# Prospective Students' Reactions to the Presentation of the Computer Science Major

by

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of the requirements for the degree of
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We hereby certify that this dissertation, submitted by Daniel Scott Weaver, satisfies the dissertation requirements for the fegree of Doctor of Professional Studies in Computing has been approved.

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# An Abstract

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The number of students enrolling in Computer Science in colleges and Universities has declined since its peak in the early 2000s. Some claim contributing factors that intimate that prospective students fear the lack of employment opportunities if they study computing in college. However, the lack of understanding of what Computer Science is and what it involves might be a more compelling reason for the decline. This dissertation investigates the attitudes and perceptions of prospective students toward studying Computer Science and the presentation of the Computer Science major on college and university websites.

The study employs four research stages that examine different aspects of this question that culminate in high school students providing their opinions of different representations of the Computer Science curriculum. The first stage evaluates college and university presentations of the Computer Science curriculum available on the web develops a Typical Curriculum. The second evaluates how businesses promote computer related job opportunities and develops an alternative presentation of the curriculum based on the findings. The third elicits perceptions, opinions, and ideas from prospective students and college students on how to develop a more exciting presentation of the curriculum. The final stage utilizes the curricula developed in the prior stages of this study in surveys designed to eliciting prospective students' reactions to the different curricula.

The results indicate that typical Computer Science curricula do not interest prospective students. The curriculum developed through the input of prospective and college students, however, was more favorably received and seemed to increase student interest in pursuing the study of Computer Science. Prospective students provided insight into their perceptions of the Computer Science curriculum. This

insight is valuable to colleges and universities that desire to present their curriculum in a manner that is exciting and motivating to prospective students.

This study informs colleges and universities of the characteristics of a curricular presentation that excite and motive prospective students to pursue studying Computer Science.

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# Chapter 1

# Introduction

Colleges and Universities that utilize the World Wide Web communicate with a broad audience of prospective students. These institutions disclose information about themselves from historical and supporting information to admissions procedures and curricula in an attempt to provide prospective students with the information they need to choose an institution. Prospective students turn to college and university web sites as their primary source of information in choosing where to attend [53, 80, 106]. However, even with the ability for prospective students to obtain information immediately through a college web site, the number of students enrolling in Computer Science today is a fraction of what it was ten years ago [67, 71, 111, 112].

This dissertation focuses on the question, “Is the reason more prospective students are not choosing to study Computer Science related to the presentation of the curricula and other information about the major?” This study explores the possibilities this question presents from two perspectives. The first focuses on the presentation of Computer Science curricula on college and university web sites. The second analyzes high school students’ reactions to the presentation of Computer Science curriculum.

## 1.1 Three Perspectives: College Presentation, Business Opportunities, and Prospective Students

The decline of enrollment in computing majors in colleges and universities is a complex problem. Today's students are "techno-savvy and capable of accessing greater breadth of information [37]" than their parents yet many are not pursuing computer degrees in college [112].

In the past, computing educators had the luxury of an increase of students enrolling in their programs. In fact, universities could not handle the numbers of students wanting to major in Computer Science [24, 51, 63]. Students during that time seemed to be motivated to study computing regardless of what was in the catalog or on the web site. What was communicated only helped to differentiate programs. With the national decline of the number of undergraduate students electing to study computing, that is no longer the case. Are Colleges and Universities communicating the major in a relevant way?

The first part of this study examines colleges' and universities' presentations of their Computer Science curricula and how they relate to current computing issues. This study also evaluates college and university curricula from five and ten years ago to see whether it has evolved over time in order to keep in sync with the ever-changing computing discipline.

The second part of this study explores business job recruitment and the method of presenting job opportunities. This study also seeks a different way of presenting Computer Science that may have a greater appeal to prospective students.

The third part of this study analyzes the reactions prospective students have to the Computer Science curricula presented to them. This study also seeks to understand the perceptions of these students about computing. What excites this up-coming generation about computers? What part of computing would they love to study? How can this generation's sophistication with technology be encouraged, igniting their passions about computing, and directing them to pursue studying those passions?

Students who are enrolling in colleges and universities today do not understand what a Computer Science major learns [39]. When viewing the curriculum do they see course titles that they cannot relate to? Having grown up with computers and being comfortable using technology, course titles and descriptions they cannot relate to does not inspire them to pursue studying Computer Science. This generation values more than income and status [37], they want to make a difference [87].

As these issues are explored, new curricular presentations are developed and reactions are once again analyzed to determine if there is a better way to communicate what the study of computing offers.

## 1.2 The Rise and Fall of Enrollment

This research's guiding question was precipitated by the decline in enrollment over the last decade. This problem has been tracked by the Computer Research Association (CRA). The CRA, formed in 1972 as the Computer Science Board, "seeks to strengthen research and advanced education in computing and allied fields [21]." CRA is committed to four mission areas related to computing research as laid out by the organization's mission statement [21]:

- influencing policy in computing research
- collecting and disseminating information

- ensuring that the need for talented and well-educated practitioners is met
- promoting community

The Taulbee survey, a research tool used by the Information branch of the CRA, is given to colleges and universities in the fall to collect data from the previous school year. The return rate is very high, an average of 79%, lending to the validity of the survey [111]. Orrin E. Taulbee of the University of Pittsburgh, for whom the survey is named, conducted these surveys for the Computer Science Board from 1974-1984 [20]. The survey collects data regarding enrollment statistics for Bachelors, Masters, and Ph.D.s majoring in Computer Science and Computer Engineering.

In 1994, 9,041 students enrolled in undergraduate degrees in Computer Science [16]. The number climbed over the next 5 years to 27,040 students with a single dip in 1998 of 16,103 (see Figure 1.1 and table 1.1). This represents a 199% increase in enrollments over those six years.

Over the years 2000, 2001, and 2002 the number of students enrolling slipped from the high of 27,040 students to 25,565, a 5.5% drop (see Table 1.1 and Figure 1.1) [33, 34, 105].

After 2002 the number of students enrolling in undergraduate degrees in Computer Science began a free fall, stabilizing in 2005 at 13,165 students, 46% higher than the enrollment in 1994 but 51% lower than the peak in 2000. Between the fall semester of 2005 and the fall semester of 2008, enrollment vacillated between -4.07% and 3.78% with the fall of 2008 experiencing an increase of 1.89% as compared to the previous year and 1.44% as compared to 2005. Enrollment beginning with the initial decline in the fall of 2000 to the fall of 2008 dropped 102.5% (see Figure 1.1 and

| Year | New Students |
|---|---|
| 1994 | 9,041 [16] |
| 1995 | 9,885 [17] |
| 1996 | 13,644 [18] |
| 1997 | 17,261 [72] |
| 1998 | 16,103 [71] |
| 1999 | 21,940 [67] |
| 2000 | 27,040 [33] |
| 2001 | 25,902 [34] |
| 2002 | 25,565 [105] |
| 2003 | 20,154 [113] |
| 2004 | 16,997 [108] |
| 2005 | 13,165 [109] |
| 2006 | 13,662 [110] |
| 2007 | 13,106 [111] |
| 2008 | 13,354 [112] |

**Table 1.1:** The Rise and Fall of Enrollment

Table 1.1) [105, 113, 108, 109, 110, 111, 112].

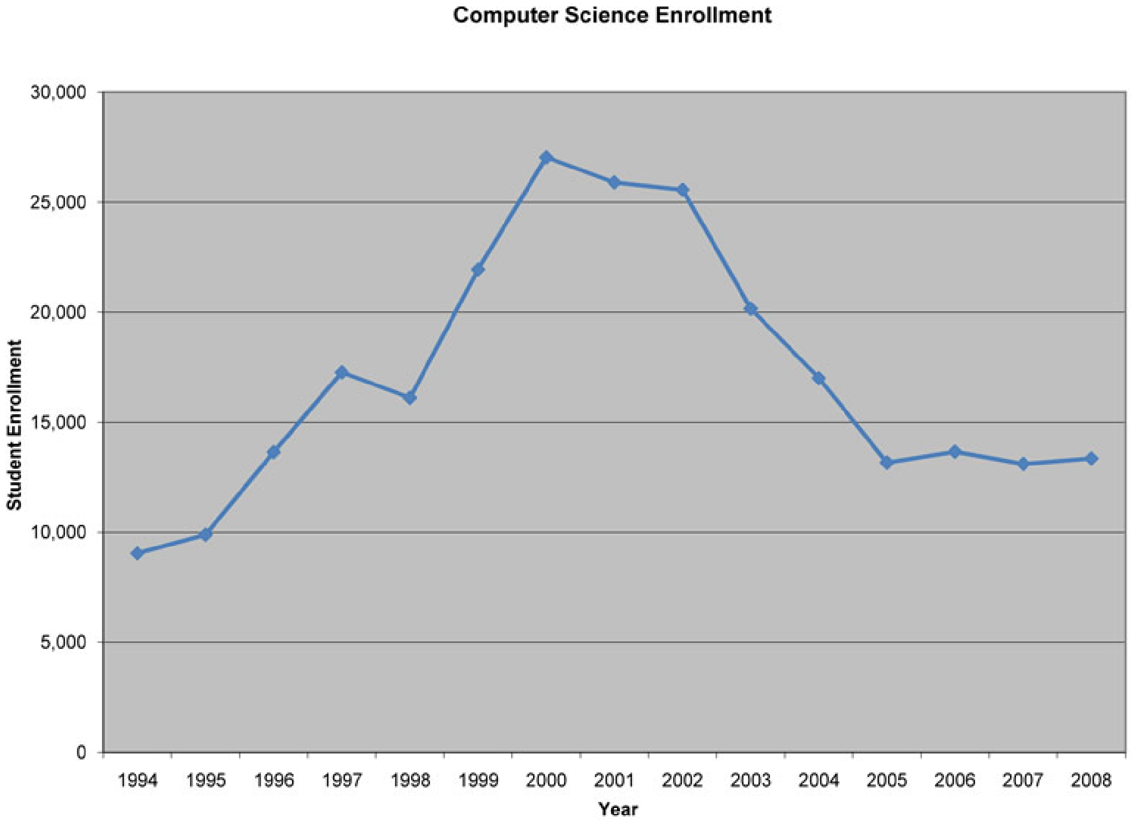


**Figure 1.1:** New Undergraduate Computer Science Majors[112]

Several changes to the methods of reporting data may cause some discrepancies in the actual changes in enrollment. In the past many colleges and universities reported pre-major and major enrollment data. Stuart Zweben in the 2007-2008 Taulbee Report [112] indicated that these numbers may not represent the same statistical data since some of these colleges and universities no longer use pre-majors and combine all students, pre-majors and majors, in a single count. He also specifies that this is the first year Information programs are being tracked, programs that include Information Science, Information Systems, Information Technology, and Informatics.

John Sargent in his article, *An Overview of Past and Projected Employment Changes in the Professional IT Occupations* [96], attributes the decline to many factors, including the dot-com bust, the end of work of Y2K, the terrorist attacks of September 11, 2001 and their related effect on the U.S. economy, a downturn in corporate IT spending, the brief 2001 recession, productivity increases, and the offshore outsourcing (off-shoring) of IT work. These factors may have contributed to the initial decline, but have they contributed to the continual decline? Each of these factors suggest that prospective students fear that jobs will not be available to them when they graduate.

## 1.3 Job Projections Over the Next Ten Years

Though the decline in enrollment is so profound, the Bureau of Labor Statistics (BLS) of the U.S. Department of Labor projects that there will be plenty of opportunities in the years to come for computer-related jobs. Every two years the BLS prepares projections for the next ten years covering industry and occupational employment [55]. The last projections were done in November of 2007, encompassing the years between 2006 to 2016. Computer-related jobs are projected to fare well in next ten years.

The BLS projects the growth of both industries and individual occupations. In industry growth, two of the computer-related industries projected to grow the fastest include the computer systems design and related services industry and the software publishers industries, projected to grow at an annual rate of 6.2% [54].

In relation to occupational growth, of the top thirty fastest growing occupations in the decade between 2006 and 2016, five of them are computer-related. In fact the projected fastest growing occupation is the networking systems and data communications analyst, expected to grow by 53.4% [52]. The other computer-related occupations in the list of thirty include computer software engineers for applications at position four, computer systems analysts at position 23, database administrators at position 24 and computer software engineers for systems software at position 25 (see Table 1.2) [52]. Employment projections, which include jobs due to both growth and net replacements, for Computer Science occupations are predicted to grow 47.6% [52]. In other words, the BLS predicts that 1 in 19 job opportunities will be in the Computer Science workforce [52].

| Rank | Occupation | Percent Change | Annual Salary Range |
|---|---|---|---|
| 1 | Network systems and data communications analysts | 53.4 | Highest |
| 4 | Computer software engineers, applications | 44.6 | Highest |
| 23 | Computer systems analysts | 29.0 | Highest |
| 24 | Database administrators | 28.6 | Highest |
| 25 | Computer software engineers, systems software | 28.2 | Highest |

**Table 1.2:** Fastest Growing Occupations, 2006-2016 [52]

Even with this bright future of Computer Science related jobs, “signs of recovery from the sharp decline [of computer science graduates] that has lasted several years have yet to materialize [111].” How will higher education address these facts? College and university bound students need a clear picture of a relevant curriculum they understand that relates to their everyday experience.

## 1.4 Other Steps Taken to Address the Declining Enrollment

Colleges and universities have been active in trying to solve this problem of the declining enrollment by tackling research in recruitment and retention. There have also been other organizations such as the Association for Computing Machinery (ACM)and the Institute of Electrical and Electronics Engineers, Inc. (IEEE)that have developed curricular guides to help colleges and universities keep in sync with the rapid growth of the discipline. The first part of this research examines the presentation of Computer Science curricula. In order to put the study in context it is important to understand the research that has gone into recruitment and retention as well as the work that has gone into the development of the Computer Science curricula over the last few decades.

Many articles have been published that promote changes to computing courses students take in their first year of college [25, 40, 43, 44, 57, 68, 73, 92]. The premise is that changing the content and delivery methodology will aid in recruiting new students as well as retaining current students. However, the names of these courses and how they are presented on the school's website remain the same. For example at one college the courses listed as CS332 Computer Organization and Architecture and CS341 Systems Analysis and Design are exactly the same in 1998 as it is in 2008. The details are explored further in chapter 2.

The recommendations of many of these research articles assume that the students will be exposed to new and exciting ideas within the initial courses which will motivate them to continue studying computing. For this to happen, however, they presume that the students will come. But students won't come if their perception to begin with is flawed. If they view computing majors as out-dated or unappealing, they will not enroll in the initial courses, and therefore, not be swayed by the exciting content. If the curricula displayed were relevant to these prospective students, they might enroll in at least one of the initial courses, then the content of those courses could be the additional motivation for those students to pursue the computing degree.

### *1.4.1 Research Addressing Declining Enrollment*

One area of research attempting to address the declining enrollment problem focuses on developing methods to identify those students who would succeed in a computing program [26, 27, 41, 65]. Some identify a student's abstraction ability as an indicator of success [26, 65], while others show previous academic and computer experience and self-perception as key [27]. One study finds a student's performance in the curriculum as a prediction of future performance [41]. While understanding factors that contribute to the success of students is important to help those students in the program succeed, it still fails to get the students into the program.

Another research area analyzes undergraduate recruitment and the success of those students [15, 38]. One study finds the qualifications of undergraduate students enrolling in Computer Science and their success in the program [15] while another uses the PSAT/NMSQT scores as an indicator of success in an Advanced Placement course [38]. Determining characteristics that may indicate the potential for higher success in Computer Science helps the selection process. However, in an age of declining enrollments, rejecting students without these characteristics may not be an option.

Yet another research area studies the factors that motivate students to choose a major in the field of computing [14, 64]. Asli Akbulut and Clayton Looney address the question, “from the students perspective, what are the factors that motivate students to choose a major in the field of computing [14]?” Their model of four interacting factors shows how the first two factors, “Self-Efficacy” and “Outcome Expectations” motivate the third factor, “Interest” which in turn motivates the final factor, “Chosen Goals”. This is the closest study to understanding student choices as they pursue a degree, however, it still deals with students already enrolled in an introductory information systems course.

None of these research areas that attempt to address the declining enrollment problem have focused on the presentation of the Computer Science major to prospective students and the reaction of these students to what they are presented.

### *1.4.2 Computer Science Curriculum Evolution*

In conjunction with research relating to recruitment and retention, Computer Science curricula has evolved. The rate of the growth of technology is exponential [56, 74, 76]. Ray Kurzweil has stated, “we find not just simple exponential growth, but ‘double’ exponential growth, meaning that the rate of exponential growth is itself growing exponentially [75].” Because of this growth several organizations such as the Association for Computing Machinery, Inc., the Institute of Electrical and Electronics Engineers, Inc, and the Liberal Arts Computer Science Consortium have developed, over the last four decades, curricular guidelines to help colleges and universities keep up with the rapid change of technology.

In 1962 the Association for Computing Machinery, Inc. (ACM) formed a subcommittee called the Curriculum Committee on Computer Science ($C^3S$) and in

1964 $C^3S$ began working on curricular recommendation [22]. In 1965 the committee published its first report entitled, “An undergraduate program in computer science—preliminary recommendations [47]” followed by a revised edition in 1968 entitled, “Curriculum ‘68 [22]”. Table 1.3 presents the curriculum recommendations of the committee’s first report.

| Recommendation Level | Course Name | Type of Course |
|---|---|---|
| Required | Introduction to Algorithmic Processes | Basic Course |
| | Computer Organization and Programming | Basic Course |
| | Numerical Calculus | Numerical Algorithms |
| | Information Structures | Basic Course |
| | Algorithmic Languages and Compilers | Theory Course |
| Highly Recommended | Logic Design and Switching Theory | Basic Course |
| | Numerical Analysis I | Numerical Algorithms |
| | Numerical Analysis II | Numerical Algorithms |
| | Computer and Programming Systems | Basic Course |
| Other | Combinatorics and Graph Theory | Basic Course |
| | Systems Simulations | Models and Apps |
| | Mathematical Optimization Techniques | Models and Apps |
| | Constructive Logic | Theory Course |
| | Introduction to Automata Theory | Theory Course |
| | Formal Languages | Theory Course |
| | Heuristic Programming | Models and Apps |

**Table 1.3:** Curricular Recommendations 1965 [47]

In Curriculum ‘68, the committee recommended specific academic programs and courses in computer science. In this first curriculum guide, ACM developed course descriptions for twenty-two courses along with prerequisites, detailed outlines, and annotated bibliographies for each course [22, 2]. It was considered to be a tremendous guide, “pointing the way to a discipline of computer science [32].” According to Gopal Gupta, this curriculum was the “most important CS education milestone of the 1960s [62]".

The next guideline related to computing curriculum published in 1978 by the ACM titled, "Curriculum '78" [23] was criticized for simply following curricula set out by large universities [32]. Some go so far as to say, "Curriculum '78 has become obsolete as a guiding light for maintaining contemporary high-quality undergraduate degree programs and cannot serve as a basis for developing a new degree program in computer science within a liberal arts setting [58]."

Curriculum '78 updated Curriculum '68 and continued providing colleges and universities with courses, prerequisites, and outlines as it did in Curriculum '68. Courses were divided into those considered core courses and those considered elective courses (See Table 1.4) [23]. Though criticized, Curriculum '78 "became the model curriculum that many computing programs in the United States and throughout the world followed [59]." Comparing the course titles in Curriculum '78 to course titles in college and university curricula presented today, you will notice that many of them are identical.

In 1977 and then in 1983 the Institute of Electrical and Electronics Engineers, Inc. (IEEE) published two curriculum guides for Computer Science as it relates to Engineering, "A Curriculum in CS and Engineering [35]" and "The 1983 Model Program in Computer Science and Engineering [66]". In 1984 they published "The IEEE Computer Society Model Program in Computer Science and Engineering" that presented a 13 subject area core curriculum [36].

In 1984 and 1985, the ACM published two articles focused on the first two computing courses, CS1 and CS2, both identifying topics to cover in the courses and suggesting a program design and implementation [69, 70]. These were the first publications focused on addressing the content of the first year courses.

| | |
|---|---|
| **Core Courses** | |
| CS 1. | Computer Programming I |
| CS 2. | Computer Programming II |
| CS 3. | Introduction to Computer Systems |
| CS 4. | Introduction to Computer Organization |
| CS 5. | Introduction to File Processing |
| CS 6. | Operating Systems and Computer Architecture I |
| CS 7. | Data Structures and Algorithm Analysis |
| CS 8. | Organization of Programming Languages |
| **Elective Courses** | |
| CS 9. | Computers and Society |
| CS 10. | Operating Systems and Computer Architecture II |
| CS 11. | Database Management Systems Design |
| CS 12. | Artificial Intelligence |
| CS 13. | Algorithms |
| CS 14. | Software Design and Development |
| CS 15. | Theory of Programming Languages |
| CS 16. | Automata, Computability, and Formal Languages |
| CS 17. | Numerical Mathematics: Analysis |
| CS 18. | Numerical Mathematics: Linear Algebra |

**Table 1.4:** The List of Courses in Curriculum '78 [23]

In 1989 Peter Denning et. al wrote a paper, "Computing as a Discipline [45]", identifying nine areas that a computing curriculum would need to address. This report became "the definition of the computing discipline [59]."

The ACM and IEEE joined forces in 1991, using Denning's work as a catalyst for Curricula '91 [104]. This was the first guideline that broke away from the earlier format of course layout. In this guideline the ACM and IEEE took the nine computing areas addressed by Denning et. al and expanded on them, incorporating what are now known as "Knowledge Units [104]".

Between the years 2001 and 2008, the ACM and IEEE have published several volumes of curricular guidelines addressing the different computing disciplines as listed below.

- Computing Curricula 2001 [2]
- Model Curriculum and Guidelines for Undergraduate Degree Programs in Information Systems [61]
- Computer Engineering 2004 [102]
- Software Engineering 2004 Curriculum Guidelines for Undergraduate Degree Programs in Software Engineering [103]
- Computing Curricula 2005 - The Overview Report [99]
- Information Technology 2008 Curriculum Guidelines for Undergraduate Degree Programs in Information Technology [79]

Beginning in 1986, the Liberal Arts Computer Science Consortium (LACS) began publishing its own Model Curriculum for a Liberal Arts Degree in Computer Science as a response to the ACM and IEEE guidelines. The first, "A Model Curriculum For A Liberal Arts Degree In Computer Science", presented courses in three categories, introductory, core, and electives (See Table 1.5) [58]. The later guideline, "A 2007 Model Curriculum for a Liberal Arts Degree in Computer Science," categorized the courses as introductory, intermediate core, advanced electives and undergraduate projects and research [46], and compared courses to the ACM/IEEE Curricula 2001.

Figure 1.2 provides a timeline of the different organizations and the curricular guidelines each developed.

The current curricular guideline published by the Joint Task Force on Computing Curricula of the IEEE Computer Society and the Association for Computing Machinery, entitled, "Computing Curricula 2001 Computer Science" is one of several addressing the different kinds of undergraduate degree programs in computing [99]. Each program has its own curricular guideline (see Figure 1.3).

"Computing Curricula 2001 Computer Science" lays out fourteen knowledge focus

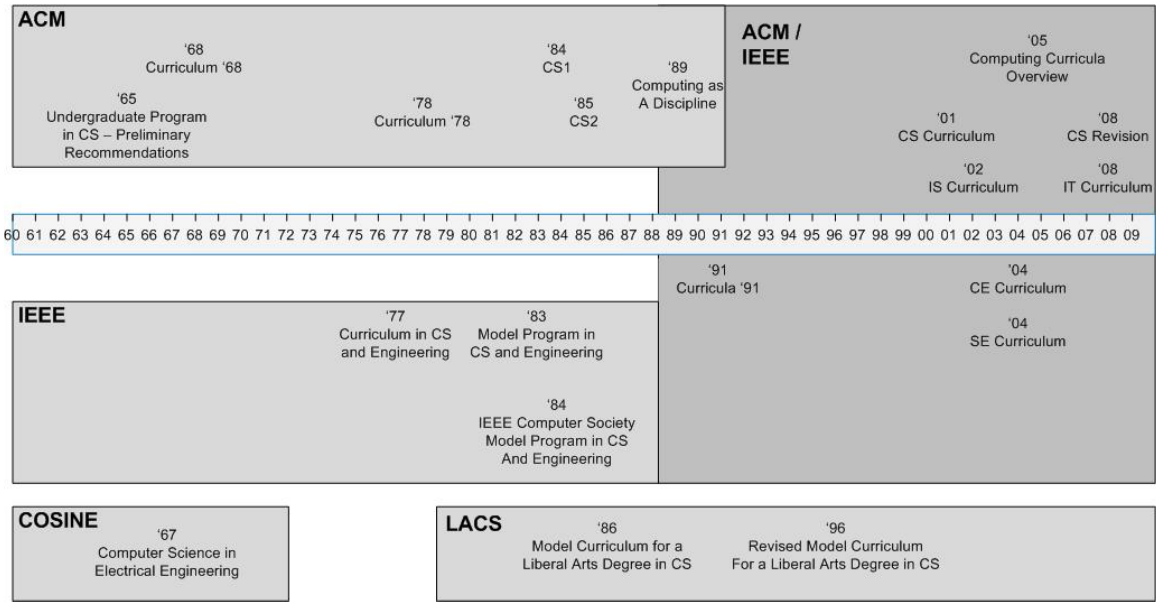


**Figure 1.2:** Curriculum Timeline

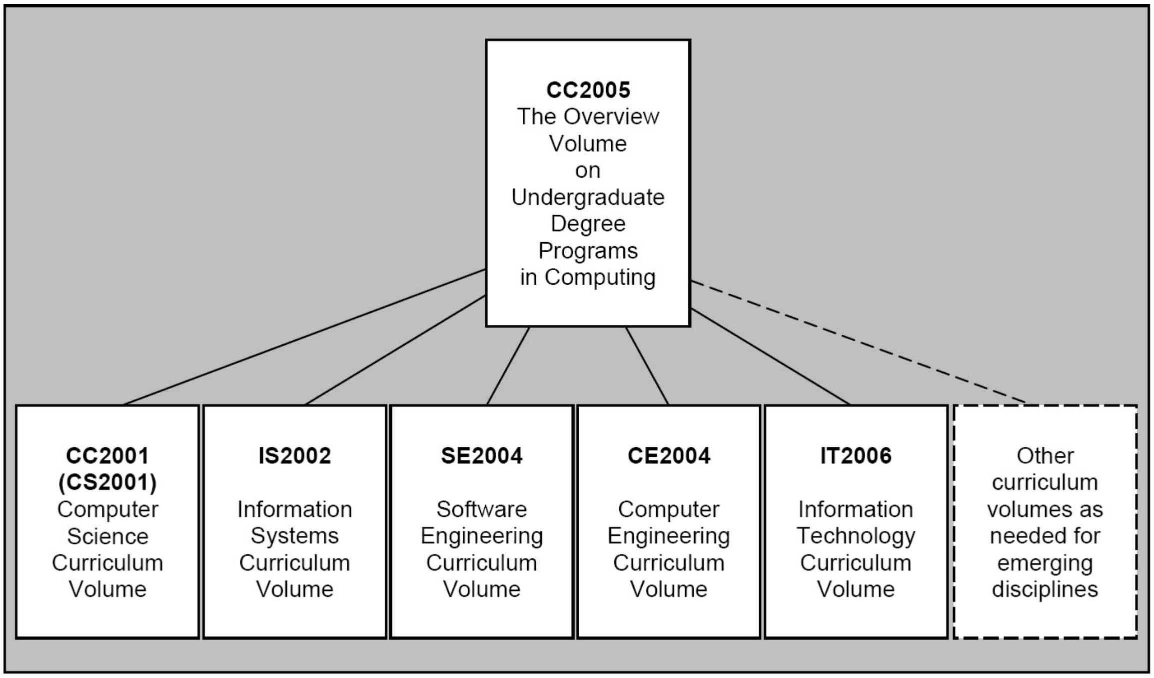


**Figure 1.3:** Structure of the Computing Curricula Series [99]
(Used with Permission from ACM)

| | | |
|---|---|---|
| CS1 | | Intro |
| CS2 | | Intro |
| CO1 | Principles of Computer Organization | Core |
| CO2 | Algorithms | Core |
| CO3 | Theory of Computation | Core |
| CO4 | Principles of Programming Languages | Core |
| EL1 | Compiler Design | Elective |
| EL2 | Artificial Intelligence | Elective |
| EL3 | Operating Systems | Elective |
| EL4 | Database Principles | Elective |
| EL5 | Computer Architecture | Elective |
| EL6 | Networks | Elective |
| EL7 | Simulation | Elective |
| EL8 | Graphics | Elective |
| EL9 | Numerical Methods | Elective |
| EL10 | Semantics and Correctness | Elective |
| EL11 | Topics | Elective |

**Table 1.5:** LACS Curricular Guideline 1986

groups "that together represent the body of knowledge for computer science at the undergraduate level [2]" (See Table 1.6). This curricular guideline provides colleges and universities with descriptions of each knowledge group area, and a list of topics with the area, indicating which are considered core and which are elective. A description is given for each topic along with multiple learning objectives. The guide then goes into full descriptions of sample courses that implement the core topics. The attempt is to give colleges and universities that desire autonomy the flexibility to build courses according to their needs while giving samples to help lead others.

The curriculum developed by the Liberal Arts Computer Science Consortium entitled, "A 2007 model curriculum for a liberal arts degree in computer science" has a more specific structure than the Computing Curricula 2001 Computer Science [46]. It proposes "three basic courses in computer science followed by a set of 4 courses capturing what is the essence or core of the discipline, followed by 3 electives made up of advanced courses for depth and applications courses for breadth, accompanied or followed by a culminating project or thesis [46, p. 4].” The guide then describes the suggested courses based on the Computer Curricula 2001 Computer Science.

Discrete Structures (DS)
Programming Fundamentals (PF)
Algorithms and Complexity (AL)
Architecture and Organization (AR)
Operating Systems (OS)
Net-Centric Computing (NC)
Programming Languages (PL)
Human-Computer Interaction (HC)
Graphics and Visual Computing (GV)
Intelligent Systems (IS)
Information Management (IM)
Social and Professional Issues (SP)
Software Engineering (SE)
Computational Science (CN)

**Table 1.6:** The Fourteen Knowledge Focus Groups [2]

### *1.4.3 Research Broadening Higher Education’s Perspective*

Another area of research addressing the declining enrollment seeks to align higher education with organizations of which graduates will become a part. Curricular guidelines attempt to define computing, address necessary knowledge, and suggest required courses or course topics to aid schools in developing curricula. This last area of research attempts to take a broader view, expanding the higher education’s perspective to include the working world.

In an attempt to promote science, the National Science Foundation (NSF) was established [90]. In September of 2000 NSF disbursed the first grant under the Partnership for Innovation, created to support “creative interaction in local communities between higher education institutions, government agencies, foundations and the private sector [91].” One organization within the NSF that is focused on Computing is the Directorate for Computer and Information Science and Engineering (CISE) [88] and has awarded over 2,000 grants to support its mission.

One study that is being conducted by a partnership between Argonne National Laboratory, Joliet Junior College, and Governors State University has been funded by CISE to "focus on the preparation of students for a computing and technology workplace that is increasingly diverse and transdisciplinary[77]." According to their proposal, they will work with the "higher education community, computing professionals from across the regional industrial sectors, the research community, and the not-for-profit community ... identifying the relevant knowledge, skills, and other qualities required for computing professionals [77]."

> "The major goals of the project are: 1) establish partnerships and leaderships in the Computer & Information Science & Engineering (CISE) community in the Chicago metropolitan region that focus on transforming computing education, 2) build an innovative, transdisciplinary model for undergraduate computing education, 3) create student learning experiences especially accessible for the adult learner.
>
> As a model for developing undergraduate computing education, the outcomes of this project may define a new focus on preparation for the diverse computing and technology workplace [77]."

## 1.5 Children Today Grow Up Exploring Computer Science

Children explore the world they live in and have learned concepts of Physics, Chemistry, Biology, English and Mathematics through play. When attempting to throw a football these early learners experiment with what throwing angle will give them the longest pass. When playing in the kitchen, children are interested in learning what happens when you combine different ingredients. Twenty years ago children did not have anything in their lives that they could explore and learn about Computer Science. Today's children have grown up with computers in their homes.

With this background, can today's prospective students connect what they have informally learned about Computer Science with what colleges and universities are presenting?

The next generation of college and university students, called Generation Y are the students enrolling today. Born in the time period between the late 1970's [19, 37, 89, 94, 107] and the early 1990's [37, 89, 94, 107] to early 2000's [19] these students, also known as the Net Generation or the Millennials, are technologically savvy having grown up with a computer in the home since nursery school [37, 89, 107]. They will spend approximately 1/3 of their lives on the Internet, their primary source of news and information [37]. Having an average of two email addresses, this generation's primary mode of communication is e-mail [37]. They are comfortable using video games, cell phones, PDAs, downloading music, MP3 players, and instant messaging [37, 107].

Students considering courses of study for their college career may not choose a computing major due to a lack of understanding of what is involved in the major. Dr. Carter, in a study of 836 high school students found that they did not choose computing as a major because they had an incorrect perception of the field or no perception at all. "A large percentage (50%) of students is opposed to CS because they imagine computer scientists as sitting in front of computers and programming all day. The vast majority of students could not provide a description of what Computer Science majors learn. [39]."

## 1.6 Structure of this Research

The purpose of this research is first, to explore how colleges present computer-related curricula on the World Wide Web and second, to examine high school students' understanding of it. The motivation for this study lies in the drop in enrollment of students pursuing computing-related majors and the need to challenge higher education to change the way it communicates courses of study.

The four tracks of this research are divided into segments, illustrated in Figure 1.4, designed to shed light on the disconnect between how colleges and universities present computer-related majors and how high school students perceive studying those majors. The segments as listed below are further developed in the following chapters of this dissertation.

- Track 1: Curricular Presentations
  - College Curricular Review
- Track 2: Technology Job Review
  - Technology Job Review
- Track 3: Student Opinions and Ideas for Developing a Student-Focused Curriculum
  - HS Student Technology Survey
  - HS Student Focus Groups
  - College Student Delphi Study
- Track 4: Survey of Prospective Students
  - Survey Instrument 1: Typical Versus Job-Focused Curricula Survey
  - Survey Instrument 2: Typical Versus Student-Focused Curricula Survey

Figure 1.4 provides an overview of the steps and processes followed during the research. The figure also identifies the intended output for each segment that will be used in the curricular surveys. Each of the segments are briefly described in the following sections.

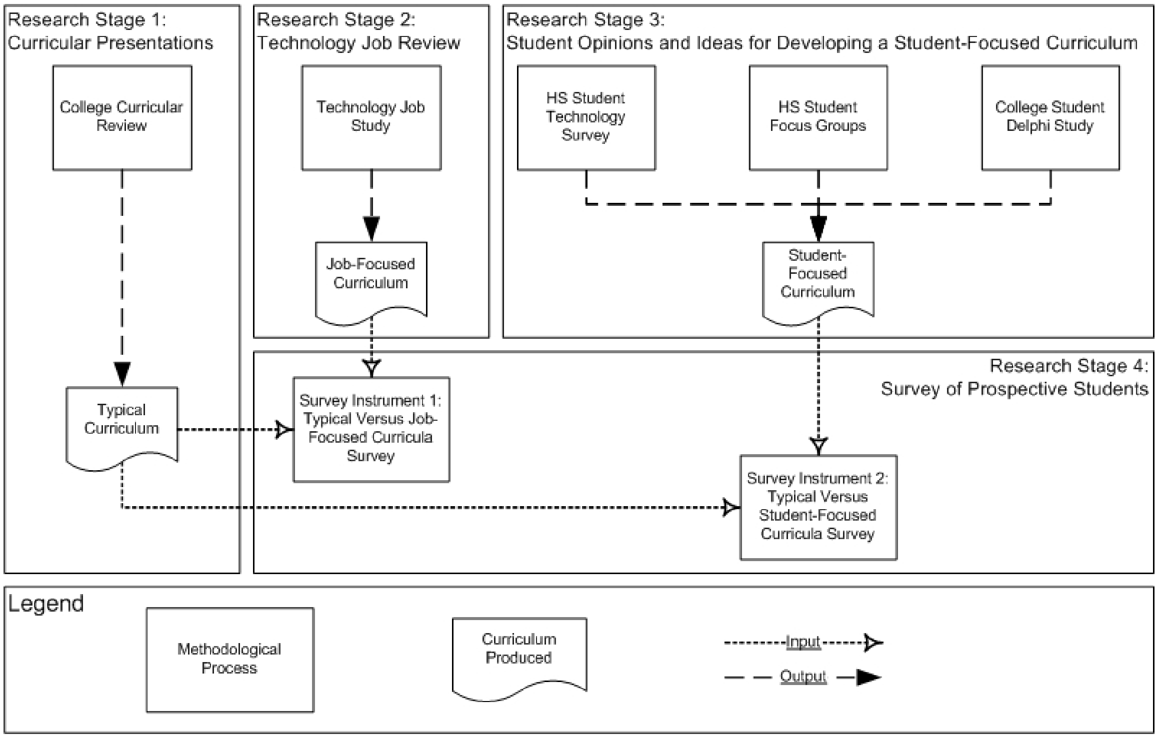


**Figure 1.4:** Research Process Design

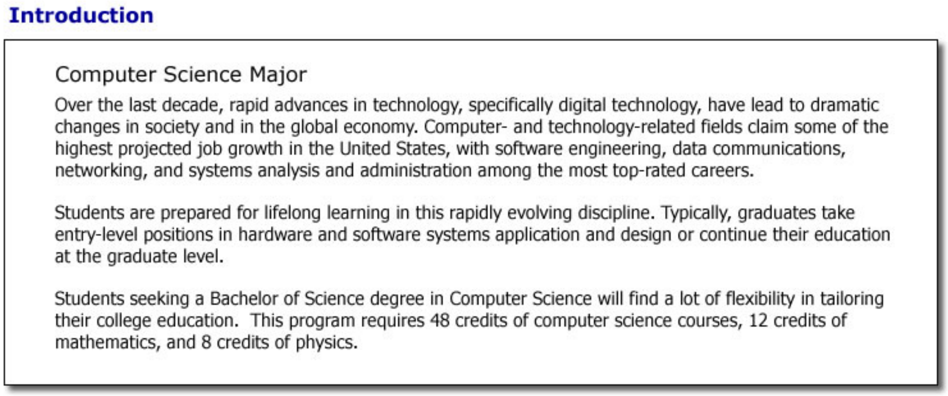
### *1.6.1 Stage 1: Curricular Presentations*

The first stage of this research, Curricular Presentations, focuses on how colleges and universities present their Computer Science major. The segment within this stage, College Curricular Review, evaluates college and university Computer Science curricula attempting to identify current components of the curricula available on the web. The purpose of this segment is to get an understanding of what students may see when looking into a college or university and how that might shape their opinions of studying computers. Even though there are at least five different titles for computer-related majors, namely Computer Science, Computer Engineering, Information Systems, Information Technology, and Software Engineering (which add to student confusion) [99], this research focuses on the Computer Science major.

