't know.

4.3 Theme 3: Family Influence

Students were asked how their families influenced their course choices. The consensus was that while their family did not affect their course choices, some students mentioned how they had an influence on their intention to major in computer science. In fact seven out of the fourteen students that were interviewed mentioned that their family and childhood impacted their decision to major in CS. These students talked about how their parents were instrumental in guiding their educational choices. When asked how their family influenced thier deciison to major in CS or their course choices.

> "*Family played a major role when choosing the path, which was computer science in my case. The electives, not so much. I mean, once I stepped into Virginia Tech, I was pretty much in control of my decisions when it [came] to [what] courses I'm going to take.*" *-Student 14*

In these cases, family influence was substantial, suggesting that for some students, family members actively encouraged or supported the decision to pursue a CS major. Another theme is how early childhood exposure to computer science concepts, facilitated by family members, shaped the intention to major in CS. One participant mentioned that their father introduced them to Scratch, a programming language for kids, which helped introduce then to the world of CS and helped pave their path in hindsight.

> *"[My dad] never really told me explicitly, like, I should do computer science. But like one time when I was in elementary school, he introduced me to, like, Scratch, which is a drag and drop programming language for kids. But overall, he kind of just let me do my own thing. But I do think that having the influence of a dad who was in the STEM field helped me to kind of gravitate towards that area." -Student 6*

Overall, while several participants noted that their families had little to no impact on their elective choices within CS, they did on their choice to major, indicating a distinction between the broader decision to pursue CS and the specific courses chosen.

4.4 Theme 4: CS Course Perception

A recurring theme is the strong correlation between course enjoyment and further interest in related topics. Students who found particular courses engaging were often inspired to explore those fields further, while those who did not enjoy certain courses were dissuaded from pursuing related paths.

> *"I thoroughly enjoyed the Data Analytics and Visualization class. [The professor] presented material well and engagement was present in class." -Student 6*

This interest was carried over to this student's career as well where they formed an interest towards data science and saw themselves wanting to pursue a career in this field despite coming from Computer Science.

Conversely, negative experiences in CS courses steered students away from certain topics or fields. When asked why they chose the electives they did, These experiences were still important in allowing students to know what aspects of CS they disliked and would not pursue in the future.

> *"I chose Cloud Software Development last semester because I initially thought it was going to be a bit easier of a course and it fit my schedule. But it turned out to be like probably the worst course I've taken at Tech so far." -Student 5*

When asked about their future career interests, they said Data Science despite coming from Computer Science and not having much exposure to Data Science.

"Well, I definitely decided not to do cloud software development because of that elective. I decided not to choose that path because of how difficult the content was. But mostly it was because of the job outlook and the growth rate of that industry." -Student 5

In these cases, students expressed a desire to avoid further exploration in areas they found challenging, unengaging, or irrelevant to their career interests. The difficulty of certain technical courses, poor course design, or a mismatch between course content and expectations led to disinterest in continuing those subjects. For some students, taking diverse courses allowed them to explore different areas of CS and discover what they were passionate about. This exploratory mindset led to the discovery of new interests, such as AI, data analytics, or HCI, and was instrumental in shaping students' future academic and career paths. Exposure to various sub-fields gave students the opportunity to refine their focus based on what resonated with them.

"I didn't really know which concentration I wanted to pursue after my graduation, or what kind of job I wanted to do in computer science. So that's why I tried to include courses that were different in the sense they covered different areas of computer science. For example, one of the courses that I took was data and visualization, just to cover the data analytics part and the data science part of computer science. Then one other course that I took was introduction to human computer interaction. For me [elective course selection] was more of exploring different fields within computer science." -Student 13

4.5 Theme 5: High School Experiences

High school experiences were found to significantly influence students' decisions to major in computer science. Many of the students interviewed reflected on how their early exposure to

the field during high school shaped their academic interests and career trajectories. Several students pointed to specific courses, extracurricular activities, or impactful teachers that played pivotal roles in guiding them toward this path. For instance, many students credited taking Advanced Placement (AP) Computer Science as a critical factor in their decision-making process. These rigorous courses not only introduced them to core programming concepts but also helped demystify the complexities of coding, giving them the confidence to pursue computer science at the collegiate level. Students mentioned their enjoyment in AP CS led to their decision to pursue Computer Science.

In addition to structured courses and extracurricular activities, several students highlighted the influence of passionate high school teachers who encouraged them to explore technology further. These teachers, through their mentorship and enthusiasm, provided students with the motivation and foundational skills necessary to continue their studies in computer science at the university level. For instance Student 1 talked about how his AP CS teacher made an impact on his interest in the field.

> *"For [my] decision to major in computer science, I think that I had one teacher in high school. The APCS teacher real shock. A main reason as to why I decided to choose CS is because he taught it to me in a way that I understood. Beyond that, I was also in robotics club in high school." -Student 1*

Whether through one-on-one guidance or school clubs that challenged students' creativity, these high school experiences played a key role in instilling both technical knowledge and a belief in the students' abilities to succeed in the field.

Overall, a student's high school not only helped them build confidence but also fostered a strong sense of purpose and direction, laying the groundwork for their pursuit of a computer science major in college.

4.6 Theme 6: Collaborative Learning Value

The value of group work among students yielded a range of perspectives, reflecting both the benefits and challenges it presents. When asked, several students mentioned that group work made learning more engaging and was beneficial for their academic and personal development. For instance, Student 14 highlighted how working in groups helped him transition smoothly into a professional environment.

> *"Being in the industry for a year now, coding in groups is good preparation for the workplace," emphasizing the relevance of collaborative coding in real-world scenarios.* *-Student 14*

The student reflected on their personal experience, highlighting the importance of collaborative coding in real-world settings. They applied the soft skills developed through CS class projects and office hours to their code review meetings at their full-time job, where they found these skills to be invaluable.

However, not all students shared the same enthusiasm for group work. Some cited negative experiences, particularly when group dynamics became strained under the pressure of demanding courses. For example, courses like 3114, known for their intensity, were mentioned as environments where friendships were tested. The difficulty arose when peers were reluctant to hold each other accountable, making it challenging to balance personal relationships with academic responsibilities. Student 12 noted that "doing group projects with friends ruins friendships due to different work ethics," pointing to the friction that can occur when team members have varying levels of commitment and dedication. This underscores the complexity of group work, where the line between maintaining friendships and ensuring fair contribution can sometimes blur.

4.7 Theme 7: Post Graduation Interests/Experiences

When several students were asked how their college experience has shaped their future goals, some talked about courses that made an impact on them, peers and professors, and internship opportunities that they got to engage in. When asked about their post graduation interests some students indicated that they wanted to continue grad school through the accelerated masters program at Tech. Many students expressed a strong interest in pursuing graduate studies, particularly in fields related to Artificial Intelligence and Data Science. Some were motivated by a desire to specialize further, while others aimed to deepen their expertise in specific areas.

> "I was interested in the grad program at VT because of the human factors program." -*Student 13*

> "I am returning for Accelerated Masters program and then want to pursue a career in data science." -*Student 5*

Other students preferred gaining industry experience before committing to a graduate degree. They explained the value practical exposure would give them in the workforce as compared to just continued academic coursework. For these students, entering the workforce immediately after graduation allows them to test their skills in real-world settings. They believe that time in industry will help them identify what specialization or further study might be necessary to advance in their careers. They were open to pursuing graduate degrees once they built some experience in the field and knew better what they wanted to focus their graduate studies on.

4.8 Open-Ended Questions

Students were asked what courses they found valuable at Virginia Tech and why. While there were many different courses that students deemed to be valuable, after reading through the comments of 72 students, a few recurrent themes were identified.

Theme	**Description**
Real World Application	Courses that introduced industry concepts like Agile, offered relevant projects, and taught about the software life cycle (e.g., Intermediate Software Design, Capstone, Database Management).
Teamwork & Collaboration	Courses that emphasized group work and communication (e.g., Capstone, Intro to HCI, Software Project Management).
Technical Skills	Courses that taught hands-on technical skills relevant to the tech industry (e.g., AI Tools for Software Engineering, Intermediate Machine Learning, Cloud Computing).
Career Relevance	Courses that aligned with career paths or specific interests (e.g., Security, Intro to Data Visualization, Deep Learning).
Inspiring Professors	Courses noted for engaging and effective instructors who enhanced learning.
Limited Access	Students expressed dissatisfaction from unable to enroll in electives due to limited availability and prerequisites.

Table 4.1: Themes for Valuable CS Electives

Students found courses that broadened their skill set and that were relevant to the industry most valuable. For instance, a student mentioned how Intermediate Software Design was an enjoyable course because "it taught all of the skills that are very valuable when you actually start working like, learning what the agile development cycle is, or how to use git commands, and even how a day to day might even go as a software engineer". Students also expressed enjoying courses that encouraged group projects and communicating with peers.

This helped their learning process and contributed to enlarging their CS network. A course was significantly impacted by the quality of the professor and several students mentioned courses they found memorable because of engaging and passionate professors. On the other hand, students mentioned the hindrance that limited course availability and prerequisite requirements caused to courses they wanted to enroll in.