The following questions guide this portion of the research:

1. How is Computer Science portrayed in documents available to students via the Internet?
2. What courses do colleges and universities offer and how do those course titles and descriptions compare to earlier versions of their curricula.

The result of this research activity is an example of a Computer Science Curriculum that a student may encounter when exploring options for majoring in Computer Science. Figure 1.5 illustrates a typical introduction to the major. Figure 1.6 illustrates a typical required course list. These figures illustrate the "Typical" Computer Science Curriculum that will be used in further research and is explained further in Chapter 2.



**Introduction**

Computer Science Major

Over the last decade, rapid advances in technology, specifically digital technology, have lead to dramatic changes in society and in the global economy. Computer- and technology-related fields claim some of the highest projected job growth in the United States, with software engineering, data communications, networking, and systems analysis and administration among the most top-rated careers.

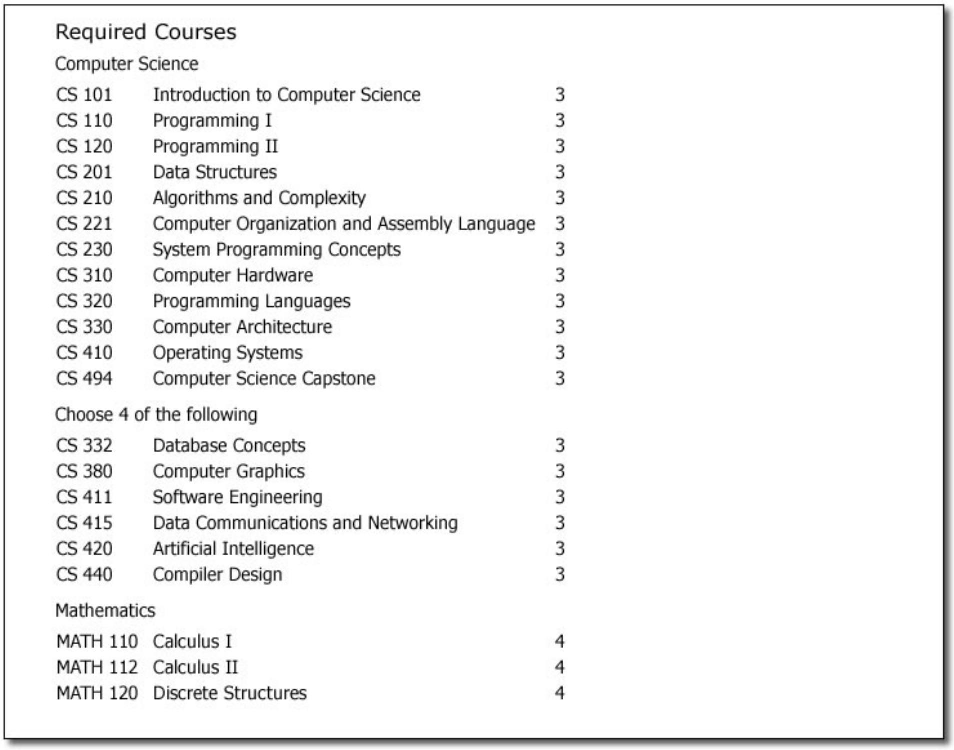
Students are prepared for lifelong learning in this rapidly evolving discipline. Typically, graduates take entry-level positions in hardware and software systems application and design or continue their education at the graduate level.

Students seeking a Bachelor of Science degree in Computer Science will find a lot of flexibility in tailoring their college education. This program requires 48 credits of computer science courses, 12 credits of mathematics, and 8 credits of physics.

**Figure 1.5:** Typical Curriculum Introduction

### *1.6.2 Stage 2: Technology Job Review*

The next stage of this research, Technology Job Review, evaluates industries promotion of computer related jobs by studying job postings. This research activity is aimed at reviewing technology job postings and the terminology used in those



Required Courses

Computer Science

| | | |
|---|---|---|
| CS 101 | Introduction to Computer Science | 3 |
| CS 110 | Programming I | 3 |
| CS 120 | Programming II | 3 |
| CS 201 | Data Structures | 3 |
| CS 210 | Algorithms and Complexity | 3 |
| CS 221 | Computer Organization and Assembly Language | 3 |
| CS 230 | System Programming Concepts | 3 |
| CS 310 | Computer Hardware | 3 |
| CS 320 | Programming Languages | 3 |
| CS 330 | Computer Architecture | 3 |
| CS 410 | Operating Systems | 3 |
| CS 494 | Computer Science Capstone | 3 |

Choose 4 of the following

| | | |
|---|---|---|
| CS 332 | Database Concepts | 3 |
| CS 380 | Computer Graphics | 3 |
| CS 411 | Software Engineering | 3 |
| CS 415 | Data Communications and Networking | 3 |
| CS 420 | Artificial Intelligence | 3 |
| CS 440 | Compiler Design | 3 |

Mathematics

| | | |
|---|---|---|
| MATH 110 | Calculus I | 4 |
| MATH 112 | Calculus II | 4 |
| MATH 120 | Discrete Structures | 4 |

**Figure 1.6:** Typical Curriculum Required Course List

postings. The purpose is to get an understanding of what students and students' parents may see when looking at computer-related jobs and to include these findings in an alternate presentation of a Computer Science curriculum. The goal is not to rewrite the Computer Science curriculum but to re-present it in a relevant way. The following questions guide this portion of the research:

1. In what areas are jobs available?
2. What are the key buzz words used in industry and in job postings?
3. How do the keywords correlate to the course titles on college web sites?

The result of this research activity is a different presentation of the Computer Science major based on industry's promotion of computer-related jobs and keywords used in job advertisements and is further explained in Chapter 3.

### 1.6.3 *Stage 3: Student Opinions and Ideas for Developing a Student-Focused Curriculum*

The third stage of this research, Student Opinions and Ideas for Developing a Student-Focused Curriculum, contains three segments, HS Student Technology Survey, HS Student Focus Groups, and College Student Delphi Study. These segments focus on student perceptions of the Computer Science major and are further explained in Chapter 4.

**HS Student Technology Survey**

The purpose of the first segment within this stage of research, High School Student Technology Survey, is to gather student opinions relative to different aspects of technology. The key questions that guide this portion of the research are as follows:

1. What are the attributes of this generation that may affect their perception of studying computers in college and university?
2. What technology do they use, own, or want to own?
3. What experiences with computers have they had on their own and in school?
4. What technology keywords used today capture the interest to students?

The expected result of this research activity is a collection of student opinions to be used in developing a student-focused curriculum.

**HS Student Focus Groups**

The purpose of the second segment of this stage of research, High School Student Focus Groups, is to understand high school student impressions of computing, delving into the students' attitudes and perceptions of computers and their study of computers in college. The goal is to find out how they view the world of technology around them, what their perceptions are of studying computing in college, and what their perceptions are of the job possibilities for those who study computing. The key questions that guide this portion of the research are as follows:

1. What excites high school juniors and seniors about computers?
2. What things do high school students look for when searching for a college and a major to pursue?
3. What do these students believe the job possibilities and opportunities are if they were to graduate with a Computer Science degree?

The expected result of this research activity is also a collection of student opinions to be used in developing a student-focused curriculum.

### College Student Delphi Study

The third segment of this stage of research, the College Student Delphi Study, seeks to coordinate a Delphi Study with current College computing majors to ascertain their ideas of changes to the Computer Science curricula to increase interest in the major. The guiding questions in the Delphi Study are:

1. If you were looking into a computing program today, what things might generate more interest in pursuing the program further?
2. List all the ways you would change the presentation of the major that will be exciting and motivating to students who have computing potential.

The expected outcome of the Delphi Study is a list of specific ideas in how to present a Computer Science curriculum that is exciting and motivating to high school students.

### *1.6.4 Stage 4: Survey of Prospective Students*

The final stage of this research, Survey of Prospective Students, contains two surveys instruments designed to gauge high school student reactions to different presentations of the Computer Science curriculum. These surveys are developed and further explained in Chapter 5.

**Typical Versus Job-Focused Curricula Survey**

The first survey instrument within this stage seeks high school student reactions to the presentation of the Typical Curriculum that was developed in Stage 1 with the Job-Focused Curriculum developed in Stage 2. The goal of this segment is to determine how prospective students react to different presentations of the Computer Science curriculum. The key questions that guide this goal are as follows:

1. How important are the different components of the displayed curricula?
2. How important is the list of required courses and course titles?
3. How well do the students understand what they will be studying based on what is displayed?
4. How well do the students understand the types of jobs they could apply for based on what is displayed?
5. Has the curriculum they have been presented changed their opinion of studying Computer Science in college?

**Typical Versus Student-Focused Curricula Survey**

The purpose of the second survey within this stage of research is to gauge high school student reactions to the presentation of Computer Science curricula on the

World Wide Web, addressing the main purpose of this research: understanding the interconnection between how colleges present computer-related curricula on the World Wide Web and high school students' understanding of it. The key questions that guide this goal are as follows:

1. How important are the different components of the displayed curricula?
2. How important is the list of required courses and course titles?
3. How well do the students understand what they will be studying based on what is displayed?
4. How well do the students understand the types of jobs they could apply for based on what is displayed?
5. Has the curriculum they have been presented changed their opinion of studying Computer Science in college?

## 1.7 Research Hypotheses and Objectives

These stages and segments previously described layout the framework for the research methodology used in the following chapters. The hypotheses to guide this study are the following:

**Hypothesis 1**: When presented with a more relevant Computer Science curriculum than a typical curriculum today, students will be encouraged and motivated to enroll in the major.

**Hypothesis 2**: Colleges and Universities have not changed the way they display Computer Science curriculum over the last ten years. When compared with earlier course catalogs, courses will have been added, but names of standard courses will remain the same.

**Hypothesis 3**: When asked about information technology, students react positively, enjoying its use.

**Hypothesis 4**: College Computer Science curricula do not correlate with job postings found on job search web sites nor with what is considered to be important areas in computing.

To successfully complete these segments, the following objectives were accomplished:

1. To survey Computer Science curricula available via the Internet from colleges and universities across the United States.
2. To survey computing issues over the last decade.
3. To survey job postings to gather information on how businesses describe computer related jobs.
4. To survey juniors and seniors at a local area high school to gather information data regarding their involvement in and enjoyment of computers.
5. To hold focus groups with juniors and seniors at a local area high school to ask the key questions related to their perceptions of computing, college, and job possibilities beyond college.
6. To model a Computer Science curriculum on the Internet that will take into account student perceptions and attitudes and gather feedback from the same juniors and seniors who took part in the focus groups.
7. To compare student reactions to the current curricula available on the Web

with the model developed that took into account student perceptions and attitudes.

## 1.8 Limitations of the Study

The data for this study was collected from students in a local area high school in Central Pennsylvania. Though they share many of the same attributes as students across the United States and possibly the world, they are the only ones involved in the majority of this study. The final survey, being available over the Internet, was opened to high school students across the United States. This study should prompt colleges and universities across the country to open lines of communication with high schools in their locale to better understand their constituents. Some of the same attitudes and perceptions will be seen and can be addressed by the way Computer Science is presented to those students.

The students who participated in this study live in the suburbs of Harrisburg, Pennsylvania. Some live in large homes of wealthy parents, others in row homes of blue-color workers. The results of this study can be generalized to similar groups of students in similar situations. The results may not adequately describe high school students in urban homes and schools.

There are other factors that contribute to the decline in enrollment in computer-related majors across this country other than how Computer Science is presented to potential students. This research focuses on a single parameter, yet one that is a major contributor to the disconnect between high school students and colleges and universities.

## 1.9 Overview of the Results of this Research

The results of the curricular surveys in the Technology Job Review stage and the Student Ideas of Computer Science stage seem to indicate that modifying the curriculum that students have access to can improve their interest level. For those participating in the survey that evaluated the Typical Curriculum, their interest level decreased as compared to their interest level at the beginning of the survey.

For those students who participated in the Typical Versus Student-Focused survey and are planning on attending college, 60% have looked at a curriculum online. Of these, 71% indicated that the online curriculum influenced their decision for a major. These results suggest that the methods employed by colleges and universities to communicate a program of study do influence student decisions and should be taken seriously.

Most of the students participating in the high school focus groups believe that studying computers in college guarantees a job after graduation. However, very few of these students intend on pursuing a computing degree. Only a few of these students have looked into Computer Science as a major. For them, changing how the Computer Science curriculum is presented on college web sites would not influence their current decision. The discussions in the focus groups that these students had relating to their experiences in computer-related courses seem to indicate that their perception of Computer Science is based on the course or courses they have taken that involve computers regardless of the discipline the course is associated with. For example, a business applications course can persuade students that studying Computer Science is simply learning how to use applications. The teacher of the course also influences their perceptions of Computer Science. If the teacher is boring, so is the subject matter.

## 1.10 Roadmap of dissertation

The remainder of this dissertation is organized as follows:

Chapter 2, College Curricular Review, encompassing the first stage of this research, evaluates college and university presentations of their Computer Science major over the last decade. The methodology, data collection, and results of the curricular survey are presented.

Chapter 3, Technology Job Review, encompassing the second stage of this research, presents the methodology, data collection, and results of two segments within this stage, Technology Job Study and the Typical Versus Job-Focused Curricula Surveys.

Chapter 4, Student Perceptions and Reactions to Computer Science Curricula, encompassing the third stage of this research, presents the methodology, data collection, and results of the four segments within this stage, HS Student Technology Survey, HS Student Focus Groups, College Student Delphi Study, and the Typical Versus Student-Focused Curricula Surveys.

Chapter 5, Summary and Reflection, wraps up the dissertation with a summary of the responses to the study's research questions and the preliminary findings, and presents suggestions for further work in this area.

# Chapter 2

# College Curricular Review

The goal of this segment of research, College Curricular Review, first presented in Figure 1.4 and illustrated in Figure 2.1, was to evaluate college and university presentations of the Computer Science major, identifying current components of the curricula available on the web. There were two purposes of this key research area. First to use the curricula obtained through this study to develop a composite curriculum; a typical curriculum exemplary of curricula students might encounter when exploring options for majoring in Computer Science. This "Typical Curriculum" was designed to reflect what students will encounter when initially investigating Computer Science and was used to determine the validity of Hypothesis #1, "When presented with a more relevant Computer Science curriculum than a typical curriculum today, students will be encouraged and motivated to enroll in the major."

The second purpose of this research area was to test Hypothesis #2 that, "Colleges and Universities have not changed the way they display Computer Science curriculum over the last ten years. When compared with earlier course catalogs, courses will have been added, but names of standard courses will remain the same."

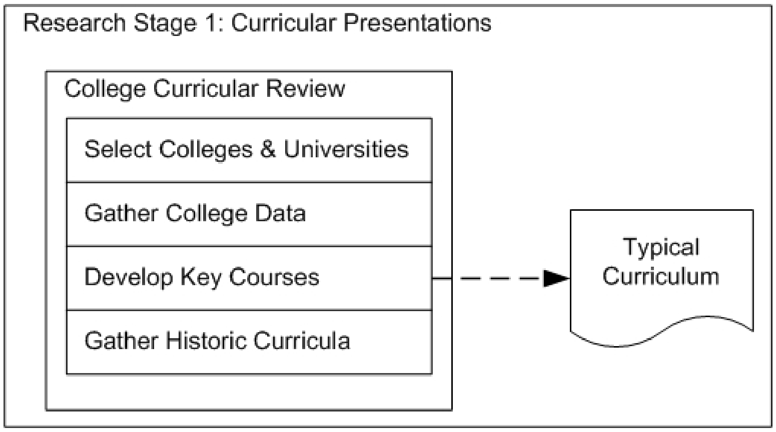


**Figure 2.1:** Research Stage 1: Curricular Presentations

## 2.1 College and University Selection

The first step in this segment of research was to choose the colleges and universities from which to gather curricular data. The College Board, a not-for-profit organization "whose mission is to connect students to college success and opportunity [28]," provides web-based tools for students in their search for a college or university to attend. This tool provides options to search through their database of 3862 schools. When searching for schools with a Computer Science major, 919 possible colleges were found. Since this study focused on four-year colleges and universities, the number of institutions was reduced to 665.

### *2.1.1 Selection Criteria*

The College Board's web-based search tool, College MatchMaker [29], provides eight pages of options used to refine the selection of colleges and universities for this study (See Figure 2.2). The pages include:

- Type of School
- Location
- Majors

- Cost & Financial Aid
- Admissions
- Sports & Activities
- Housing & Programs
- Specialized Options

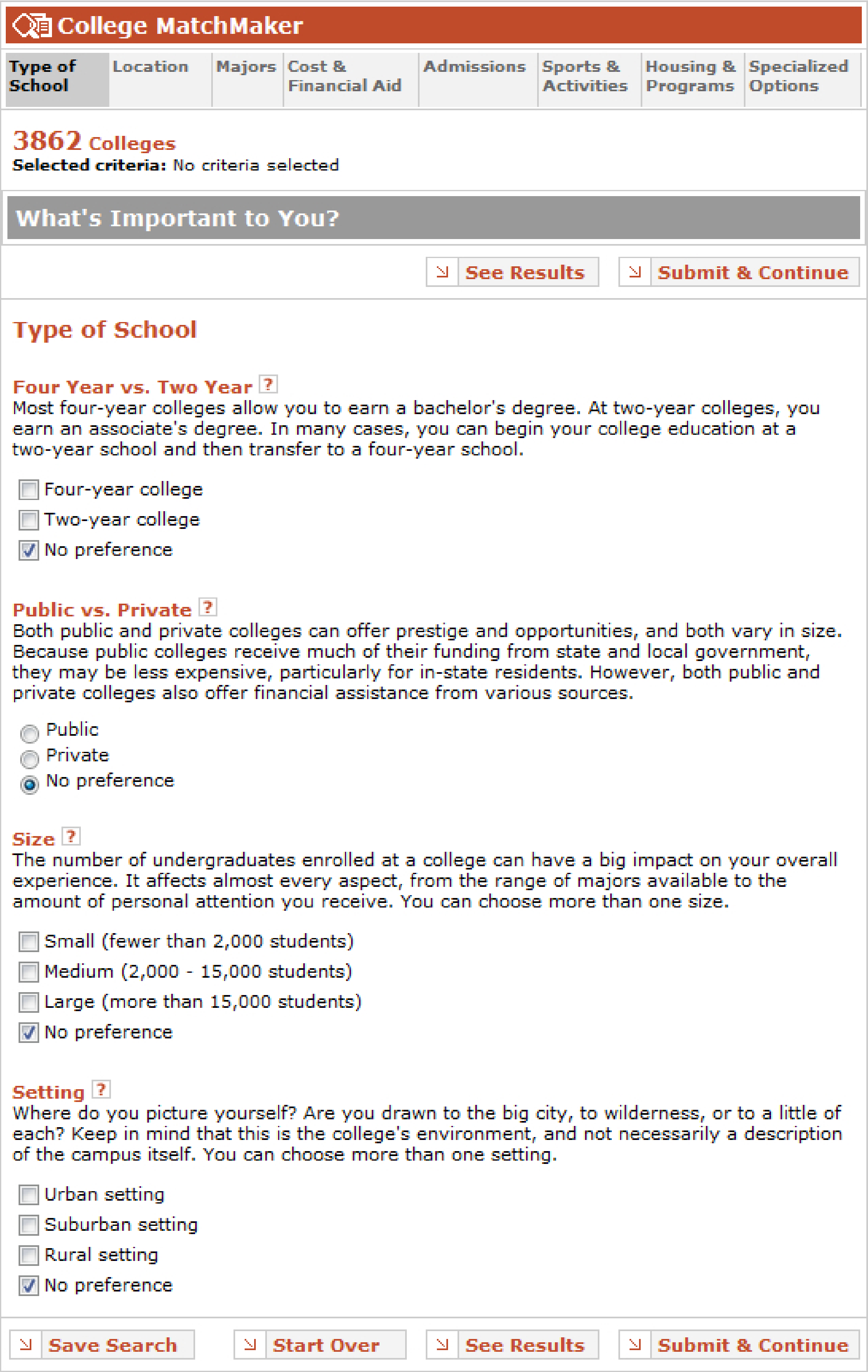
On the "Type of School" tab, shown in Figure 2.2, the options a student may choose include

- **Four Year vs. Two Year**. Choices include Four-year college, Two-year college, and No preference.
- **Public vs. Private**. Choices include Public, Private, and No preference.
- **Size**. Choices include Small (fewer than 2,000 students), Medium (2,000 - 15,000 students), Large (more than 15,000 students), and No preference.
- **Setting**. Choices include Urban setting, Suburban setting, Rural setting, and No preference.

The three criteria presented on the "Type of School" tab in which this study was interested include Public versus Private, Size, and Setting.

On the "Location" tab, the student is given the opportunity to choose a combination of regions or specific states (See Figure 2.3). Table 2.1 provides the list of available regions and the states included in each. In this study, regions were used to ensure colleges and universities were selected from across the United States.

On the "Majors" tab, students may select multiple majors of interest. If they do not select a major, all majors are valid. In this study, "Computer Science" was the only major added to the search criteria list.



**3862** Colleges

**Selected criteria:** No criteria selected

What's Important to You?

Type of School

**Four Year vs. Two Year**

Most four-year colleges allow you to earn a bachelor's degree. At two-year colleges, you earn an associate's degree. In many cases, you can begin your college education at a two-year school and then transfer to a four-year school.

☐ Four-year college
☐ Two-year college
☑ No preference

**Public vs. Private**

Both public and private colleges can offer prestige and opportunities, and both vary in size. Because public colleges receive much of their funding from state and local government, they may be less expensive, particularly for in-state residents. However, both public and private colleges also offer financial assistance from various sources.

○ Public
○ Private
● No preference

**Size**

The number of undergraduates enrolled at a college can have a big impact on your overall experience. It affects almost every aspect, from the range of majors available to the amount of personal attention you receive. You can choose more than one size.

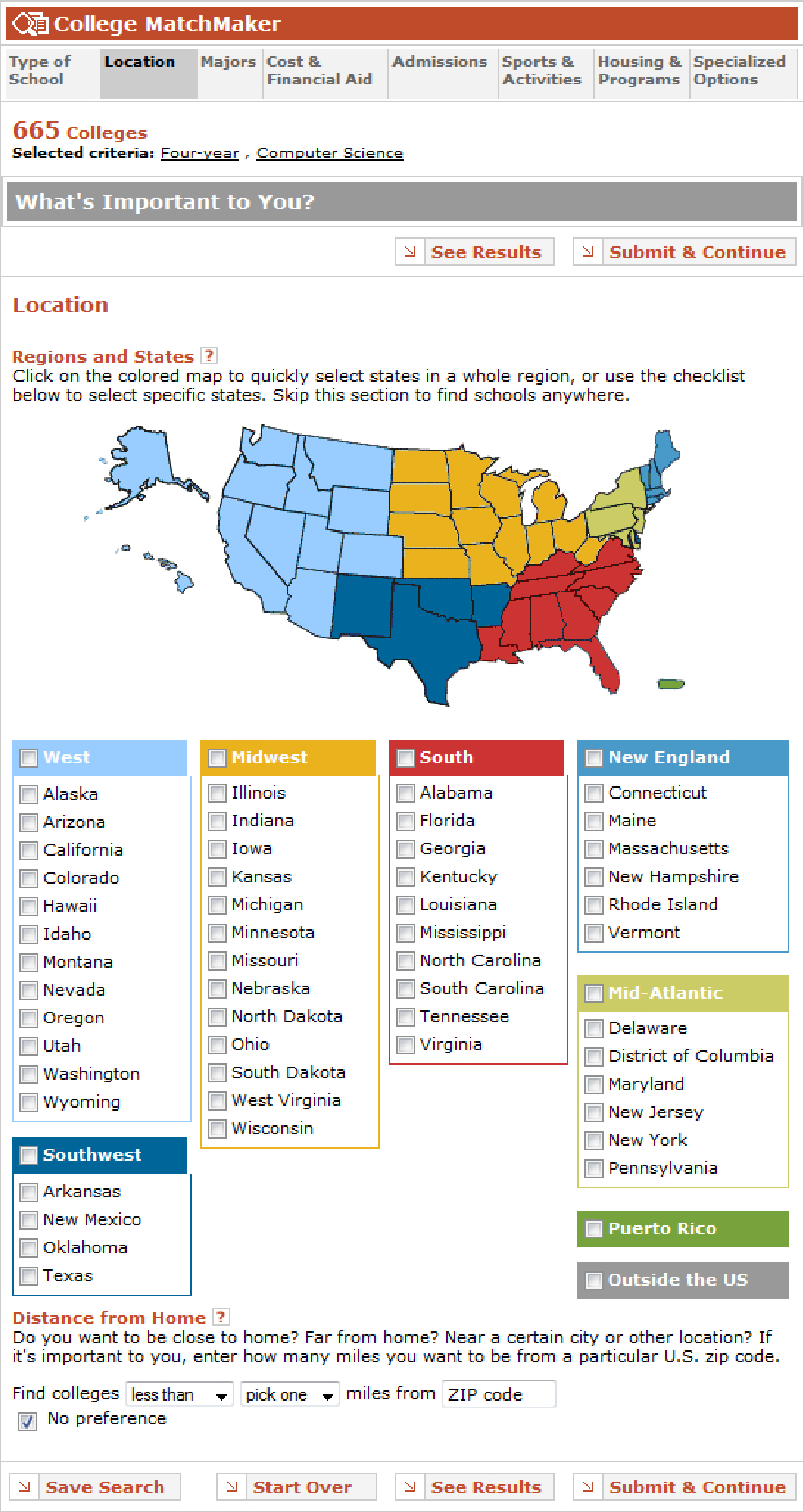
☐ Small (fewer than 2,000 students)
☐ Medium (2,000 - 15,000 students)
☐ Large (more than 15,000 students)
☑ No preference

**Setting**

Where do you picture yourself? Are you drawn to the big city, to wilderness, or to a little of each? Keep in mind that this is the college's environment, and not necessarily a description of the campus itself. You can choose more than one setting.

☐ Urban setting
☐ Suburban setting
☐ Rural setting
☑ No preference

**Figure 2.2:** The "Type of School" page in College MatchMaker [29]



665 Colleges
**Selected criteria:** Four-year , Computer Science

Location

Regions and States ?
Click on the colored map to quickly select states in a whole region, or use the checklist below to select specific states. Skip this section to find schools anywhere.

☐ West
☐ Alaska
☐ Arizona
☐ California
☐ Colorado
☐ Hawaii
☐ Idaho
☐ Montana
☐ Nevada
☐ Oregon
☐ Utah
☐ Washington
☐ Wyoming

☐ Southwest
☐ Arkansas
☐ New Mexico
☐ Oklahoma
☐ Texas

☐ Midwest
☐ Illinois
☐ Indiana
☐ Iowa
☐ Kansas
☐ Michigan
☐ Minnesota
☐ Missouri
☐ Nebraska
☐ North Dakota
☐ Ohio
☐ South Dakota
☐ West Virginia
☐ Wisconsin

☐ South
☐ Alabama
☐ Florida
☐ Georgia
☐ Kentucky
☐ Louisiana
☐ Mississippi
☐ North Carolina
☐ South Carolina
☐ Tennessee
☐ Virginia

☐ New England
☐ Connecticut
☐ Maine
☐ Massachusetts
☐ New Hampshire
☐ Rhode Island
☐ Vermont

☐ Mid-Atlantic
☐ Delaware
☐ District of Columbia
☐ Maryland
☐ New Jersey
☐ New York
☐ Pennsylvania

☐ Puerto Rico

☐ Outside the US

Distance from Home ?
Do you want to be close to home? Far from home? Near a certain city or other location? If it's important to you, enter how many miles you want to be from a particular U.S. zip code.

Find colleges less than ▾ pick one ▾ miles from ZIP code
☑ No preference

**Figure 2.3:** The "Location" page in College MatchMaker [29]

The “Cost & Financial Aid” tab allows students to indicate a maximum tuition fee and financial aid opportunity choices. None of these options were selected for this study therefore, colleges and universities were not eliminated from the resultant list due to cost or financial aid criteria.

The “Admissions” tab allows students to select options that search for colleges “that offer academic credit and/or placement out of introductory courses to qualifying students [29].” For this study these options were not used to limit school selection.

The “Sports & Activities” tab allows students to specific selection criteria based on their interests in sports, activities such as Choral Groups, Dance, Film, etc, and whether the school has or does not have Fraternities and Sororities. None of these options were used to limit school selection in this study.

The “Housing & Programs” tab provides selection criteria for students on or off campus housing, housing needs (including women or men only, coed, handicap, etc.) as well as specific academic programs which include Accelerated study, double major, ROTC, etc. None of these options were used to limit school selection in this study.

The “Specialized Options” tab addresses other needs a student may be interested in such as single-sex vs. coed schools, disability services, religious affiliation, and ethnic related schools. None of these options were used to limit school selection in this study.

Four-year institutions that award bachelor degrees in Computer Science were chosen using only five of the criteria provided by the College Board [29]. Table 2.1 shows the five criteria and the options in each that were used to select a broad cross section of colleges and universities.

| Criteria | Choice Options used in this study |
|---|---|
| Public versus Private | Public<br>Private |
| Setting | Rural<br>Suburban<br>Urban |
| Size | Small: below 2000 students<br>Medium: between 2000 and 15,000 students<br>Large: over 15,000 students |
| Region | **West** includes the following states:<br>Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, Oregon, Utah, Washington, Wyoming<br>**Southwest** includes the following states:<br>Arkansas, New Mexico, Oklahoma, Texas<br>**Midwest** includes the following states:<br>Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, West Virginia, Wisconsin<br>**South** includes the following states:<br>Alabama, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Virginia<br>**New England** includes the following states:<br>Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont<br>**Mid-Atlantic** includes the following states:<br>Delaware, District of Columbia, Maryland, New Jersey, New York, Pennsylvania |
| Type of Curriculum | Liberal Arts Curriculum (LA)<br>Specialized Curriculum (S) |

**Table 2.1:** Selection Criteria used to select the colleges and universities for this study

The only criterion that was not an option on any of the College Board Search tabs was Liberal Arts versus Specialized. This criterion was only found once the schools were selected. When a school was selected, the detail provided by the College Board includes whether the school offers a liberal arts education or not. This criterion was chosen for this study because of the different perspectives on what belongs in a Computer Science curriculum. Liberal Arts Curricula "generally emphasize multiple perspectives of problem solving (from computer science and other disciplines), theoretical results and their applications, breadth of study, and skills in communication [46]" and are therefore more constrained in the course requirements than a specialized curriculum in a non-liberal arts setting.

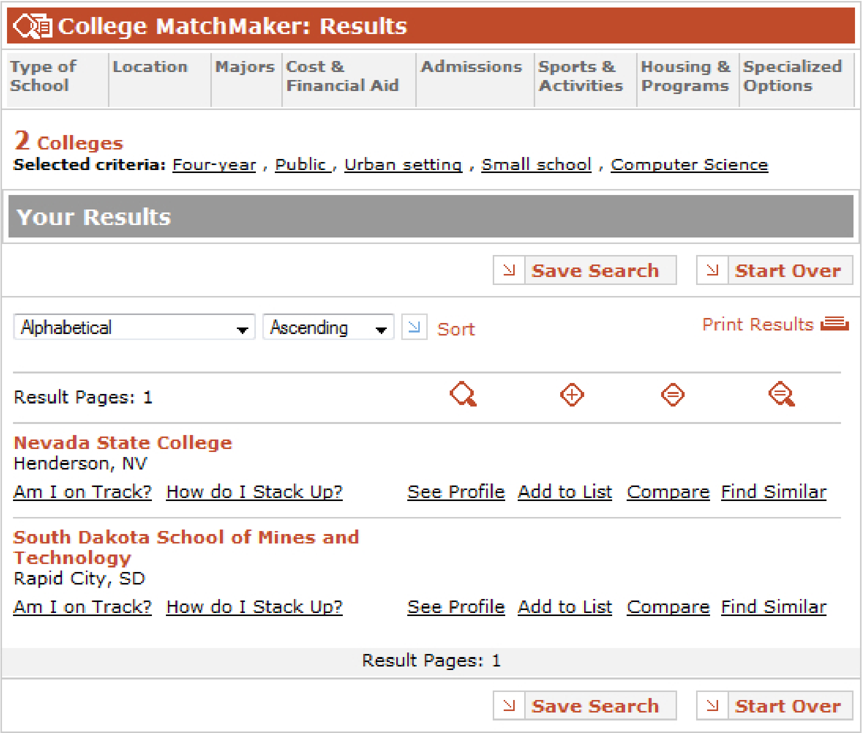
### *2.1.2 Selection Process*

Two of the options provided by the web-based tool were selected and remained selected for the entire search: the four-year school option on the "Type of School" tab and the "Computer Science" major on the "Majors" tab. This yielded 665 institutions from which to choose. It was decided that fifty schools would adequately provide information for this segment of the research. Ideally all 665 institutions would be surveyed, however, the institutions that were chosen provided 1534 courses to process which was decided to be an adequate number of courses for this segment of the research.

Of the other five criteria, the first three, Public vs. Private, Setting, and Size, were chosen as the main criteria that distinguish the kind of schools and programs prospective students would expect to see. These three criteria provided a good starting point in selecting a broad distribution of colleges and universities. These criteria generated eighteen possible combinations resulting from matching the different criterion options. Each of these combinations was entered into the web-based tool and schools were randomly selected from the resultant list. Table 2.2 lists the number of schools provided for each combination of criteria chosen. The process of randomly choosing schools simply involved choosing random integers between one and the number of resultant institutions. Figure 2.4 presents a resultant set for small, public schools in an urban setting.

| | | Public | Private |
|---|---|---|---|
| Urban | Small | 2 | 41 |
| | Medium | 41 | 74 |
| | Large | 38 | 4 |
| Suburban | Small | 0 | 86 |
| | Medium | 54 | 116 |
| | Large | 26 | 1 |
| Rural | Small | 11 | 72 |
| | Medium | 40 | 25 |
| | Large | 8 | 0 |

**Table 2.2:** Number of schools listed for public vs. private, setting and size.



College MatchMaker: Results

2 Colleges

**Selected criteria:** Four-year , Public , Urban setting , Small school , Computer Science

Your Results

Result Pages: 1

**Nevada State College**
Henderson, NV

**South Dakota School of Mines and Technology**
Rapid City, SD

Result Pages: 1

**Figure 2.4:** A Sample Result Set from College MatchMaker [29]

The number of institutions randomly chosen per resultant set was based on the total number of institutions provided in the set. For results providing less than twenty-five institutions, only one was randomly chosen. For results providing between twenty-five and fifty, two were randomly chosen. For results providing between fifty and seventy-five, three were randomly chosen. For results providing between seventy-five and one hundred, four were randomly chosen. For results over one hundred, five were randomly chosen. This procedure provided an initial list of thirty-seven schools. Once schools were chosen from all the possible combinations of the three criteria mentioned above, a table was made similar to Tables 2.3 and 2.4 with each school's information for all the criteria listed in Table 2.1.

The table was then consulted to determine if there were schools for each of the other criteria, Region, and Liberal Arts versus Specialized. For those criteria for which there were no schools, the College Board College MatchMaker was once again consulted using values for the criterion which was not represented in the list. This was done to provide a broad distribution of institutions from which to gather Computer Science curricula. At the end of this process, forty-seven schools had been selected which was adequate for this segment of the research.

Table 2.3 lists the private, four-year colleges and universities and Table 2.4 lists the public, four-year colleges and universities chosen for this study after the selection process was complete. The two lists are sorted by setting (rural, suburban, urban) followed by size. Some criteria combinations did not provide school choices. For example there are no private, four-year colleges that are considered large (over 15,000 students) in a rural setting that offer the Computer Science major. There are also no public schools that are in a suburban setting that have less than 2,000 students. The column labeled "Type" in the tables refers to the type of curriculum, whether a Liberal Arts (LA) curriculum or a Specialized (S) curriculum.

| School | Setting | Size | Region | Type |
|---|---|---|---|---|
| **Lyon College** | Rural | Small ( 614 ) | Southwest | LA |
| **Eastern Mennonite University** | Rural | Small ( 1,073 ) | South | LA |
| **Linfield College** | Rural | Small ( 1,677 ) | West | LA |
| **Amherst College** | Rural | Small ( 1,744 ) | Mid-Atlantic | LA |
| **Bethel University** | Rural | Medium ( 2,550 ) | South | LA |
| **Oberlin College** | Rural | Medium ( 2,888 ) | Midwest | LA |
| **Cedarville University** | Rural | Medium ( 3,029 ) | Midwest | LA |
| **Bucknell University** | Rural | Medium ( 3,543 ) | New England | S |
| **Cornell University** | Rural | Medium ( 13,931 ) | New England | S |
| **Hendrix College** | Suburban | Small ( 1,456 ) | Southwest | LA |
| **William Penn University** | Suburban | Small ( 1,811 ) | Midwest | LA |
| **Stevens Institute of Technology** | Suburban | Medium ( 2,234 ) | New England | S |
| **Worcester Polytechnic** | Suburban | Medium ( 3,453 ) | Mid-Atlantic | S |
| **Calvin College** | Suburban | Medium ( 4,015 ) | Midwest | LA |
| **Princeton University** | Suburban | Medium ( 5,113 ) | New England | S |
| **Rochester, University of** | Suburban | Medium ( 5,447 ) | New England | S |
| **Duke University** | Suburban | Medium ( 6,578 ) | South | S |
| **Brigham Young University** | Suburban | Large ( 30,745 ) | West | S |
| **Christian Brothers University** | Urban | Small ( 1,425 ) | South | S |
| **Kettering University** | Urban | Medium ( 2,080 ) | Midwest | S |
| **Abilene Christian University** | Urban | Medium ( 3,916 ) | Southwest | S |
| **Johns Hopkins University** | Urban | Medium ( 4,998 ) | New England | S |
| **Carnegie Mellon University** | Urban | Medium ( 6,023 ) | New England | S |
| **Southern California, University of** | Urban | Large ( 16,751 ) | West | S |

**Table 2.3:** Private, Four-Year Institutions Chosen

| School | Setting | Size | Region | Type |
|---|---|---|---|---|
| **Maine at Fort Kent, University of** | Rural | Small ( 1,126 ) | Mid-Atlantic | S |
| **West Virginia University Institute of Technology** | Rural | Small ( 1,244 ) | Midwest | S |
| **New Mexico Institute of Mining and Technology** | Rural | Small ( 1,322 ) | Southwest | LA |
| **Lyndon State College** | Rural | Small ( 1,500 ) | Mid-Atlantic | LA |
| **Pittsburgh Bradford, University of** | Rural | Small ( 1,652 ) | New England | S |
| **Virginia's College at Wise, University of** | Rural | Medium ( 2,015 ) | South | LA |
| **Northern Arizona University** | Rural | Large ( 18,301 ) | West | S |
| **Virginia Polytechnic Institute and State University** | Rural | Large ( 23,558 ) | South | S |
| **Texas A & M** | Rural | Large ( 38,810 ) | Southwest | S |
| **Midwestern State University** | Suburban | Medium ( 5,607 ) | Southwest | LA |
| **Rhode Island College** | Suburban | Medium ( 7,883 ) | Mid-Atlantic | LA |
| **Oklahoma State University** | Suburban | Large ( 17,849 ) | Southwest | S |
| **Oregon State University** | Suburban | Large ( 18,067 ) | West | S |
| **Massachusetts Amherst, University of** | Suburban | Large ( 20,873 ) | Mid-Atlantic | S |
| **Michigan State University** | Suburban | Large ( 36,489 ) | Midwest | S |
| **South Dakota School of Mines and Technology** | Urban | Small ( 1,913 ) | Midwest | S |
| **Pace University** | Urban | Medium ( 7,971 ) | New England | S |
| **Nevada, Reno, University of** | Urban | Medium ( 13,327 ) | West | S |
| **Kentucky, University of** | Urban | Large ( 19,183 ) | South | S |
| **Texas Arlington, University of** | Urban | Large ( 21,370 ) | Southwest | S |
| **California Berkely, University of** | Urban | Large ( 25,530 ) | West | S |
| **Wisconsin, University of** | Urban | Large ( 30,343 ) | Midwest | S |
| **Illinois, University of** | Urban | Large ( 30,694 ) | Midwest | S |

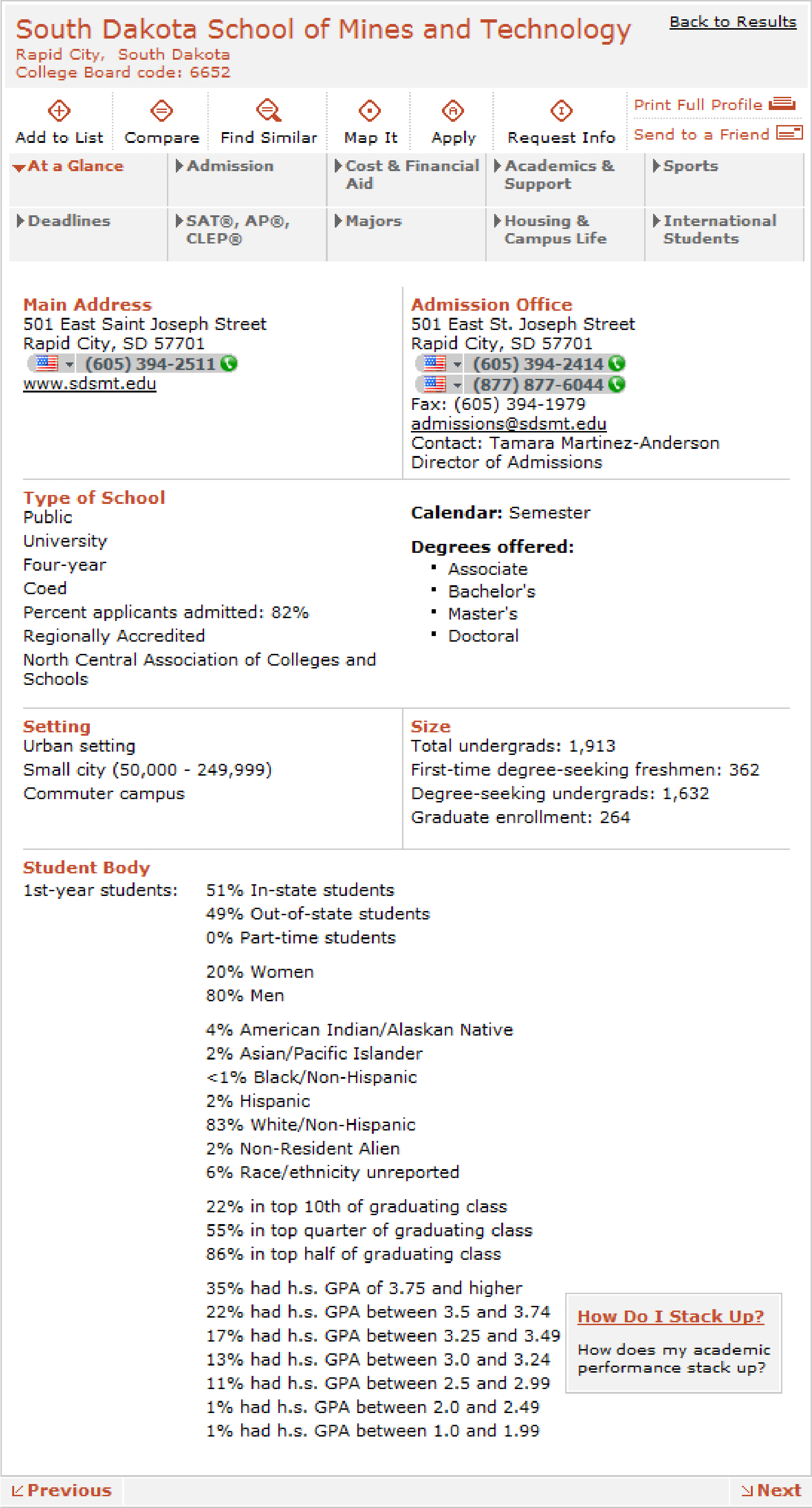
**Table 2.4:** Public, Four-Year Institutions Chosen

## 2.2 Gathering College Curricula

After the selection process was complete, forty seven colleges and universities were chosen. The next step in this curriculum study was to gather the available curricula from each of the schools via the World Wide Web. The main assumption in gathering the Computer Science curricula on each college website for this study, was that the searcher would not give up when the searching proved difficult.

The main page of each of the chosen college's website was found using the link provided by the College MatchMaker [29] tool. Figure 2.5 presents an example of the detailed information provided by the College Board for an Institution. From the main page of each of the schools' websites the search for the Computer Science curriculum began. Most schools have a link on their main page to an Academics page where majors can be found. Many of the curricula were found using these links. Some schools however structure their websites differently. For school websites which hindered locating the curriculum, the college catalog was located and used. For many of these schools, the college catalog is simply an electronic version of the publication they make available to prospective students.

Once the curriculum was found, the courses and course definitions were copied to a spreadsheet where the data was arranged to be uploaded to a database designed for this study. Figure 2.6 displays the diagram of the database that was used for this segment of the research. The main tables in the database were the College table that stored the information gathered from the College MatchMaker [29] tool and the Course table that contained the course information and a link to the College table. Other tables such as Region, State, PublicPrivate, Setting, and School_Year made searching and organizing the data easier. The Course table, containing the main data in this study, included the following data fields:



South Dakota School of Mines and Technology
Rapid City, South Dakota
College Board code: 6652

**Main Address**
501 East Saint Joseph Street
Rapid City, SD 57701
(605) 394-2511
www.sdsmt.edu

**Admission Office**
501 East St. Joseph Street
Rapid City, SD 57701
(605) 394-2414
(877) 877-6044
Fax: (605) 394-1979
admissions@sdsmt.edu
Contact: Tamara Martinez-Anderson
Director of Admissions

**Type of School**
Public
University
Four-year
Coed
Percent applicants admitted: 82%
Regionally Accredited
North Central Association of Colleges and Schools

**Calendar:** Semester

**Degrees offered:**
- Associate
- Bachelor's
- Master's
- Doctoral

**Setting**
Urban setting
Small city (50,000 - 249,999)
Commuter campus

**Size**
Total undergrads: 1,913
First-time degree-seeking freshmen: 362
Degree-seeking undergrads: 1,632
Graduate enrollment: 264

**Student Body**

1st-year students:
51% In-state students
49% Out-of-state students
0% Part-time students

20% Women
80% Men

4% American Indian/Alaskan Native
2% Asian/Pacific Islander
<1% Black/Non-Hispanic
2% Hispanic
83% White/Non-Hispanic
2% Non-Resident Alien
6% Race/ethnicity unreported

22% in top 10th of graduating class
55% in top quarter of graduating class
86% in top half of graduating class

35% had h.s. GPA of 3.75 and higher
22% had h.s. GPA between 3.5 and 3.74
17% had h.s. GPA between 3.25 and 3.49
13% had h.s. GPA between 3.0 and 3.24
11% had h.s. GPA between 2.5 and 2.99
1% had h.s. GPA between 2.0 and 2.49
1% had h.s. GPA between 1.0 and 1.99

How Do I Stack Up?
How does my academic performance stack up?

**Figure 2.5:** An Example of Information Provided by the College Board for an Institution

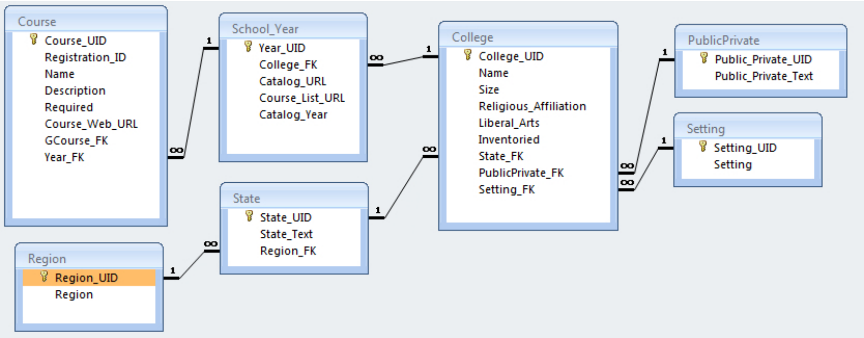


**Figure 2.6:** The College and Course Database Model

- Year: The year in which this course was found
- Registration_ID: The course number (i.e. CS 105)
- Name: The name of the course
- Description: The course description copied from the website
- Required: An indicator identifying the requirement level of this course.
    - "R" = Required: Required courses are the courses that students taking this major must take.
    - "C" = Choice Option: In some curricula a certain number of courses must be taken from a larger group of courses. These are considered Choice Option courses.
    - "E" = Elective: Elective courses are courses that students do not need to take but may if they so choose.

During the gathering process, many challenges were encountered that may cause students interested in what Computer Science entails to abandon their search. The first challenge was determining which department, school, or college was responsible for the Computer Science major. In searching for the Computer Science major, many college and university websites require the visitor to select the appropriate school or department. In this study's search, the Computer Science major was found in the school of Information Technology and Computing, the school or college of Engineering, the school or college of Arts and Sciences, and the Department of

Computer Science, among others. This makes it very confusing for prospective students.

Once the appropriate school or department was determined, finding the requirements for the Computer Science major also proved challenging. The curriculum on many schools web sites is located many pages deep making the search difficult for prospective students. Getting to the desired page not only requires traversing multiple pages, but also requires guessing at the correct path to get there. If the path is too difficult, the prospective student may simply give up. Some schools provide obvious links to their catalogs which provide much of the necessary information.

A final challenge to students interested in what the major requires is in comparing curriculum of different schools. Each school and university displays curricula differently with different numbering schemes, course titles, and layouts. In order to compare courses and requirements from college to college, a prospective student is required to locate course descriptions and compare the topics covered in one college with courses from another college. Some schools list courses that do not have descriptions which makes understanding the curriculum difficult.

## 2.3 Determining Key Course Titles

The intent of this study is to mimic a student's initial search for the requirements of the Computer Science major. The desire is to gather information that students would initially see when their first impression of the major is formed. To that end, for each school, the Computer Science program requirements were collected along with all the courses and course descriptions for the major. The course descriptions provided information necessary in equating courses between schools and was not used to form the initial impression of the major. Although all courses and course descriptions were collected, only the required and choice-option courses were used in this segment of the research. It was decided that the prospective student's initial inspection of the major would focus on the courses that are presented to the student on the major requirements page which generally consists of required and choice-option courses. Each of the chosen schools' Computer Science program is documented in Appendix A.

After the information was collected, each course was compared with the courses from other schools based on course title and description and lists were developed, grouping courses covering the similar material. Courses with the same or similar name were easily grouped together. For those with different names, the course descriptions were consulted to determine if they were similar. Each grouping of courses representing the same course was given a name based on the most descriptive name or the most frequently used terms used within the group. The group is referred to in this study as the Key Course and the name of the group as the Key Course Name.

For example, thirty-two schools had an introduction course with names including, "Introduction to Computer Science", "Introduction to Computing", "Introduction to Computer Science I", and "Introduction to Programming" among others. Seven schools use the phrase "Introduction to Computer Science" as the beginning of the course title. The second most frequently used title was "Introduction to Programming" with eight schools using that phrase in their title. The most common word used in the titles is "Introduction" with eighteen schools using the term. The second most commonly used phrase is "Computer Science" with fifteen schools using that phrase. The next most commonly used term is "Programming" with thirteen schools using that term. Since the majority of schools use the term

“Introduction” and the phrase “Computer Science”, “Introduction to Computer Science” was the name given to that Key Course (see Table 2.5).

| Course Name | College or University |
|---|---|
| Computer Science 1 | Bethel University |
| Computer Science Orientation | Oregon State University |
| Concepts Of Computer Science | Pittsburgh Bradford, University of |
| Foundations Of Computer Science I | Hendrix College |
| Fundamentals Of Computer Science | Christian Brothers University |
| General Computer Science | Princeton University |
| Intro To Computer Science | Illinois, University of |
| Introduction To Computer Science | Maine at Fort Kent, University of |
| Introduction to Computer Science | Abilene Christian University |
| Introduction To Computer Science | Stevens Institute of Technology |
| Introduction To Computer Science And Engineering | Texas Arlington, University of |
| Introduction To Computer Science And Information Technology | New Mexico Institute of Mining and Technology |
| Introduction To Computer Science I | Amherst College |
| Introduction To Computer Science I | Bucknell University |
| Introduction To Computing | Nevada, Reno, University of |
| Introduction To Computing | Calvin College |
| Introduction To Computing | Texas A & M |
| Principles Of Computer Science I | Oberlin College |
| Introduction To Programming | Wisconsin, University of |
| Introduction To Programming | Maine at Fort Kent, University of |
| Introduction To Programming | Bethel University |
| Introduction To Programming | New Mexico Institute of Mining and Technology |
| Introduction To Programming I | Michigan State University |
| Introduction To Programming I | Lyon College |
| Introduction To Programming In Java | Johns Hopkins University |
| Introduction To Programming Systems | Princeton University |
| Principles Of Programming | Carnegie Mellon University |
| Programming Abstractions | Oberlin College |
| Programming I | Abilene Christian University |
| Programming Techniques | William Penn University |
| The Science Of Programming | Rochester, University of |

**Table 2.5:** Example of Introduction to Computer Science

Another Key Course given the name “Programming I” had courses from thirty-three schools (See Table 2.6). There were a wide variety of names for this course. Of the thirty-three schools, twenty-four of them have the term “Programming” in their title. Many of them, fourteen, use the term “Introduction.” Since most schools follow this course with a second programming course, the term “Introduction” was dropped and the course titles were compared to the second programming course to determine what name should be given (See Table 2.7). Names of specific programming languages within the titles were also dropped. Since most of the course names included “Programming” and a notation indicating the first or second course, “Programming I” and “Programming II” were selected.

Data Structures, another example, was an easy Key Course to name since all of the twenty-three schools used the phrase “Data Structures” and the majority, fifteen, used the exact phrase as the title (See Table 2.8).

Sixteen schools have a course on “Data Structures and Algorithms” as opposed to simply “Data Structures” (See Table 2.9). Since more schools listed “Data Structures” as a required course versus “Data Structures and Algorithms”, “Data Structures” was chosen to be a part of the typical curriculum. To cover the “Algorithms” portion of the curriculum, thirty-one of the schools had a different course for “Algorithms” (See Table 2.10). Many of the schools listing “Data Structures” also used this other course for “Algorithms”, so it was added to the curriculum as “Algorithms and Complexity”.

One guiding principle in grouping these courses was the need to keep the overall number of Key Courses to a minimum. One main difficulty in equating courses is that in one college a course may cover a broad number of topics that another college covers in two different courses. This study does not intend that the Key Courses listed in Appendix B be used as a determinant of course equality. One of the main purposes of this segment of research is to develop a Typical Curriculum based on the courses provided through the college search. To that end, the equality suggested in these Key Courses is sufficient in developing a Typical Curriculum that was then used in a survey instrument presented to prospective students (See Chapter 5).

The list of all key course groupings and the specific college courses are presented in Appendix B. Tables 2.11 and 2.12 list all the required and choice-option Key Courses and the number of schools represented by each Key Course.

| Course Name | College or University |
|---|---|
| Beginning Programming: Objects | Linfield College |
| C Programming | Oklahoma State University |
| C++ Programming | Lyndon State College |
| C++ Programming | Cedarville University |
| Computer Programming I | Pace University |
| Computer Programming I | Rhode Island College |
| Computer Science 1 | West Virginia University Institute of Technology |
| Computer Science I | Midwestern State University |
| Computer Science I | Northern Arizona University |
| Computer Science I | Nevada, Reno, University of |
| Computer Science I | South Dakota School of Mines and Technology |
| Concurrent Programming | Stevens Institute of Technology |
| Foundations Of Computer Programming In C/(No Suggestions) | Virginia's College at Wise, University of |
| Fundamentals Of Computer Programming | Southern California, University of |
| Introduction To Computer Programming | Brigham Young University |
| Introduction To Computer Programming | Kentucky, University of |
| Introduction To Computer Science | Pittsburgh Bradford, University of |
| Introduction To Computer Science | Christian Brothers University |
| Introduction To Computer Science I | Oregon State University |
| Introduction To Computing Using Java | Cornell University |
| Introduction To Programming | Wisconsin, University of |
| Introduction To Programming | Maine at Fort Kent, University of |
| Introduction To Programming | Bethel University |
| Introduction To Programming | New Mexico Institute of Mining and Technology |
| Introduction To Programming I | Michigan State University |
| Introduction To Programming I | Lyon College |
| Introduction To Programming In Java | Johns Hopkins University |
| Introduction To Programming Systems | Princeton University |
| Principles Of Programming | Carnegie Mellon University |
| Programming Abstractions | Oberlin College |
| Programming I | Abilene Christian University |
| Programming Techniques | William Penn University |
| The Science Of Programming | Rochester, University of |

**Table 2.6:** Example of Programming I

| Course Name | College or University |
|---|---|
| Advanced Programming Concepts | Brigham Young University |
| Advanced Programming Techniques | Princeton University |
| Computer Programming – C++ | Maine at Fort Kent, University of |
| Computer Programming II | Pace University |
| Computer Programming II | Rhode Island College |
| Computer Science 2 | Bethel University |
| Computer Science 2 | West Virginia University Institute of Technology |
| Computer Science II | Midwestern State University |
| Computer Science II | Northern Arizona University |
| Computer Science II | Nevada, Reno, University of |
| Computer Science II | South Dakota School of Mines and Technology |
| Intermediate Programming | Johns Hopkins University |
| Intermediate Programming | Texas Arlington, University of |
| Intermediate Programming: Data Abstractions | Linfield College |
| Intermediate Programming: Java | Eastern Mennonite University |
| Intermediate/Advanced Programming | Carnegie Mellon University |
| Introduction To Computer Science II | Amherst College |
| Introduction To Computer Science II | Oregon State University |
| Introduction To Programming II | Michigan State University |
| Introduction To Programming II | Lyon College |
| Java Programming | Lyndon State College |
| Principles Of Computer Science II | Oberlin College |
| Programming Ii: Data Structures | Abilene Christian University |
| Programming In Java | Virginia's College at Wise, University of |

**Table 2.7:** Example of Programming II

| Course Name | College or University |
|---|---|
| Data Structures | Pittsburgh Bradford, University of |
| Data Structures | Midwestern State University |
| Data Structures | Illinois, University of |
| Data Structures | Johns Hopkins University |
| Data Structures | West Virginia University Institute of Technology |
| Data Structures | Christian Brothers University |
| Data Structures | Northern Arizona University |
| Data Structures | Oregon State University |
| Data Structures | Stevens Institute of Technology |
| Data Structures | Nevada, Reno, University of |
| Data Structures | Eastern Mennonite University |
| Data Structures | California Berkely, University of |
| Data Structures | Virginia's College at Wise, University of |
| Data Structures | South Dakota School of Mines and Technology |
| Data Structures | Southern California, University of |
| Data Structures And Functional Programming | Cornell University |
| Data Structures And Objects | Bethel University |
| Data Structures Using Java | Cedarville University |
| Introduction To Data Structures | Wisconsin, University of |
| Introduction To Data Structures | Calvin College |
| Programming With Data Structures | Massachusetts Amherst, University of |
| Software Design And Data Structures | Virginia Polytechnic Institute and State University |
| The Science Of Data Structures | Rochester, University of |

**Table 2.8:** Example of Data Structures

| Course Name | College or University |
|---|---|
| Algorithms & Data Structures | Texas Arlington, University of |
| Algorithms And Data Structures | Michigan State University |
| Algorithms And Data Structures | Lyndon State College |
| Algorithms And Data Structures | Princeton University |
| Algorithms And Data Structures | Bucknell University |
| Algorithms And Data Structures | New Mexico Institute of Mining and Technology |
| Data Structures & Algorithm Analysis | William Penn University |
| Data Structures And Algorithm Analysis I | Oklahoma State University |
| Data Structures And Algorithms | Virginia Polytechnic Institute and State University |
| Data Structures And Algorithms | Brigham Young University |
| Data Structures And Algorithms | Calvin College |
| Data Structures And Algorithms | Texas A & M |
| Data Structures And Algorithms I | Amherst College |
| Data Structures And Algorithms I | Pace University |
| Data Structures And Algorithms I | Lyon College |
| Fundamental Data Structures And Algorithms | Carnegie Mellon University |

**Table 2.9:** Example of Data Structures And Algorithms

| Course Name | College or University |
|---|---|
| Advanced Topics In Algorithms, Complexity And Intelligent Systems | Linfield College |
| Algorithm Design And Analysis | Carnegie Mellon University |
| Algorithm Design And Analysis | Kentucky, University of |
| Algorithms | Stevens Institute of Technology |
| Algorithms | Northern Arizona University |
| Algorithms | Christian Brothers University |
| Algorithms | Cedarville University |
| Algorithms & Programming | William Penn University |
| Analysis Of Algorithms | West Virginia University Institute of Technology |
| Analysis Of Algorithms | Oregon State University |
| Analysis Of Algorithms | Eastern Mennonite University |
| Analysis Of Algorithms | Worcester Polytechnic |
| Analysis Of Algorithms | Nevada, Reno, University of |
| Analysis Of Algorithms | South Dakota School of Mines and Technology |
| Analysis Of Algorithms | Rhode Island College |
| Applied Algorithms | Amherst College |
| Data And Algorithm Analysis | Virginia Polytechnic Institute and State University |
| Design And Analysis Of Algorithms | Texas A & M |
| Design And Analysis Of Algorithms | Southern California, University of |
| Design And Analysis Of Algorithms | New Mexico Institute of Mining and Technology |
| Design And Analysis Of Efficient Algorithms | Rochester, University of |
| Efficient Algorithms And Intractable Problems | California Berkely, University of |
| Introduction To Algorithms | Virginia's College at Wise, University of |
| Introduction To Algorithms | Oberlin College |
| Introduction to Analysis of Algorithms | Cornell University |
| Introduction To Computational Theory | Brigham Young University |
| Introduction To The Design And Analysis Of Algorithms | Duke University |
| Introduction To Theory Of Computing | Wisconsin, University of |
| Logic, Computability And Complexity | Calvin College |
| Theory Of Computation | Kettering University |
| Theory Of Computation | Hendrix College |

**Table 2.10:** Example of Algorithms and Complexity

| Key Course Title | School Count |
|---|---|
| Algorithm Analysis | 9 |
| Algorithms and Complexity | 36 |
| Algorithms II | 3 |
| Algorithms III | 1 |
| Artificial Intelligence | 36 |
| Assembly Language Programming | 1 |
| Automata Theory | 9 |
| Compiler Design | 28 |
| Computational Theory | 12 |
| Computer Architecture | 29 |
| Computer Architecture II | 2 |
| Computer Graphics | 38 |
| Computer Models | 1 |
| Computer Organization and Assembly Language | 18 |
| Computer Science Capstone | 18 |
| Computer Science Capstone II | 4 |
| Computer Science Capstone III | 1 |
| Data Communications and Networking | 28 |
| Data Structures | 23 |
| Data Structures And Algorithms | 16 |
| Data Structures And Algorithms II | 3 |
| Data Structures and Algorithms Using OO | 1 |
| Database Concepts | 29 |
| Discrete Mathematics | 16 |
| Finite Structures | 1 |
| Great Theoretical Ideas In Computer Science | 1 |
| Human Computer Interface | 8 |
| Information Structures | 2 |
| Internship | 14 |
| Introduction to Computer Science | 25 |
| Introduction To Engineering | 1 |
| Introduction To Programming | 6 |
| Logic Design | 3 |
| Machine Organization | 2 |
| Mathematics Of Computer Science | 3 |
| Media Computing | 2 |
| Microcomputers | 2 |

**Table 2.11:** List of the Required and Choice Option Key Courses (Part I)

| Key Course Title | School Count |
|---|---|
| Microcontroller Architecture Programming | 1 |
| Numerical Methods | 13 |
| Numerical Methods II | 2 |
| Object Oriented Programming | 11 |
| Object-Oriented Design | 4 |
| Operating Systems | 45 |
| Operating Systems II | 2 |
| Operations Workshop I | 1 |
| Perspectives On Computing | 1 |
| Portfolio | 2 |
| Problems Solving | 2 |
| The Computing Professional | 4 |
| Program Design | 4 |
| Programming I | 38 |
| Programming II | 24 |
| Programming Languages | 36 |
| Programming Languages II | 5 |
| Programming Studio | 2 |
| Security | 19 |
| Seminar | 10 |
| Seminar II | 2 |
| Senior Design I | 3 |
| Social and Ethical Issues in Computer Science | 12 |
| Software Design | 2 |
| Software Development | 4 |
| Software Engineering | 34 |
| Software Engineering II | 4 |
| Software Systems | 1 |
| Sophomore Seminar | 1 |
| Topics in Computer Science | 37 |
| Structure of Programs | 1 |
| Systems | 16 |
| Systems Programming | 19 |
| Systems II | 2 |
| Technical Communication And Analysis | 1 |
| Unix Programming | 5 |
| Web Programming | 12 |

**Table 2.12:** List of the Required and Choice Option Key Courses (Part II)

## 2.4 Developing a Typical Curriculum

The next step after Key Courses were established and named was to develop the "Typical Curriculum". Courses in any curriculum fall into one of three categories. The first category are courses that are mandatory; courses that students must take toward fulfillment of their degree. In this dissertation, these courses are labeled required courses and given a requirement indicator of "R".

The second category are the courses that are listed together from which students must choose a certain number of courses. These courses in this dissertation are labeled choice option courses and given a requirement indicator of "C".

The third category of courses are the courses that students may elect to take. These courses in this dissertation are called elective courses and given a requirement indicator of "E". Elective courses were not included in the Typical Curriculum since this study focuses on students' first impressions of the Computer Science major they encounter on the web.

All courses were given a key name that represents the content of the course in order to more easily group like courses from the different colleges and universities (See section 3.2). There were seventy-four Key Courses in the entire list that were required courses denoted by a requirement indicator of "R". A percentage was calculated for each key name that represents the percentage of colleges that require a course in that key name category. The courses were then restricted to those that were required by 25% or more of the colleges and universities.

The sequence of Key Course was important in the selection process. Therefore, a sequencing number was calculated for each Key Course using the course registration ID from the courses within each Key Course. Colleges and universities usually number courses in a sequence students follow as they progress through their academic career. Therefore, sequencing is an attempt at putting the Key Courses in the order in which a student would normally take them. Many schools use a 3-digit numbering system where the most significant digit represents the level of the course. For example, Introduction to Programming I at the Michigan State University has a course number of 213 whereas Software Engineering has a course number of 435 indicating the students of higher standing would take Software Engineering. Some schools use a 2- and 3-digit numbering system, such as Amherst College which numbered “Introduction to Computer Science” 11 and “Artificial Intelligence” 310. Still others use a 4-digit numbering system, such as Cedarville University which numbered “Operating Systems” 3310 and “Computer Graphics” 4710. The different numbering systems proved sequencing courses accurately challenging. To calculate the sequence of a Key Course, the first two digits of the registration id for each of the courses in the Key Course were averaged. This provided a way of sequencing all Key Courses.

Table 2.13 presents the Key Courses for those courses that students are required to take as ordered by their sequencing number. In the list, Programming I was the Key Course required by the majority of schools. 68% of the colleges and universities surveyed required students to take the course. The next most required course was Operating Systems with 55% of colleges requiring it. In this table, only required courses within the Key Course were included in the sequencing. Due to the differences in requirements and numbering standards, the calculated sequence number for Programming II positioned it before Programming I.

Table 2.14 presents all the Key Course Name categories for courses that students must take either as a required course or as a choice option. These are the courses identified with a requirement indicator of “R” or “C”. The highest average key

| Key Course Name | Sequence Number | Number of Colleges | Percent of Colleges | Included in Typical Curriculum |
|---|---|---|---|---|
| Introduction to Computer Science | 1358 | 18 | 38.3% | Yes |
| Programming II | 1685 | 21 | 44.68% | Yes |
| Programming I | 1768 | 32 | 68.09% | Yes |
| Data Structures | 2498 | 23 | 48.94% | Yes |
| Computer Organization and Assembly Language | 2500 | 16 | 34.04% | Yes |
| Data Structures And Algorithms | 2611 | 16 | 34.04% | |
| Discrete Mathematics | 2629 | 14 | 29.79% | |
| Systems Programming | 2706 | 14 | 29.79% | Yes |
| Computer Architecture | 3005 | 12 | 25.53% | Yes |
| Algorithms and Complexity | 3308 | 25 | 53.19% | Yes |
| Database Concepts | 3322 | 14 | 29.79% | Choice |
| Data Communications and Networking | 3403 | 12 | 25.53% | Choice |
| Software Engineering | 3473 | 20 | 42.55% | Choice |
| Programming Languages | 3638 | 22 | 46.81% | Yes |
| Operating Systems | 3646 | 26 | 55.32% | Yes |
| Computer Science Capstone | 4471 | 16 | 34.04% | Yes |

**Table 2.13:** Key Course Names for Courses that are required

name course is still Programming I which is a required or a choice option by 68% of the colleges and universities surveyed followed by Operating Systems at 55% and Algorithms and Complexity at 53%. Both tables 2.13 and 2.14 presents the Key Courses above 20%.

The purpose of this analysis is to provide information in developing the curriculum that represents any curriculum students may encounter in their search for a college with a Computer Science major. Courses were chosen from the Key Courses to develop the Typical Curriculum. The top courses in the required list were chosen with the exception of Data Structures and Algorithms since two other courses were chosen that covers both those topics. Table 2.15 presents the Typical Curriculum that was used in the student surveys.

| Key Course Name | Sequence Number | Number of Colleges | Percent of Colleges | Included in Typical Curriculum |
|---|---|---|---|---|
| Introduction to Computer Science | 1358 | 18 | 38.3% | Yes |
| Programming I | 1748 | 33 | 70.21% | Yes |
| Programming II | 1841 | 24 | 51.06% | Yes |
| Object Oriented Programming | 2122 | 10 | 21.28% | |
| Data Structures | 2498 | 23 | 48.94% | Yes |
| Data Structures And Algorithms | 2611 | 16 | 34.04% | |
| Computer Organization and Assembly Language | 2612 | 18 | 38.3% | Yes |
| Discrete Mathematics | 2621 | 15 | 31.91% | |
| Systems Programming | 2763 | 16 | 34.04% | Yes |
| Systems | 2889 | 12 | 25.53% | |
| Computer Architecture | 3311 | 20 | 42.55% | Yes |
| Computational Theory | 3428 | 11 | 23.4% | |
| Algorithms and Complexity | 3433 | 31 | 65.96% | Yes |
| Software Engineering | 3447 | 24 | 51.06% | Choice |
| Database Concepts | 3548 | 25 | 53.19% | Choice |
| Artificial Intelligence | 3602 | 12 | 25.53% | Choice |
| Programming Languages | 3654 | 30 | 63.83% | Yes |
| Operating Systems | 3715 | 32 | 68.09% | Yes |
| Data Communications and Networking | 3751 | 22 | 46.81% | Choice |
| Numerical Methods | 3780 | 11 | 23.4% | |
| Compiler Design | 4034 | 11 | 23.4% | |
| Computer Science Capstone | 4439 | 17 | 36.17% | Yes |

**Table 2.14:** Key Course Names for Courses that are required or choice-options

| Computer Science | |
|---|---|
| CS 101 | Introduction to Computer Science |
| CS 110 | Programming I |
| CS 120 | Programming II |
| CS 201 | Data Structures |
| CS 210 | Algorithms and Complexity |
| CS 221 | Computer Organization and Assembly Language |
| CS 230 | System Programming Concepts |
| CS 310 | Computer Hardware |
| CS 320 | Programming Languages |
| CS 330 | Computer Architecture |
| CS 410 | Operating Systems |
| CS 494 | Computer Science Capstone |
| Choose 4 of the following | |
| CS 332 | Database Concepts |
| CS 380 | Computer Graphics |
| CS 411 | Software Engineering |
| CS 415 | Data Communications and Networking |
| CS 420 | Artificial Intelligence |
| CS 440 | Compiler Design |
| Mathematics | |
| MATH 110 | Calculus I |
| MATH 112 | Calculus II |
| MATH 120 | Discrete Structure |

**Table 2.15:** The Typical Computer Science Curriculum

## 2.5 Gathering and Analyzing Historic Curricula

The last step in this segment of the research is to evaluate historic curricula available on the World Wide Web. During the curriculum gathering step as described in section 2.2, college web sites were also searched for Computer Science curricula from 2000 and 2005. Of the forty-seven colleges and universities surveyed, thirty-three had 2005 curricula available and nineteen had 2000 curricula available.

Each of the required courses in 2010 for the schools for which historic data was available were compared with courses in 2000 and 2005 by comparing both registration IDs and course names. The number of equivalent courses, by ID and name, were counted and a percentage of equality was calculated per school. These percentages were collected and the minimum, first quartile, median, third quartile and maximum were calculated for each comparison.

### *2.5.1 Course Comparisons between 2000 and 2010*

**By Registration ID**

There were nineteen schools with curricular data from the year 2000. Table 2.16 displays the averages for each college that has curricular history dating back to 2000. For example, the first percentage, zero represents one college whose course registration IDs in 2010 do not match any registration IDs for courses offered in 2000. Similarly, the last percentage, 90, represents a school in which 90% of the course registration IDs in 2010 match registration IDs for courses offered in 2000.

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 43 | 50 | 56 | 64 | 80 | 81 | 85 | 88 | 89 | 90 |

**Table 2.16:** Raw Averages Each Representing the Percentage

Table 2.17 presents the comparison of courses by ID and name between the years

2010 and 2000. It shows that over a quarter of the schools had no courses in 2010 whose registration IDs were equivalent with courses in 2000. In fact, eight of the nineteen schools with historic data from the year 2000 had no duplicate registration IDs when compared with required courses in 2010. The median school as ordered by percentage of equivalency, had 43% of the registration IDs duplicated between the years 2010 and 2000. The third quartile school shows 81% of the registration IDs equivalent. 90% of the registration IDs in the school with the most similar curricula between 2000 and 2010, were equivalent. Figure 2.7 presents the Box and Whiskers diagram showing the comparison of registration IDs of required courses in 2010 with courses in 2000.

| | By ID | By Name |
|---|---|---|
| minimum | 0% | 0% |
| first quartile | 0% | 27% |
| median | 43% | 63% |
| third quartile | 81% | 78% |
| maximum | 90% | 88% |

**Table 2.17:** Statistics Comparing Required Courses in 2010 to Courses in 2000

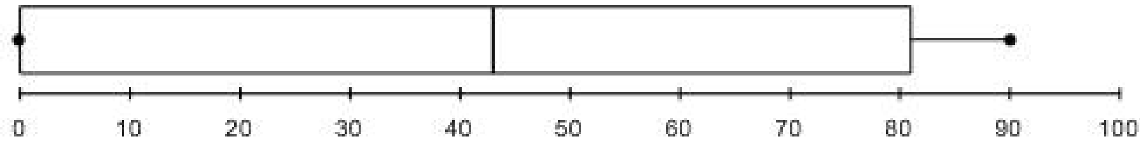


**Figure 2.7:** Box and Whiskers Presenting Comparison of Registration IDs Between 2000 and 2010 Courses

### By Course Name

Table 2.18 displays the averages for each college that has curricular history dating back to 2000. For example, the first percentage, zero represents one college whose course names in 2010 do not match any of the names for courses offered in 2000. Similarly, the last percentage, 88, represents a school in which 88% of the course names in 2010 are identical to names found in courses offered in 2000.

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 20 | 27 | 45 | 50 | 55 | 58 | 63 | 64 | 67 | 73 | 75 | 78 | 80 | 80 | 85 | 88 |

**Table 2.18:** Raw Averages Each Representing the Percentage

Table 2.17 also shows that less than a quarter of the schools had no courses in 2010 that matched by name with courses in 2000. In fact only three schools had no matches when comparing course names from required courses in 2010 with those courses in 2000. Over half of the schools had 63% or more of their course names matching the course names from 2000. The school that duplicated the most had 88% of the course names equivalent to those of 2000. Figure 2.8 presents the Box and Whiskers diagram showing the comparison of course names of required courses in 2010 with courses in 2000.

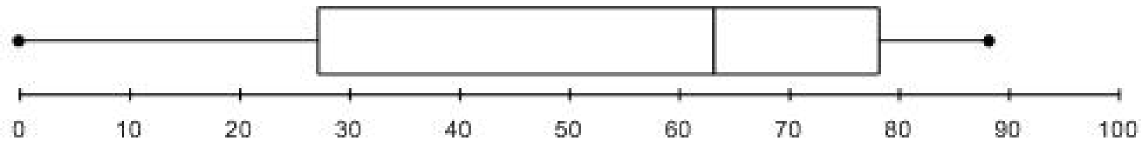


**Figure 2.8:** Box and Whiskers Presenting Comparison of Registration IDs Between 2000 and 2010 Courses

### *2.5.2 Course Comparisons between 2005 and 2010*

#### By Registration ID

There were thirty-three schools with curricular data from the year 2005. Table 2.19 displays the averages for each college that has curricular history dating back to 2005. For example, the first percentage, 0 represents one college whose course registration IDs in 2010 do not match any registration IDs for courses offered in 2005. Similarly, the last thirteen percentages, listed as 100s, represent schools in which 100% of the course registration IDs in 2010 match registration IDs for courses offered in 2005.