Next students were asked to comment about the changes they would like to see in order to improve their CS elective course experiences. A few recurrent themes were identified.

Theme	**Description**
Curriculum Update	Students want electives to teach skills such as in game development, DevOps, React, and Spring. There were also suggestions to update outdated course content to reflect emerging technology.
Instruction Quality	Students expressed the need for passionate and engaging professors rather than disinterested TAs. They also wanted more organized classes with clear instructions and consistent communication from instructors.
Class Size	Students advocated for smaller classes to promote interaction, engagement, and learning.
Projects	Student feedback included wanting more flexible and milestone-based projects. There was also a want for balancing lectures and tests with hands-on projects.
Group Work Accountability	Students reported frustration with unequal contributions in group projects and suggested using systems to better manage accountability.
Increased Options	Students asked for more elective offerings across times of day, creative options, and the ability to count relevant non-CS courses (e.g., Math or Machine Learning electives) towards a CS degree.
Professional Preparation	Students suggested offering electives that introduce projects about real-world problems, teach interview prep, host tech conferences, and bring industry speakers into the classroom.

Table 4.2: Themes to Improve CS Elective Experiences

Students reflected on what made courses valuable and were able to provide suggestions to improve the quality of electives. A recurring theme was of updating course curriculums so they aligned with industry trends This meant incorporating up-to-date software tools and technologies so students were better prepared in the job market. Several students expressed the value of engaging instructors. Students indicated dissatisfaction with TAs leading courses, who were not as connected to the course material as professors were. Students expected a high standard of communication in classes, particularly in establishing course expectations and requirements.

Furthermore, class size was a factor that influenced students' learning experiences. Students commented that they were not able to get enough time with TAs or professors due to large classes. They preferred smaller classes to have better learning experiences. In addition, while students enjoyed group work and projects, they advocated systems that tracked accountability and contribution of group members, so as to avoid negative outcomes.

Students suggested expanding elective offerings and increasing the variety of specialization areas so as to avoid limited course availability and lack of variety. Additionally, they expressed a strong interest in courses like Capstone that provide opportunities to work on real-world problems. Students also emphasized the value of adding courses that focused on technical interview preparation, as well as facilitating professional development through conference participation and networking with industry professionals.

4.9 Discussion

Overall, these student interviews enabled insight into the multi-faceted process of social, academic, and career-related factors that influence a student's choice of electives. It also provided an insight to how elective courses shape a student's interest in the CS field and what they plan to do in the future. While students did make sure that they were responsible to complete credit requirements and create schedules that were practical, they took responsibility for their learning to make sure that expanded their skill set through electives and explore enjoyable fields of CS that would help their future careers. In order to make their choices easier, students relied on their peer networks of mentors, friends, seniors, advisers, and online platforms. These points of contact gave them an idea to gauge course difficulty, professor quality, and overall course experience. Sometimes this informal way of advising was used when students couldn't rely on their program advisors for better insight or were not able to establish a better relationship with them. Students' families did not impact their elective course choices, but did have some influence on their selection of CS as a major. Early exposure to CS through high school courses and by students' families gave them the confidence and knowledge to pursue CS. These findings align with the social cognitive theory which states how people learn primarily through observation, prior experience, and outcome expectation, compared to solely by direct experience [1].

CS Course Perception was identified as a theme because it was a recurrent pattern that was seen where student's either enjoyed courses that made impacts on their future interest, or largely disliked courses which also made impacts on their future interests. This judgement was made through course difficulty, instruction, and overall topic of interest. Electives serve as stepping stones for students to explore subfields in CS and gain a focused direction for their career goals and direction.

Some students were lucky to have a solid high school exposure of CS which gave them a predefined idea of what a college degree in CS would look like. This was through taking

Advanced Placement CS courses or engaging in extracurricular CS activities such as clubs or camps. This idea supports research of how giving students early exposure to STEM fields can help shape their academic and career goals [14, 55]. It also underscores the gap in students' learning and how high school exposure may give some students an early advantage coming in as a freshman student where they were able to skip courses or grasp knowledge better.

Collaborative learning was seen as a boon and bane for CS students taking electives. They mentioned how it was good preparation for students moving to the work-force as STEM graduates often move on to work and code in teams. However, while collaborative learning is promoted throughout the world and is indeed beneficial to a student's learning, many students explained the detriments of working with friends. Instructors can take note of how students often struggle working in friend groups and this can be addressed in their courses. Insights like these can help instructors design better courses, keeping in mind the challenges students often face.

In order to gain an understanding of what made courses enjoyable and engaging, Virginia Tech student feedback was studied. Courses that were most popular included facets such as introducing technical skills that aligned with professional standards, encouraging group work, and passionate professors. These added to a course's enjoyment level and utility in students' academic and professional journeys.

In addition, Virginia Tech students were also asked about ways to improve elective course experiences. They expressed concerns including a low level of material relevance, and logistical concerns such as limited course offerings, large class sizes, and lack of group work accountability. Students offered suggestions to tackle these issues such as updating course syllabi more often, offering more instances of classes along with a wider range of topics, and introducing courses to help ease transition to the professional space in technology.

Chapter 5

Quantitative Results and Discussion

This chapter presents the quantitative analysis of survey data collected from computer science students. The process began with data preprocessing, which included removing responses submitted in under two minutes and checking for duplicate entries based on email, IP address, response ID, and the built-in QuestionPro duplicate identifier.

5.1 Statistical Analysis

Year Standing	**Count**	**Percent**
Freshman	0	0%
Sophomore	0	0%
Junior	4	5%
Senior	21	26.25%
Grad Student	39	48.75%
Alumni	16	20%
Prefer not to say	0	0%
Total	80	100%

Table 5.1: Distribution of Academic Levels Virginia Tech Students

Year Standing	**Count**	**Percent**
Freshman	3	14.29%
Sophomore	2	9.52%
Junior	8	38.1%
Senior	4	19.05%
Grad Student	3	14.29%
Alumni	0	0%
Prefer not to say	1	4.76%
Total	21	100%

Table 5.2: Distribution of Academic Levels Non-VT Students

A Mann-Whitney U test and Kruskal-Wallis test was conducted on a key survey question assessing the importance of various items in elective course selection. Gender and Year of Study of students was studied to see if it had an affect on how students made technical elective decisions. At $\alpha = 0.05$, statistical significance was tested. This was followed by additional inferential statistical analyses across different student demographics.

The statistical tests explored the question: When choosing CS elective courses, how likely are you to consider the following? This question had a list of 16 items which students rated on a scale of 1-5 in terms of how likely they were to consider the given item when choosing a technical elective course. These items ranged from professor likeability to course timing to class size and to career relevance. To understand how these items were ranked a bar graph was created, which allowed an easy comparison of all the different items' ratings in importance.

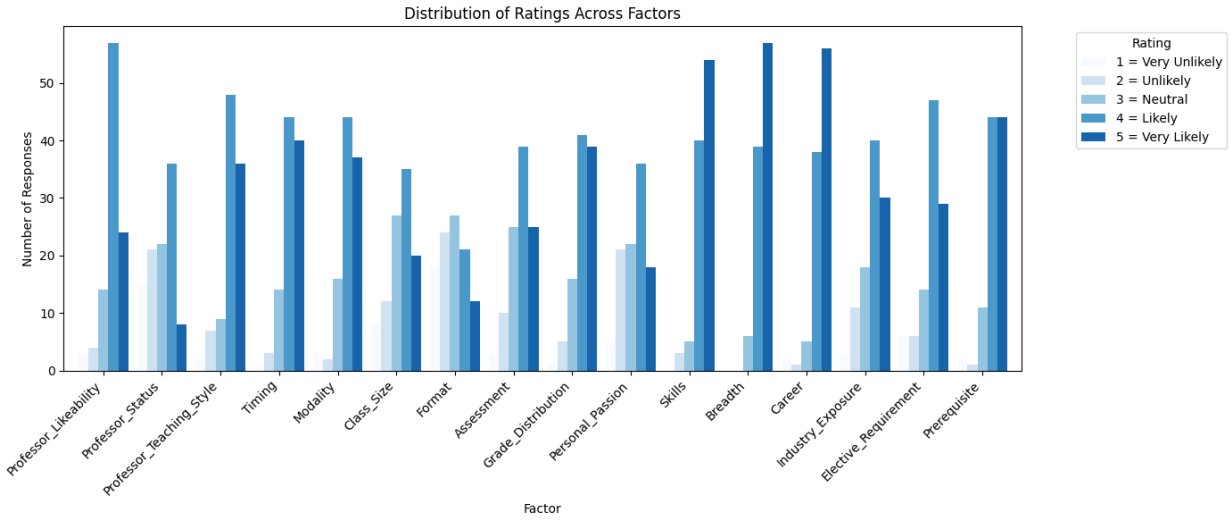

Figure 5.1: Bar Chart for Rating of Different Items Affecting Elective Course Choice

This graph showed the distribution of student ratings (from 1 = Very Unlikely to 5 = Very Likely) across various items influencing elective course selection. Overall, ratings of 4 (Likely) and 5 (Very Likely) dominates across most items, indicating that students generally considered these aspects to be important in their elelctive decision-making. From the graph it appeared that that skills, breadth, and career had the highest ratings of 5. However to make the analysis cohesive, related items were grouped together into categories and then descriptive statistics were performed.

The items were grouped based on five categories: Professor-Related Items, Course Structure-Related Items, Personal Growth-Related Items, Career-Related Items, and Degree-Requireemnt Related Items.

Item	**Mean**	**Std Dev**
Professor Likeability	3.93	0.89
Professor Status	3.01	1.21
Professor Teaching Style	4.07	0.95

Table 5.3: Professor-Related Items in Elective Course Selection

Item	Mean	Std Dev
Timing	4.17	0.85
Modality	4.08	0.93
Class Size	3.46	1.17
Format	2.85	1.27
Assessment	3.72	1.04
Grade Distribution	4.10	0.91

Table 5.4: Course Structure-Related Items in Elective Course Selection

Item	Mean	Std Dev
Personal Passion	3.40	1.15
Skills	4.42	0.72
Breadth	4.50	0.61

Table 5.5: Personal Growth-Related Items in Elective Course Selection

Item	Mean	Std Dev
Career	4.42	0.80
Industry Exposure	3.81	1.07

Table 5.6: Career-Related Items in Elective Course Selection

Item	Mean	Std Dev
Elective Requirement	3.85	1.08
Prerequisite	4.25	0.84

Table 5.7: Degree-Requirement Related Items in Elective Course Selection

These statistics emphasize the value that students give to curriculum breadth (mean = 4.5), career alignment (mean = 4.42), and skill acquisition (mean = 4.42) when selecting CS

elective courses. These factors had the highest mean ratings, showing that students prioritize taking electives that offered long-term professional growth along with personal development. The next highest rated factor was prerequisites (mean = 4.25). Nevertheless, prerequisites are a factor that students don't have much choice over as certain electives might be required to take structurally. The top three factors tells us of the importance students give to the skills they learn from elective classes and how courses can serve their career goals.

Prior research has shown that career prospects significantly influence students' decisions to major in computer science [25, 32, 46]. The findings from these factor ratings suggest that this goal orientated mindset persists throughout students' academic journeys. Students continue to take steps in college in terms of taking courses that will increase their skill set and value in the workforce. Today's students appear to be highly career-oriented and intentional in selecting courses that build relevant skills and broaden their knowledge base [2, 16]. This often starts in high school where students take college-level courses and complete programs such as AP ans IB to be college-ready [8, 34, 47]. Students are making conscientious decisions early on in their journey, such that they are not only completing courses for their degree but also taking them to learn and apply new skills. This goal-directed approach in turn helps CS students complete their degrees, grow, and build a solid path for a successful future [42].

5.1.1 Gender

There were 59 male and 40 female students, and 1 student who identified as other. Considering the minority we eliminated the 1 response for a total of 99 gender-identified responses. One participant did not complete the final two open-ended questions and was therefore excluded from the complete response count (98 students), though their responses to the closed-ended questions were retained for the purpose of this analysis. In order to investigate whether gender plays a role in how students rate different factors when making elective course choices, a Mann-Whiteny U test was performed. As non-normality was observed this

was the best test to conduct. The null hypothesis states that there are no significant differences in mean ratings of each factor between male and female students: gender does not influence how students rank these factors.

Factor Group	**p-value**
Professor Factors	0.1420
Career Factors	0.0024
Course Format Factors	0.4821
Degree Requirement	0.1408
Personal Growth Factors	0.9039

Table 5.8: Mann-Whitney U Test for Gender: p-values

The Mann-Whitney result for Course Format Factors yields a statistically significant result ($p = 0.001 < 0.05$). This provides sufficient statistical evidence to conclude that gender has a significant effect on how students consider course format factors, including timing, modality, class size, format, assessment, and grade distribution, when making CS elective course decisions.

In order to further examine the differences in Course Format Factors for each gender, the mean ratings for each sub-factor were calculated.

Gender	**Timing**	**Modality**	**Class Size**	**Format**	**Assessment**	**Grade Distribution**
Female	4.28	4.25	3.82	3.25	3.90	4.18
Male	4.12	3.95	3.22	2.49	3.56	4.02

Table 5.9: Mean Ratings of Course Format Sub-Factors by Gender

Table 5.7 shows the mean ratings for male and female students for Course Format Sub-Factors. Across all six factors female students ranked higher importance ratings than male students. The most notable difference was Class Size (Female: 3.82, Male: 3.22) and Class

Format (Female: 3.25, Male: 2.49), suggesting that female students placed higher importance the elective course structure and size of class when making choices. had the biggest difference in mean ratings. Overall, these results tell us that the course delivery characteristics play a more significant role in elective decision-making for female students compared to their male peers.

In summary, the gender-based Mann-Whitney U analysis revealed that female students rated course format factors, such as timing, modality, class size, and assessment, significantly higher than male students. This suggests that course delivery logistics play a more influential role in elective decision-making for female students. While career-related factors approached significance, no meaningful gender-based differences were observed in how students rated professor-related factors, degree requirements, or personal growth motivators.

5.1.2 Year of Study

Next, a Kruskal-Wallis test was conducted to determine whether students' year of study impacted how they made elective course choices. The null hypothesis states that that there are no significant differences in mean ratings between different years of study: year of study does not affect how students rank these factors. Before conducting the analysis, the assumption of normality was tested. As normality was not satisfied, we proceeded with the Kruskal-Wallis test. We had to eliminate students who answered 'Freshmen', 'Sophomore', and 'Prefer not to say' when asked of their year of study, due to insufficient sample sizes (fewer than 3 students).

Factor Group	**p-value**
Professor Factors	0.0065
Career Factors	0.1097
Course Format Factors	0.0178
Degree Requirement	0.0906
Personal Growth Factors	0.1033

Table 5.10: Kruskal-Wallis Results by Year of Study: p-values

The Kruskal-Wallis results for Professor Factors ($p = 0.0065 < 0.05$) and Course Format Factors ($p = 0.0178 < 0.05$) were statistically significant. A students' year of study has a meaningful effect on how they evaluate professor-related and course-format related dimensions when selecting CS electives. For Professor Factors, this variation reflects differing student emphasis on teaching style, perceived status, and likability of instructors. Similarly, differences in Course Format Factors indicate that structural elements such as timing, modality, class size, instructional format, assessment methods, and grade distribution are valued differently depending on a student's year in the program.

In contrast, no significant differences were observed across years for Career Factors ($p = 0.1264$), Degree Requirement Factors ($p = 0.2842$), or Personal Growth factors ($p = 0.1033$), indicating that students across different years rated the importance of these factors similarly.

Although the Kruskal-Wallis test for the other three categories across year groups were not statistically significant , indicating no differences in the overall distributions across years. We explored the mean ratings based on each category to explore any underlying trends or insights.

Year of Study	Likability	Status	Teaching Style
Junior	3.95	3.10	4.05
Senior	4.10	3.20	4.15
Graduate	3.80	2.95	4.00
Alumni	4.00	3.00	4.10

Table 5.11: Mean Ratings of Professor-Related Items by Year Category

All groups of students regardless of year of study rated a professor's teaching style to be most important compared to likability and status when making elective choices. Overall, alumni and senior year students rated all Professor-Related Factors slightly higher than juniors and graduate students did, indicating that they placed greater value to instructional quality.

Year of Study	Timing	Modality	Class Size	Format	Assessment	Grade Distribution
Junior	4.50	3.42	3.17	2.08	3.08	4.08
Senior	4.04	3.96	3.24	2.56	3.64	4.16
Graduate	4.05	4.21	3.67	2.95	3.76	3.83
Alumni	4.50	4.25	3.50	3.38	4.00	4.62

Table 5.12: Mean Ratings of Course Format Items by Year Category

The mean ratings of Course Format Sub-Factors yielded noticeable differences among students of different years of study. Alumni and graduate students consistently rated factors such as timing, modality, class size, format, assessment, and grade distribution higher than the other two groups of students. Junior year students gave the lowest ratings to most sub-factors, especially to format and assessment, indicating that course format factors may become more worthy to students as they advance in their academic journey.

Year of Study	Personal Passion	Skills	Breadth
Junior	2.75	4.67	4.67
Senior	3.04	4.08	4.36
Graduate	3.48	4.52	4.60
Alumni	4.06	4.31	4.31

Table 5.13: Mean Ratings of Personal Growth Items by Year Category

From the mean ratings of Personal Growth Sub-Factors we can see that the role of personal passion while making elective choices increased as a student advanced in their degree. While junior-year students had the lowest rating (mean = 2.75), graduate (mean = 3.48) and alumni students (mean = 4.06) had the highest ratings. On the other hand it is interesting to note that junior-year students did place the highest importance to skill acquisition and curriculum breadth they attained from a course.