Table 2.20 presents the comparison of courses by ID and name between the years 2010 and 2005. It shows that half of the thirty-three schools that had historic data

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 7 | 9 | 30 | 36 | 44 | 50 | 65 | 67 | 78 | 82 | 83 | 86 | 86 | 89 | 91 |
| 92 | 93 | 94 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | |

**Table 2.19:** Raw Averages Each Representing the Percentage

for the 2005 school year had 91% or more of the registration IDs exactly the same in 2010 as those in 2005. In fact, for thirteen of the thirty-three schools, 100% of the registration IDs were exactly the same. Figure 2.9 presents the Box and Whiskers diagram showing the comparison of registration IDs of required courses in 2010 with courses in 2005.

| | By ID | By Name |
|---|---|---|
| minimum | 0% | 0% |
| first quartile | 58% | 66% |
| median | 91% | 82% |
| third quartile | 100% | 96% |
| maximum | 100% | 100% |

**Table 2.20:** Statistics Comparing Required Courses in 2010 to Courses in 2005

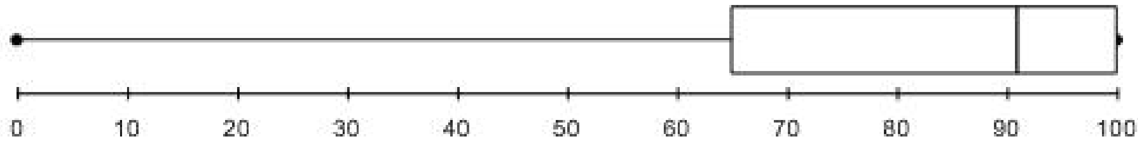


**Figure 2.9:** Box and Whiskers Presenting Comparison of Registration IDs Between 2005 and 2010 Courses

### By Course Name

Table 2.21 displays the averages for each college that has curricular history dating back to 2005. For example, the first percentage, 0 represents one college whose course names in 2010 do not match any of the names for courses offered in 2005. Only one college has renamed every required course in 2010 from those found in the curriculum in 2005. The last eight percentages, listed as 100s, represent schools in which 100% of the course names in 2010 are identical to names found in courses offered in 2005.

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 18 | 20 | 20 | 41 | 50 | 57 | 64 | 67 | 67 | 69 | 71 | 75 | 78 | 82 | 82 | 82 |
| 83 | 83 | 86 | 89 | 89 | 90 | 91 | 92 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | |

**Table 2.21:** Raw Averages Each Representing the Percentage

Table 2.20 also shows that three quarters of the schools 66% or more of the course names in 2010 exactly the same as courses in 2005. Eight schools duplicated the names of their entire required courses list in 2010 with courses found in 2005. Figure 2.10 presents the Box and Whiskers diagram showing the comparison of course names of required courses in 2010 with courses in 2005.

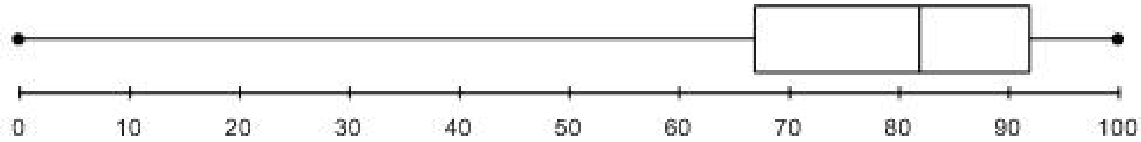


**Figure 2.10:** Box and Whiskers Presenting Comparison of Registration IDs Between 2005 and 2010 Courses

### *2.5.3 Conclusions*

This data would suggest that the required courses in Computer Science in most colleges and universities have remained the same over the last five years and have changed very little over the last ten years. Table 2.14 shows that over half of the colleges and universities analyzed have kept between 63% and 88% of their course names exactly the same in 2010 as in 2000. Table 2.15 shows that over half these colleges and universities have kept between 91% and 100% of their required courses the same when comparing course identifiers and between 82% and 100% the same when comparing course names in 2010 as in 2005.

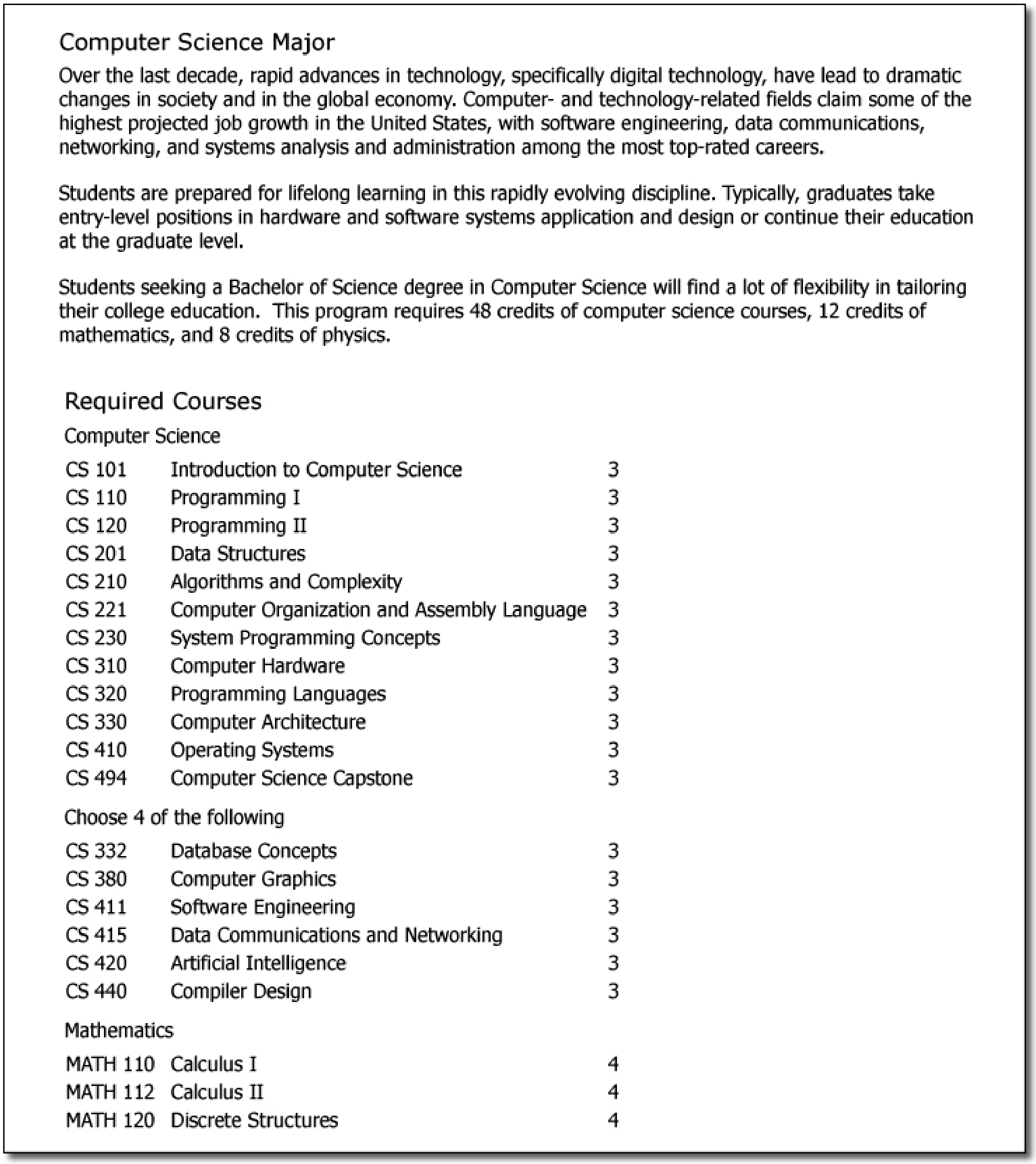
## 2.6 Summary

This segment of the research focused on college curricula that can be found on the World Wide Web. There were forty-seven schools selected using five criteria including public versus private, setting, size, region, and type of curriculum. Curricula was gathered from those forty-seven schools for the 2010 school year. Where possible, curricula was also gathered for the years 2000 and 2005.

During the gathering process several obstacles were observed that may cause interested students to give up their search. The three obstacles presented revolved around the difficulty students might face in looking into the major. The first obstacle was needing to know what school or department in which to find the Computer Science major. The second obstacle was finding the page that presented the curriculum once the school or department was determined. The third obstacle was the challenge in being able to compare curricula from different schools since the presentations differed greatly.

Once the curricula was gathered, courses were compared from different schools and Key Courses were developed. Key Courses are groups of similar courses from different schools that are given a name (For the entire list of Key Courses and their group of specific college courses see Appendix B). These Key Courses were then evaluated and a typical curriculum was developed. The goal in developing the typical curriculum was to put together a curriculum that a student would first encounter when exploring the Computer Science major. Figure 2.11 presents the full Typical Curriculum, including the introduction, that students would expect to encounter in their search.

The last portion of this segment of the research was comparing courses in 2010 with courses presented in 2000 and 2005. In comparing registration IDs from 2010 with



### Computer Science Major

Over the last decade, rapid advances in technology, specifically digital technology, have lead to dramatic changes in society and in the global economy. Computer- and technology-related fields claim some of the highest projected job growth in the United States, with software engineering, data communications, networking, and systems analysis and administration among the most top-rated careers.

Students are prepared for lifelong learning in this rapidly evolving discipline. Typically, graduates take entry-level positions in hardware and software systems application and design or continue their education at the graduate level.

Students seeking a Bachelor of Science degree in Computer Science will find a lot of flexibility in tailoring their college education. This program requires 48 credits of computer science courses, 12 credits of mathematics, and 8 credits of physics.

### Required Courses

Computer Science

| | | |
|---|---|---|
| CS 101 | Introduction to Computer Science | 3 |
| CS 110 | Programming I | 3 |
| CS 120 | Programming II | 3 |
| CS 201 | Data Structures | 3 |
| CS 210 | Algorithms and Complexity | 3 |
| CS 221 | Computer Organization and Assembly Language | 3 |
| CS 230 | System Programming Concepts | 3 |
| CS 310 | Computer Hardware | 3 |
| CS 320 | Programming Languages | 3 |
| CS 330 | Computer Architecture | 3 |
| CS 410 | Operating Systems | 3 |
| CS 494 | Computer Science Capstone | 3 |

Choose 4 of the following

| | | |
|---|---|---|
| CS 332 | Database Concepts | 3 |
| CS 380 | Computer Graphics | 3 |
| CS 411 | Software Engineering | 3 |
| CS 415 | Data Communications and Networking | 3 |
| CS 420 | Artificial Intelligence | 3 |
| CS 440 | Compiler Design | 3 |

Mathematics

| | | |
|---|---|---|
| MATH 110 | Calculus I | 4 |
| MATH 112 | Calculus II | 4 |
| MATH 120 | Discrete Structures | 4 |

**Figure 2.11:** The Typical Curriculum

those in 2000, it appears that more of the required course registration IDs in 2010 changed from those in 2000. The median percent of similarity was 43%. In comparing registration IDs from 2010 with those in 2005, however, more registration IDs stayed the same for a greater number of colleges and universities. The median percent of equality was 63%.

In comparing names of courses in 2010 with those in 2000 and 2005, more names stayed the same than the registration IDs. The median percent of similarity of course names between 2010 and 2000 was 57.5%, much higher than the median percent of similarity in registration IDs for the same years. The median percent of similarity of course names between 2010 and 2005 was 65.5%, also higher than the registration IDs of the same years.

This data would suggest that the required courses in Computer Science in most colleges and universities have remained the same over the last five years and have changed very little over the last ten years. Table 2.17 shows that over half of the colleges and universities analyzed have kept between 63% and 88% of their course names exactly the same in 2010 as in 2000. Table 2.20 shows that over half these colleges and universities have kept between 91% and 100% of their required courses the same with between 82% and 100% of them keeping the same name over the last 5 years.

# Chapter 3

# Technology Job Review

Chapter one introduced this research by identifying the issue of decreasing enrollment in Computer Science. It presented the rise and fall of enrollment over the last several decades as well as the hope presented by the Bureau of Labor Statistics for computing-related job prospects over the next decade. Colleges and Universities have made an effort to address the issue of declining enrollment through updating course content and methodology as well as researching factors that may indicate student future success in the major. The history of curricular guidelines was also presented. With all the work put into addressing the declining enrollment, none have focused on the presentation of curricula to prospective students and asked the question, “Is the curriculum presented to prospective students understandable and attractive to these students?” If the curriculum is not understandable to these prospective students, what actions can be taken to better communicate what computing is all about?

Chapter two explored the current state of the Computer Science curriculum as presented on the World Wide Web. Curricula was obtained and evaluated from forty-seven colleges and universities from a variety of settings and sizes. The intent was to explore curricula from the perspective of students who are initially investigating Computer Science. The outcome of that segment of research was a Typical Computer Science curriculum that was used in surveys to prospective students.

The next stage of this research, Technology Job Review, as first presented in Figure 1.4 and illustrated in Figure 3.1 was designed to evaluate how businesses promote computer related job opportunities. The goal of this segment was to develop a job-related curriculum by identifying job categories and keywords used in computer-related job openings that would help explain the Computer Science major and the courses of study. The idea behind this segment is to determine if the methods used in job advertisements in presenting computer-related jobs would have an impact on the perceptions of high school students and their parents if utilized in presenting the Computer Science curriculum. If a curriculum were developed around the way industry promotes computer related jobs, maybe students would be attracted and motivated to pursue that course of study.

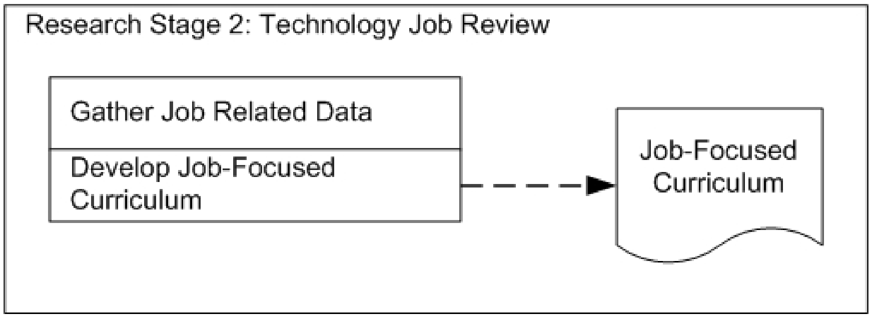


**Figure 3.1:** Research Stage 2: Technology Job Review

The outcome of this segment was the developed presentation of a Job-Focused Computer Science Curriculum that incorporates keywords found in technology job advertisements and attempts to deviate from the Typical Computer Science curriculum found online. This Job-Focused Curriculum was used in surveys along with the Typical Computer Science Curriculum as designed in Chapter 2 to seek the opinions and perceptions of high school students to the presentation of these curricula. The surveys are explained in further detail in Chapter 5.

This chapter describes the method of gathering the job related data, presents the found data, and describes the method of designing the Job-Focused Curriculum.

## 3.1 Gathering Technology Job Data

There are many possible avenues to search for computer-related jobs from newspaper advertisements and head hunters to online job search engines. The intent of this study was to gather job advertisements in a manner similar to what current prospective students would search for them. Since the generation of prospective students' primary source of news and information is the Internet [37], it was decided to gather advertisements using online job search engines. To find possible job search engines, once again the Internet was consulted using Google, a popular search engine of Generation Y [30, 81, 95]. Six job search web sites were selected from Google's response to the search "Job Search Engines" (See Table 3.1). These job search engines are described further in Appendix C. Over 200 job advertisements were obtained over a two-week period in 2009 using the job search engines.

| Search Engine | URL |
|---|---|
| Yahoo Hot Jobs | http://hotjobs.yahoo.com/ |
| Career Builder | http://www.careerbuilder.com/ |
| Monster | http://jobsearch.monster.com/ |
| Simply Hired | http://www.simplyhired.com/ |
| Snag a Job | http://www.snagajob.com/ |
| Dice | http://www.dice.com/ |

**Table 3.1:** Job Search Engines Consulted

The job postings were randomly selected from each of the search engines from the technology-related categories. Nine computer-related categories were identified in the job search engines: Information Technology, Web, Database, Networking, Software Engineering, Software Quality and Testing, Security, and Application.

The following are examples of postings collected and categorized from the different search engines.

## Information Technology

### Account Executive

Maryville Technologies, a systems integration services firm, is seeking an Account Executive in multiple geographies including; Milwaukee, Minneapolis, Kansas City, Houston, and St. Louis. Maryville works on some of the most challenging and complex problems faced by our clients today. This position will allow you to see a variety of environments and get involved with the latest technology. The AE is responsible for business development within a specified region and/or set of accounts. This person will identify and qualify opportunities within the full range of Maryville offerings.

*Job posted at Monster*

### Senior Unix Systems Administrator

Senior Unix (Sun Solaris and LINUX) system administrator also experienced with Windows systems (Active directory). Dealing with cross platform networks consisting of Unix, Linux and Windows 2000 is a must. Clearcase installation and set up on cross platform networks (LINUX and Unix) experience is highly desired. Tasks include hardware/software installation, performing backups, system configuration, and network administration in program development labs, which consist of Unix and Windows systems. Plan for and maintain development networks, storage, COTS upgrades, virus definitions and collaboration tools; create and maintain user accounts. Be responsible for network security, system recovery and system troubleshooting.

*Job posted at Dice*

## Web

### Web Analyst

You will work with the Lutron.com team to develop and deploy our new website making back end changes to the website to support new business. You will interact with all strategic business units and various departments in the corporation to develop plans for the new site. 75% of this position will be technical development.

*Job posted at Career Builder*

### Sr. GUI Developer

Seeking a Sr. Web Developer to help develop, maintain, and support a complex retail eCommerce site. Utilize your proficiencies with HTML, CSS, Java Script, Java Script Frameworks (i.e. Prototype, JQuery), AJAX, and JSP to support our websites. PLEASE no Java Server side experts. This is a Front end development initiative.

*Job posted at Dice*

## Database

### SQL Database Analyst

An SQL Database Analyst is needed for a secure long-term contract. This Analyst should be able to write database SQL queries/sub queries against Access or other databases. As well as, manipulating and update database data using VBA scripts; writing Reports in Access and creating handles from Excel to a data source for repeatable reporting. Position requires proficiency in Word templates and ability to update templates using VBA scripts. Also, must analyze data based on query results, with a proficiency in Excel (macros, Complex-vlookup, Pivot charts, etc) is a must.

*Job posted at Simply Hire*

### QL Server DBA - Database Administrator

Senior Database Administrator to support a growing IT infrastructure. The DBA will design, engineer, implement and support technical databases for externally facing web-based and back-office applications. The DBA will work with application developers, systems administrators, software testers and business analysts.

*Job posted at Yahoo Hot Jobs*

## Networking

### Network Support

Our experience and expertise ranges from large network support projects that include the configuration, management, and documentation for nationwide internet protocol (IP) infrastructures to the support for individual local area networks. Our network support services cover these areas: WAN design, Firewalls and VPNs, Routers, Installation and configuration, Network documentation, Troubleshooting, Network security, LAN support.

*Job posted at Monster*

### Network Manager

Global Telecommunications company has an immediate opening for a Network Manager. RESPONSIBILITIES: Provides essential Capacity Management support for all Layer 3 services. Including MIS, AVPN, PNT, VoIP, Network Management Devices, Core Routers, Route Reflectors, Juniper, Fiber Drawers, and WiFi.

*Job posted at Snag a Job*

## Software Engineering

### Software Developer

Strategic Analysis is seeking a mid-level individual to be an integral part of a team building web-database applications with scientific models. You will perform software development and integration duties in support of complex modeling and simulation programs. As an Intermediate-level Software Engineer, you will contribute to all phases of the software development life cycle, including requirements, design, development, and testing.

*Job posted at Career Builder*

### Software Engineers (Java, J2EE, Secret Clearance)

Next Century Corporation, a growing technology company in Alexandria, Virginia, is seeking software developers/engineers to join our team  but not just any software developers. Were searching for those rare individuals who share our passion for using their skills to make a difference in this world with an unwavering commitment to excellence, integrity and customer satisfaction.

*Job posted at Monster*

## Software Quality and Testing

### QA Analyst with RUP

An intermediate Quality Assurance (QA) Analyst (5+ year's experience) is needed for testing application development in a Visual C++ (VC++), Visual C#/.NET, and Oracle PL/SQL environment. Business domain is asset management in the transportation industry. Supply chain, Logistics and Finance experience is also applicable. Experience with a structured iterative development methodology (i.e., Rational Unified Process (RUP)) is absolutely required.

*Job posted at Dice*

### Performance Tester

PERFORMANCE TESTER is assigned to ensure the performance and readiness of the product developed by the Programming Software Engineer. The Performance Tester is responsible for performance & automation testing implementation by performance testing tools, leading processes E2E from the planning, design, development into execution, work very close with the customer. The performance testing process is ongoing communication with other teams related to the task.

*Job posted at Dice*

## Security

### Digital Forensics Investigator

Digital Forensic Investigators examine and analyze electronic media in support of computer intrusion, counterterrorism, counterintelligence, and criminal cases supporting both Federal law enforcement and intelligence agencies. After analyzing such media using a broad range of computer forensic tools, Digital Forensic Investigators summarize their findings in a technical report that must be useful to other technical specialists but also understandable by laypersons. On rare occasions, Digital Forensic Investigators may be required to testify in a court of law as a fact witness to the specifics of a case or as an expert witness to the computer forensic analysis process.

*Job posted at Simply Hired*

### Information Security Engineer

Applies current Information Assurance technologies to the architecture, design, development, evaluation and integration of systems and networks to maintain system security.

*Job posted at Career Builder*

## Application

### Data Analyst

Act as data analyst for large-scale initiative, running MS Access and MS Excel based reports. Must have a strong attention to detail, and the

> ability to work with large amounts of data (50K 100K lines), which should include filtering, sorting, lookups, conditional analysis. Strong working knowledge of MS Access, MS Excel required. Biz Objects would be a plus. Must quickly learn and run a complex set of MS Access queries and MS Excel macros to generate several dozen reports. Act as data analyst for large-scale initiative, running MS Access and MS Excel based reports. Act as data analyst for large-scale initiative, running MS Access and MS Excel based reports.
>
> *Job posted at Snag a Job*
>
> **Desktop Support Technician**
>
> We are looking for a Desktop Support Technician for a 6 month contract position with our client in the Miami, Florida area. Provide hardware and software first level support. Ensure problem tickets and Move Adds Changes (MACs) are completed within service levels. Installing, configuring and troubleshooting hardware & software.
>
> *Job posted at Yahoo Hot Jobs*

The collected job postings were reduced to job title and job description and stored in a tab-delimited document along with the job category.

## 3.2 Processing the Gathered Technology Job Data

The purpose of processing the gathered job advertisements was to gather technology-related keywords that would be used in describing courses of study for a Job-Related curriculum. To that end a java application was written to read the tab-delimited document and produce a keyword list for the categories described in Section 3.1.

The job description was then reduced to technology-related words. The technology-related words were processed through a Java program written to consolidate the list, identifying keywords and how many times the words were used. The categories identified on the job search engine websites were used and the keywords discovered in the job postings were included with those categories. For example, “Adobe” was found in many advertisements yet was only related to web-based jobs. “Analysis” on the other hand was used in web, database, information technology, and software engineering jobs, so was categorized in each.

The Java program read the tab-delimited job description file and built a list of jobs to process. The program read a second file, tagged keywords, that contained the currently identified list of keywords and the category in which the word was found. A data structure was developed to contain the keyword and all the categories with which it belongs. The program would then run through the list of jobs and compare all the words in the description with the keyword list. If the word was found in the keyword list, it was added to another data structure that contained the keyword, a count of the number of times the word was found, and a list of job titles in which the keyword was found. Words that were not found in the keyword list were written to a file, “non-tagged.txt”, that contained the word and the job title and category in which the word was found. This list was then manually reviewed and new keywords were added to the keyword list for the next round. Common words such as “and”, “or”, and “the” were the only words left in the “non-tagged.txt” file when the process was completed. The Java program that processed the gathered jobs provided a list of keywords and their category.

## 3.3 Technology Job Data

The purpose of this technology job study is to identify job categories and keywords used in computer-related job openings to be used in explaining courses of study in the Computer Science major. Keyword lists for each category were developed from the list provided by the Java program described in Section 3.2. The following are the results of the developed lists with only those keywords with a minimum use count of five.

### *3.3.1 Information Technology*

Information Technology keywords were found mainly in such jobs as "Business Analyst with Sharepoint Experience", "Change Manager", "Data Analyst", "Microstrategy, Datastage Consultant", and "SR Desktop Support". Table 3.2 contains the top ten keywords used in Information Technology related job advertisements.

| Keyword | Number of Times Used |
|---|---:|
| Unix | 35 |
| Linux | 32 |
| Scripting | 24 |
| Windows | 23 |
| Systems | 17 |
| IT | 15 |
| Operating systems | 15 |
| System | 15 |
| Troubleshooting | 15 |
| Performance | 12 |

**Table 3.2:** Keywords in Information Technology-related Jobs

### *3.3.2 Web*

Web-related keywords were found mainly in jobs such as “Drupal Web Developer”, “Flash Developer”, “Front End Web Developer”, “HTML, Web Developer”, and “Java Web Engineer”. Table 3.3 contains the top ten keywords used in Web related job advertisements.

| Keyword | Number of Times Used |
|---|---:|
| HTML | 28 |
| Ajax | 18 |
| JSP | 16 |
| Perl | 16 |
| PHP | 16 |
| J2EE | 14 |
| Analysis | 10 |
| ASP | 10 |
| Flash | 10 |
| Web Services | 10 |

**Table 3.3:** Keywords in Web-related Jobs

### *3.3.3 Database*

Database-related keywords were found mainly in jobs such as “Oracle Forms Developer”, “Smallworld GIS Application Support”, “SQL Database Analyst”, and “SQLServer Database Administrator”. Table 3.4 contains the top ten keywords used in Database related job advertisements.

| Keyword | Number of Times Used |
|---|---:|
| SQL | 42 |
| Oracle | 26 |
| XML | 24 |
| MySQL | 14 |
| Database | 12 |
| Access | 10 |
| Design | 10 |

**Table 3.4:** Keywords in Database-related Jobs

### *3.3.4 Networking*

Networking-related keywords were found mainly in jobs such as “Design Engineer”, “Internet Product Engineer”, “Network Admin”, “Network Analyst”, and “Network Research Engineer”. Table 3.5 contains the top ten keywords used in Networking related job advertisements.

| Keyword | Number of Times Used |
|---|---:|
| Network | 15 |
| Networking | 11 |
| VOIP | 11 |
| TCP/IP | 10 |
| Telecommunications | 9 |
| VPN | 8 |
| WAN | 8 |
| Firewall | 7 |
| LAN | 7 |
| HTTP | 6 |

**Table 3.5:** Keywords in Networking-related Jobs

### *3.3.5 Software Engineering*

Software Engineering-related keywords were found mainly in jobs such as “Application Engineer”, “Product Manager”, “Program Analyst”, “Software Design Engineer”, and “System Architect”. Table 3.6 contains the top ten keywords used in Software Engineering related job advertisements.

### *3.3.6 Software Quality and Testing*

Software Quality and Testing-related keywords were found mainly in jobs such as “QA Analyst with RUP”, “QA Engineer”, and “Requirements Coordinator”. Table 3.7 contains the top keywords used in Software Quality and Testing related job advertisements.

| Keyword | Number of Times Used |
|---|---|
| Java | 39 |
| Javascript | 29 |
| Development | 27 |
| CSS | 23 |
| Software | 22 |
| .Net | 18 |
| Application | 15 |
| Communication | 14 |
| C# | 13 |
| Cisco | 13 |

**Table 3.6:** Keywords in Software Engineering-related Jobs

| Keyword | Number of Times Used |
|---|---|
| Testing | 12 |
| Test | 12 |
| QA | 5 |
| Quality | 4 |
| Quality Assurance | 3 |

**Table 3.7:** Keywords in Software Quality and Testing-related Jobs

### *3.3.7 Security*

Security-related keywords were found mainly in jobs such as “Systems Security Engineer”, “Product / Application Security Architect”, “Security Architect”, “Application Security Engineer”, and “C & A Security Analyst”. Table 3.8 contains the top keywords used in Security related job advertisements.

| Keyword | Number of Times Used |
|---|---|
| Security | 15 |
| Risk Management | 4 |
| TS/SCI | 3 |
| Hacking | 3 |

**Table 3.8:** Keywords in Security-related Jobs

### *3.3.8 Application*

Application-related keywords were found mainly in jobs such as "Data Analyst" and "Desktop Support Technician". Table 3.9 contains the top keywords used in Application related job advertisements.

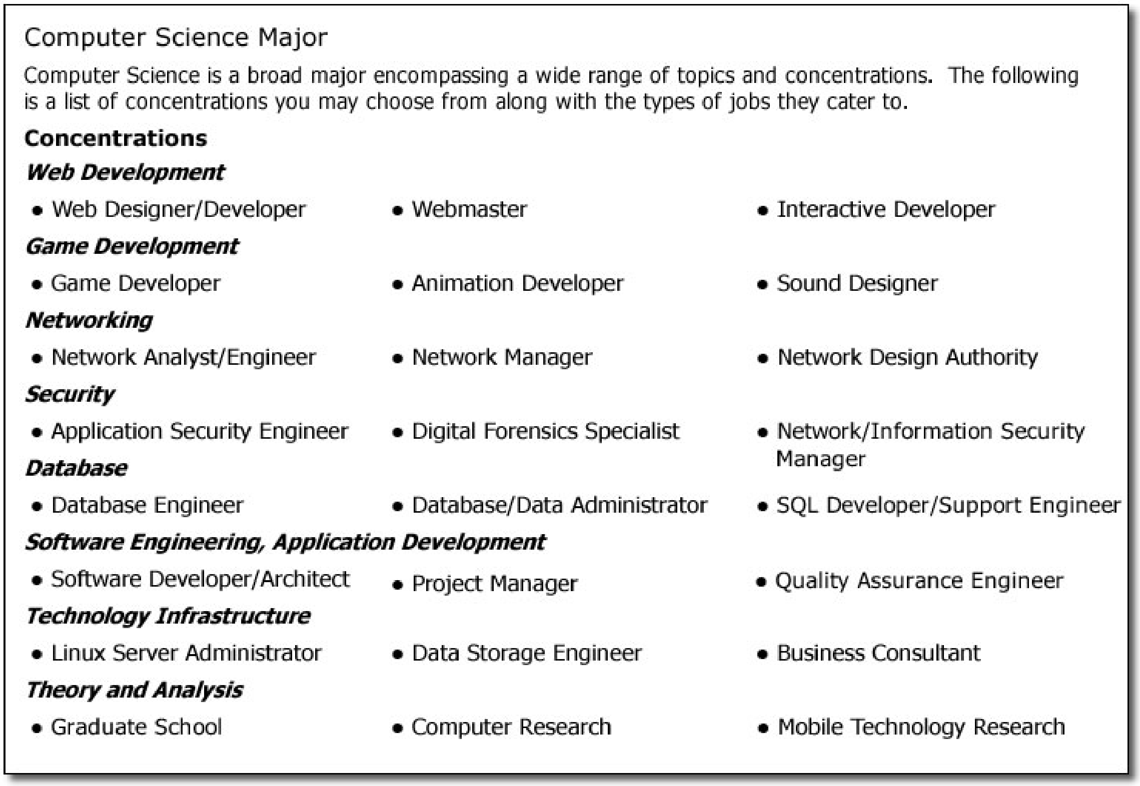
| Keyword | Number of Times Used |
|---|---|
| Excel | 7 |
| Visio | 6 |
| VB | 5 |
| Microsoft | 5 |
| Basic | 5 |
| VB.Net | 3 |
| Visual Basic | 3 |

**Table 3.9:** Keywords in Application-related Jobs

## 3.4 Job-Focused Curriculum Design

The Job-Focused curriculum, divided into an Introduction section and an Areas of Study section, was designed using the requirements of the Typical Curriculum and information gathered from the Technology Job Review. The Introduction section to the Job-Focused Computer Science Curriculum was divided into two parts. The first, an introductory paragraph, introduces Computer Science as a broad major encompassing a wide range of topics and introduces the second part, the list of concentrations. Since job search engines provide categories of jobs, the introduction to the Job-Focused Curriculum provides categories of concentrations for the Computer Science major. Figure 3.2 presents the introduction that was used in the survey.

The concentrations used were derived from the categories in the job search engines. The concentrations listed include Web Development, Game Development, Networking, Security, Database, Software Engineering, Application Development,



Computer Science Major

Computer Science is a broad major encompassing a wide range of topics and concentrations. The following is a list of concentrations you may choose from along with the types of jobs they cater to.

**Concentrations**

***Web Development***

- Web Designer/Developer
- Webmaster
- Interactive Developer

***Game Development***

- Game Developer
- Animation Developer
- Sound Designer

***Networking***

- Network Analyst/Engineer
- Network Manager
- Network Design Authority

***Security***

- Application Security Engineer
- Digital Forensics Specialist
- Network/Information Security Manager

***Database***

- Database Engineer
- Database/Data Administrator
- SQL Developer/Support Engineer

***Software Engineering, Application Development***

- Software Developer/Architect
- Project Manager
- Quality Assurance Engineer

***Technology Infrastructure***

- Linux Server Administrator
- Data Storage Engineer
- Business Consultant

***Theory and Analysis***

- Graduate School
- Computer Research
- Mobile Technology Research

**Figure 3.2:** Job-Focused Curriculum Introduction

Technology Infrastructure, Theory and Analysis, Information Systems, and Mobile Application Development / New Technology.

Included with each concentration in the list were three job titles appraising students of the job opportunities after graduation. The only non-job related concentration relates to students who may proceed to graduate school and/or research and was titled, “Theory and Analysis”. The job titles list for that “concentration” focused more on graduate school and research.

The next section of the Job-Focused Curriculum is similar to the Typical Curriculum in that it identifies what students will study; however, instead of specific course names, general areas of study were provided. When job advertisements were collected, the position requirements for each job were never numbered or labeled with a categorization like courses are numbered and categorized. Therefore, it was decided that specific courses would not be listed, but the topics or areas of study would be.

The Areas of Study section began with an introduction explaining that the following areas are not courses, but topics that students will encounter. It goes on to explain that there are core areas of study for all Computer Science majors and specific areas of study for each concentration. The list of areas of study was developed using a combination of technology terms from the Technology Job Review, the Typical Curriculum courses, and the Computing Curricula 2005 - The Overview Report by Russell Shackelford et. al [98]. The courses that were used from the Typical Curriculum were renamed with more explanatory titles. In several cases, multiple areas of study were added for a single Typical Curriculum course. The additional areas of study were added to provide a clearer picture of what a Computer Science student studies and were based on description of the course in the Typical Curriculum. Figure 3.3 presents the Areas of Study section that students were presented during the survey.

For each concentration the list of study areas was developed using the College Curricular Review and majors that were found which focused on that concentration. The job descriptions from the Technology Job Review were also used to ensure that each concentration would prepare students for jobs in their concentration. The area names were developed using the keywords from the Technology Job Review. Only six concentrations were expanded upon in this second section for two reasons. The first reason relates to the surveys discussed in Chapter 5. The curriculum presented in Figures 3.2 and 3.3 would be displayed to prospective students and therefore there was concern that the length of the page that students would have to view would discourage them.

The second reason relates to the two concentrations not included. There was not

## Areas of Study

The following list identifies the areas of study that all Computer Science majors will engage in regardless of their concentration. These are not courses but are topics included in the courses you will be taking. Following this list of areas are the areas of study found in the different concentration areas.

- Artificial Intelligence and Robots
- Building Servers
- Choosing appropriate Languages
- Using Computers in Other Fields
- Computer Graphics – 3D Focus
- Computer Science and Society
- Project Management
- Data Management
- Human & Computer Interaction
- Introduction to Networking
- Machine Level Architecture
- Methods for Building Software
- Methods for Organizing Data
- Security
- Step-By-Step Problem Solving
- Web Graphics
- Windows, Linux, Mac OS, etc.
- Programming
  Object Oriented, Event Driven, Gaming , Web-Based

## Concentration Specific Areas of Study

***Web Development***

- Digital Imaging, Streaming Media
- Flash, Video
- Website Design
- Dynamic Web
- E-Commerce
- Content Management
- Usability
- Web Production and Analysis
- Servers and Databases
- Security

***Software Engineering / Application Develpment***

- Different Methodologies
  Building large software Applications
- Application Build
- Mobile Applications
- Cloud Computing

***Security***

- Hacking
- Computer Security
- Cryptography
- Network Security
- Biometrics

***Database***

- Database Management Systems
  Oracle, MySQL, SQLServer
- Data mining
  Managing huge amounts of data
- Data warehousing/storage

***Technology Infrastructure***

- Information Systems Managers
- Evaluating Information Systems
- Designing Information Systems
- Opportunities in Business
- Enterprise Resource Planning
- Logistics

***Networking***

- Network Basics
- Routing Administration
- Client-Server Programming
- Multi-User Computing
- Business Networking
- Network Security

**Figure 3.3:** Job-Focused Curriculum Required Course List

enough information in the Typical Curriculum to expand upon the Game Development concentration, so it was left out of the second section. The Theory and Analysis concentration focused more on graduate school and less on future jobs, therefore it was also left out of the second section.

## 3.5 Technology Job Summary

This segment of research focused on the presentation of technology job advertisements and how that could be used in presenting the Computer Science curriculum differently. Six job search engines were used to gather over 200 job advertisements. These advertisements were used to develop a list of keywords and the categories in which those keywords were found. The categories and keywords were used in developing a Job-Focused Curriculum, shown in Figure 3.4, which was used in a survey to solicit prospective students' opinions.

## Computer Science Major

Computer Science is a broad major encompassing a wide range of topics and concentrations. The following is a list of concentrations you may choose from along with the types of jobs they cater to.

**Concentrations**

***Web Development***

- Web Designer/Developer
- Webmaster
- Interactive Developer

***Game Development***

- Game Developer
- Animation Developer
- Sound Designer

***Networking***

- Network Analyst/Engineer
- Network Manager
- Network Design Authority

***Security***

- Application Security Engineer
- Digital Forensics Specialist
- Network/Information Security Manager

***Database***

- Database Engineer
- Database/Data Administrator
- SQL Developer/Support Enginee

***Software Engineering, Application Development***

- Software Developer/Architect
- Project Manager
- Quality Assurance Engineer

***Technology Infrastructure***

- Linux Server Administrator
- Data Storage Engineer
- Business Consultant

***Theory and Analysis***

- Graduate School
- Computer Research
- Mobile Technology Research

## Areas of Study

The following list identifies the areas of study that all Computer Science majors will engage in regardless of their concentration. These are not courses but are topics included in the courses you will be taking. Following this list of areas are the areas of study found in the different concentration areas.