Overall, the ANOVA analysis for year of study showed significant differences in how students prioritize professor-related and course format factors when selecting CS electives. Alumni and senior students placed higher importance on teaching style and professor reputation compared to junior-year and graduate students. Although personal growth factors, such as passion, skills, and breadth, approached statistical significance, no meaningful differences were observed across years for career-related or degree requirement factors. These findings suggest that as students progress through their academic careers, their emphasis shifts toward factors related to teaching and course structure.

5.1.3 Group Work

A portion of the study examined the role group work plays in elective course choices, how students feel about working with peers, and the collaborative learning process.

When asked how often students participated in group work in CS elective course, 116 CS students answered.

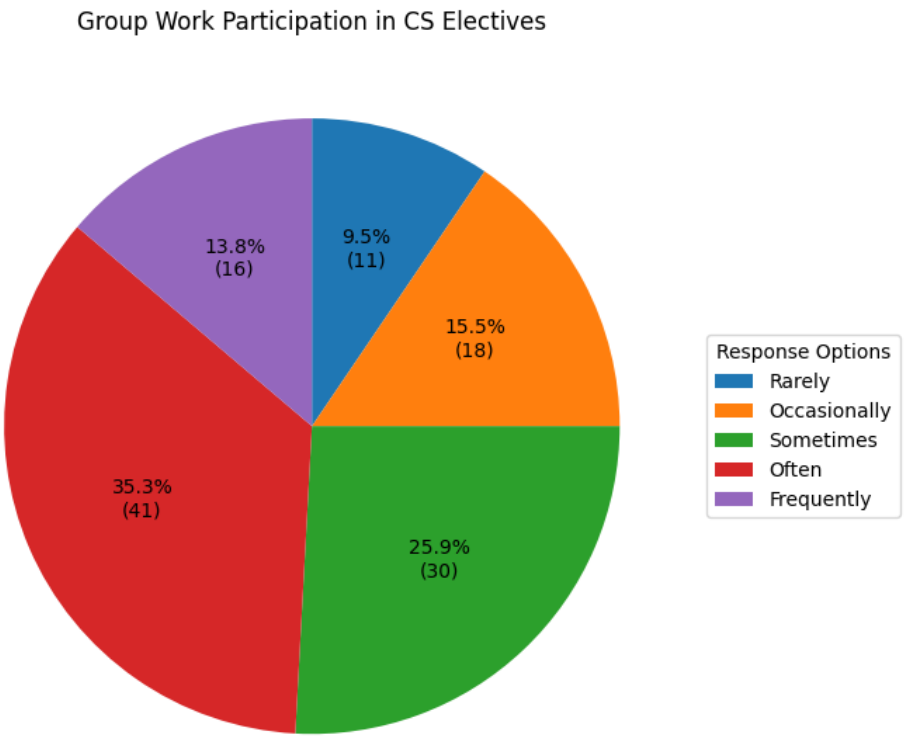

Figure 5.2: Group Work Participation Statistics

Majority of the students answered often, which constituted about 35% of the responses, with second most being sometimes at about 26%. This tells us that CS students engaged in group work to a great extent in their elective courses.

The next set of questions focused on students' perceived benefits of collaborative group work, specifically regarding academic development and preparation for professional environments. To examine potential gender differences in responses, mean ratings were calculated separately for male and female students.

Gender	Academic Development	Professional Skill Development
Female	3.50	3.70
Male	3.15	3.25

Table 5.14: Mean Ratings of Group Work Benefit by Gender

Overall female students rated group work aiding academic development and skills needed for transitioning into a professional environment higher than male students. This aligns with prior research indicating that women often place greater value on collaborative learning [9, 50]. Studies suggest that female students tend to appreciate working in groups, sharing ideas, and contributing toward shared goals more than their male counterparts [13, 23, 39].

Next the negative impacts of group work were assessed. Students were asked if they've ever had a negative group work experience impact their overall learning. 99 students' responses were collected.

Figure 5.3: Negative Impacts of Group Work

While more male students participated in the survey (59 male students, 49 female students), a higher proportion of female students reported negative experiences. While female students

are seen to enjoy group work, they are also most impacted by the negative detriments of it, including challenges such as being talked over, uneven task distribution, or lack of belonging [11, 13, 52].

In order to understand these negative student experiences from group work, a couple of recurrent themes were identified from the comments that some students added.

Theme	**Description**
Uneven Contribution	Group members failed to participate equally, often leaving one or two members to carry the bulk of the work.
Disorganization	Work was frequently delayed until the last moment, creating time pressure and stress for others in the group.
Poor Communication	Students faced difficulties coordinating tasks, reaching teammates, or aligning schedules.
Gender Bias	Some female students reported being ignored or not taken seriously in their group due to their gender.
Dishonesty	Group members engaged in dishonest practices such as copying work, submitting incomplete code, or lying about their contributions.
Stress	Students described stress resulting from carrying group projects alone, often leading to missed lectures or mental health concerns.

Table 5.15: Common Themes from Negative Group Work Experiences

An analysis of students' written responses revealed recurring themes that highlight the challenges students face during group work. The most frequently cited issue was uneven contribution, where students reported carrying the majority of the workload due to lack of initiative and responsibility from other teammates. Closely tied to this was disorganiza-

tion, with many students describing last-minute deadlines and poor planning that led to increased pressure and compromised learning. Poor communication also emerged as a significant barrier, as students struggled to coordinate tasks or even establish consistent contact with group members. Notably, a female student highlighted experiences of gender bias, where her ideas were dismissed due to gender under representation. Instances of dishonesty, including peers copying work or overcompensating their skill set, further added to the frustration and imbalance. These factors collectively contributed to academic stress. Students describing emotional exhaustion, missed lectures, and deteriorated mental well-being due to their negative group work experiences. As responses were only taken from students who experienced negative impacts of group work and were willing to share, this represents one aspect of group work in CS courses.

5.1.4 Peer Influence

Next we investigated the role of peer influence on student elective course choices. Students were asked how likely they were to consider peer input for a set of factors. This represented the extent to which peers played in students' elective choice evaluations. 105 student responses for accumulated for this question.

Factor	**Mean**	**Std Dev**
Content difficulty level	4.07	0.90
Course workload	4.23	0.78
Take a course as peers are taking it	3.65	1.13
Professor difficulty level	4.01	1.00
Quality of instruction	4.30	0.78

Table 5.16: Combined Descriptive Statistics for Peer Input Considerations When Choosing Electives

Overall students consulted peer advice for 'Quality of instruction' (mean = 4.3) and 'Course

workload' (mean = 4.23) most. As these two factors had the lowest standard deviation, it tells us that there was consensus on students' agreeing of its importance. On the other hand, the lowest rated was if 'Peers are also taking it' (mean = 3.65). This factor had the highest standard deviation (std = 1.13). This means that while some students found it valuable to take elective courses if their peers were too, others did not value it. Considering that the average ratings for all factors ranged between 3.5 and 4.5 on the 5-point Likert scale, the results indicate that students moderately to strongly valued peer input when evaluating elective course options.

In order to further assess the role peers play on course selection and enjoyment, students were asked if taking courses with friends improved their performance or enjoyment.

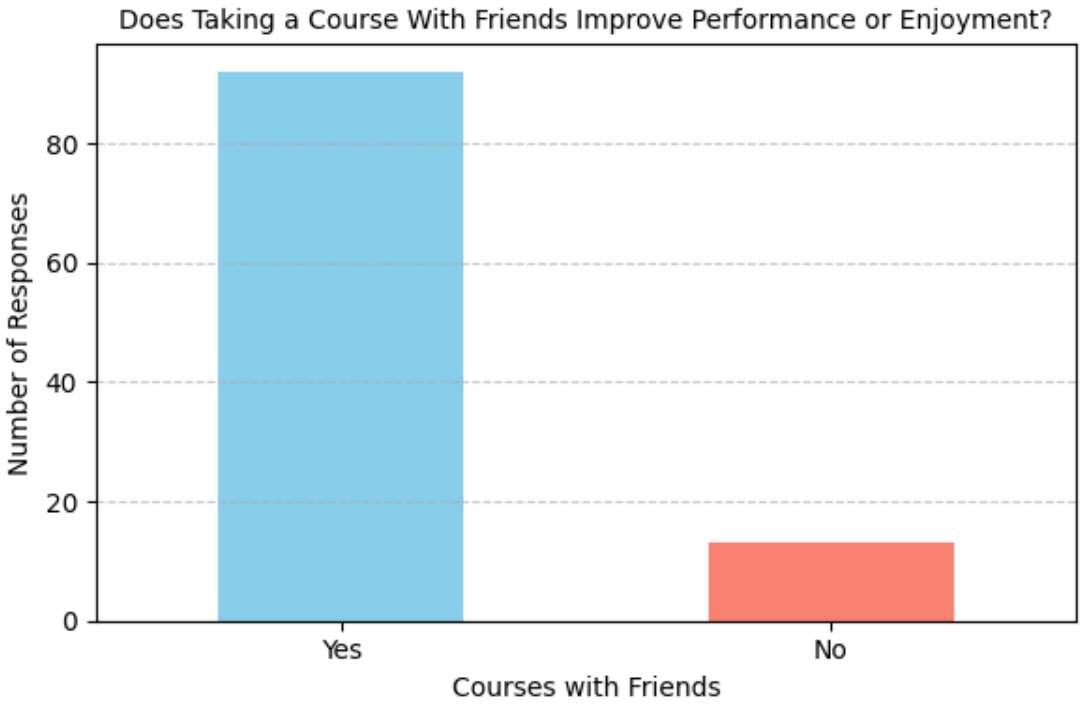

Figure 5.4: Taking Courses with Friends

An overwhelming number of students (~88%) agreed that taking courses with their friends positively impacted their performance and enjoyment of an elective class.