- Artificial Intelligence and Robots
- Building Servers
- Choosing appropriate Languages
- Using Computers in Other Fields
- Computer Graphics – 3D Focus
- Computer Science and Society
- Project Management
- Data Management
- Human & Computer Interaction
- Introduction to Networking
- Machine Level Architecture
- Methods for Building Software
- Methods for Organizing Data
- Security
- Step-By-Step Problem Solving
- Web Graphics
- Windows, Linux, Mac OS, etc.
- Programming
  Object Oriented, Event Driven, Gaming , Web-Based

## Concentration Specific Areas of Study

***Web Development***

- Digital Imaging, Streaming Media
- Flash, Video
- Website Design
- Dynamic Web
- E-Commerce
- Content Management
- Usability
- Web Production and Analysis
- Servers and Databases
- Security

***Software Engineering / Application Develpment***

- Different Methodologies
  Building large software Applications
- Application Build
- Mobile Applications
- Cloud Computing

***Security***

- Hacking
- Computer Security
- Cryptography
- Network Security
- Biometrics

***Database***

- Database Management Systems
  Oracle, MySQL, SQLServer
- Data mining
  Managing huge amounts of data
- Data warehousing/storage

***Technology Infrastructure***

- Information Systems Managers
- Evaluating Information Systems
- Designing Information Systems
- Opportunities in Business
- Enterprise Resource Planning
- Logistics

***Networking***

- Network Basics
- Routing Administration
- Client-Server Programming
- Multi-User Computing
- Business Networking
- Network Security

**Figure 3.4:** The Entire Job-Focused Curriculum

# Chapter 4

# Student Opinions and Ideas for Developing a Student-Focused Curriculum

Chapter 3 presented the Technology Job Review stage of this research. The purpose of the Technology Job Review stage was to evaluated how businesses promote computer related job opportunities with the goal of developing an alternative curriculum to the Typical Curriculum that was developed in Chapter 2. The next stage of this research, Student Opinions and Ideas for Developing a Student-Focused Curriculum, as first presented in Figure 1.4 and depicted in Figure 4.1 was divided into four segments. The first segment, High School Student Technology Survey, was designed to gather student opinions relative to different aspects of technology.

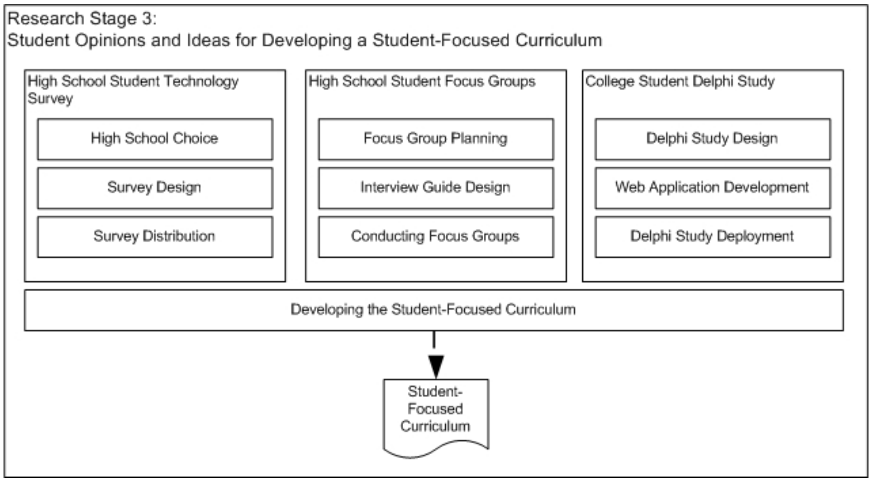


**Figure 4.1:** Research Stage 3: Student Opinions and Ideas for Developing a Student-Focused Curriculum

The second segment in this stage of research, High School Student Focus Groups, was designed to understand high school student impressions of computing, delving into the students' attitudes and perceptions of computers and the study of computers in college.

The third segment in this stage of research, College Student Delphi Study, seeks specific advice from college students currently enrolled in a computing major related to the presentation of the major.

The goal of each of these segments is the design of a Student-Focused curriculum that takes into account the perceptions of prospective students. This Student-Focused Curriculum was used in surveys along with the Typical Computer Science Curriculum as designed in chapter 2 to solicit the opinions of high school students toward the curriculum presented to them. These surveys are explained in further detail in Chapter 5.

## 4.1 High School Student Technology Survey Methodology

The framework for the methodology of this stage of the study is illustrated in Figure 4.1. The bulk of this research focuses on a study of high school students, their impressions of computing and the attitudes and perceptions of studying computers in college. This section explains the methodology used to develop the student technology survey and the collection process.

The purpose of this technology survey is two-fold:

1. to gather student opinions relative to different aspects of technology in the following categories:
    - Course interests in High School

  - Use of technology
  - College Intent and Focus
  - Technology-related terms

2. to recruit students to the next study, the High School Student Focus Groups.

The two outcomes of this section of the research will be students recruited for the High School Focus Groups and data that will provide insight into building a Student-Focused Curriculum. This Student-Focused Curriculum will be used in the second survey instrument detailed in section 3.4. The students that participate in this study and the ones that follow attend Mechanicsburg Area High School which was chosen because of the affinity of the researcher with the high school.

### *4.1.1 Mechanicsburg Area High School*

The Mechanicsburg Area School District, located in Mechanicsburg, Pennsylvania, enrolls over 3,700 students in kindergarten through 12th grade [3]. In the 2006-2007 school year in Pennsylvania, the average enrollment for the 500 public school districts was 3,642 students per school (1,821,383 total students) with the median school enrolling between 2,000 and 2,999 students [1]. Mechanicsburg is 2% larger than the average school and falls between the median and the upper third quartile [1].

The school spends, on average, $10,651 per student which "ranks in the top 25 percent of school districts in the state" of Pennsylvania [7]. "Approximately 90% of [Mechanicsburg] graduates select post-graduate education, 7% seek employment and 3% enlist in the armed services [7]." In Pennsylvania, on average 73% of graduating students are college-bound.

In the 2005-2006 school year the average SAT scores were higher than the national average: 527 for verbal versus 508 national average and 536 for mathematics versus 529 national average [7]. This makes Mechanicsburg Area School District 23% higher than the average high school in Pennsylvania.

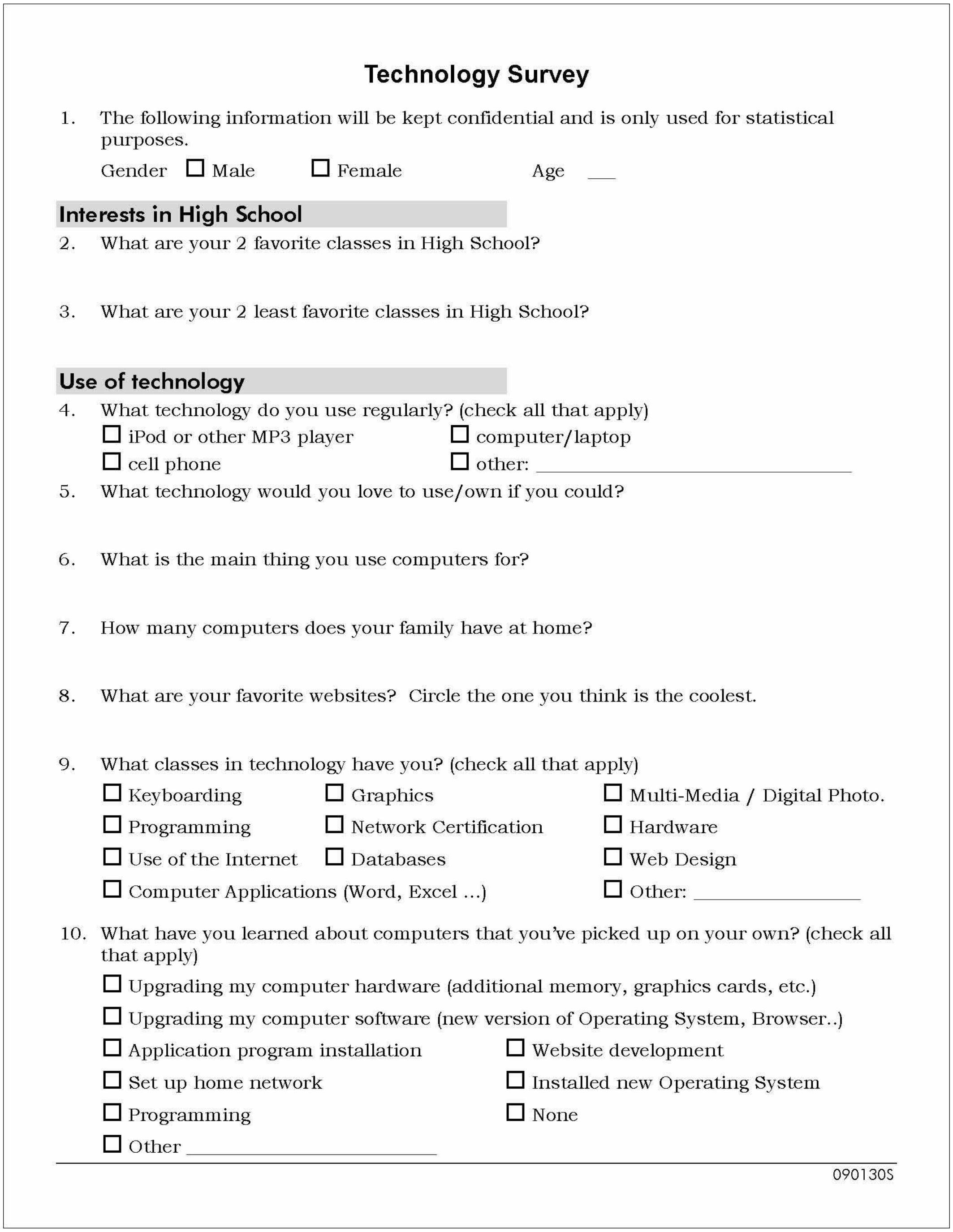
| Building | Enrollment | Average Daily Attendance (05-06) | Free & Reduced Lunch Eligibility | Date of Building Renovation |
|---|---|---|---|---|
| Broad St. (Gr. K-5) | 276 | 95.7 | 15.2% | Planned 2007 |
| Elmwood (Gr. K-5) | 448 | 96.3 | 37.5% | 2005 |
| Northside (Gr. K-5) | 253 | 97.2 | 25.6% | Planned 2007 |
| Shepherdstown (Gr. K-2) | 308 | 96.2 | 12.9% | 2006 |
| Upper Allen (Gr. 3-5) | 316 | 96.7 | 12.3% | 2006 |
| Middle School (Gr. 6-8) | 891 | 96.2 | 18.5% | 2004 |
| High School (Gr. 9-12 | 1227 | 94.1 | 12.8% | 2002 |
| TOTAL | 3719 | 96.2 | 18% | |

**Table 4.1:** Mechanicsburg Area School District Demographics [7]

Though Mechancisburg Area School District may not exemplify urban or inner city schools, it is a good example of a suburb school district. These are the kinds of students addressed in the technology survey and focus groups.

### *4.1.2 Survey Design*

Lori Carter designed and conducted a survey of nine high schools in California to "determine why more students with an apparent aptitude for Computer Science did not consider it as a future major [39]." Her survey was modified and used, with her permission, for this survey. The modifications include changing some of the options, such as the selection of courses, to better match the Mechanicsburg Area High School. A section on Interests in High School was added to determine where Computer Science fell in student's favorite and least favorite courses. Another section on the use of technology was added to affirm the analysis of the Y-Generation and a section identifying technology terms was also added to determine what student impressions were of current "buzz" words.



## Technology Survey

1. The following information will be kept confidential and is only used for statistical purposes.

Gender ☐ Male ☐ Female Age ___

### Interests in High School

2. What are your 2 favorite classes in High School?

3. What are your 2 least favorite classes in High School?

### Use of technology

4. What technology do you use regularly? (check all that apply)

☐ iPod or other MP3 player
☐ cell phone
☐ computer/laptop
☐ other: ______________________________

5. What technology would you love to use/own if you could?

6. What is the main thing you use computers for?

7. How many computers does your family have at home?

8. What are your favorite websites? Circle the one you think is the coolest.

9. What classes in technology have you? (check all that apply)

☐ Keyboarding
☐ Programming
☐ Use of the Internet
☐ Computer Applications (Word, Excel ...)
☐ Graphics
☐ Network Certification
☐ Databases
☐ Multi-Media / Digital Photo.
☐ Hardware
☐ Web Design
☐ Other: ________________

10. What have you learned about computers that you've picked up on your own? (check all that apply)

☐ Upgrading my computer hardware (additional memory, graphics cards, etc.)
☐ Upgrading my computer software (new version of Operating System, Browser..)
☐ Application program installation
☐ Set up home network
☐ Programming
☐ Other ________________________
☐ Website development
☐ Installed new Operating System
☐ None

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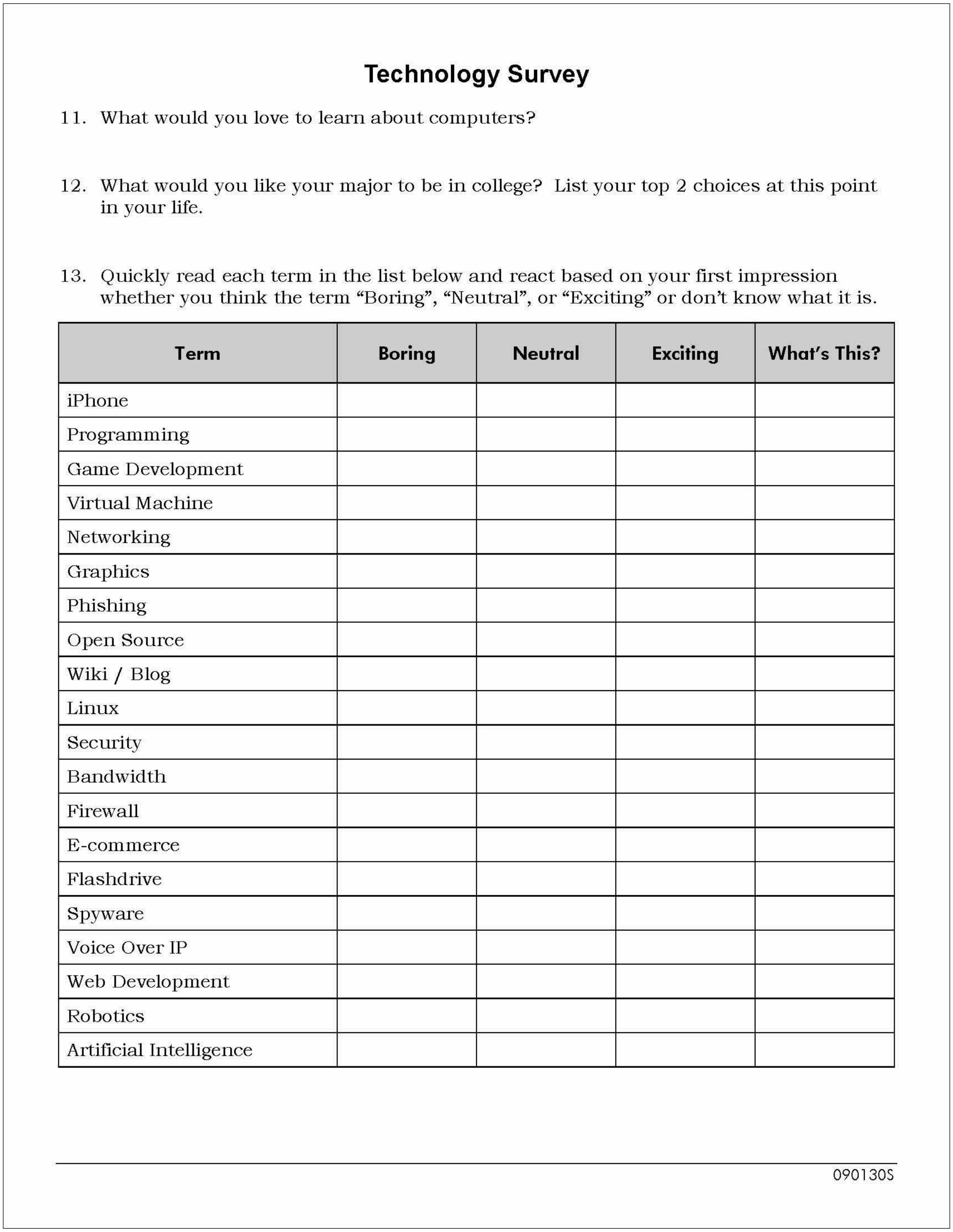
**Figure 4.2:** High School Technology Survey - Page 1



## Technology Survey

11. What would you love to learn about computers?

12. What would you like your major to be in college? List your top 2 choices at this point in your life.

13. Quickly read each term in the list below and react based on your first impression whether you think the term “Boring”, “Neutral”, or “Exciting” or don’t know what it is.

| Term | Boring | Neutral | Exciting | What’s This? |
|---|---|---|---|---|
| iPhone | | | | |
| Programming | | | | |
| Game Development | | | | |
| Virtual Machine | | | | |
| Networking | | | | |
| Graphics | | | | |
| Phishing | | | | |
| Open Source | | | | |
| Wiki / Blog | | | | |
| Linux | | | | |
| Security | | | | |
| Bandwidth | | | | |
| Firewall | | | | |
| E-commerce | | | | |
| Flashdrive | | | | |
| Spyware | | | | |
| Voice Over IP | | | | |
| Web Development | | | | |
| Robotics | | | | |
| Artificial Intelligence | | | | |

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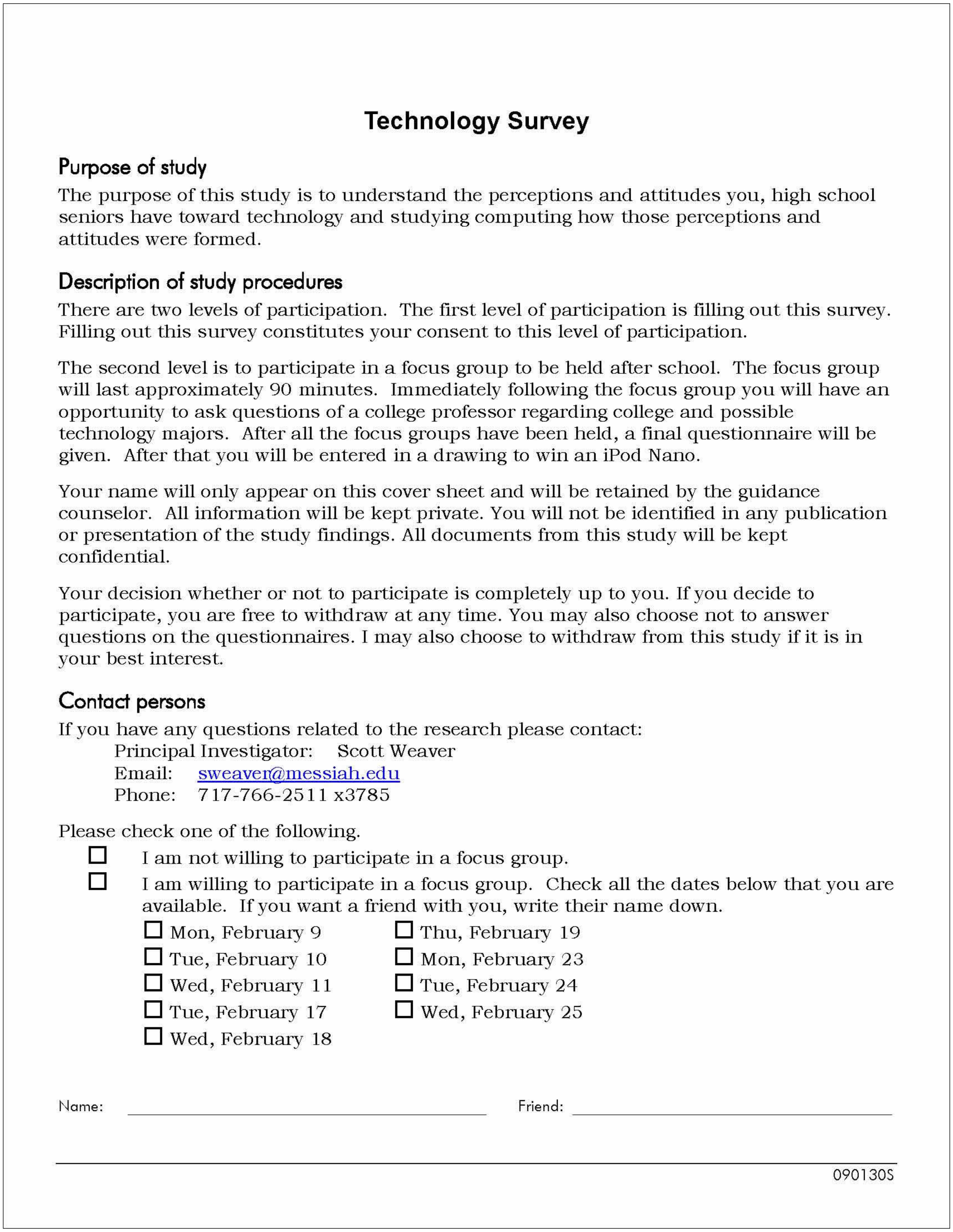
**Figure 4.3:** High School Technology Survey - Page 2

### *4.1.3 Subject Privacy and Confidentiality*

Cho et. Al. indicates in Privacy Issues in Internet Surveys [42] there are four forms of privacy: Physical privacy; Anonymity, or informational privacy; reserve, or psychological privacy; and intimacy, or interactional privacy. He defined physical privacy as "the state of privacy in which persons are free from unwanted intrusion or observation [42]." Anonymity, or informational privacy as, "the desire to have control over the conditions under which personal data are released [42]." Reserve, or psychological privacy as "the control over release or retention of personal information to guard one's cognitions and affects [42]." And Intimacy, or interactional privacy as "relevant to relationships in social units as it preserves meaningful communication between individuals and among group members [42]."

Mark Stamp defines confidentiality as the prevention of the unauthorized reading of information [101].

In the High School Students Technology Survey, the privacy they might be concerned with is informational privacy as defined by Hyunyi Cho and Robert LaRose. Since most of these students are under 18, an IRB was established with Messiah College to protect their rights as participants. Since the survey was also used to solicit involvement in the Focus Groups, student names and availability was necessary. To provide privacy and confidentiality, the cover sheet of the survey was designed to be removed and kept in the custody of the High School Guidance Counselor. This cover sheet provided an introduction to the survey and contact information for the researcher. It also requested the student's name, his/her willingness to participate in the focus group and his/her availability for the focus group.



## Technology Survey

### Purpose of study

The purpose of this study is to understand the perceptions and attitudes you, high school seniors have toward technology and studying computing how those perceptions and attitudes were formed.

### Description of study procedures

There are two levels of participation. The first level of participation is filling out this survey. Filling out this survey constitutes your consent to this level of participation.

The second level is to participate in a focus group to be held after school. The focus group will last approximately 90 minutes. Immediately following the focus group you will have an opportunity to ask questions of a college professor regarding college and possible technology majors. After all the focus groups have been held, a final questionnaire will be given. After that you will be entered in a drawing to win an iPod Nano.

Your name will only appear on this cover sheet and will be retained by the guidance counselor. All information will be kept private. You will not be identified in any publication or presentation of the study findings. All documents from this study will be kept confidential.

Your decision whether or not to participate is completely up to you. If you decide to participate, you are free to withdraw at any time. You may also choose not to answer questions on the questionnaires. I may also choose to withdraw from this study if it is in your best interest.

### Contact persons

If you have any questions related to the research please contact:

Principal Investigator: Scott Weaver
Email: sweaver@messiah.edu
Phone: 717-766-2511 x3785

Please check one of the following.

☐ I am not willing to participate in a focus group.

☐ I am willing to participate in a focus group. Check all the dates below that you are available. If you want a friend with you, write their name down.

- ☐ Mon, February 9
- ☐ Tue, February 10
- ☐ Wed, February 11
- ☐ Tue, February 17
- ☐ Wed, February 18
- ☐ Thu, February 19
- ☐ Mon, February 23
- ☐ Tue, February 24
- ☐ Wed, February 25

Name: ______________________ Friend: ______________________

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**Figure 4.4:** High School Technology Survey - Cover Sheet

### *4.1.4 Subject Selection*

The population that was chosen for this survey was the Juniors and Seniors at Mechanicsburg Area High School. Juniors and Seniors were selected due to their chronological proximity to choosing a college major. This sample is not intended to represent a broader population of high school students in the United States and is satisfactory for the needs of this research.

### *4.1.5 Distribution and Response Management*

In order to distribute, explain, and collect the technology survey, class meetings were scheduled on separate days for the juniors and seniors of Mechanicsburg Area High School. The survey, reproduced in Appendix D , was hand delivered to the class meetings and distributed to each student during the meeting where they were informed of the purpose of the surveys and the opportunity to participate in one of many scheduled focus groups. Students were given the option to participate or not to participate as they saw fit. The surveys were then collected and the identifying information removed.

590 surveys were administered to the Juniors and Seniors. 417 surveys were collected, 5 were obviously off-task and/or unusable leaving 412 surveys, a 69.4% return rate.

### *4.1.6 Survey Piloting*

Prior to administering the survey to the high school students, a pilot of the survey was conducted with 6 college students. The focus of the pilot was on ease of use and understandability of the survey. The purpose was to eliminate ambiguity, estimate the time required to take the survey, shorten survey where necessary, rework troubled areas, and clarity any questions that arose. After the pilot, revisions made based on the feedback given and the survey was conducted.

### *4.1.7 Overview of the Survey*

The purpose of the survey is to gather data in four areas: Demographics, Interests in High School, Use of Technology, College focus, and opinions of technology-related terms.

**Demographics** The demographics collected include gender and age.

**Interests in High School** The section on interests in high school asks students what their favorite and least favorite classes are. The purpose of this section is to get an idea of the classes preferred and those most disliked by high school students.

**Use of Technology** In the Use of Technology section the first five questions revolve around what the student knows, perceives and enjoys. The last questions in this section ask students about what they have learned about computers and technology, both formally as well as informally.

1. What technology do you use regularly? (check all that apply)
    (a) iPod or other MP3 player
    (b) Computer/laptop
    (c) cell phone
    (d) other:
2. What technology would you love to use/own if you could?
3. What is the main thing you use computers for?

4. How many computers does your family have at home?
5. What are your favorite websites? Circle the one you think is the coolest.
6. What classes in technology have you taken? (check all that apply) with the following ten options.
    (a) Keyboarding
    (b) Graphics
    (c) Multi-Media / Digital Photo.
    (d) Programming
    (e) Network Certification
    (f) Hardware
    (g) Use of the Internet
    (h) Databases
    (i) Web Design
    (j) Computer Applications (Word, Excel . . . )
    (k) Other
7. What have you learned about computers that you've picked up on your own? (check all that apply)
    (a) Upgrading my computer hardware (additional memory, graphics cards, etc.)
    (b) Upgrading my computer software (new version of Operating System, Browser..)
    (c) Application program installation

(d) Website development

(e) Set up home network

(f) Installed new Operating System

(g) Programming

(h) None

(i) Other

**College Focus** The college focus questions relate to what the student would like to study when in college.

1. What would you love to learn about computers?
2. What would you like your major to be in college? List your top 2 choices at this point in your life.

**Technology-related Terms** The technology-related terms section seeks to determine which terms seem exciting to high school students, which are boring and which are either neutral or unknown. The directions for this section instruct the students to “Quickly read each term in the list below and react based on your first impression whether you think the term ‘Boring’, ‘Neutral’, or ‘Exciting’ or don’t know what it is.” The following terms were listed:

1. iPhone
2. Programming
3. Game Development
4. Virtual Machine

5. Networking
6. Graphics
7. Phishing
8. Open Source
9. Wiki / Blog
10. Linux
11. Security
12. Bandwidth
13. Firewall
14. E-commerce
15. Flashdrive
16. Spyware
17. Voice Over IP
18. Web Development
19. Robotics
20. Artificial Intelligence

## 4.2 High School Student Technology Survey Data

The technology survey was administered to over 590 juniors and seniors at Mechanicsburg Area High School. Of the 417 surveys returned, 5 were obviously off task and unusable leaving 412 surveys representing a return rate of 69.4%. The technology survey data will be presented in five data areas: Demographics, Interests in High School, Use of Technology, College focus, and Technology-related Terms.

### *4.2.1 Demographics*

The gender gap in this survey was very small, only a difference of four with 208 women and 204 men submitting the survey (see Table 4.2). Juniors outnumber the seniors 221 to 191 (see Table 4.3).

| Gender | Count | Percent |
|---|---|---|
| Men | 204 | 49.5% |
| Women | 208 | 50.5% |

**Table 4.2:** Gender Breakdown

| Class | Count | Percent |
|---|---|---|
| Juniors | 221 | 53.6% |
| Seniors | 191 | 46.4% |

**Table 4.3:** Junior/Senior Class Breakdown

### *4.2.2 Interests in High School*

Two questions in the survey referenced students' favorite courses they had taken in high school. Only subjects that had a selection percentage of 10% or higher are listed in Tables 4.4 and 4.5. Students could indicate interest in several courses. Computer courses made the bottom of both lists. Later in the survey, students were asked what computer courses they have taken. Of those surveyed, 321 students have taken at least one computer related course ranging from Keyboarding to Network Certification or Web Design. Of those students who have taken a computer course, 23 or 7.2% indicated that the computer course was their favorite course whereas two students or 0.6% indicated that the computer course was their least favorite.

| Subject | Count | Percent |
|---|---|---|
| Social Studies | 188 | 45.6% |
| Science | 117 | 28.4% |
| Math | 97 | 23.5% |
| English | 84 | 20.4% |
| Speech & Language | 54 | 13.1% |
| Physical Education | 52 | 12.6% |
| Art | 50 | 12.1% |
| ... Computer | 23 | 7.2% |

**Table 4.4:** Favorite Class

| Subject | Count | Percent |
|---|---|---|
| English | 88 | 21.4% |
| Science | 87 | 21.1% |
| Social Studies | 67 | 16.3% |
| Math | 55 | 13.3% |
| ... Computer | 2 | 0.6% |

**Table 4.5:** Least Favorite Class

### *4.2.3 Use of Technology*

The questions relating to the technology that students use clearly show that the majority have and use the latest technology. Over three quarters of the students use MP3 players and over 90% use cell phones and computers (See Table 4.6). The two most desired technology are Apple's iPhone and a laptop or Macbook (See Table 4.7).

| Technology | Count | Percent |
|---|---|---|
| iPod/MP3 Player | 325 | 78.9% |
| Cell Phone | 388 | 94.2% |
| Computer/Laptop | 382 | 92.7% |

**Table 4.6:** Technology Used Regularly

| Technology | Count | Percent |
|---|---|---|
| iPhone | 74 | 18.0% |
| Laptop/Macbook | 68 | 16.5% |

**Table 4.7:** Technology Wanted

Students have, on average, three computers in the home (See Figure 4.5) that they use for many things from school work and communicating with friends to gaming and using the Internet(See Table 4.8).

These students have indicated a wide variety of web sites they call their favorite, listing 160 different web sites. The top sites relate to social networking, online video watching, and Internet searching (See Table 4.9).

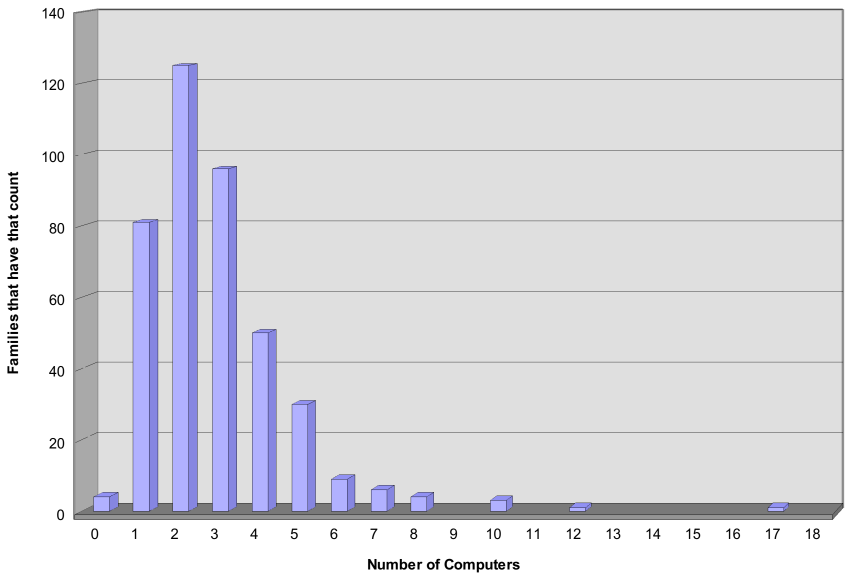


**Figure 4.5:** Number of Computers in the Home

| Computer Use | Count | Percentage |
|---|---|---|
| Internet | 183 | 44.4% |
| Communication | 114 | 27.7% |
| School/Homework | 158 | 38.3% |
| Music | 62 | 15.0% |
| Gaming/Entertainment | 57 | 13.8% |
| Research | 50 | 12.1% |

**Table 4.8:** Main Use of Computer

| Favorite Website | Count | Percentage |
|---|---|---|
| Facebook | 201 | 48.8% |
| Google | 122 | 29.6% |
| Myspace | 88 | 21.4% |
| Youtube | 54 | 13.1% |

**Table 4.9:** Favorite Website

321 students of these juniors and seniors have taken a computer class ranging from Keyboarding to Network Certification or Web Design. Most have taken Keyboarding and Computer Applications (See Table 4.10). Over half of the students surveyed have installed a program on a computer and many have upgraded software or hardware. Around a quarter have built a web site, set up a home

network, or installed a new operating system. Only 13% have done any programming on their own (See Table 4.11).

| Class | Count | Percent |
|---|---|---|
| Keyboarding | 232 | 56% |
| Computer Applications | 151 | 37% |
| Internet | 85 | 21% |
| Graphics | 61 | 15% |
| Web Design | 38 | 9% |
| Multi-Media | 32 | 8% |
| Programming | 28 | 7% |
| Hardware | 26 | 6% |
| Databases | 20 | 5% |
| Network | 12 | 3% |

**Table 4.10:** Formal Class

| Topic | Count | Percent |
|---|---|---|
| Program Installation | 218 | 53% |
| Upgrading | | |
| Software | 179 | 43% |
| Hardware | 142 | 34% |
| Networking | 116 | 28% |
| Web Site Design | 89 | 22% |
| Installing a New Operating System | 86 | 21% |
| None | 85 | 21% |
| Programming | 54 | 13% |

**Table 4.11:** Self-Learned

### *4.2.4 College Focus*

The two questions dealing with studying computers were open-ended and the responses varied widely. Because of this, the cut-off for displaying was lowered to 4% or higher.

Of the first question asked students, "What would you love to learn about computers?" 305 students answered the question with 95 different responses ranging from "nothing" to "build a computer." Most responses mentioned something specific like "how to install memory" or "how to create complex html codes" (See Table 4.12).

The second question asked, "What would you like your major to be in college?" 196 different majors were listed and those above 4% are listed in Table 4.13. Six students indicated they would like to major in computer science representing 1.5% of responses.

| Area of Study | Count | Percentage |
|---|---|---|
| Nothing | 36 | 8.7% |
| Programming | 33 | 8.0% |
| Hacking | 23 | 5.6% |
| Build a Computer | 18 | 4.4% |
| How Computers Work | 18 | 4.4% |

**Table 4.12:** Like to Learn

| Major in College | Count | Percentage |
|---|---|---|
| Business | 34 | 8.3% |
| Psychology | 24 | 5.8% |
| Biology | 18 | 4.4% |
| Elementary Education | 18 | 4.4% |

Response of 4% or greater shown

**Table 4.13:** Major in College

### *4.2.5 Technology-Related Terms*

The last area in the technology survey listed current technology terminology and asked students, based on their first impression, if the term was boring, neutral, exciting, or they did not know the term. Table 4.14 lists the terms, the number of students who believed the term to be exciting and those that believed it to be boring. Those that indicated the term was "Neutral" or those that left it blank were left out of the table.

The Chi-square test of association was performed for each term between the responses that indicate the term was exciting and those that believe the term was boring using an alpha of 0.05. All of the terms show a significant difference one way or the other except for "Game Development" which showed no significant difference. The Chi-square calculation along with the P-Value are displayed in Table 4.14. The only terms that were exciting to students were iPhone, Virtual Machine, Graphics, Robotics, and Artificial Intelligence. The rest of the terms the students found boring.

| Term | Exciting | | Boring | | Chi-Sq | P-Value |
|---|---|---|---|---|---|---|
| iPhone | 302 | 73.1% | 9 | 2.2% | 276.042 | < 0.001 |
| Programming | 37 | 9.0% | 205 | 49.6% | 116.628 | < 0.001 |
| Game Development | 138 | 33.4% | 123 | 29.8% | 0.862 | 0.353 |
| Virtual Machine | 141 | 34.1% | 81 | 19.6% | 16.216 | < 0.001 |
| Networking | 52 | 12.6% | 170 | 41.2% | 62.721 | < 0.001 |
| Graphics | 134 | 32.4% | 67 | 16.2% | 22.333 | < 0.001 |
| Phishing | 35 | 8.5% | 95 | 23.0% | 27.692 | < 0.001 |
| Open Source | 21 | 5.1% | 108 | 26.2% | 58.674 | < 0.001 |
| Wiki / Blog | 62 | 15.0% | 128 | 31.0% | 22.906 | < 0.001 |
| Linux | 35 | 8.5% | 99 | 24.0% | 30.567 | < 0.001 |
| Security | 46 | 11.1% | 141 | 34.1% | 48.262 | < 0.001 |
| Bandwidth | 22 | 5.3% | 129 | 31.2% | 75.821 | < 0.001 |
| Firewall | 30 | 7.3% | 170 | 41.2% | 98.000 | < 0.001 |
| E-commerce | 38 | 9.2% | 156 | 37.8% | 71.773 | < 0.001 |
| Flashdrive | 71 | 17.2% | 122 | 29.5% | 13.477 | < 0.001 |
| Spyware | 54 | 13.1% | 157 | 38.0% | 50.280 | < 0.001 |
| Voice Over IP | 62 | 15.0% | 113 | 27.4% | 14.863 | < 0.001 |
| Web Development | 93 | 22.5% | 128 | 31.0% | 5.543 | 0.019 |
| Robotics | 189 | 45.8% | 91 | 22.0% | 34.300 | < 0.001 |
| Artificial Intelligence | 210 | 50.8% | 77 | 18.6% | 61.634 | < 0.001 |

**Table 4.14:** Interest in Technical Terminology

## 4.3 Impact of the Technology Survey

The "Interests in High School" section indicates that only two students out of 412, or 0.6% ranked a Computer class as one of their least favorite classes. From the same group, 23 students, or 7.2% ranked a Computer class as their favorite. This data leads the researcher to believe that Computer Science was a viable area of study for students, or one that, in worst case, was not on students' minds.