In order to further understand why peers make such an impact, students were asked for a short explanation. After reading the comments of students who agreed that they saw positive influences of taking courses with friends, a short list of themes were identified.

Theme	**Description**
Motivation & Accountability	Friends help maintain discipline, increase motivation, and encourage consistent participation.
Collaborative Learning	Studying with friends helps reinforce material, improve understanding, and fill knowledge gaps.
Emotional Support	Presence of friends reduces anxiety, builds confidence, and creates a sense of community.
Logistical Convenience	Coordinating study sessions, sharing notes, and collaborating on assignments becomes easier with friends.
Increased Enjoyment	Social interactions with friends enhance classroom engagement and make the experience more enjoyable.

Table 5.17: Common Themes in Taking Courses with Friends

Overall, while CS students didn't solely depend on peer input on their elective course decision making, they consistently saw having peers in a course to be beneficial to their learning. As one student wrote: "Friends can share knowledge / teach each other. And its more fun to suffer together." Students in CS relied on studying in groups and working together, which was made easier with having peers in their classes. They also saw peers as an extrinsic motivator to attendance in class, participation, and taking an active role in their learning and grades.

5.1.5 Post-Graduation Plans and Experiences

Another important component of this study was understanding what students' plans were after completing their CS degree.

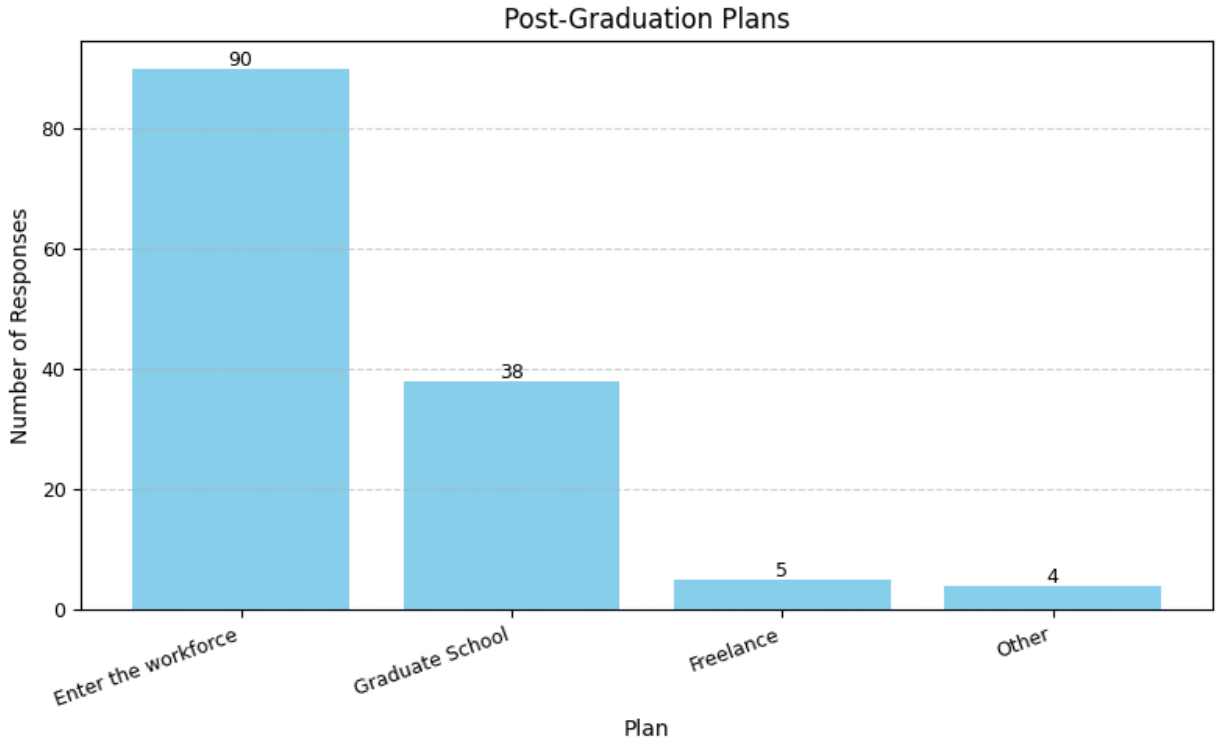

Figure 5.5: Post-Graduation Plans

The majority of CS students planned to or already entered the workforce after the completion of their CS degree. About 28% of CS students planned to enroll in graduate school to complete a Masters or PhD degree. In order to further understand the importance that most students give to industry experience, students were asked whether they valued getting industry exposure before studying further.

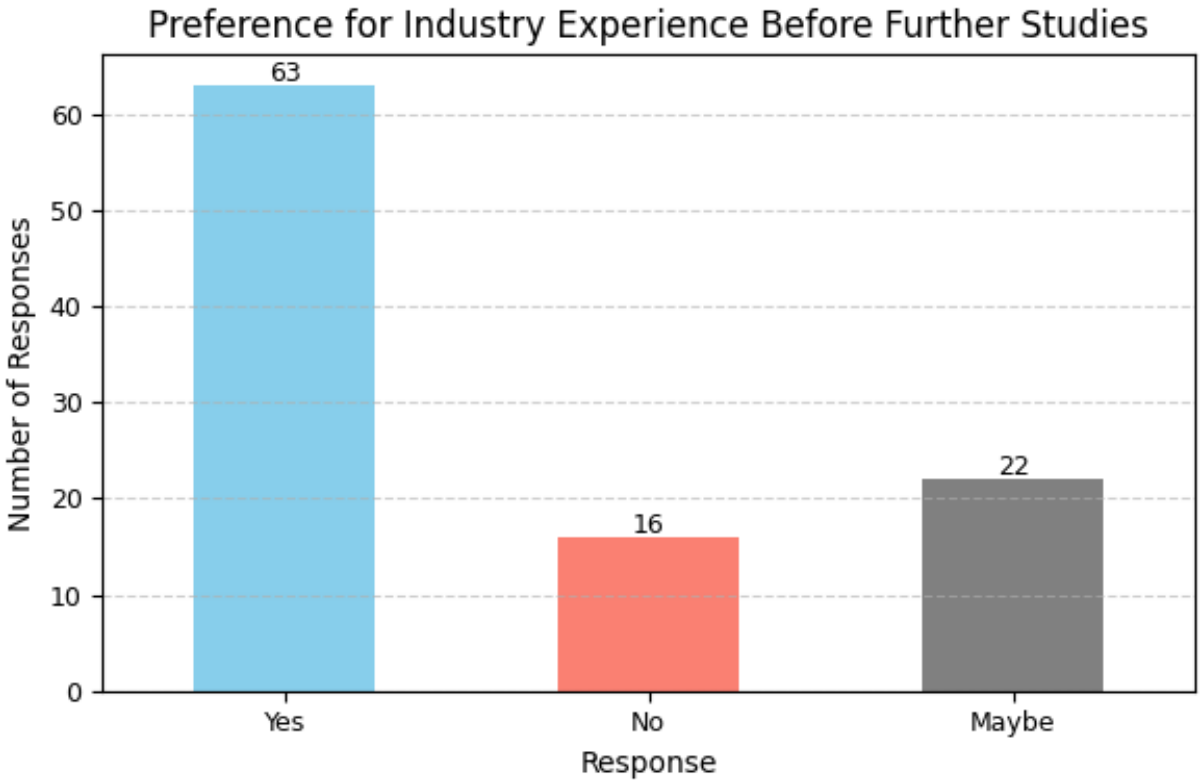

Figure 5.6: Industry Exposure

A large group of CS students ($\sim 60\%$) answered that they do think having industry exposure is beneficial before pursuing a second degree. A fifth of the students weren't sure about their preference, understandably. They could still be in their former years of their undergraduate education or unsure of their future path as of yet.

In order to explore students' perceptions of industry exposure they were asked for a short explanation to their choice. Student comments were analyzed and recurrent themes were identified.

Theme	Description
Real-world Exposure	Students believe industry experience offers practical context and helps hone their technical skills.
Career Path	Many expressed a desire to explore jobs first to better define long-term academic or career goals.
Financial Motivation	Some students prioritize financial independence or want to earn money before returning to school.
Academic Momentum	A few students prefer to continue studies immediately, citing fear of losing academic focus.
Flexibility	Responses like "maybe" suggest wanting to explore both or the idea that it depends on the specific opportunity available at the time.
Burnout	Some respondents noted wanting a break from school or a mental reset after undergraduate studies.

Table 5.18: Common Themes from Comments on Industry Experience Before Further Studies

Many students expressed a desire to gain professional experience after completing their undergraduate degrees, viewing it as a valuable step toward shaping their career paths. Practical experience was widely seen as essential for increasing marketability in today's competitive job market. Beyond the professional advantages, several students cited financial concerns and academic fatigue as reasons for delaying or avoiding further education. Others stated that pursuing a master's degree, while gaining industry experience, would be a strategic way to enhance both their credentials and exposure. Other students expressed an interest in academia and preferred to continue their education immediately, while they were still in an academic mindset and familiar with the structure of school life.

In order to see what skills students felt would be important to their future careers, they

were asked to rate the importance of three factors: technical skills, soft skills, and industry exposure. 101 student responses were collected for this question.

Skill/Experience	**Mean Rating**	**Standard Deviation**
Technical Skills	4.54	0.56
Soft Skills	4.50	0.61
Industry Exposure	4.32	0.89

Table 5.19: Mean Ratings and Standard Deviations of Career-Relevant Skills

From Table 5.17 it is evident that students valued technical skills, soft skills, and industry exposure highly when it came to preparing them for their career. Industry exposure (mean = 4.32) was rated slightly lower than technical and soft skills, which were rated at 4.5 or greater. A study in Oregon State University interviewed 11 recruiters for software development roles and cited how important they stated soft skills such innovating, coping with changes, and ambiguity and learning quickly, were in addition to technical expertise [48]. Another technology institute at Israel talked about a course offered in the Department of Computer Science that taught software engineering soft skills to students [22]. This course was in fact developed due to requests by industry recruiters to incorporate such soft skills into students' CS degrees. These findings suggest that students are attuned to industry expectations and recognize the practical value of both technical and interpersonal skills.

Technology career fields that students are interested in were explored in order to gauge what technology sub-fields in Computer Science are most sought after presently. Students were asked what tech areas of study they plan to focus on post-graduation, with the option to choose multiple options from: AI/Machine Learning, Software Engineering, Data Science, and Cybersecurity.

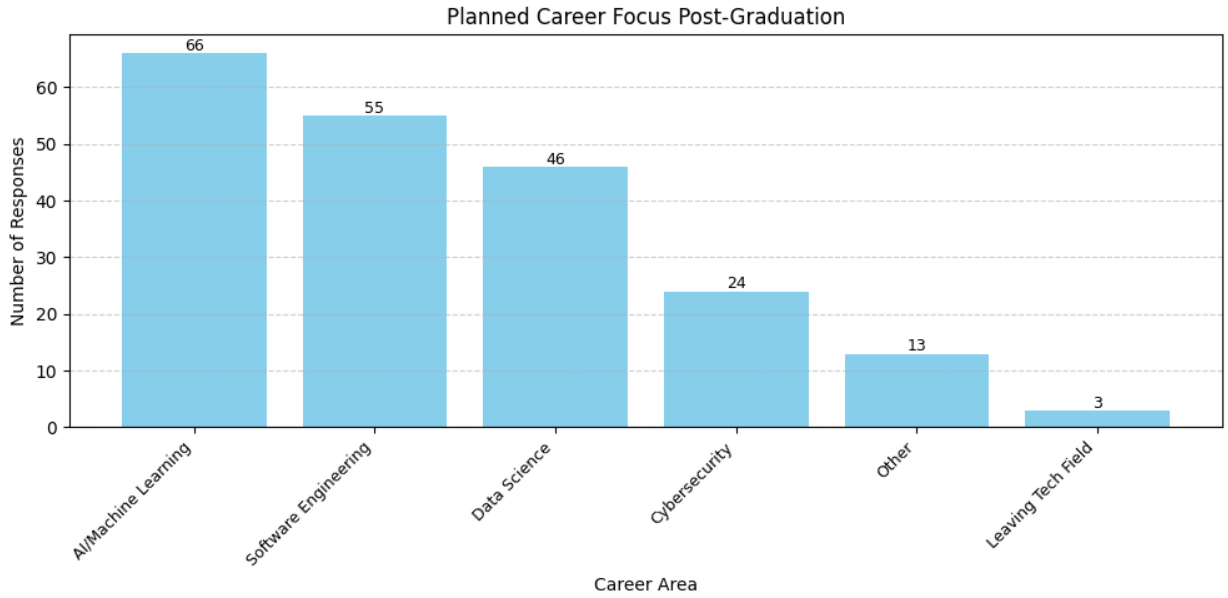

Figure 5.7: Tech Career Field Interest

The most popular subfield was AI/Machine Learning followed by Software Engineering and then Data Science. Studies have shown how artificial intelligence and machine learning are being integrated into various industries including medicine, manufacturing, finance, and more [15, 35, 43, 43]. This cross-industry adoption has contributed to a surge in related job opportunities, making these sub-fields attractive to students preparing for the workforce [18, 21].

5.2 Discussion

The quantitative findings from this study help us understand the factors that impact student elective course choices and how they shape students' post-graduation plans. Patterns and trends that emerged enabled findings such as of the goal-oriented nature of CS students in their degrees and the diverse influences that shaped their journeys. Students consistently rated career alignment, skill acquisition, and curriculum breadth of highest importance when making elective choices. This tells us of the strategic decision-making that CS college stu-

dents are making today in order to better shape their future goals and aspirations. Additionally, students prioritized professional development, reflecting their focus on ensuring their education translates into tangible career outcomes.

While there weren't many gender-based differences in course choice processes, it was seen that female students rated course-format factors higher than male students. This suggests that female students valued logistical factors, such as course timing, class size, or modality, to be of greater significance when making elective choices. After COVID, there are many studies that compare the learning styles between male and female students, and some speak of the moderate differences [7, 37, 49]. It is important to note that there are several factors and nuances for students' learning preferences and course choices. The ANOVA test conducted through this study saw male and female students rating professor-related factors, career factors, degree requirements, and personal growth factors similarly, the exception being course-format factors. This insight can be useful for CS academic departments and professors when designing courses.

The year of study was also examined through ANOVA to see how it impacted a student's course choice process. Alumni and senior-year students valued professor-related and course format factors greater than junior-year or graduate students. This could account for the learning process. As students gain more experience making course choices, they value aspects such as personal passion, professors' teaching style, professor's likability, course modality, and grade distribution. While this wasn't the case that the importance of all factors increased as students spent more time in their degrees, it was seen clearly for factors such as personal passion, indicating that students' found their niche and took courses they enjoyed towards the end of their degrees.

The role of group work was examined in CS electives and this study found that students engaged in collaborative work quite often in CS electives. Students agreed that group work added to their professional and academic growth, however female students ranked the con-

tribution of group work to be greater in significance. The disadvantages of group work were assessed and it was found that about 41% of students reported having experienced negative impacts to their learning due to a bad group experience. Additionally, a higher proportion of female students had reported a negative experience affecting their learning compared to male students. Prior research validated how female students were more susceptible to the negative aspects of group work, including feelings of being excluded or lack of a role in the project's success [23]. Overall group work was seen as a factor that added value but could also pose challenges.

Students utilize different resources when making elective choices such as advisor recommendations, online platforms, or professor reviews. Another important factor was peer influence in students' elective course choices. Multiple students expressed that taking electives with peers increased their level of enjoyment and improved their academic performance too. Specifically, many students expressed the added motivation and accountability that having peers in their classes gave them. Furthermore it helped progress their learning, as they were able to discuss assignments and projects. Having peers in the same classes allowed students to be more engaged in classes, feel supported, and increased their enjoyment too. When students were asked to what extent they relied on peer recommendations, taking courses because peers were was rated low on the scale compared to factors such as peer input for content difficulty of a course and quality of instruction.

When asked about post-graduation plans, a majority of students expressed the desire to enter the workforce and gain real-world experience in tech. Some students still wanted to return to school after gaining industry experience, or planned to complete their degrees while working. A small group of students wanted to pursue a higher education immediately after their undergraduate degree completion. Building skills was seen as an important factor in elective course selection as well as in being career ready. When asked what skills students deemed importance in preparation for their careers, students rated both technical and soft skills highly valuable, with industry exposure was a close third. This speaks of the broad skill

set that young professionals are expected to have today. In terms of areas of interest in tech, Artificial Intelligence and Machine Learning emerged as the most sought out specializations. This was followed by Software Engineering and Data Science. Cybersecurity was a far fourth on the list. This aligned with current industry trends around the world and showed students having a relevant tech perspective for their future careers.

Overall, the survey results showed CS students at Virginia Tech making intentional choices in their course selection. They were able to make informed decisions that were consistent with their goals, whilst also navigating logistical constraints, peer influence, and personal interests. Computer Science students were able to learn through their good and bad experiences and understood the importance of electives in shaping their careers in CS.

Chapter 6

Conclusions

Overall this study tested the influence of different factors on elective course choices. These included professor related factors: likability, status, and teaching style, course structure related factors: timing, modality, class size, format, assessment, and grade distribution, personal growth related factors: personal passion, skills learned, breadth of course, career related factors: industry exposure, career alignment, and degree requirement factors: elective requirements and prerequisites. Our first research question was as follows:

RQ1. What factors influence CS major's elective choices?