The next section in the Technology Survey, "Use of Technology", provided insight into technology students currently have and what they would like to have. Currently students have iPods or some other MP3 player, cell phones, and computers. The technology they would like to have include iPhone and Laptop/Macbook. These were incorporated where possible into the Student-Focused Curriculum. For example, “iPhones” were mentioned in the description of the Software Engineering concentration and the phrase “smart phones” was used in the course description for Wireless Networks and Mobile Computing.

Within the same section 44.4% of the students indicate they use computers for Internet access. The term “Internet” was also used throughout the Student-Focused Curriculum when it fit. The term can be found in the description of the Networking and Web and Media Development concentrations as well as in course descriptions that use the Internet.

The last part of the “Use of Technology” section asked students what formal computing courses they have had and what have they done that was self-taught. The two formal computing courses that ranked the highest in attendance were “Keyboarding” and “Computer Applications”. This indicates that a typical student has no experience in courses such as Graphics, Web Design, Multi-Media, Programming, or any of the other classes listed. So in building the Student-Focused Curriculum, it was important to describe courses well in a way that was intriguing. For example a course named Cryptography would mean nothing to these students. In order to help them understand the course and peek their interest the following description was provided.

**Cryptography**

Students learn how two people can exchange a message in such a way

> that no one else can understand it, or cause problems with it. A real-world example is online banking which uses cryptography to ensure online transactions are conducted privately by the authorized person.

The last section in the Technology Survey, “Technology-Related Terms” provided five terms that seemed to excite students: iPhone, Virtual Machine, Graphics, Robotics, and Artificial Intelligence. These terms were used throughout the Student-Focused Curriculum when they were deemed appropriate.

## 4.4 High School Focus Groups Methodology

On the technology survey, students were given the opportunity to sign up for one of several focus groups offered. The purpose of the focus groups is to elicit student reactions to technology and computers and studying computing in college.

Using focus groups is a method of qualitative research that allows the researcher to listen to the stake holders and learn from them. In this case, high school students are the stake holders from which to learn. Several questions must be answered to determine the usefulness of qualitative methods such as focus groups. “Do you need to explore poorly understood topics and discover new insights? Do you need to investigate the contexts in which your participants operate and generate in-depth data about the range of things that matter to them? Do you need to interpret how and why people think and act as they do [84, p13]?”

The answer to each of these questions indicates the need for this study. “Do you need to explore poorly understood topics and discover new insights [84, p13]?” Yes. Understanding high school students’ perceptions of computer science and how studying computing fits into their world view is key to understanding the decline in enrollment. Without their input, the reasons for the drop in computing majors over the last five years [111] will continue to be guesswork.

"Do you need to investigate the contexts in which your participants operate and generate in-depth data about the range of things that matter to them [84, p13]?" This generation of high school students has grown up with computers and are not afraid of technology. Gathering in-depth data about the things that matter to them will shed light on their perceptions and attitudes toward computers and will give insight to understand what excites them about computers.

"Do you need to interpret how and why people think and act as they do [84, p13]?" The primary goal of this study is to understand high school students' attitudes and perceptions of computers and studying computers in college. Implicit in the second part of that goal is their choice not to study computers in college. Utilizing focus groups will provide a glimpse into understanding why students have stopped choosing to study computers in college.

According to David Morgan, there are five phases of conducting successful focus groups: Planning, Recruiting, Moderating, Analysis, and Reporting [84].

In planning for the use of focus groups, identifying and developing solutions for several key issues, identified by David Morgan [86, p10], will make a difference during execution of the other phases of the focus group research.

- Define the purpose and outcomes of the project
- Develop the timeline for the project
- Determine who the participants will be
- Write the questions in the interview guide
- Develop a recruitment plan

- Set the locations, dates, and time for the sessions
- Design the analysis plan
- Specify the elements of the final report

**Purpose**

The purpose of this focus group research is to understand high school students' technical abilities and computing savvy; to explore the reasons they are not choosing to major in computing; to investigate the contexts in which they operate; to generate in-depth data about the range of things that matter to them; and to understand what they think about computing and what causes them to choose other majors.

**Expected Outcomes**

It is expected that this research will provide valuable feedback that may be used to better communicate to high school students, guidance counselors, and parents what computing is and what opportunities await those who study this discipline.

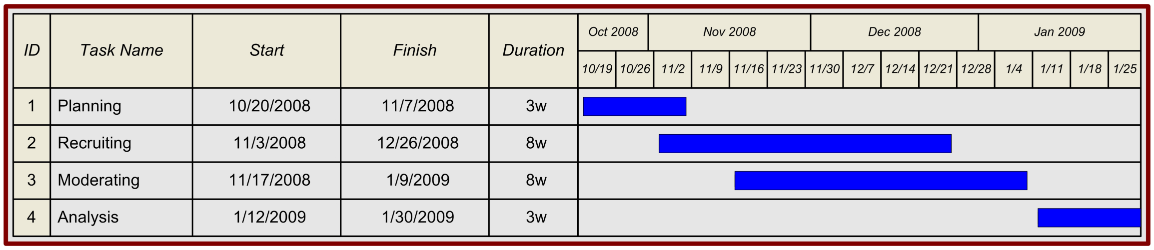
**Time Line**

There are four major tasks that need to be completed for this focus group research to be successful.

1. Planning The planning phase develops the framework from which the study will be conducted. Expounding on the issues raised above affects the rest of the study.
2. Recruiting During this phase careful planning must go into choosing and inviting the participants. "There is nothing more frustrating and embarrassing than to go through all the effort to put together a focus group and have only three people show up [86, pp10,11]."

3. Moderating Moderating is the part of the focus group research that most people think of when talking about focus groups. It is the group time during which the moderator guides discussions and is "involved in a complex process of generating and analyzing data [85, p10]."

4. Analysis The last task in the focus group research is the analysis of the data collected. The planning of this phase takes into account the scope and purpose of the project.



| ID | Task Name | Start | Finish | Duration |
|---|---|---|---|---|
| 1 | Planning | 10/20/2008 | 11/7/2008 | 3w |
| 2 | Recruiting | 11/3/2008 | 12/26/2008 | 8w |
| 3 | Moderating | 11/17/2008 | 1/9/2009 | 8w |
| 4 | Analysis | 1/12/2009 | 1/30/2009 | 3w |

**Figure 4.6:** Planning Timeline

### The Players

There are several groups of people to think about when developing focus groups: the sponsor(s), moderator(s), and participants. The sponsor or sponsors of a focus group research project are those people who benefit from the results of the research project. In this research study, the benefactors are future high school students, guidance counselors, parents, and colleges that offer the Computer Science major.

The moderator is the person who actually facilitates the focus group discussion. The moderator takes the Interview Guide and follows it, keeping in mind that the main goal of moderating is getting to the "why" behind participant responses; truly understanding what they are saying. The moderator and the sponsor in this study are the same, namely the researcher.

The participants are those chosen to be a part of the focus group. In this study, the participants are juniors and seniors at Mechanicsburg Area High School.

### Interview Guide

The Interview Guide contains the plan for moderating the focus groups. The first decision to make in developing the Interview Guide is the type of guide. There are two kinds of guides that can be developed, a topic guide or a specific question guide.

"The topic guide is a list of topics or issues to be pursued in the focus group. The list consists of words or phrases that remind the moderator of the topic of interest. By contrast, the questioning route is a sequence of questions in complete, conversational sentences [83, p9]." There are advantages and disadvantages to both. The following were taken from David Morgan's Developing Questions for Focus Groups (Focus Group Kit) [83].

The advantages of the two kinds of interview guides are as follows:

### Topic Guide

- Questions developed more quickly.
- Questions more conversational when asked since the full sentence is developed on the spot.
- Allows the moderator to be more spontaneous, weaving previous comments into future questions.

### Question Guide

- Sponsor confidence since the questions and path are well established.
- Quality analysis because it reduces subtle differences in questions.
- Enhanced consistency when different moderators are being used.

The disadvantages of the two kinds of interview guides are as follows:

### Topic Guide

- Makes the analysis more difficult since changes in questions can cause changes in meaning.
- Difficult feedback prior to focus groups.
- Inconsistency between moderators.

### Question Guide

- Asking the questions has the potential to be awkward.
- Development time is longer.
- False impressions to the sponsor, since they may think the moderator will ask the question exactly as written, which is not often the case.

The Interview Guide was developed as a specific question guide, identifying the questions to be asked. However, during the sessions, the goal is to understand the students. Therefore, if necessary, deviation from the guide may be required. The Interview Guide is copied in Appendix E.

### Recruitment Process

In planning the recruitment process, several issues need to be addressed: define the target population, identify the appropriate composition for each group, develop eligibility and exclusion criteria for individual participants, make the initial recruitment contacts with potential participants, and determine the follow-up procedures that will ensure attendance [86, p11].

This study allowed the high school juniors and seniors to self-select rather than recruiting specific students, providing a random mix of students that enjoy studying computers with those enjoying other disciplines. In order to facilitate a self-selection process, it was decided, with the suggestion of the principal of Mechanicsburg Area High School, to address the junior class during one homeroom period, and the senior class during another. The recruitment script can be found in Appendix F.

### Focus Group Scheduling

The selection process was part of the Technology Survey. The front sheet of the survey, which was designed to tear off, allowed the student to indicate their name and the name of a friend with whom they would like to be in a focus group. Several dates were listed and students were asked to check all the dates that they were available. The front page, being detachable, allowed the students to answer the questionnaire anonymously, and still facilitated scheduling the students for each focus group.

To entice students to participate, one participant would be chosen at random to win an iPod. This was effective in recruiting 87 juniors and 28 seniors to participate in a focus group. Students were then put into focus groups based on the dates they chose along with the friends they requested. The groups were limited to a maximum of ten students to allow dialog and input from all students in the group.

### The Setup of Each Focus Group

The focus groups were planned after the school day ended, beginning at 3:30 p.m. with 5:00 p.m. being the target ending time. Pizza and soda were provided at 4:15 which was also a good recruiting tool for high school students.

The chairs in a class room within the school were rearranged into a semi-circle with the voice recorder positioned in the center. A flip chart was attached to the wall to allow key points to be written down. The initial plan was to have a moderator who would facilitate the discussion along with one or two secretaries to write down key points made by the students. However, only the moderator was available for the focus groups, therefore, the moderator relied on the flip-chart to enable him to summarize the discussions. The transcript of the voice recordings of the focus groups alone was relied upon for the analysis of the discussions.

### Conducting the Focus Group

At the start of each focus group, students were greeted by the moderator and invited to take a seat. Once all participants arrived, introductions were made and a sign in sheet was passed around. The sign in sheet was only used to randomly draw a winner of the iPod. The Interview guide was then used to guide the rest of the focus group session.

### Analysis and Final Report

The analysis and final report of the data from focus groups is documented in the next section, section 4.5. The outcome of the focus groups aided in developing the Student-Focused Curriculum used in the Survey Instruments explained in Chapter 5.

## 4.5 High School Focus Groups Data

The purpose of the focus groups is to elicit student reactions to technology and computers and studying computing in college.

The interview guide for the focus groups can be found in Appendix E. The questions were designed to understand high school students' perceptions and opinions in three areas: technology and computers, computer related majors in college, and the job opportunities for those graduating with a degree in computing. The moderator of the focus groups used the interview guide to conduct each session. The main goal of the moderator was to understand why students respond the way they do.

### *4.5.1 Introductory Questions*

At the start of each focus group, students were greeted by the moderator and invited to take a seat. After preliminary introductions and instruction, the moderator proceeded to use the Interview Guide. The first questions in the Interview Guide were introductory questions designed to ease student anxiety and make them comfortable responding in the group. Some of these questions shed light on the perceptions students have of technology.

**Question 1**: Tell us your name and what your favorite web site or computer game is.

The rationale for this question is to give students an easy question that each can answer adding to their comfort level within the group. Many students enjoy action games such as Halo while others enjoy Guitar Hero, Bejeweled, and Tetris.

**Question 2**: Describe the benefits of using technology and computers.

The rational for this question is again to make students comfortable in contributing to the discussion. Many students indicated getting things done faster and more efficient.

- Contact People, Email, Instant Messaging
- Fast

- Store information

**Question 3**: In your view, what is the difference between technology and computing? Which term is more appealing? Is there another term that fits better?

The purpose for this question was to determine the students' connection between technology and computing. The following were the top responses:

- Technology is the broad thing; computers are the slice of it.
- Technology is anything that gets something done; done faster and easier.
- Computers are a branch off of technology, but are totally different.

**Question 4**: When you think about computing, what comes to mind?

The term "computing" appears in the title of computing majors in some college. This question was designed to determine what comes to mind when students see a major with "computing" in the title. Most students connected "computing" with mathematics and not computer science. The following are common responses:

- "Mathy" – It sounds like a math term.
- Like calculating something or figuring something out. Getting an answer to a math problem.
- Make quick calculations
- Solve problems efficiently

### *4.5.2 View of computers in general*

Following the introduction, questions were introduced to elicit student opinions of computers in general.

**Question 1**: What excites you about computers?

This is one of the key questions in this survey designed to determine what aspects of computers motivate these students. The most frequent response related to communicating with friends. Students listed applications that excite them and many of those applications, such as Facebook, relate to social networking.

- Communication / Communication around the world / Convenient communication / Possibilities for communications
- Always improving / Always getting better / Get information faster
- Building computers
- Continuously changing
- Different formats of web sites
- Editing movies / Making movies
- Entertainment / Games
- Helps with homework / Makes calculations and physics easier
- Organization

**Question 2**: What has been your greatest disappointment in using computers?

Much like the previous question, this question is designed to understand what de-motivates students. Most responses refer to problems resulting from malicious attacks such as viruses, spam, and pop-ups, or problems with the machine or operating system itself. Some mentioned cost while a few admitted to wasting time. The responses below are ordered by frequency.

- Malicious attacks
    - Viruses
    - Spam / Junk Mail
    - Popups
    - Hacking
    - Predators
- Problems with the computer itself
    - Incompatibilities
    - Batteries dying
    - Slow / Slow Internet
    - Windows' browser is slow and crashes a lot
    - When they are programmed wrong
- Expensive / Expensive upkeep / Cost
- Accidentally delete stuff
- Addiction - waste hours

- Advance too fast, you need to keep upgrading and getting new parts, as soon as you get them, better stuff comes out

**Question 3**: If you could change anything about computers and computing, what would you change?

This question was designed to determine what students think can be changed and made better. Responses to this question may give insight into what some students would be motivated to study. The results range from responses related to support, hardware, malicious attacks, software, personalization and compatibility.

- Better Tech Support
- Hardware
    - Faster / Speed
    - Quieter fans
    - Smaller / More powerful / Longer lasting batteries
    - Make everything wireless
    - Smaller physical size (the size of playing cards type size)
- Addressing Malicious Attacks
    - Automatic system to keep spam and viruses out / Get rid of spam
    - No popups
- Software
    - More helpful "Help"
    - Easier updates / Upgrades

- Personalization
    - More personalized
    - Let the user do stuff
- Compatibility
    - More universal hardware
    - Make everything universal

### *4.5.3 Job Opportunities in Computing*

The next section in the Interview Guide focused on job opportunities for those graduating with a computing degree. In the pilot focus group, this section came after the section relating to initial thoughts of college. However, responses to the questions in that section relating to creating a computing major and what it would look like, focusing on the pedagogy rather than the content. When questions relating to jobs were asked before questions relating to the major, students were more apt to think in terms of skills they need for the jobs, and therefore responded better to those questions relating to topics in a major.

**Question 1**: What kind of jobs do you think are available to those who major in computing?

This question is designed to determine what jobs students think relate to studying computing. Many students responded with, "Anything. Computers are everywhere, so if you studied computers, you could choose almost any job and it would relate" and "Few jobs don't use computers." There were other responses focused on specific jobs as shown below.

- Programming / Programming for games, optical displays, software applications
- Tech support / Technician / Geek Squad
- Teachers
- Web design / Web site development / Graphic design
- Advertising
- Computer Network Specialist
- CSI jobs / Forensic Scientists
- Designers
- Engineer
- IT people / Security
- Manager of like a server system
- NASA / National Security Agency
- Xray Technicians

**Question 2**: If you study computing in college, what do you think your job opportunities would be when you graduate?

The purpose of this question is to determine what students think of the job market and possibilities after graduating with a computer related degree. The responses to the question asked as stated above were, “Average”, “Pretty open”, “A lot easier” and “Very likely”. To determine just how likely, the question was rephrased to, “On a scale from 0 to 5, how easy will it be to get a job if you graduate with a degree related to computers? Zero indicates, 'Good luck with that' and five indicates you have a job before you graduate." All students chose between 4 and 5 indicating they think it would be very easy to get a job.

**Question 3**: Have you heard of outsourcing?

This question was added into the Interview Guide due to the responses of the previous question. It appeared that when thinking about people who study computers in college, there was no fear in getting a job after college. So this question was asked to determine if these students have heard of outsourcing. If they have, then it must not affect the job opportunities they are thinking about. Only four students could define outsourcing. However, once defined, others indicated a recollection of the idea.

**Question 4**: If you got a job using technology of some sort, what would your dream job look like?

The purpose of this question is to understand what motivates students to pick a job or career. Many students identified specific jobs such as pastry chef, civil engineer, computer teacher, and marine biologist. Some identified characteristics of an ideal job and those are listed below.

- Serves some sort of purpose
- A little work with a lot of pay
- Doesn't work me to death
- Fridays off
- Leaving work at work

- No job stress
- Physically see my progress

**Question 5**: What do you think you need to study to get a "computing" job?

This question seeks to understand what areas of study students connect with "computing" jobs. The responses varied and are shown below.

- How to use a computer
- Learn C++ / Java and all those languages / Different languages.
- Math
- You'd have to work with people

### *4.5.4 Initial thoughts of College*

The next section in the Interview Guide focuses on the students' thoughts of college and what students will be studying in college.

Question 1: Have you thought about what you'd like your major to be when you go to college?

The purpose of this question is to transition the focus to college and determine the types of majors represented by those participating in the focus groups. The results show a wide range of interests on the part of the students participating in the focus groups, only two of which were computer related: Fix computers and Web design.

- Accounting

- Art
- Business
- Civil Engineering
- Criminal Justice
- Culinary Arts and Music
- Early Childhood Education / Elementary Education
- Economics
- English
- Finance
- Fix computers
- Math
- Physical Education
- Psychiatry
- Psychology
- Small Business Management
- Social Science
- Special Education
- Teaching with wood or metal technology
- Web Design

**Question 2**: What aspects of that major interest or intrigue you?

Since very few students indicated an interest in computer related majors, this question was posed to understand what drives students to their chosen major. Many students responded that they like the subject matter of their chosen major. There were, however, several responses that intimate attitudes towards their chosen major, many of which could relate to computer related majors.

- My chosen major is more realistic for me and who I am
- I like the design part and making stuff
- I like figuring things out / Problem solving
- I want to travel
- Since I was little, I loved the topics in my chosen major

**Question 3**: Have you looked at any college web sites to learn about their majors? What were your impressions of the web site?

The purpose of this question is to understand student interaction with college web sites and what things they look for. Very few students surf college web sites to look at their chosen major's curriculum. From their responses it appears that they have already made their decision regarding their major and are looking at the web site for other reasons.

- Confusing / Couldn't find what I needed / Not laid out nicely
- Admissions is difficult / Online application would be easier
- I looked at the athletic rankings / Athletics was good

- Easier than mailings
- Easy to navigate
- I look at the financial aspect
- Find if my AP courses would transfer
- Find out about other incoming freshmen
- Freshman and out of state resources

**Question 4**: Have you looked at any computing majors online? What were your impressions about the majors?

This question was designed to get an idea of what students thought of the online computing major, or any major's curriculum. Unfortunately none of the students looked at any of their chosen majors and therefore could not give feedback about their impressions of the major on the college's web site.

### *4.5.5 Majoring in Computing*

Although few of the students that participated in the focus groups were interested in a computing major, they were asked to imagine majoring in computing and were asked the following questions targeting their perceptions of a major related to computers.

**Question 1**: When you think about majoring in computing what comes to mind?

The purpose of this question is to understand student perceptions of majoring in computing. Students reflected a stereotype of geeks with pocket protectors staying inside working on their computer all day.

- People with PCs being inside the whole day / Spending a lot of time in front of a computer screen
- Tech Support / Geek squad
- Carpal Tunnel
- Criminal Minds
- Lots of work
- Programming classes

**Question 2**: What do you hear people say about majoring in computing?

This question seeks to understand what those who influence students' opinions communicate about majoring in computing. Students responded similarly to this question as they did to the one above with the exception of the following excerpt: "I've worked with computers all my life. Why do I need to take classes in it?"

**Question 3**: Who would you say is the person who has influenced you the most?

The question was asked in the context of the majors they chose and was asked to understand who the people of influence are in today's students' lives. Most students are influenced by teachers and parents/family.

The questions that follow in the interview guide focused on the student's perception of a computer related major. Since most of the students are not interested in a computer related major, some of the questions were dropped and others were reworded to reflect the major of their choice.

**Question 4**: What influenced you to choose the major you did?

This question, modified from its original form, is intended to better understand what influences the choices students make regarding the major they choose.

- My brother / Parents / Teachers / Friends
- I like working with people / Kids
- I love reading / Writing
- Other people I've seen who work with computers a lot as a primary job
- I like talking
- The money
- My enjoyment level
- I've always grown up helping people so criminal justice seemed to fit
- Learning about the stock market and how to plan stocks / Played a stock market game

**Question 5**: If you could make your own computing major, what would it look like?

This question seeks to understand what students would like to study in the area of computers. However, since many of the students participating in the focus groups do not plan on majoring in computer science, the question was reworded to, "If you could make up your own college major, what would it be?" It was changed to understand what the students value and would like to study. Most students identified specific courses such as Biology, Art, Child Development, English, etc.

Many of those identified on the technology survey. However, some used terms that gave properties to their major as follows:

- Design
- Hands on
- Mixture of multiple subjects

**Question 6**: How would you explain the computing major you just created to interest your friends or gain approval from someone in your family?

This question seeks to understand how students would market their major. However, since the question relating to building their own major was changed, this question was also changed to ask student how they would market their major. The question specifically asked, "How would you market the major you designed to other people? How would you get them excited about it?" Many students identified advertising and web sites as the main means of marketing their new major. Others are listed below.

- Responses related to marketing in the high school
    - Go to high schools / Places where kids hang out and talk about it
    - Local school newspapers
    - School radio
    - They could put in agendas that the school gives out. Some random pages, do you enjoy such-and-such-a-subject. Half the kids are going to throw them away but the ones that are interested in specialized degrees are probably going to actually look at it.

- All teachers would be Ph.D.s
- Emails to prospective students
- Funding for that major
- Good teachers
- Interview real Civil Engineers and find out what they like in high school and advertise to them at a college fair
- It would have to be interesting
- Letters / Mail / Postcards

The following questions were added due to the responses to the previous question and are not found in the interview guide.

**Question 7**: How would you get someone excited about majoring in computers?

This was added to understand what things would motivate students toward a major.

- Advertise on TV
- Have a course that gives an overview of what's exciting about the major
- Offer classes like web design, computer applications instead of programming to high school students because going right into that is stupid and hard
- Talk to people who take similar classes
- Target the teachers in those areas so they can talk to their classes about it

**Question 8**: What kinds of things would you do on the web site?

The purpose of this question is to understand what things on a web site are important to students.

- Appeal to people that want to go in that direction
- Bright colors and pictures
- Details
- Put the information in obvious places, like student life or student activities

### *4.5.6 Wrap-up regarding computing*

At the end of the formal focus group time wrap up questions were asked to conclude the discussion up and review what students think about computers.

**Question 1**: Tell me up to five positive things about computing, no matter how small the positive thing is.

The top five responses are listed below:

- Communication
- Makes things (learning / research) easier
- Entertaining / Fun
- The Internet
- Makes things efficient

**Question 2**: Tell me up to five negative things about computing, no matter how small the negative thing is.

The top five responses are listed below:

- Viruses
- Breakable / Sometimes it doesn't work / Doesn't always work
- Complicated / Confusing
- Advances too quickly / Always updating
- Hacking

### *4.5.7 Concluding the Focus Group*

The ending questions and discussion spurred other discussion that is important to this research. Though the questions were not in the interview guide, once students began discussion it was apparent they should have been added. The following questions were asked at most of the focus groups and the responses reflect student opinions from the majority of those students who participated.

**Question 1**: What classes here at Mechanicsburg have you taken in computing?

This question was added to understand the courses that have influenced student perception of what computer science is. Most courses students have taken relate to applications such as Excel, Power Point and Word.

- Excel
- Microsoft Word / "They have a lot though, I'm taking Word next year."

- PowerPoint / “PowerPoint and Outlook are together, Word and Excel are by themselves”
- I think Access is a course but I don’t think anybody takes it
- Graphic design
- Web design
- Communicating with pixels
- In 6th grade we learned about computers but I can’t remember what we learned
- IT Essentials 1 teaches you software and how to use and troubleshoot programs
- IT Essentials 2 teaches you the fundamentals of hardware and how to properly switch things out

**Question 2**: What has been good about those classes?

This question seeks to understand the positive aspects of the classes that have influenced the students’ opinions. Many students learned a lot in the class.

- I learned a lot
- You have them everyday
- I liked the photography one.
- You get to teach yourself.

**Question 3**: What has been bad about those classes?

- It's a class
- The person who is teaching it
- The class was annoying because it's stuff we already know
- Word was like all typing, it was terrible

## 4.6 Impact of the Focus Groups

The majority of the students that volunteered for the focus groups did not intend to pursue Computer Science in college. Therefore, the results of the focus groups influenced the Student-Focused Curriculum in a more holistic way. For example the term "Computing" wasn't used by itself anywhere in the curriculum because these students viewed the term as a mathematics term rather than a computer term. "Technology" in a similar way was used wherever the discipline was addressed because, according to the students, "technology" is the broad term and "computers" are simply a slice of it.

According to the students, the idea that computers are ever changing, evolving and getting better was exciting, so where possible this idea of making things better and evolving influenced the Student-Focused Curriculum. The introductory paragraph includes references to "rapid advances", "dramatic changes in society", and "rapidly evolving discipline" in order to incorporate this idea.

Students that took part in the focus groups believe that jobs are available to those who study Computer Science. In a scale of 0 to 5, students rated the ability to get a job after studying Computer Science at 4.5 indicating that graduates should be able to get a job immediately after graduation. This influenced the Student-Focused Curriculum by the addition of what employment recent graduates have acquired in each of the concentration areas. The employment section was added also in part because of the stereotype that these students expressed. The idea was to show job possibilities that push against the stereotype.

During the High School Focus Group study, it was learned that students became disinterested in Computer Science based on the courses they had been taking. They equate Computer Science with any course they have taken that focuses on computers in some fashion. Courses like on teaching students how to use Microsoft Office were included in the list of computing courses though those courses do not reflect the nature of the Computer Science discipline. Other courses more accurately present Computer Science, though only a portion of it. Students are learning about Computer Science like the proverbial story of the blind men learning about an Elephant (See Appendix K). Work is currently being done to address the curricular issues at the high school through Exploring Computer Science [60].

## 4.7 College Student Delphi Study Methodology

Building the Student-Focused Curriculum in this dissertation requires knowing the interests of the target audience which is high school students that will be pursuing further education after graduation. Focus groups provided broad information about what information students refer to when choosing a college. Unfortunately, the data from these groups was too broad to use in redesigning the online Computer Science curriculum. In addition, many of the students that participated were not interested in computing majors, therefore, could not provide much help in developing a more attractive computing curriculum.

To concentrate the perceptions of the target audience to possible changes in the presentation of the online curriculum, a Delphi study was conducted with college students majoring in computer related fields. These students were chosen because of their chronological proximity to high school students and because of their interest and involvement in a computing degree. They possess a better understanding of Computer Science than high school students yet are not too far removed to reflect on their high school career; identifying ideas to make the curriculum relate better to today's high school students.

### *4.7.1 Introduction to the Delphi Technique*

The Delphi Technique is a group process that aggregates the opinions of individuals via a series of questionnaires. Linstone and Turoff provide a general definition of the Delphi technique, "Delphi may be characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem [78]."

"The Delphi method works especially well when the goal is to improve our understanding of problems, opportunities, solutions, or to develop forecasts [100]." In this study, the "experts" on how to present a computing curriculum that will motivate and encourage high school students viewing it on the web are college students enrolled in a computing program. The Delphi study was chosen because these "experts" provide the ideas for changing the curriculum displayed online, and then together rate the ideas in order of importance. The results of this study influenced the Student-Focused Curriculum.

There are several reasons to using the Delphi study over other alternatives, such as focus groups. The first is the ability to perform the study asynchronously.

Students can participate when they have time, freeing them from the necessity of meeting as a group.

The second reason to use a Delphi study is to allow participants to contribute anonymously, providing an environment in which they are free to voice their opinions [31]. This anonymity extends to all participants. However, administrators of the study must have access to each individual's responses in order to solicit clarification when necessary.

### *4.7.2 An Overview of the Delphi Technique*

The Delphi study, according to Andre Delbecq et. al, uses a series of three questionnaires [49]. The first questionnaire poses a broad question on which participants will comment. The second questionnaire summarizes the responses to the first questionnaire, asking participants to prioritize the top ten summarized responses, ranking them from ten down to one with 10 representing the highest priority. It also asks participants to comment on each summarized response, clearly indicating whether they agree, disagree, or need further clarification. The third questionnaire summarizes the results of the second questionnaire and allows participants to make their opinions known in a final vote of priority, much like the second questionnaire. The final step is to get consensus with the results of the third questionnaire by providing the results of the third questionnaire and asking participants for their assessment of the results.

### *4.7.3 The Process*

According to Delbecq et. al [49], there are ten steps the make up the Delphi process: The Question, Recruitment, Select Sample Size, Develop Questionnaire #1, Analyze

Questionnaire #1, Develop Questionnaire #2, Analyze Questionnaire #2, Develop Questionnaire #3, Analyze Questionnaire #3, and Preparation of the final report. Below, each of the ten steps is identified along with the process taken in this study.

#### 4.7.3.1 The Process Step One – The Question

The first step requires developing a research question that will provide the participants the forum to present their ideas. It is important to develop the question in such a way as to "generate as many feasible responses as possible [82]." For this research the desired responses focus on how to change the presentation of the Computer Science curriculum on the web in such a way that it motivates and encourages students to pursue the study Computer Science.

Two questions were posed in this study:

1. If you were looking into a computing program today, what things might generate more interest in pursuing the program further?
2. List all the ways you would change how the major is presented that will be exciting and motivating to students who have computing potential.

#### 4.7.3.2 The Process Step Two - Recruitment

The participants in this study are students at Messiah College enrolled in computing majors. The pilot group, a group of six Computer Science seniors, was recruited to evaluate the application used to present the questionnaire as well as the flow of each questionnaire before administered to all participants.

#### 4.7.3.3 The Process Step Three - Select Sample Size

The six students in the pilot participated through each step of the Delphi study before any other participants. At the completion of the pilot, they were asked to critique the process. Things were changed in the process after which 52 students were contacted and asked to participate in the full Delphi study. Of the 52 students contacted 14 students participated in the first iteration, a 26.9% response rate. After the first iteration, the ideas generated by the pilot group were incorporated with those of the full study, bringing the total student participation to 20 out of 52. The pilot study students were included in the invitation for the full study but did not contribute in the first iteration. This brought the response rate up to 38.5%.

During the second iteration nine students participated and in the third iteration, 16 students participated. In all, 30 distinct students participated in some part of this study, a response rate of 58%.

#### 4.7.3.4 The Process Step Four - Develop Questionnaire #1

The use of the word "Questionnaire" comes from the process used by Andre Delbecq et. al [49] that predates the use of email and the World Wide Web. In the process questionnaires would be written out on paper and mailed along with a cover letter through the U.S. Postal Service to each participant. The process would take up to forty days and beyond simply because of the time required in mailing the questionnaires.

This study, utilizing the Internet and online communication, retains the term "questionnaire" even though it no longer fits the mode. Using today's technology, an application was developed to facilitate the Delphi study.

### Application Architecture

To facilitate the asynchronous nature of the Delphi study, a web site was developed using PHP on an Apache Web Server running the Linux operating system. Dynamic PHP web pages would access a MySQL database to build the necessary pages, presenting the "questionnaires" to the students and recording their responses. This application was modeled after a Delphi web application developed by Deshpande et. Al [50].

The application is based on a 3-tier web architecture [50] in which the user interacts with the application through a web browser on their computer. The Web Server, Apache running on a Linux system, communicating with the database, MySQL Database Management System, sends the web pages to the user's computer to be displayed by their web browser.

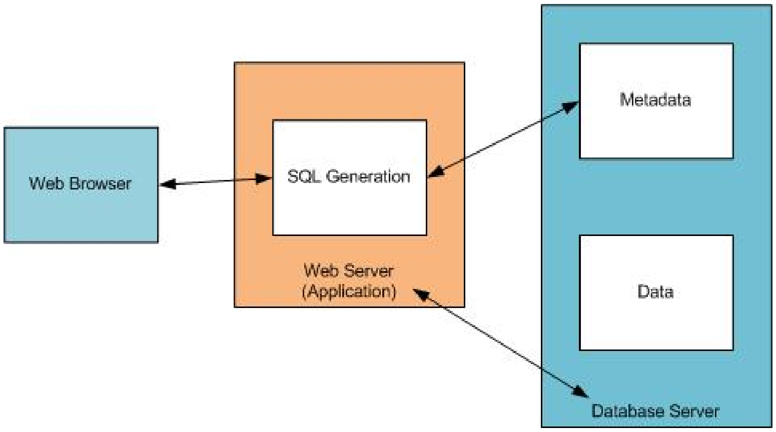


**Figure 4.7:** The Web Application Architecture

### Application Structure

The application's home page provides information about the study including dates for the iterations. Participants can use this page to register using their email address and are provided with a password. Their login would then be their email address along with the password sent to them. After successfully logging in, participants are directed to the Iteration's Instructions page if the iteration required it. From the instruction page, participants are taken to the Iteration Response page to enter their ideas. A sample session is presented in Appendix G.

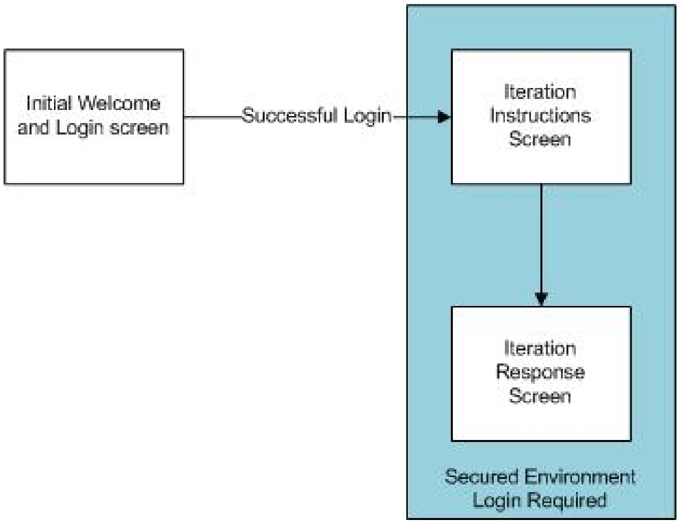


**Figure 4.8:** The Web Application Basic Flow

**The Database Structure** The database design, though initially modeled after Deshpande et. Al, was remodeled to facilitate. The key database structures for this application include:

- The User table contains the login and user information
- The Study table allows further Delphi studies to be conducted through this application
- The Iteration table contains the specific iteration instructions and active dates
- The Question and Brainstorm tables are used in the first iteration when participants are not commenting on other ideas, but answering the question(s)
- The Idea and Response tables are used for subsequent iterations to allow participants to comment on and rate all ideas.

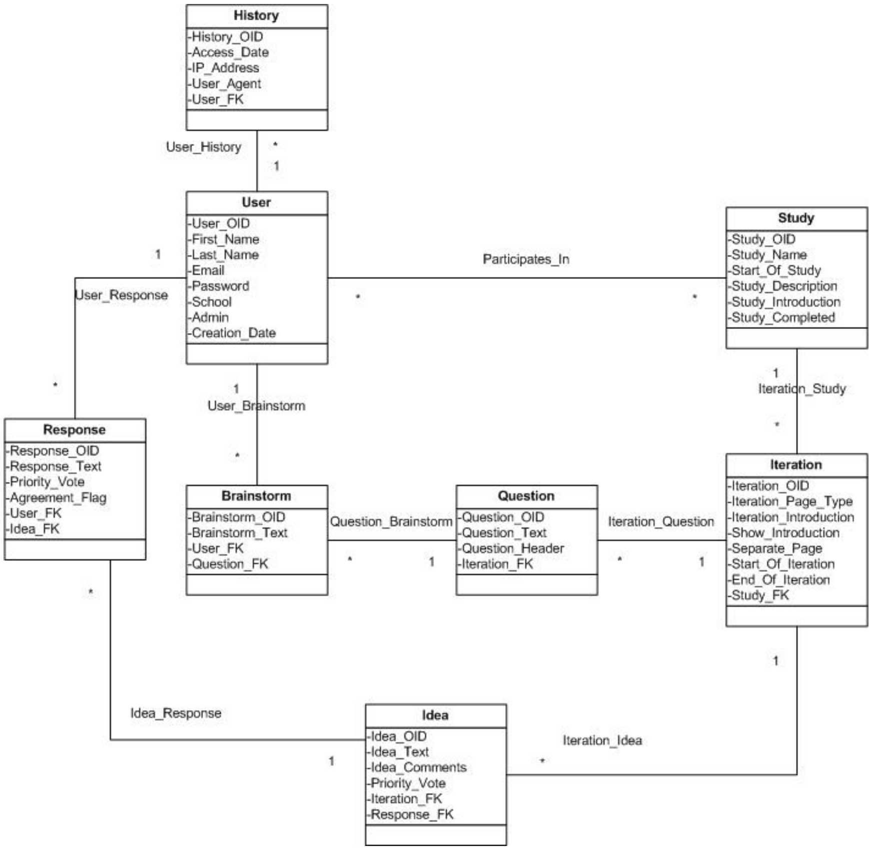


**Figure 4.9:** The Database Diagram

## A Delphi Application Session

The pilot study students were each given their own login through email. The full study participants were invited via email that provided a link to the web site. Once at the web site, they were presented with the opportunity to register for the study. Once their information was entered, an email was sent to their email address with a randomly generated password with which they were able to log into the study.