The greatest mean ratings were given to the factors curriculum breadth, skills learned, and career alignment when choosing an elective course. All in all, students prioritized personal growth and career most when making decisions to their courses. Previous studies have analyzed how CS students form professional identities and pointed out that opportunities such as courses, internships, and research helped students engage in computing communities and connect to the major and long-term goals [28]. On the other hand the lowest rated factors were course format, professor status, and personal passion. This suggests that students placed less emphasis on a professor's experience and credentials, rather they prioritized their teaching style such as level of engagement and professor likability. While factors such as course timing and grade distribution had mean ratings above 4, general course format did not play much importance. Lastly, personal passion was low on the list while skills and breadth were the most important factors. This tells us that students based choices on practical factors that would help improve their skillset and knowledge.

RQ2. Does the CS elective course choice influence interests or future plans?

As CS students make their way through their 4-year undergraduate degrees they shift from an exploration phase of courses to a goal oriented mindset [25]. This study showed that students put a great deal of importance in making sure that courses they take prepare them for their professional careers and equip them with technical skills that were relevant to the technology industry. These were factors that were most important when students talked about the reasons that made electives most valuable. As a result, ongoing research shows how college institutions are adapting curricula to better support students' career readiness and professional development through addition of capstone courses and internship preparation courses [55]. Furthermore, this study displayed the importance students gave to passionate professors and courses inspiring them towards interests and future plans in CS. Overall a culmination of different factors such as courses, internships, research, and external factors such as professors, monetary incentive and opportunities present at the time affected students interests and future plans in CS.

RQ3. Are there any obvious differences between certain groups of students: female vs male students or different years of study?

Overall there was statistical evidence to prove that course format factors were rated differently between male and female students. All other factor groups were rated similarly between both genders. Findings from previous studies did not always concur with these results. For instance one study talked about how male students gave importance to reputation and usefulness to schooling and career more often than female students [40, 56]. Secondly female students gave a higher priority to course content and doing courses that were perceived as challenging, as those were courses with higher value [40, 56]. This study told us that there weren't significant differences in how female and male students made elective course selections.

In terms of year of study, professor related factors and course format factors were seen as

significant. This meant that year of study had an effect on the way students ranked professor related factors and course format factors. Specifically it was seen that senior-year students and alumni rated all professor related factors slightly higher than juniors and graduate students did.

6.1 Limitations

The sample size serves as a limitation of this research study. Although about 170 participant data was collected from the survey, only 98 student answered the entire survey, of which 97 participants' data was able to be used. This sample size could affect the ability to detect subgroup differences in the study due to data limitations. Additionally, this study primarily draws data from students in Virginia Tech which limits its applicability to other institutions that may have different course formats or body of students. Lastly this study although includes participants who range from juniors to grad students to alumni, it does not capture the change in perspective of students as they progress from start to finish of their degree. Student responses could change as they gain more exposure to CS through research, internships, or completion of courses.

6.2 Future Work

Future research could incorporate academic performance data to explore how elective grades correlate with student interests and career outcomes. Furthermore, a more nuanced qualitative study could be done in order to deeply examine different genders and year of study differences in course selection. Lastly, in order to better help students in the daunting task of elective course selection, the results from this study could be used to develop a tool such as a dashboard to guide students through elective course selection.

Appendices

Appendix A

First Appendix

A.1 Interview Questions

The following questions were used as a guide during student interviews. However, the flow and specific follow-up questions varied based on each participant's response.

1. What factors play a role in how you choose your CS elective classes? Please rank the following categories in order of importance.
   If the participant struggles, prompt them with:
   - Professor
   - Time the class is offered
   - Friends' recommendations or taking it with friends
   - Course description/class subject
   - Credit requirement
   - Course difficulty
   - Advisor recommendation
2. Why did you choose the CS elective courses that you did?
3. Were the elective courses what you expected? Why or why not?
4. Have you added any CS electives for next semester? How did you choose them? Have you planned your future CS electives?

5. How important are collaborative learning and peer interaction when choosing an elective course?

6. Reflecting on freshman year as a general engineering student, did you know you wanted to major in Computer Science?

7. Have your family or network (friends, advisors, professors, classmates, mentors) influenced your elective choices or your decision to major in CS?

8. What do you see yourself doing after graduation?
   If needed, prompt with:

   - Cloud Software Engineer
   - Data Scientist
   - Machine Learning Engineer
   - Software Development Engineer
   - Other (please specify)
   - Not in the tech industry

9. What interests you about that role?

10. What kind of impact would you like to have on the CS community?

11. Did you have any programming experience before college? If yes, please describe.

12. Do you plan to continue your education at Virginia Tech? Will you choose the MEng or MS Thesis option?

13. What excites you about your choice?

14. If you are considering the MEng option, which concentration are you most interested in?

- Software Development & Applications
- Data Analytics & Artificial Intelligence
- Computer Security
- Human-Computer Interaction

15. If you are considering the MS Thesis option, do you have any research interests? (Prompt with examples if needed)

    - Digital Education
    - Machine Learning
    - Systems
    - Theory & Algorithms
    - Quantum Computing

16. If you are planning to pursue graduate study elsewhere, what area would you focus on?

17. How did you find out about this interview study?

Bibliography

[1] Amnah Alshahrani, Isla Ross, and Murray I Wood. 2018. Using social cognitive career theory to understand why students choose to study computer science. In *Proceedings of the 2018 ACM conference on international computing education research*. 205–214.

[2] Chardie L Baird, Stephanie W Burge, and John R Reynolds. 2008. Absurdly ambitious? Teenagers' expectations for the future and the realities of social structure. *Sociology compass* 2, 3 (2008), 944–962.

[3] Axel Böttcher, Veronika Thurner, and Tanja Häfner. 2020. Applying data analysis to identify early indicators for potential risk of dropout in cs students. In *2020 IEEE Global Engineering Education Conference (EDUCON)*. IEEE, 827–836.

[4] Steven Bradley, Miranda C Parker, Rukiye Altin, Lecia Barker, Sara Hooshangi, Thom Kunkeler, Ruth G Lennon, Fiona McNeill, Julià Minguillón, Jack Parkinson, et al. 2023. Modeling Women's Elective Choices in Computing. In *Proceedings of the 2023 Working Group Reports on Innovation and Technology in Computer Science Education*. 196–226.

[5] Christopher L Brown and Stephen M Kosovich. 2015. The impact of professor reputation and section attributes on student course selection. *Research in Higher Education* 56 (2015), 496–509.

[6] Sam Butterbaugh. 2013. The Parental Influences on a Student's Undergraduate Collegiate Choices. (2013).

[7] Reynaldo Abrea Cabual. 2021. Learning styles and preferred learning modalities in the new normal. *Open Access Library Journal* 8, 4 (2021), 1–14.

[8] Marisa E Castellano, George B Richardson, Kirsten Sundell, and James R Stone. 2017.

Preparing students for college and career in the United States: The effects of career-themed programs of study on high school performance. *Vocations and Learning* 10 (2017), 47–70.

[9] Ling Cen, Dymitr Ruta, Leigh Powell, and Jason Ng. 2014. Does gender matter for collaborative learning?. In *2014 IEEE International Conference on Teaching, Assessment and Learning for Engineering (TALE)*. IEEE, 433–440.

[10] Sorathan Chaturapruek, Tobias Dalberg, Marissa E Thompson, Sonia Giebel, Monique H Harrison, Ramesh Johari, Mitchell L Stevens, and Rene F Kizilcec. 2021. Studying undergraduate course consideration at scale. *AERA open* 7 (2021), 2332858421991148.

[11] Carol L Colbeck, Susan E Campbell, and Stefani A Bjorklund. 2000. Grouping in the dark: What college students learn from group projects. *The Journal of Higher Education* 71, 1 (2000), 60–83.

[12] Wendy J Dahl, Katrina R Alford, Daniela Rivero-Mendoza, Melissa L Moreno, Sruthy R Emmanuel, and Gabrielle L Gorwitz. 2024. Factors Influencing Undergraduate Students toward Choosing a New Course. *NACTA Journal* 68 (2024), 35–43.

[13] Nilanjana Dasgupta, Melissa McManus Scircle, and Matthew Hunsinger. 2015. Female peers in small work groups enhance women's motivation, verbal participation, and career aspirations in engineering. *Proceedings of the National Academy of Sciences* 112, 16 (2015), 4988–4993.

[14] Nancy DeJarnette. 2012. America's children: Providing early exposure to STEM (science, technology, engineering and math) initiatives. *Education* 133, 1 (2012), 77–84.

[15] Li Deng. 2018. Artificial intelligence in the rising wave of deep learning: The historical path and future outlook [perspectives]. *IEEE Signal Processing Magazine* 35, 1 (2018), 180–177.