In the first iteration after a participant successfully logs in, they were presented with the iteration's instruction page. Since the purpose of this Delphi study is to get students to brainstorm possibilities in displaying Computer Science on the web, this instruction page presented links to the computing curricula of Penn State University, Georgia Institute of Technology, Messiah College, Lehigh University, and a fictitious curriculum developed from the First Survey Instrument. Students were encouraged to look at those curricula to get ideas of what to change and how to change it. Once they viewed the provided curricula, they could begin brainstorming by clicking the "Start the Brainstorming" link at the bottom of the iteration instruction page.

The Brainstorming page of the first iteration asks participants to respond to the following two questions:

1. If you were looking into a computing program today, what things might generate more interest in pursuing the program further?
2. List all the ways you would change how the major is presented that will be exciting and motivating to students who have computing potential.

Students were then given the opportunity to enter as many ideas as they could come up with. The web site was designed so that students could return as many times as they wanted during the dates when the iteration was active and update or add to what they had already entered.

The student interaction with the other parts of the Delphi application is presented during the discussion of the development of the other questionnaires.

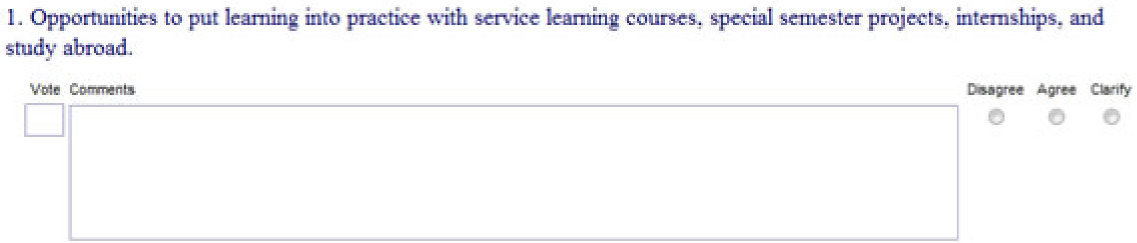
#### 4.7.3.5 The Process Step Five - Analysis of Questionnaire #1

To analyze Questionnaire #1 each of the responses were grouped into broad categories and summarized. "The list should reflect the initial opinions of respondents concerning key variables, yet be short enough for all respondents to easily review, criticize, support, or oppose [49]." The brainstorming ideas of both the pilot and the full study groups generated 42 ideas that were used to build the second questionnaire.

#### 4.7.3.6 The Process Step Six - Develop Questionnaire #2

The second questionnaire is built from the responses of the first questionnaire. The format of this questionnaire displays each item from questionnaire #1 in complete sentences with space for the participants to comment on each item. Participants are also asked to indicate whether they agree or disagree with an item or if they need more information to clarify the idea. Participants are also asked to choose ten ideas they decide are the top ten and to rate them from ten to one where ten is the top priority.

Since the second and third questionnaire no longer focus on brainstorming, but on evaluating ideas already submitted, the ideas and participant responses were stored in the Idea and Response tables of the database. Students were reminded of the dates of the second iteration by email and encouraged to proceed to the web site and sign-in with their previous information and begin iteration two. Once again, students were able to log in and update or add to their responses within the time frame that this iteration was open. Once the time period expired, the data was collected, analyzed and the next step began. An example of a single item is displayed below in Figure 4.10.



1. Opportunities to put learning into practice with service learning courses, special semester projects, internships, and study abroad.

**Figure 4.10:** Iteration #2 Example of Single Item

## The Process Step Seven - Analysis of Questionnaire #2

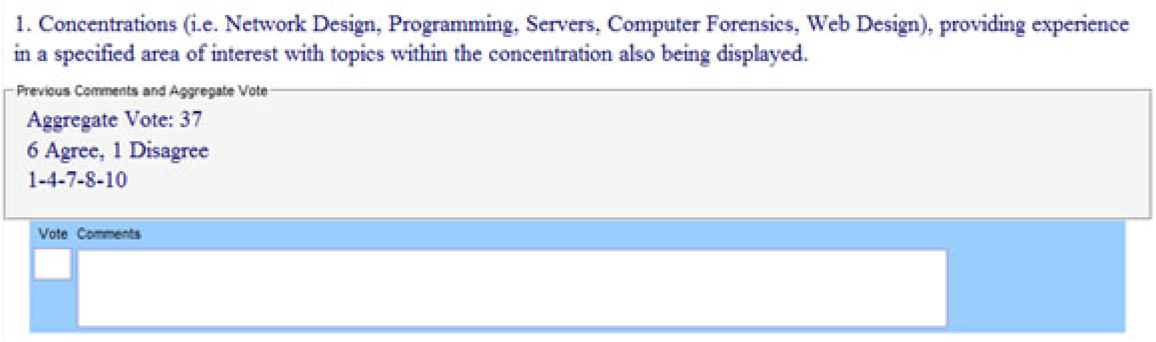
"The analysis of Questionnaire #2 should: (1) tally votes for items; and (2) summarize comments made about the items in a form that is both thought-provoking and easy to understand [49]." To tally the votes, since the votes are in the form of ranks, the ranks are summed and a total is given along with the list of individual votes. The total gives the overall rank of the item and the individual list of votes allows the analyst to see the diversity of rankings for each item. In other words, a total rank may be something like 63 which gives the importance of the item; however, the list of initial votes may be 10-9-10-9-6-9-10 which allows the analyst to see that most of the respondents agree, choosing a high priority. Another advantage to the list of responses allows the analyst to contact an individual respondent whose vote was extreme from the rest of the votes. This would provide more information as to the reason he/she voted that way. During the full survey it was apparent that several votes were outliers. It appeared as if some of the students ranked the highest in their top ten using a one rather than a ten. Those students were contacted and asked to clarify their vote and it became clear that votes where inverted from reflecting their real intent. The votes were adjusted and the analysis continued.

Students who submitted items that needed clarification were also contacted and asked to clarify their thoughts which were included in the next iteration.

#### 4.7.3.7 The Process Step 8 - Develop Questionnaire #3

By questionnaire #3 the issues have been identified and hopefully clarified. The purpose of the third questionnaire is to give a final vote for each item. The format of the third questionnaire is to list each item in complete sentences along with a summary of earlier comments. The previous total rank is also given with the option for participants to once again rank the top ten categories. This also brings closure for the participants.

The third questionnaire is another part of the web site. The students sign-in with their previous information to participate in this third iteration. Once again, a time period is given during which students are able to log in and update or add to their response. Once the time period expired, the data was collected and the next step commenced. An example of an item displayed in the third iteration can be seen below in Figure 4.11. The idea that is presented in Figure 4.11 began the list of ideas that were sorted based on the aggregate of the previous vote. The idea is presented followed by the aggregate vote, which is simply the sum of all votes listed at the bottom of that box. The number of students that indicated they agree and disagree are also displayed. After the information is presented, a vote and comment box are provided for the participant to provide their final assessment.



1. Concentrations (i.e. Network Design, Programming, Servers, Computer Forensics, Web Design), providing experience in a specified area of interest with topics within the concentration also being displayed.

Aggregate Vote: 37
6 Agree, 1 Disagree
1-4-7-8-10

**Figure 4.11:** Iteration #3 Example of a single item

#### 4.7.3.8 The Process Step Nine - Analysis of Questionnaire #3

The analysis of the third questionnaire follows the analysis of the second questionnaire.

#### 4.7.3.9 The Process Step Ten - Prepare a final report

Since this study is being used to change the curriculum being displayed on a school's website, the final report is actually the redesigned curriculum for Computer Science that will be used in the second survey instrument to be given to students across the United States.

Each participant in this study was contacted with the final results and asked if they concur with the results. Every participant but one agreed to the results. The individual that disagreed indicated he would agree if the fifth item were first. Since more than the first five items were used in presenting a Student-Focused Curriculum, it was assumed that his specific ordering did not matter.

## 4.8 College Student Delphi Study Data

### *4.8.1 Iteration 1*

The following is a summary of the data from the pilot and full Delphi study.

**Question 1**: If you were looking into a computing program today, what things might generate more interest in pursuing the program further?

- Adding various concentrations/emphases to the major
- Display details about the major such as languages used
- Display each course focus (i.e. this course focuses on hardware / this course focuses on software)
- Provide an overview of the major
- Provide a list of all the necessary classes
- Provide lists and descriptions of classes offered outside of the 'required' classes
- Identify what students will be learning
- Indicate the goal of the major
- Provide the expected length to completion (i.e. in general 4 years, but could be done in 3 and a half)
- Provide examples of programs and projects students have done (curricular and extra-curricular)
- Identify the Ranking of the program

**Question 2**: List all the ways you would change how the major is presented that will be exciting and motivating to students who have computing potential.

- More intuitive layout of department website
- Offer high school sit in days (especially for labs)
- Divide the program into concentrations: (Hardware and Software, and maybe specialized programs such as Hardware with Network Design emphasis, or Software with System Automation emphasis)
- Alternatives to high-level math: Require Calculus I (whether MATH 111 or 109 AND 110), and then give options for the remainder (e.g. two of the following: Statistics for CS, Advanced algebra, or Calculus II)
- The curriculum as a PDF is just frustrating
- Include the 'snippet' description on the course list
- Publicly available project demonstrations
- Positions graduates have received (whether grad school or a job) - include employer/school and position/area of study
- Extra-curricular activities/programs with which students are/have been involved
- Links to 'real-world' applications for each area/concentration

### *4.8.2 Iteration 2*

The following items represent the summarized ideas from Iteration 2. The summarized ideas from Iteration 1 were presented to the participants who were given the opportunity to comment on and vote for each idea. The results are shown below.

- Concentrations (i.e. Network Design, Programming, Servers, Computer Forensics, Web Design), providing experience in a specified area of interest with topics within the concentration also being displayed
- A course of web site languages such as HTML, CSS, Javascript, and PHP

  *Comments*

  - Using forward looking practices such as HTML5
  - I'm not sure if there should be a whole course about web site languages
- Developing real-world applications (current research, technology being invented, software being developed) in scenarios that are realistic to a work environment
- A larger variety of programming language courses
- Opportunities to put learning into practice with service learning courses, special semester projects, internships, and study abroad
- Software engineering concentration
- Offer the major as a B.S. degree instead of a B.A.

  *Comments*

  - yes, yes, yes ,yes I agree with this so much it should be a science instead of an art
  - definitely

- Presenting various job opportunities and best to apply my talents to a future profession

  *Comments*

  - already done by Career Center, Dr Weaver, and others

- An over-arching project for the whole major

- Provide opportunities to use the major outside of class with work study, clubs and organizations (such as robotics, gaming, web design), and volunteer opportunities

  *Comments*

  - work study would be great volunteer opportunities especially are great for resumes

- Use of different systems in addition to Win-machines such as Macintosh and Linux systems

  *Comments*

  - A class devoted to Linux would be greatly appreciated - it's a very popular server architecture

- Provide programming competitions

  *Comments*

  - this would be a lot of fun
  - fun

- An Accredited program

- A class that combines hardware and software i.e. taking inputs from an outside/analog source, such as temperature, movement, weight etc, converting it to digital and evaluating it
- Provide a course at the beginning of a student's college career that allows them to experience a very broad idea of the various concentration areas
  *Comments*
  - Don't we already have this?
- More options for courses we get to take under our choice options that are more specific in different areas
- Integration of faith into the program
- Alternatives high-level math: Require Calculus I (whether MATH 111 or 109 AND 110), and then give options for the remainder (e.g. two of the following: Statistics for CS, Advanced algebra, or Calculus II)
  *Comments*
  - Linear algebra would be a good course
- Computer gaming concentration combining computer graphics and programming
- Shadowing a CS student day, or high school sit in days (especially for labs)
- Logical thinking courses, how to think
  *Comments*
  - I'm curious what or how you would do this
  - This should be an element of all classes, not a separate class

- Provide lectures and conferences for prospective students
- Require students to participate in internships or co-ops, providing an opportunity for students to perform in the real world

  *Comments*

  - requiring them could cause scheduling difficulties, but having many opportunities to do so would be good
  - Maybe provide the possibility, but I'm not sure requiring it would be a good idea?
- Recognition amongst the relevant community
- Have a clean, understandable, and modern website with an intuitive layout
- Explain difference between Computer Science knowledge and "computer nerd" knowledge, emphasizing how you need not be good with a computer to study computer science by emphasizing the math, logic, and problem solving aspects

  *Comments*

  - I would have been more attracted to Computer Science as a major if I had known this
- Provide more courses dealing with information management and other business aspects of the computer industry. Business information is more than just computer systems, it requires management and human resources.
- Express thoroughly that not all Computer related majors are programming intensive
- Work with using and designing IS in the real world: ERP (SAP or Oracle), CRM (Siebel), and knowledge management

- Links to “real-world” applications for each area or concentration

  *Comments*

  - maybe showing alumni work, see what graduates have done

### *4.8.3 Iteration 3*

The following items represent the summarized ideas from Iteration 3. Participants were presented the ideas from Iteration 2 sorted by aggregate vote. The vote was also provided to them and they were given the opportunity to vote once more. The following are the results of Iteration 3 sorted in descending order by aggregate vote. Below each item are the individual votes as well as the total aggregate vote for the idea.

1. Concentrations (i.e. Network Design, Programming, Servers, Computer Forensics, Web Design), providing experience in a specified area of interest with topics within the concentration also being displayed

   *Votes*: 10 - 10 - 10 - 10 - 10 - 10 - 10 - 10 - 10 - 9 - 9 - 9 - 9 - 5 *Total*: 131

   *Comments*

   - More specific concentrations like computer forensics and web design would be very attractive. Not many people know what exactly Computer Science entails. I would be interested in taking classes in computer forensics and web design
   - Computer Science is too broad of a topic: this would be very useful in classifying the direction of study.

2. Developing real-world applications (current research, technology being invented software being developed) in scenarios that are realistic to a work

environment

*Votes*: 10 - 10 - 9 - 9 - 8 - 8 - 7 - 7 - 6 - 5 - 3 - 2 *Total*: 84

*Comments*

- Real-world and current technology is critical for computer scientists, for technology changes too rapidly to be learning outdated material.
- Developing real-world applications are a great way to introduce what kinds of projects we may be working on when we get jobs after school.

3. Opportunities to put learning into practice with service learning courses, special semester projects, internships, and study abroad

   *Votes*: 10 - 10 - 10 - 9 - 8 - 8 - 7 - 6 - 6 - 2 *Total*: 76

   *Comments*

   - Computer Science as a major is more about the action than the learning; we need more action involved in class.
   - Giving us opportunities to put our learning to practice in things such as projects or internships would be a good way to get CS majors to use their knowledge and put it to practical use.

4. A course of web site languages such as HTML, CSS, Javascript, and PHP

   *Votes*: 9 - 9 - 8 - 8 - 8 - 8 - 7 - 7 - 3 - 1 *Total*: 63

   *Comments*

   - I was interested in web design when coming to Messiah, but there is no specific course in learning the language like Programming I for Java.

5. Provide opportunities to use the major outside of class with work study, clubs and organizations (such as robotics, gaming, web design), and volunteer opportunities

   *Votes*: 9 - 8 - 7 - 7 - 7 - 7 - 6 - 4 - 4 - 2 - 1  *Total*: 62

   *Comments*

   - As previously mentioned, great for resumes.

6. Provide a larger variety of programming language courses

   *Votes*: 9 - 9 - 7 - 6 - 5 - 4 - 3  *Total*: 43

7. Use of different systems in addition to Win-machines such as Macintosh and Linux systems

   *Votes*: 8 - 6 - 5 - 5 - 5 - 3 - 3 - 2 - 1 - 1  *Total*: 39

   *Comments*

   - I think it would be great for CS majors to be taught the differences between different operating systems such as Mac and Linux. It would be good to have courses that deal with all three OS's.

8. Links to "real-world" applications for each area or concentration

   *Votes*: 9 - 8 - 7 - 6 - 4 - 2  *Total*: 36

   *Comments*

   - Real world applications would be great especially for concentrations. This way more students will be interested because they could find something that interests them in their concentration.

9. Offer the major as a B.S. degree instead of a B.A.

   *Votes*: 8 - 7 - 7 - 7 - 6  *Total*: 35

10. More options on the classes we get to take under our choice options that are more specific in different areas

    *Votes*: 10 - 8 - 5 - 4 - 4 - 2  *Total*: 33

11. Software engineering concentration

    *Votes*: 8 - 7 - 6 - 5 - 3 *Total*: 29

12. Express thoroughly that not all Computer related majors are programming intensive

    *Votes*: 9 - 6 - 4 - 3 - 1 *Total*: 23

    *Comments*

    - Most people think CS is just programming. When advertising the CS major at Messiah, it is important for people to know that there is much more than just programming.

13. A class that combines hardware and software i.e. taking inputs from an outside/analog source, such as temperature, movement, weight etc, converting it to digital and evaluating it

    *Votes*: 6 - 5 - 5 - 4 - 2 *Total*: 22

14. Require students to participate in internships or co-ops, providing an opportunity for students to perform in the real world

    *Votes*: 7 - 6 - 5 - 3 - 1 *Total*: 22

    *Comments*

    - Critical for entering the work force.
    - Definitely provide the possibility, but not require.
    - Perhaps not requiring, but having more opportunities to do so is always good.

15. Provide a course at the beginning of a student's college career that allows them to experience a very broad idea of the various concentration areas

    *Votes*: 9 - 8 - 5 *Total*: 22

16. Provide more courses dealing with information management and other business aspects of the computer industry. Business information is more than just computer systems, it requires management and human resources

    *Votes*: 9 - 5 - 4 - 2 - 2 *Total*: 22

    *Comments*

    - It's good to have a wide spectrum of classes from business to CS so that people know that they can get a job in their specific concentration. Learning about business aspects is great for a CS major so they can see if they would want to get a job in business, BIS, or CS.

17. Showcase graduates, statistics on placement after graduation and current careers, present the major in a way that emphasizes the ease of finding a job with a Messiah degree and Messiah's contributions to the field

    *Votes*: 8 - 7 - 7 *Total*: 22

    *Comments*

    - It would be helpful for incoming students to be able to see what Messiah grads are doing with their CS degree. It will be encouraging for CS majors to stick it out and finish the degree even if some of the classes they do not enjoy.

18. Computer gaming concentration combining computer graphics and programming

    *Votes*: 9 - 6 - 4 - 2 *Total*: 21

19. Exploration and implementation of social networking and online identity and presence. This can be combined with a marketing approach to present towards market sectors and demographics with the effects of anonymity

    *Votes*: 6 - 6 - 6 - 3 *Total*: 21

20. Software Quality Assurance is an important aspect of development in the workplace, yet gets no attention in college. ISO 9000 series, CMMI, SPICE. Process is as important as product

    *Votes*: 10 - 6 - 5 *Total*: 21

    *Comments*

    - This is a very critical piece of CS education that is completely absent from the curriculum, yet shows up daily in software development in the real world.

21. Provide programming competitions

    *Votes*: 8 - 6 - 2 *Total*: 16

22. Alternatives high-level math: Require Calculus I (whether MATH 111 or 109 AND 110), and then give options for the remainder (e.g. two of the following: Statistics for CS, Advanced algebra, or Calculus II)

    **Votes**: 10 - 5 **Total**: 15

23. Have a clean, understandable, and modern website with an intuitive layout

    *Votes*: 8 - 3 - 3 - 1 *Total*: 15

24. Work with using and designing IS in the real world: ERP (SAP or Oracle), CRM (Siebel), and knowledge management

    *Votes*: 5 - 4 - 2 - 2 - 1 *Total*: 14

    *Comments*

    - Working with real world applications is always a great way to gain real world experience and a look into what we could potentially be doing at our first jobs

25. An Accredited program

*Votes*: 6 - 6 - 1 *Total*: 13

26. Options in course selection

    *Votes*: 6 - 5 *Total*: 11

27. Provide lectures and conferences for prospective students

    *Votes*: 5 - 4 - 2 *Total*: 11

28. Recognition amongst the relevant community

    *Votes*: 5 - 5 - 1 *Total*: 11

29. Integration of faith into the program

    *Votes*: 9 - 1 *Total*: 10

30. Shadowing a CS student day, or high school sit in days (especially for labs)

    *Votes*: 5 - 4 - 1 *Total*: 10

31. Provide the expected length to completion (i.e. in general 4 years, but could be done in 3 and a half)

    *Votes*: 5 - 5 *Total*: 10

32. Logical thinking courses, how to think

    *Votes*: 5 - 4 *Total*: 9

    *Comments*

    - This is very well integrated in the Digital Electronics engineering course - an excellent course to include in the CS curriculum

33. Explain difference between Computer Science knowledge and “computer nerd” knowledge, emphasizing how you need not be good with a computer to study computer science by emphasizing the math, logic, and problem solving aspects

    *Votes*: 5 - 3 - 1 *Total*: 9

34. Showcase student projects, internships and research

    *Votes*: 8 - 1 *Total*: 9

35. Identify what students will be learning

    *Votes*: 5 - 3 *Total*: 8

36. Indicate the goal of the major

    *Votes*: 6 - 2 *Total*: 8

37. Presenting various job opportunities and best to apply my talents to a future profession

    *Votes*: 7 *Total*: 7

38. Display each course focus (i.e. this course focuses on hardware and this course focuses on software)

    *Votes*: 7 *Total*: 7

39. Provide an overview of the major

    *Votes*: 6 *Total*: 6

40. An over-arching project for the whole major

    *Votes*: 5 *Total*: 5

41. Faculty bios with interests highlighting their accessibility and help

    *Votes*: 5 *Total*: 5

42. Provide a list and description of required classes as well as a list and description of optional classes

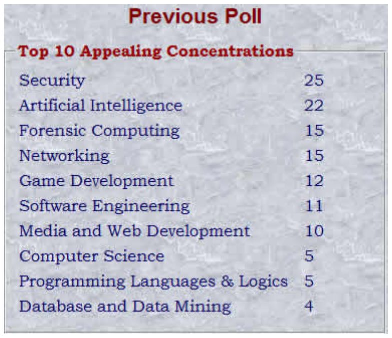
    *Votes*: 5 *Total*: 5

## 4.9 Impact of the Delphi Study

Since the participants of the Delphi Study were students currently in a computing major, most of their input directly affected the Student-Focused Curriculum. The ideas that were generated from the Delphi Study were ranked in the order of importance by the students through their voting on them. The ideas generated with a score of twentyor more were used as much as possible in the development of the Student-Focused Curriculum. Section 4.8.3 provides the details for each idea as well as the voting record and scoring.

- **Concentrations** (Item 1)

  Much like the Job-Focused curriculum, concentrations were identified as being attractive as well as informative. As one student put it, "Computer Science is too broad of a topic: this would be very useful in classifying the direction of study." Therefore, concentrations were used in the Student-Focused Curriculum. Some of the concentrations were suggested during the Delphi Study. However, these suggestions were made by a few individuals. Therefore, to determine the concentrations to be used, a poll was developed for the same group of students to identify the concentrations they believe are the most attractive. The poll was opened and students, via email, were invited to participate. In the first round they had the opportunity to vote for the concentrations they thought were the most important as well as add any concentration that might also be a candidate. During the second round, students were once again invited via email to participate and were asked to choose their top three choices of concentrations and the results are shown in Figure 4.12. The concentrations that had ten or more votes were used in the Student-Focused Curriculum. The only modification to the polled data was the combination of Security and Forensics into a single concentration. This was decided in order to reduce the size of the curriculum that students taking the survey would have to evaluate.



Previous Poll

Top 10 Appealing Concentrations

| | |
|---|---|
| Security | 25 |
| Artificial Intelligence | 22 |
| Forensic Computing | 15 |
| Networking | 15 |
| Game Development | 12 |
| Software Engineering | 11 |
| Media and Web Development | 10 |
| Computer Science | 5 |
| Programming Languages & Logics | 5 |
| Database and Data Mining | 4 |

**Figure 4.12:** The Results of the Concentrations Poll

- **Developing Real-World Applications** (Item 2)

  The phrase "real-world" was used as often as possible where appropriate. For example in the concentrations definition section it was used in the Software-Engineering concentration. It was also used in the following course descriptions: Discrete Mathematics, Database Applications, Senior Capstone, Computer Forensics, Cryptography, Introduction to Artificial Intelligence, Knowledge-Based Software Engineering, Converged Networks, Object-Oriented Modeling, and Webmasters and Servers.

- **Practice Opportunities** (Item 3 and Item 14) - Service learning courses, special semester projects, internships, and study abroad

  This was used in the introductory paragraph in the sentence, "To prepare for this exciting field, students are encouraged to participate in internships; placement aid is provided."

- **Web Site Languages Course** (Item 4)

  Since Web and Media Development was designated a concentration, this ideas was incorporated into the courses for the major. The original idea identified specific scripting languages, but it was decided that using the phrase "scripting languages" would be more timeless than using specific languages that would change over time. The idea was used in the Principles of Web Site Design, Webmasters and Servers, and Intermediate Web Design.

- **Opportunities to Use the Major Outside of Class** (Item 5)
  This idea was incorporated into some of the concentration descriptions. For example, student-run clubs were identified in the Artificial Intelligence and Game Development concentrations, namely the robotics club and the gaming club. A Web Development organization was identified in the Web and Media Development concentration that "provides web solutions to many non-profit organizations."

- **Larger variety of programming language courses** (Item 6)
  Courses in Web and Media Development as well as courses in the Core show a breadth of programming languages that students would learn as tools to broaden their abilities.

- **Use of Multiple Operating Systems** (Item 7)
  Where appropriate different operating systems were identified in course descriptions. In courses such as Computer and Network Security and Operating Systems Linux, Macintosh and Windows were identified.

- **Links to "Real-World" Applications for Each Area or Concentration** (Item 8 and 17)
  In each concentration description, a section was added that identified the jobs on which recent graduates are currently working. An attempt to identify specific projects for the recent graduates was also made in order to provide prospective students with an understanding of where this concentration could be used in the real-world.

- **A Bachelor of Science degree instead of a Bachelor of Arts** (Item 9)
  Though this is more a reflection of the students at Messiah College, it was integrated into the introductory paragraph, "Students seeking a Bachelor of Science degree...".

- **More Variety of Choice Options** (Item 10 and 26)
  With the number of concentrations and the different courses provided throughout the curriculum, it was decided that this idea could easily be accomplished by simply having an Electives section for each concentration where students would choose three other courses from any other concentration. The statement reads, "Students may choose 3 other courses from any concentration to round out their degree."

- **Software Engineering Concentration** (Item 11)
  Incorporated into the choice of concentrations.

- **Express the Idea that not all Computer Related Majors are Programming Intensive** (Item 12)
  It was decided that through the recent graduates work section and the different concentrations, the stereotype that a computing major is programming intensive would be dispelled.

- **Course Combining Hardware And Software** (Item 13)
  This idea was not incorporated into the Student-Focused Curriculum since it was determined that it didn't fit within the concentrations that were listed. This idea would function well in a Computer Engineering major more so than a Computer Science major.

- **Provide an Introductory Course Providing an Overview of all Concentrations** (Item 15)

This was implemented in the course, "Introduction to Computer Science" where the course description states, "Students are introduced to the various aspects of Computer Science through a general survey course of technology meccas, the history of various aspects of development in Computer Science, ethical practices in the field and emerging technologies."

- **Provide Courses in Information Management** (Item 16)
  It was decided that this idea belongs more in an Information Systems or Business Information Systems major than this Computer Science major and therefore would not be incorporated into this Student-Focused Curriculum. This is an idea that challenges the basic makeup of the Computer Science major, and since this Student-Focused Curriculum is based on the underlying curriculum found in the Typical Curriculum, it would not be included.

- **Computer Gaming Concentration** (Item 18)
  Incorporated into the choice of concentrations.

- **Exploration and Implementation of Social Networking and Online Identity and Presence** (Item 19)
  Like Item 16, this idea presents a challenge to the underlying makeup of the Computer Science major and therefore was not included in the Student-Focused Curriculum.

- **Software Quality Assurance** (Item 20)
  Quality assurance is addressed in both the description of the Software Engineering concentration as well as within courses in the Software Engineering concentration.

Though the focus was on the ideas with a total score over twenty, some of the ideas scoring lower than twentywere easily incorporated into the Student-Focused

Curriculum.

- **An Accredited Program** (Item 25)

  This was easily incorporated into the introductory paragraph with the phrase, “accredited by ABET”.

- **Identify What Students will be Learning** (Item 35)

  This was incorporated into the curriculum through the attempt to make all descriptions understandable and motivating.

- **Presenting Various Job Opportunities** (Item 37)

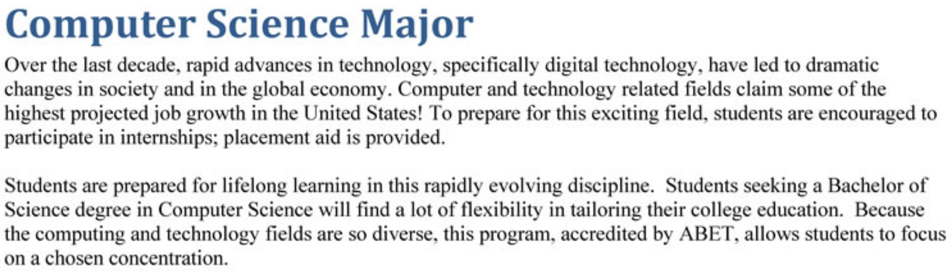
  This was also incorporated into the recent graduates job section in the concentration descriptions.

## 4.10 Student-Focused Curriculum Design

The Student-Focused curriculum was designed using the requirements of the Typical Curriculum and information gathered from the research segments within the Student Ideas of Computer Science stage, HS Student Technology Survey, HS Student Focus Groups, and College Student Delphi Study. The Introduction section to the Student-Focused Computer Science Curriculum was divided into three parts. The first part of the introduction is two paragraphs describing the major. The second part of the introduction presents the major’s concentrations.

The first introductory paragraph describes the field as growing rapidly with dramatic effects on society. It also indicates the project growth of the job market and how students are encouraged to prepare for this exciting field. The second introductory paragraph an overview of the major. The wording within these introductory paragraphs was deliberately chosen based on information from the

Bureau of Labor Statistics and the Delphi study conducted in one of the segments of this stage of research. Specifically, the phrase, “highest projected job growth in the United States,” was developed from the Bureau of Labor Statistics study. The phrase, “students are encouraged to participate in internships,” comes from the results of the Delphi study as well as the phrases, “Bachelor of Science”, and “accredited by ABET”. Figure 4.13 shows the introduction to the Student-Focused Curriculum.



**Computer Science Major**

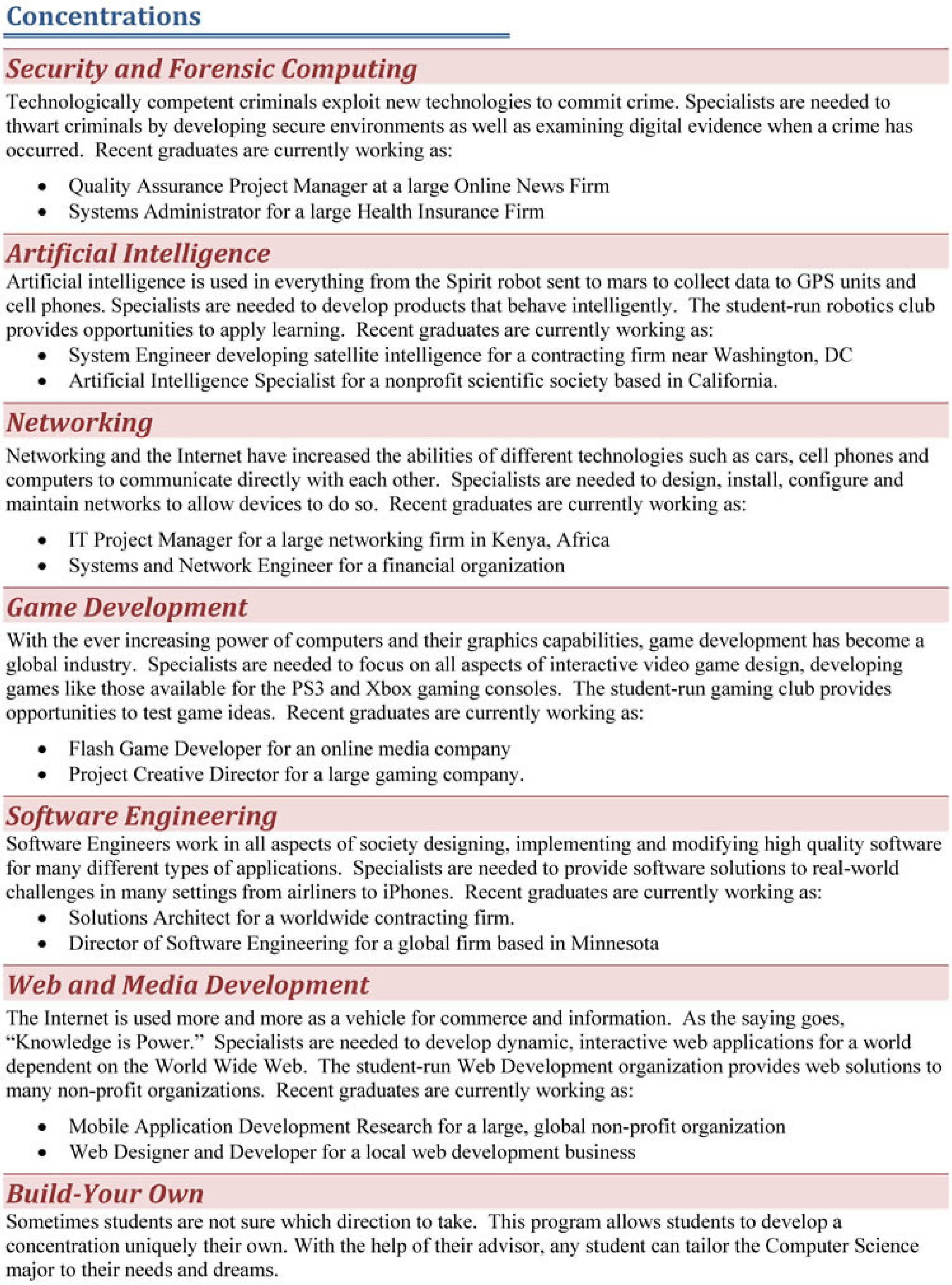
Over the last decade, rapid advances in technology, specifically digital technology, have led to dramatic changes in society and in the global economy. Computer and technology related fields claim some of the highest projected job growth in the United States! To prepare for this exciting field, students are encouraged to participate in internships; placement aid is provided.

Students are prepared for lifelong learning in this rapidly evolving discipline. Students seeking a Bachelor of Science degree in Computer Science will find a lot of flexibility in tailoring their college education. Because the computing and technology fields are so diverse, this program, accredited by ABET, allows students to focus on a chosen concentration.

**Figure 4.13:** Student-Focused Curriculum Introduction

The idea of using concentrations in the major was the highest ranked idea in the Delphi study. Some of the concentrations were suggestions made in the Delphi study, the others were the top choices in an informal survey of college students. The concentrations listed include Security and Forensic Computing, Artificial Intelligence, Networking, Game Development, Software Engineering, Web and Media Development and a Build-Your Own concentration. Included with the introduction of each concentration was a paragraph describing the concentration using language that students may hear on television. After the introduction paragraph of the concentration, two examples of recent graduate student employment are presented. The idea of presenting the jobs in which recent graduates are currently involved was introduced in the Delphi study. Figure 4.14 shows the introduction to the concentrations of the Student-Focused Curriculum.

After the introduction, the core required courses are presented. These courses were chosen from the Typical Curriculum but were given descriptions aimed at high



## Concentrations

### Security and Forensic Computing

Technologically competent criminals exploit new technologies to commit crime. Specialists are needed to thwart criminals by developing secure environments as well as examining digital evidence when a crime has occurred. Recent graduates are currently working as:

- Quality Assurance Project Manager at a large Online News Firm
- Systems Administrator for a large Health Insurance Firm

### Artificial Intelligence

Artificial intelligence is used in everything from the Spirit robot sent to mars to collect data to GPS units and cell phones. Specialists are needed to develop products that behave intelligently. The student-run robotics club provides opportunities to apply learning. Recent graduates are currently working as:

- System Engineer developing satellite intelligence for a contracting firm near Washington, DC
- Artificial Intelligence Specialist for a nonprofit scientific society based in California.

### Networking

Networking and the Internet have increased the abilities of different technologies such as cars, cell phones and computers to communicate directly with each other. Specialists are needed to design, install, configure and maintain networks to allow devices to do so. Recent graduates are currently working as:

- IT Project Manager for a large networking firm in Kenya, Africa
- Systems and Network Engineer for a financial organization

### Game Development

With the ever increasing power of computers and their graphics capabilities, game development has become a global industry. Specialists are needed to focus on all aspects of interactive video game design, developing games like those available for the PS3 and Xbox gaming consoles. The student-run gaming club provides opportunities to test game ideas. Recent graduates are currently working as:

- Flash Game Developer for an online media company
- Project Creative Director for a large gaming company.