[16] ROBERT A DUBICK, RALPH B MCNERNEY, and BRADLEY K POTTS. 1996. CAREER SUCCESS AND STUDENT SATISFACTION: A STUDY OF COMPUTER SCIENCE COOEPRATIVE EDUCATION GRADUATES. *Continuing education* 11 (1996), 4–6.

[17] Aurora Esteban, Amelia Zafra, and Cristóbal Romero. 2020. Helping university students to choose elective courses by using a hybrid multi-criteria recommendation system with genetic optimization. *Knowledge-Based Systems* 194 (2020), 105385.

[18] Carlos Orellana Fantoni, Andrea Mero, and Carmen Vaca. 2020. Tech for hire: data science-related jobs signal economic growth. In *2020 Seventh International Conference on eDemocracy & eGovernment (ICEDEG)*. IEEE, 151–156.

[19] Kathleen M Galotti and Valerie A Umscheid. 2019. Students choosing courses: Real-life academic decision making. *The American Journal of Psychology* 132, 2 (2019), 149–159.

[20] Ronald I Greenberg, Julie Medero, Samuel A Rebelsky, Frances P Trees, and Dale Reed. 2020. The impact of CS for all on college placement in computer science. In *Proceedings of the 51st ACM Technical Symposium on Computer Science Education*. 327–328.

[21] Krishna Gubili. 2024. Career in Artificial Intelligence, Machine Learning, and Data Science. In *Data-Driven Decision Making*. Springer, 255–274.

[22] Orit Hazzan and Gadi Har-Shai. 2014. Teaching and learning computer science soft skills using soft skills: the students' perspective. In *Proceedings of the 45th ACM technical symposium on Computer science education*. 567–572.

[23] Margaret Healy, John Doran, and Maeve McCutcheon. 2018. Cooperative learning outcomes from cumulative experiences of group work: differences in student perceptions. *Accounting Education* 27, 3 (2018), 286–308.

[24] Sylvia Ann Hewlett, Carolyn Buck Luce, Lisa J Servon, Laura Sherbin, Peggy Shiller, Eytan Sosnovich, and Karen Sumberg. 2008. The Athena factor: Reversing the brain drain in science, engineering, and technology. *Harvard Business Review Research Report* 10094 (2008), 1–100.

[25] Michael Hewner. 2014. How CS undergraduates make course choices. In *Proceedings of the tenth annual conference on International computing education research*. 115–122.

[26] Michael Hewner and Mark Guzdial. 2011. How CS majors select a specialization. In *Proceedings of the seventh international workshop on Computing education research*. 11–18.

[27] Ruth E Kallio. 1995. Factors influencing the college choice decisions of graduate students. *Research in higher education* 36 (1995), 109–124.

[28] Amanpreet Kapoor and Christina Gardner-McCune. 2018. Understanding professional identities and goals of computer science undergraduate students. In *Proceedings of the 49th ACM Technical Symposium on Computer Science Education*. 191–196.

[29] Amanpreet Kapoor and Christina Gardner-McCune. 2019. Understanding CS undergraduate students' professional identity through the lens of their professional development. In *Proceedings of the 2019 ACM conference on innovation and technology in computer science education*. 9–15.

[30] Gulsah Hancerliogullari Koksalmis. 2019. Factors Affecting Selection of Elective Courses: The Use of Multi-Criteria Decision Making Model. *Journal of Business Administration Research* 1, 1 (2019).

[31] Nicholas Laberge, K Hunter Wapman, Allison C Morgan, Sam Zhang, Daniel B Larremore, and Aaron Clauset. 2022. Subfield prestige and gender inequality among US computing faculty. *Commun. ACM* 65, 12 (2022), 46–55.

[32] Kathleen J Lehman, Linda J Sax, and Hilary B Zimmerman. 2016. Women planning to major in computer science: Who are they and what makes them unique? *Computer Science Education* 26, 4 (2016), 277–298.

[33] Boxuan Ma, Min Lu, Yuta Taniguchi, and Shin'ichi Konomi. 2021. Investigating course choice motivations in university environments. *Smart Learning Environments* 8 (2021), 1–18.

[34] Lori C Mack, Olivia Halic, and Emma Burd. 2019. Career oriented and university bound: higher education outcomes of IB Career-related Programme graduates in the US. *Journal of Vocational Education & Training* 71, 2 (2019), 289–311.

[35] V Mahalakshmi, Nirzar Kulkarni, KV Pradeep Kumar, K Suresh Kumar, D Nidhi Sree, and S Durga. 2022. The role of implementing artificial intelligence and machine learning technologies in the financial services industry for creating competitive intelligence. *Materials Today: Proceedings* 56 (2022), 2252–2255.

[36] Jane Margolis, Allan Fisher, and Faye Miller. 2000. The anatomy of interest: Women in undergraduate computer science. *Women's Studies Quarterly* 28, 1/2 (2000), 104–127.

[37] Peter McPartlan, Teomara Rutherford, Fernando Rodriguez, Justin F Shaffer, and Amanda Holton. 2021. Modality motivation: Selection effects and motivational differences in students who choose to take courses online. *The Internet and Higher Education* 49 (2021), 100793.

[38] Dee Michell, Anna Szorenyi, Katrina Falkner, and Claudia Szabo. 2017. Broadening participation not border protection: How universities can support women in computer science. *Journal of Higher Education Policy and Management* 39, 4 (2017), 406–422.

[39] Amanda Montoya, Allison Master, and Sapna Cheryan. 2020. Increasing Interest in Computer Science through Group Work: A Goal Congruity Approach. (2020).

[40] Yvonne J Moogan and Steve Baron. 2003. An analysis of student characteristics within the student decision making process. *Journal of further and Higher Education* 27, 3 (2003), 271–287.

[41] National Academies of Sciences, Medicine, Division on Engineering, Physical Sciences, Computer Science, Telecommunications Board, Global Affairs, Board on Higher Education, and Committee on the Growth of Computer Science Undergraduate Enrollments. 2018. *Assessing and responding to the growth of computer science undergraduate enrollments*. National Academies Press.

[42] Markeya S Peteranetz, Abraham E Flanigan, Duane F Shell, and Leen-Kiat Soh. 2018. Future-oriented motivation and retention in computer science. In *Proceedings of the 49th ACM Technical Symposium on Computer Science Education*. 350–355.

[43] Robert J Reynolds and Steven M Day. 2018. The growing role of machine learning and artificial intelligence in developmental medicine. *Developmental Medicine & Child Neurology* 60, 9 (2018), 858–859.

[44] Eric S Roberts, Marina Kassianidou, and Lilly Irani. 2002. Encouraging women in computer science. *ACM SIGCSE Bulletin* 34, 2 (2002), 84–88.

[45] Fatin Samara. 2015. Factors influencing students' choice of elective science courses: a case study from the American University of Sharjah. *Open Journal of Social Sciences* 3, 8 (2015), 93–99.

[46] Cassandra Sample. 2018. Implications of Elective Course Selection by Grade Maximization. (2018).

[47] Dorothy Sanchez. 1996. Producing Knowledge in Career-Oriented Programs: Students' Perspectives on Schooling Experiences. *Research for Education in a Democratic Society.* (1996), 14.

[48] Christopher Scaffidi. 2018. Employers' needs for computer science, information technology and software engineering skills among new graduates. *International Journal of Computer Science, Engineering and Information Technology* 8, 1 (2018), 1–12.

[49] Jill A Slater, Heidi L Lujan, and Stephen E DiCarlo. 2007. Does gender influence learning style preferences of first-year medical students? *Advances in physiology education* 31, 4 (2007), 336–342.

[50] Glenda S Stump, Jonathan C Hilpert, Jenefer Husman, Wen-ting Chung, and Wonsik Kim. 2011. Collaborative learning in engineering students: Gender and achievement. *Journal of engineering education* 100, 3 (2011), 475–497.

[51] Erla Guðrún Sturludóttir, Eydís Arnardóttir, Gísli Hjálmtỳsson, and María Óskarsdóttir. 2021. Gaining insights on student course selection in higher education with community detection. *arXiv preprint arXiv:2105.01589* (2021).

[52] Sachiko Takeda and Fabian Homberg. 2014. The effects of gender on group work process and achievement: an analysis through self-and peer-assessment. *British Educational Research Journal* 40, 2 (2014), 373–396.

[53] Ding Hooi Ting and Christina Kwai Choi Lee. 2012. Understanding students' choice of electives and its implications. *Studies in Higher Education* 37, 3 (2012), 309–325.

[54] Jonathan H Tomkin, Matthew West, and Geoffrey L Herman. 2018. An improved grade point average, with applications to CS undergraduate education analytics. *ACM Transactions on Computing Education (TOCE)* 18, 4 (2018), 1–16.

[55] Zhi Hong Wan, Yushan Jiang, and Ying Zhan. 2021. STEM education in early childhood: A review of empirical studies. *Early Education and Development* 32, 7 (2021), 940–962.

[56] John S Wilson, Vicki Bartosik Stocking, and David Goldstein. 1994. Gender differences in motivations for course selection: Academically talented students in an intensive summer program. *Sex Roles* 31 (1994), 349–367.