### Software Engineering

Software Engineers work in all aspects of society designing, implementing and modifying high quality software for many different types of applications. Specialists are needed to provide software solutions to real-world challenges in many settings from airliners to iPhones. Recent graduates are currently working as:

- Solutions Architect for a worldwide contracting firm.
- Director of Software Engineering for a global firm based in Minnesota

### Web and Media Development

The Internet is used more and more as a vehicle for commerce and information. As the saying goes, "Knowledge is Power." Specialists are needed to develop dynamic, interactive web applications for a world dependent on the World Wide Web. The student-run Web Development organization provides web solutions to many non-profit organizations. Recent graduates are currently working as:

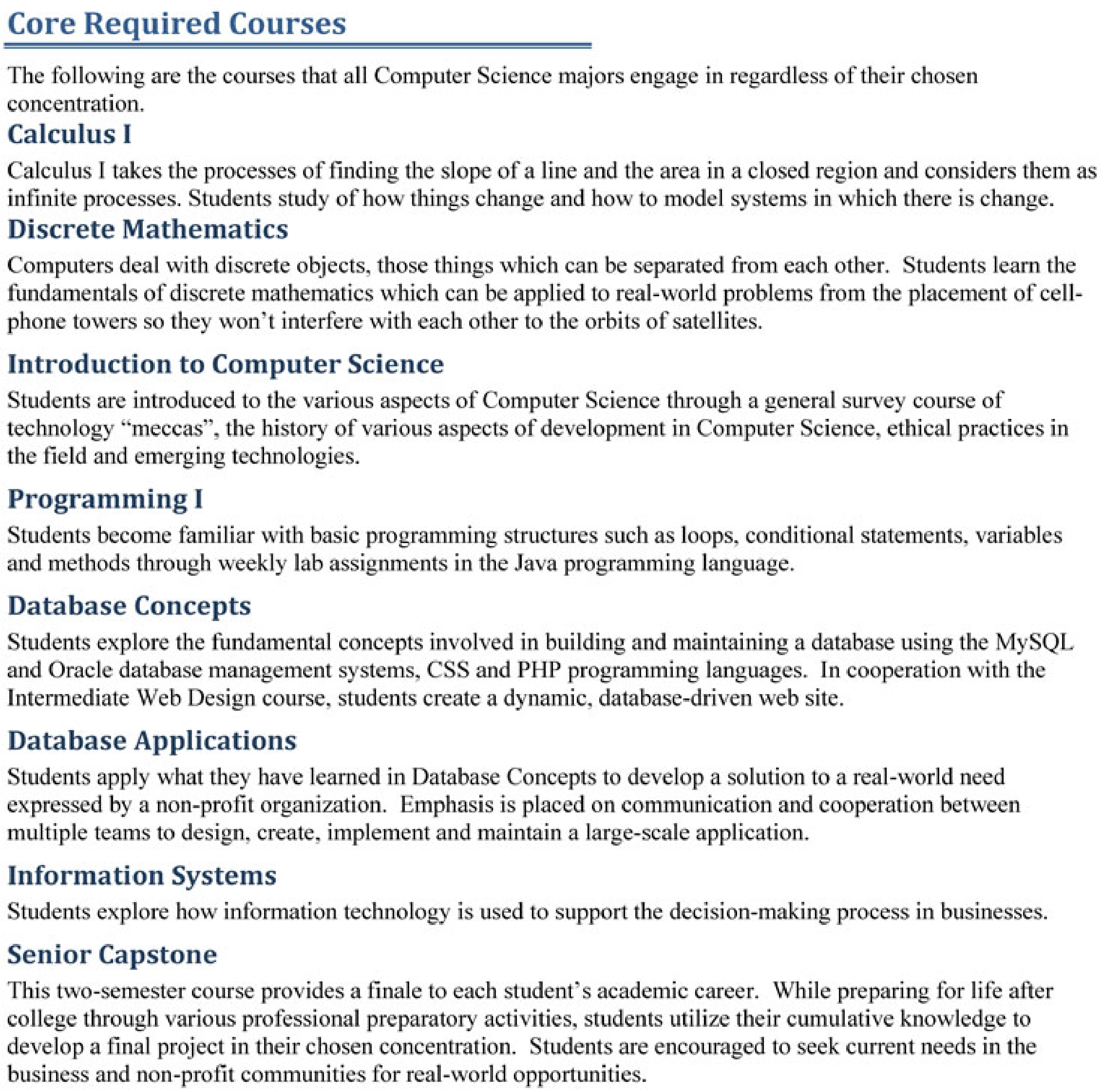
- Mobile Application Development Research for a large, global non-profit organization
- Web Designer and Developer for a local web development business

### Build-Your Own

Sometimes students are not sure which direction to take. This program allows students to develop a concentration uniquely their own. With the help of their advisor, any student can tailor the Computer Science major to their needs and dreams.

**Figure 4.14:** Student-Focused Curriculum Concentrations Introduction

school students. Course numbers were intentionally left out of the Student-Focused curriculum. Figure 4.15 shows the core required courses of the Student-Focused Curriculum.



## Core Required Courses

The following are the courses that all Computer Science majors engage in regardless of their chosen concentration.

### Calculus I

Calculus I takes the processes of finding the slope of a line and the area in a closed region and considers them as infinite processes. Students study of how things change and how to model systems in which there is change.

### Discrete Mathematics

Computers deal with discrete objects, those things which can be separated from each other. Students learn the fundamentals of discrete mathematics which can be applied to real-world problems from the placement of cell-phone towers so they won't interfere with each other to the orbits of satellites.

### Introduction to Computer Science

Students are introduced to the various aspects of Computer Science through a general survey course of technology "meccas", the history of various aspects of development in Computer Science, ethical practices in the field and emerging technologies.

### Programming I

Students become familiar with basic programming structures such as loops, conditional statements, variables and methods through weekly lab assignments in the Java programming language.

### Database Concepts

Students explore the fundamental concepts involved in building and maintaining a database using the MySQL and Oracle database management systems, CSS and PHP programming languages. In cooperation with the Intermediate Web Design course, students create a dynamic, database-driven web site.

### Database Applications

Students apply what they have learned in Database Concepts to develop a solution to a real-world need expressed by a non-profit organization. Emphasis is placed on communication and cooperation between multiple teams to design, create, implement and maintain a large-scale application.

### Information Systems

Students explore how information technology is used to support the decision-making process in businesses.

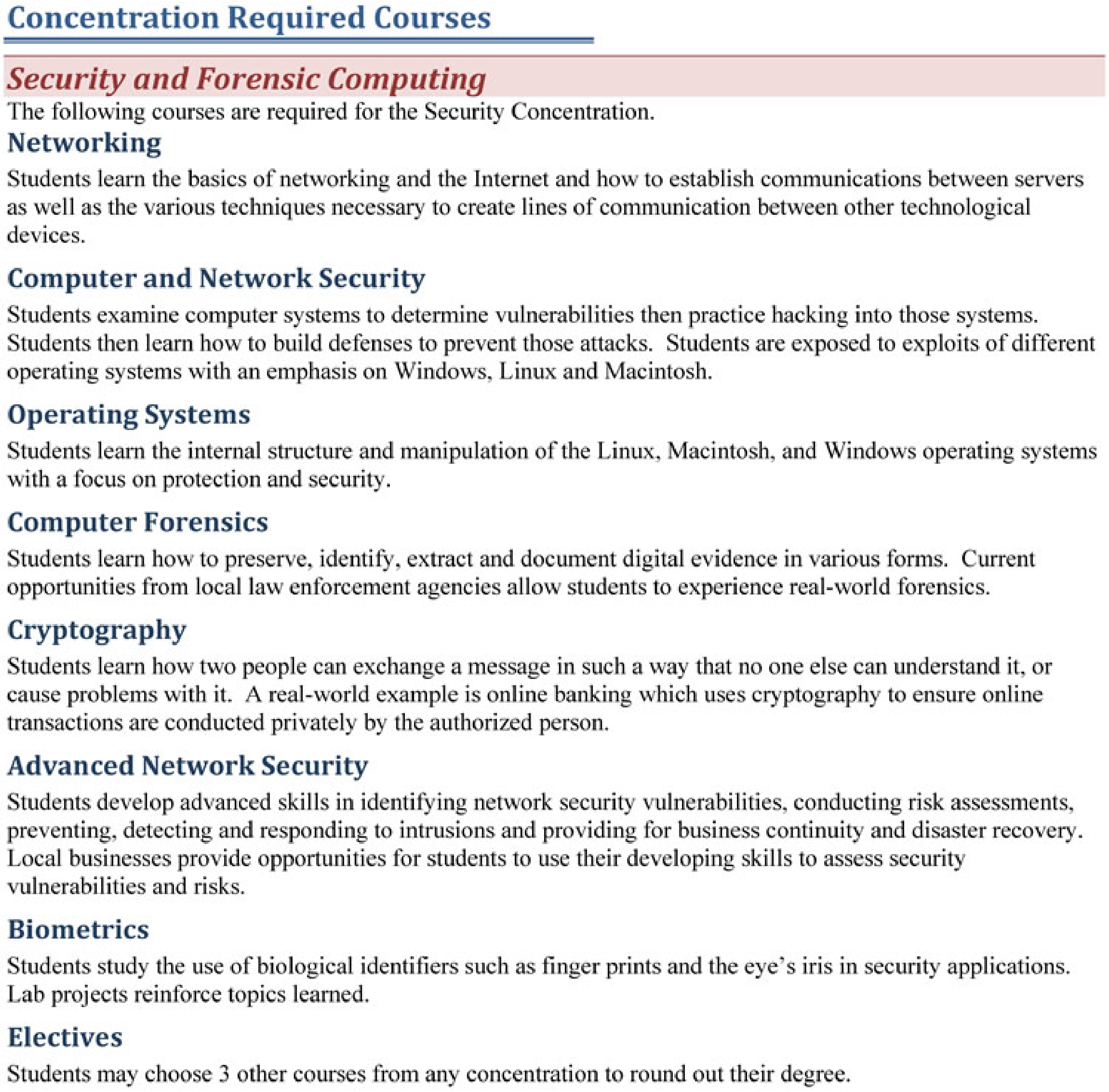
### Senior Capstone

This two-semester course provides a finale to each student's academic career. While preparing for life after college through various professional preparatory activities, students utilize their cumulative knowledge to develop a final project in their chosen concentration. Students are encouraged to seek current needs in the business and non-profit communities for real-world opportunities.

**Figure 4.15:** Student-Focused Curriculum Core Required Courses

Following the core required courses are the required courses for each concentration. These courses were chosen from colleges and universities that offer majors in these specific concentration areas. Once again the course numbers were intentionally omitted and descriptions were given that were geared toward high school students. Figure 4.16 shows one of the concentration areas in the Student-Focused

Curriculum. For the full Student-Focused Curriculum, see Appendix H.



**Concentration Required Courses**

***Security and Forensic Computing***

The following courses are required for the Security Concentration.

**Networking**

Students learn the basics of networking and the Internet and how to establish communications between servers as well as the various techniques necessary to create lines of communication between other technological devices.

**Computer and Network Security**

Students examine computer systems to determine vulnerabilities then practice hacking into those systems. Students then learn how to build defenses to prevent those attacks. Students are exposed to exploits of different operating systems with an emphasis on Windows, Linux and Macintosh.

**Operating Systems**

Students learn the internal structure and manipulation of the Linux, Macintosh, and Windows operating systems with a focus on protection and security.

**Computer Forensics**

Students learn how to preserve, identify, extract and document digital evidence in various forms. Current opportunities from local law enforcement agencies allow students to experience real-world forensics.

**Cryptography**

Students learn how two people can exchange a message in such a way that no one else can understand it, or cause problems with it. A real-world example is online banking which uses cryptography to ensure online transactions are conducted privately by the authorized person.

**Advanced Network Security**

Students develop advanced skills in identifying network security vulnerabilities, conducting risk assessments, preventing, detecting and responding to intrusions and providing for business continuity and disaster recovery. Local businesses provide opportunities for students to use their developing skills to assess security vulnerabilities and risks.

**Biometrics**

Students study the use of biological identifiers such as finger prints and the eye's iris in security applications. Lab projects reinforce topics learned.

**Electives**

Students may choose 3 other courses from any concentration to round out their degree.

**Figure 4.16:** Student-Focused Curriculum Core Required Courses

# Chapter 5

# Student Perceptions and Reactions to Computer Science Curricula

In Chapter 2, a Typical Curriculum was developed by evaluating College and University curricula found on the World Wide Web. The full Typical Curriculum is shown in Table 2.15.

In Chapter 3, a Job-Focused Curriculum was developed by evaluating how businesses promote computer related job opportunities. Categories and keywords extracted from job advertisements were used to develop concentrations and areas of study in the new presentation of a Computer Science major. Areas of study were used in place of specific courses. The full Job-Focused Curriculum is shown in Figure 3.4.

In Chapter 4, a Student-Focused Curriculum was developed through three separate research tools, a High School Student Technology Survey, High School Student Focus Groups, and a College Student Delphi Study. Through the data gathered, a new presentation of the Computer Science major was designed with concentrations and descriptions identified by students as being interesting and explanatory.

The goal of the final stage of research, Survey of Prospective Students, as presented in Figure 1.4 and detailed in Figure 5.1 was to assess the reaction of high school students to the different presentations of the Computer Science curriculum. The purpose in conducting these surveys was to test the hypothesis, "When presented with a more relevant Computer Science curriculum than a typical curriculum today, students will be encouraged and motivated to enroll in the major."

The results from the first three stages of research provided data necessary to develop the curricula to be used in the Curriculum Presentation Surveys. The first stage, Curricular Presentations, provided the data necessary to develop the Typical Curriculum. The second stage, Technology Job Review, provided the data necessary to develop the Job-Focused Curriculum. The last stage, comprised of the three research segments, the High School Student Technology Survey, the High School Student Focus Groups, and the College Student Delphi Study, provided the data to develop the Student-Focused Curriculum.

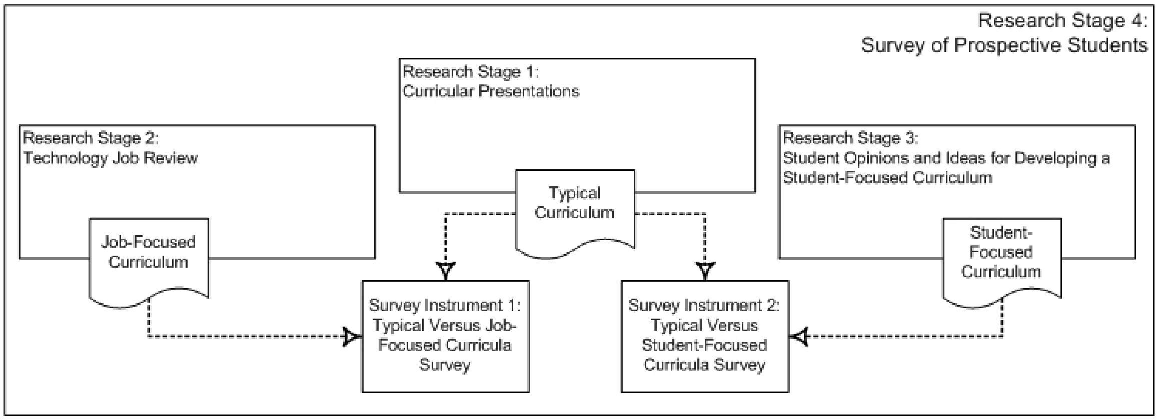


**Figure 5.1:** Research Stage 4: Survey of Prospective Students

## 5.1 Overview of the Curricular Presentation Surveys

Two survey instruments were developed to present curricula to high school students and ask for their reaction. Each survey instrument contained a pair of surveys with each of the pairs dedicated to a specific curriculum. These instruments were developed using the Qualtrics.com software, which is "an industry-leading provider of enterprise feedback management and survey software solutions [93].” Each survey pair within a survey instrument had sections that were common to the pair such as the Introduction, Technology, and Demographic and Closure sections. The sections that differ addressed the particular curriculum presentation, Typical Curriculum, Job-Focused Curriculum, and Student-Focused Curriculum. When participants started a survey instrument, they would be presented with only one of the survey pairs which contained only one of the curricula. Therefore, practically speaking, each survey instrument was responsible for administering two surveys. Each survey instrument was administered at different times to different populations. Therefore, no participant took more than a single survey. Figure 5.2 shows the two survey instruments and the sections in each.

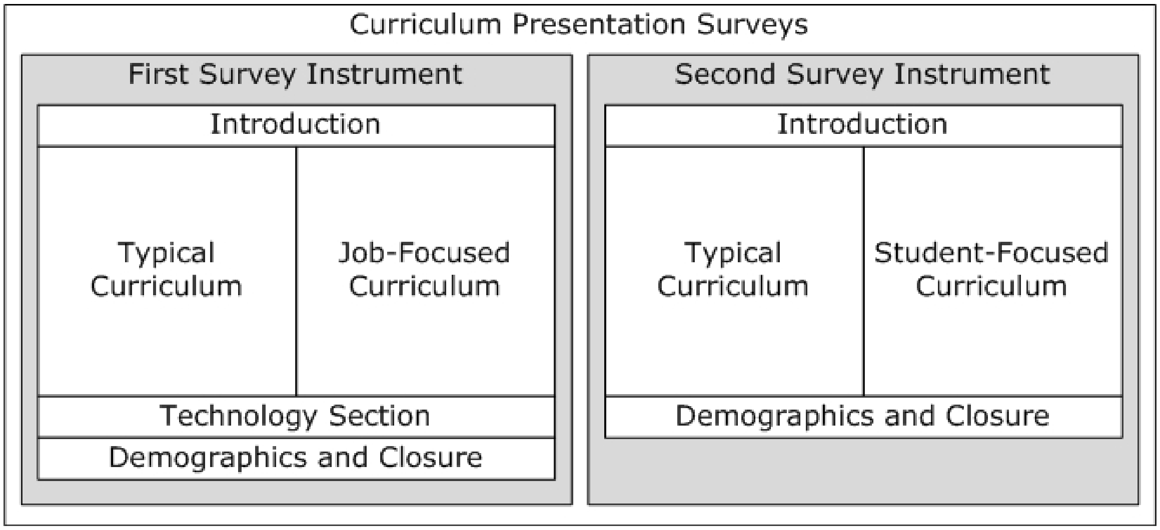


**Figure 5.2:** Curriculum Presentation Survey Instruments

### *5.1.1 The First Survey Instrument*

The first survey instrument was designed to compare student reaction to the Typical Curriculum and the Job-Focused Curriculum. It contained five blocks, the Introduction block, the Typical Curriculum block, the Job-Focused Curriculum block, the Technology block, and the Demographic and Closure block. The individual curricular surveys shared the Introduction, Technology, and Demographics and Closure blocks.

Figure 5.3 shows the survey flow graphically. The Introduction block introduced the students to the survey as a whole. After the Introduction block, the Qualtrics.com software randomly chose either the Typical Curriculum block or the Job-Focused Curriculum block for each participant so that each participant evaluated only one of the curricula. No participant evaluated both. After a participant completed the curriculum block provided, the Technology and Demographic blocks would be presented. After the completion of the Technology and Demographic blocks, the survey was completed.

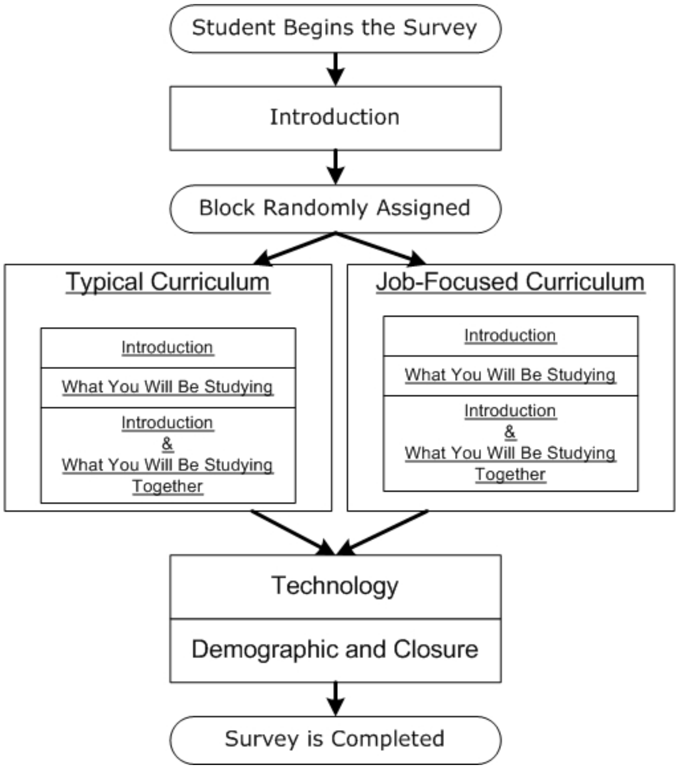
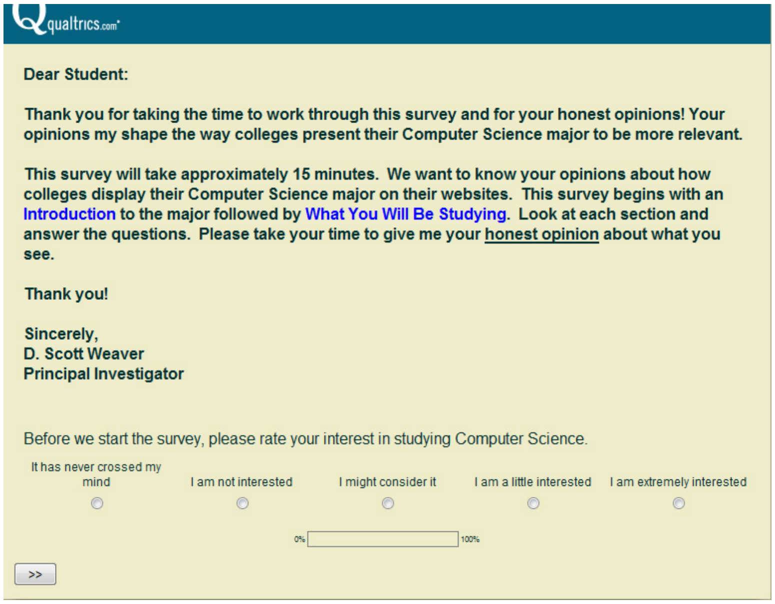


**Figure 5.3:** Survey Flow for the first survey instrument

### Introduction Block

The Introduction block, shared by both surveys, thanks the students for participating and provides instructions. The first question, presented on the same screen, reads, "Before we start the survey, please rate your interest in studying Computer Science." The purpose of this question is to establish the participant's initial interest in studying computer science. A similar question is posed at the end of the survey for comparison purposes. Figure 5.4 presents the introduction screen that students saw.



**Dear Student:**

**Thank you for taking the time to work through this survey and for your honest opinions! Your opinions my shape the way colleges present their Computer Science major to be more relevant.**

**This survey will take approximately 15 minutes. We want to know your opinions about how colleges display their Computer Science major on their websites. This survey begins with an Introduction to the major followed by What You Will Be Studying. Look at each section and answer the questions. Please take your time to give me your honest opinion about what you see.**

**Thank you!**

**Sincerely,**
**D. Scott Weaver**
**Principal Investigator**

Before we start the survey, please rate your interest in studying Computer Science.

| It has never crossed my mind | I am not interested | I might consider it | I am a little interested | I am extremely interested |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

Figure 5.4: Introduction Block of the First Survey Instrument

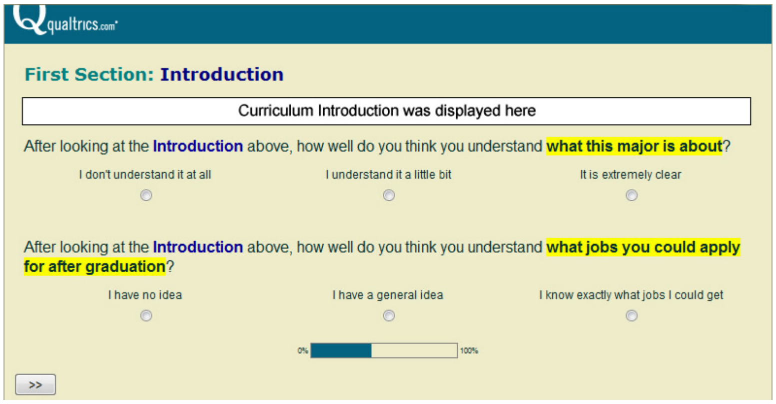
## Curricular Blocks

The two curricular blocks, similarly designed, are broken into three subsections to allow the students to evaluate different parts of the curriculum. The first subsection presents the "Introduction" to the curriculum and asks questions about it. The second subsection, "What You Will Be Studying", presents the required courses or areas of study and asks related questions. The last subsection puts the curriculum subsections together and asks questions relevant to the curriculum as a whole. Since many of the questions in the Typical Curriculum and Job-Focused Curriculum blocks are similar, they will be explained together.

### *The "Introduction" subsection*

The student is presented with the introduction to the specific curriculum followed by two questions (See Figures 5.4 and 5.6).

- After looking at the Introduction above, how well do you think you understand what this major is about?
- After looking at the Introduction above, how well do you think you understand what jobs you could apply for after graduation?



**First Section: Introduction**

Curriculum Introduction was displayed here

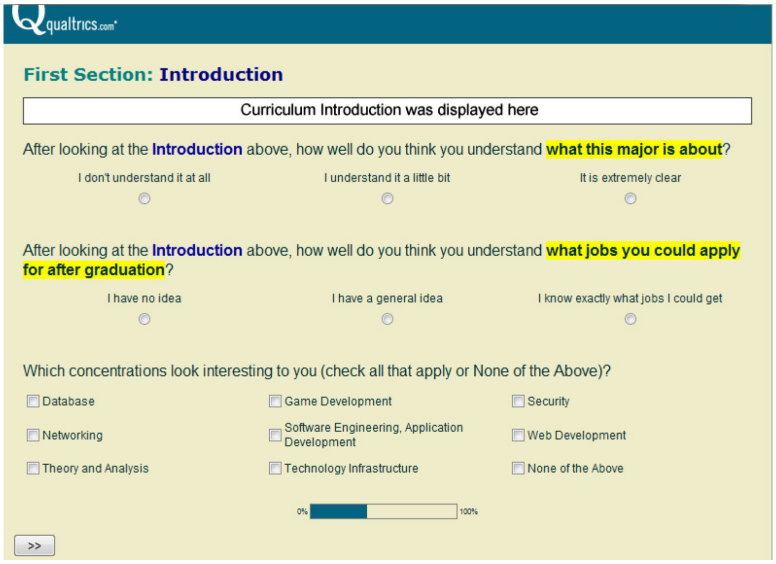
After looking at the **Introduction** above, how well do you think you understand **what this major is about**?

| I don't understand it at all | I understand it a little bit | It is extremely clear |
|---|---|---|
| ○ | ○ | ○ |

After looking at the **Introduction** above, how well do you think you understand **what jobs you could apply for after graduation**?

| I have no idea | I have a general idea | I know exactly what jobs I could get |
|---|---|---|
| ○ | ○ | ○ |

**Figure 5.5:** Introduction of the Typical Curriculum in the First Survey Instrument



**First Section: Introduction**

Curriculum Introduction was displayed here

After looking at the **Introduction** above, how well do you think you understand **what this major is about**?

| I don't understand it at all | I understand it a little bit | It is extremely clear |
|---|---|---|
| ○ | ○ | ○ |

After looking at the **Introduction** above, how well do you think you understand **what jobs you could apply for after graduation**?

| I have no idea | I have a general idea | I know exactly what jobs I could get |
|---|---|---|
| ○ | ○ | ○ |

Which concentrations look interesting to you (check all that apply or None of the Above)?

| | | |
|---|---|---|
| ☐ Database | ☐ Game Development | ☐ Security |
| ☐ Networking | ☐ Software Engineering, Application Development | ☐ Web Development |
| ☐ Theory and Analysis | ☐ Technology Infrastructure | ☐ None of the Above |

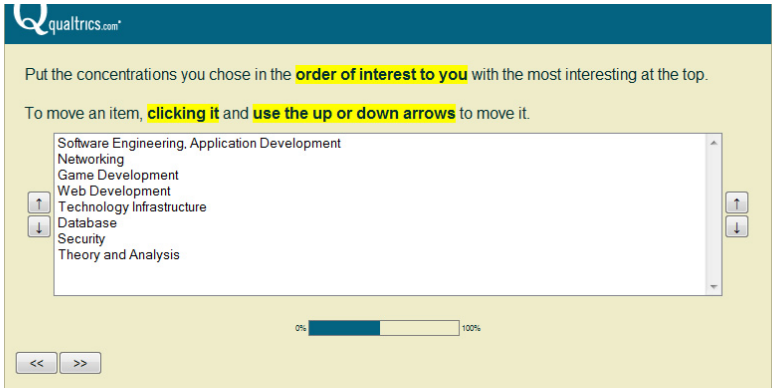
**Figure 5.6:** Introduction of the Job-Focused Curriculum in the First Survey Instrument

The purpose of the first question is to determine if the introduction provides enough information to help prospective students understand what the major is about. The purpose of the second question is to determine if the introduction provides enough information to help prospective students understand the jobs they could apply for after graduation.

In the "Introduction" subsection of the Job-Focused Curriculum two additional questions are posed (See Figure 5.6).

- Which concentrations look interesting to you (check all that apply or None of the Above)?
- Put the concentrations you chose in the order of interest to you with the most interesting at the top.

The purpose of the first additional question is to determine which concentrations interest students. If the participant chose more than one concentration, the second additional question, displayed on another page, was posed to provide ranking information for those concentrations chosen (See Figure 5.7).



Put the concentrations you chose in the **order of interest to you** with the most interesting at the top.

To move an item, **clicking it** and **use the up or down arrows** to move it.

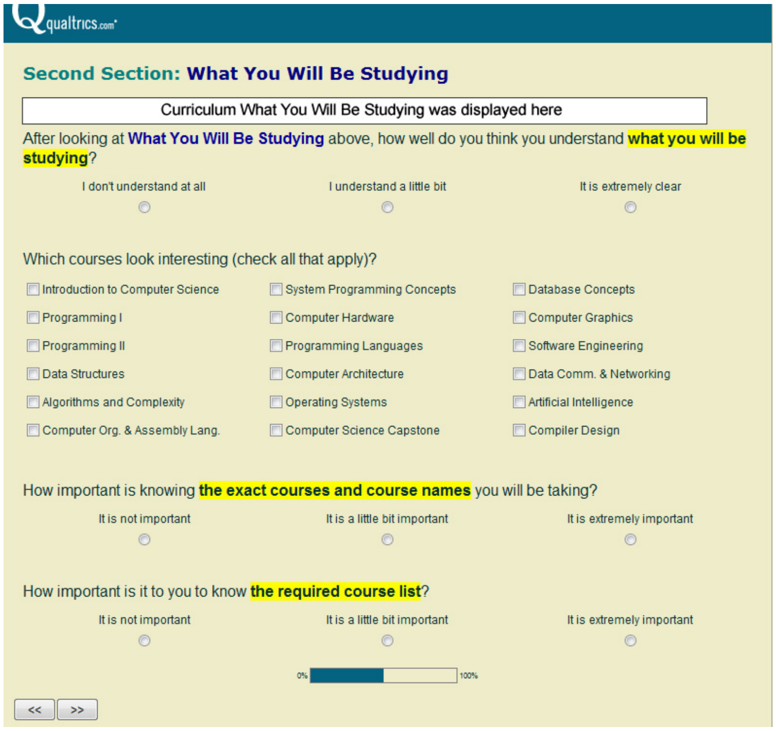
Software Engineering, Application Development
Networking
Game Development
Web Development
Technology Infrastructure
Database
Security
Theory and Analysis

**Figure 5.7:** Arranging concentrations in the Job-Focused Curriculum in the First Survey Instrument

### *The "What You Will Be Studying" subsection*

In the "What You Will Be Studying" subsection, the student is presented with the required courses for the Computer Science curriculum. For the Typical Curriculum the required course list is presented (See Figure 5.8). For the Job-Focused Curriculum, areas of study are presented (See Figure 5.9). The following questions are common to both curricular surveys.

- After looking at What You Will Be Studying above, how well do you think you understand what you will be studying?
- How important is knowing the exact courses and course names you will be taking?
- How important is it to you to know the required course list?



**Second Section: What You Will Be Studying**

Curriculum What You Will Be Studying was displayed here

After looking at **What You Will Be Studying** above, how well do you think you understand **what you will be studying**?

| | | |
|---|---|---|
| I don't understand at all | I understand a little bit | It is extremely clear |
| ○ | ○ | ○ |

Which courses look interesting (check all that apply)?

☐ Introduction to Computer Science
☐ Programming I
☐ Programming II
☐ Data Structures
☐ Algorithms and Complexity
☐ Computer Org. & Assembly Lang.
☐ System Programming Concepts
☐ Computer Hardware
☐ Programming Languages
☐ Computer Architecture
☐ Operating Systems
☐ Computer Science Capstone
☐ Database Concepts
☐ Computer Graphics
☐ Software Engineering
☐ Data Comm. & Networking
☐ Artificial Intelligence
☐ Compiler Design

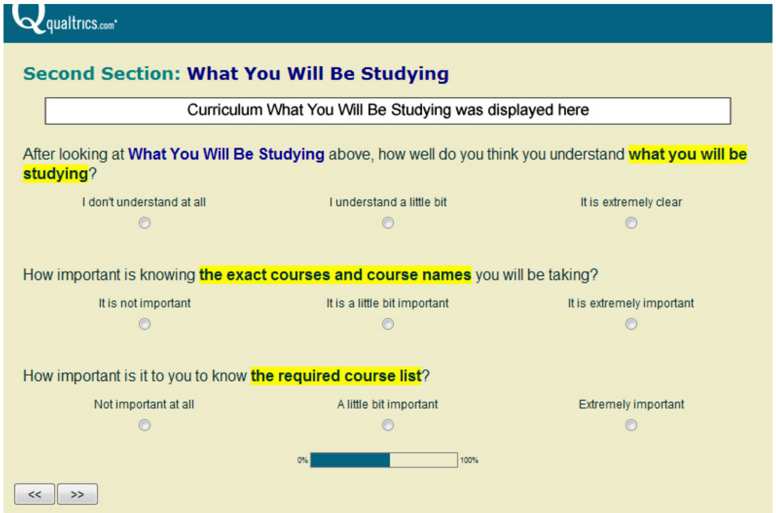
How important is knowing **the exact courses and course names** you will be taking?

| | | |
|---|---|---|
| It is not important | It is a little bit important | It is extremely important |
| ○ | ○ | ○ |

How important is it to you to know **the required course list**?

| | | |
|---|---|---|
| It is not important | It is a little bit important | It is extremely important |
| ○ | ○ | ○ |

**Figure 5.8:** The "What You Will Be Studying" Section of the Typical Curriculum in the First Survey Instrument



**Second Section: What You Will Be Studying**

Curriculum What You Will Be Studying was displayed here

After looking at **What You Will Be Studying** above, how well do you think you understand **what you will be studying**?

| I don't understand at all | I understand a little bit | It is extremely clear |
|---|---|---|
| ○ | ○ | ○ |

How important is knowing **the exact courses and course names** you will be taking?

| It is not important | It is a little bit important | It is extremely important |
|---|---|---|
| ○ | ○ | ○ |

How important is it to you to know **the required course list**?

| Not important at all | A little bit important | Extremely important |
|---|---|---|
| ○ | ○ | ○ |

**Figure 5.9:** The "What You Will Be Studying" Section of the Job-Focused Curriculum in the First Survey Instrument

The purpose of the first question is to determine if what is presented for study aids the prospective student in understanding what is studied in the major. The purpose of the second question is to determine if exact courses and course names are important. The purpose of the third question is to determine if a required course list is important.

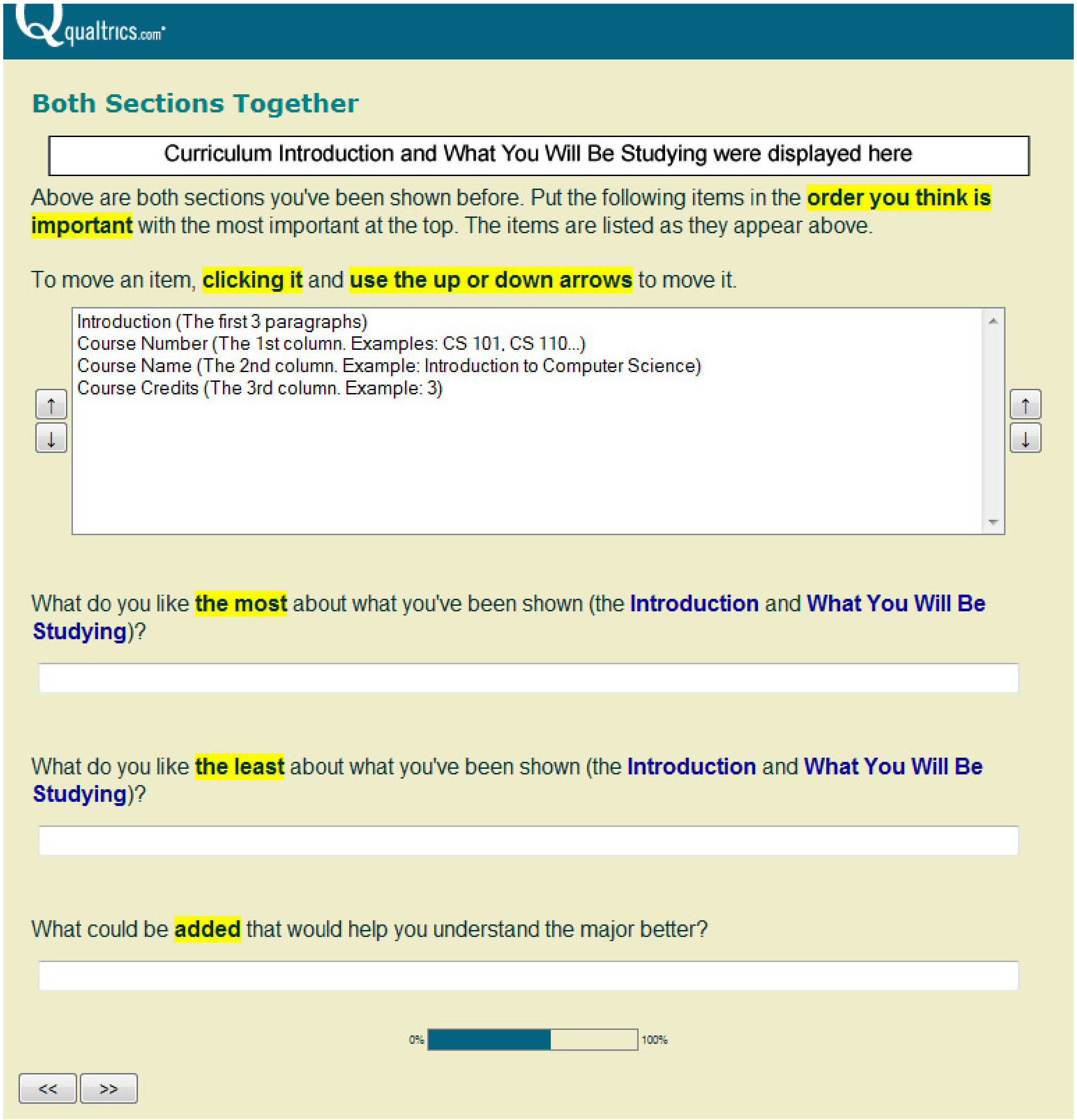
The "What You Will Be Studying" subsection of the Typical Curriculum has an additional question which is posed to determine which typical courses are still interesting to students (See Figure 5.8).

- Which courses look interesting (check all that apply)?

### *Both Subsection Together*

Both the "Introduction" and "What You Will Be Studying" subsections were then presented together (See Figures 5.10 and 5.11). The following question was then posed:

- Above are both sections you've been shown before. Put the following items in



Both Sections Together

Curriculum Introduction and What You Will Be Studying were displayed here

Above are both sections you've been shown before. Put the following items in the **order you think is important** with the most important at the top. The items are listed as they appear above.

To move an item, **clicking it** and **use the up or down arrows** to move it.

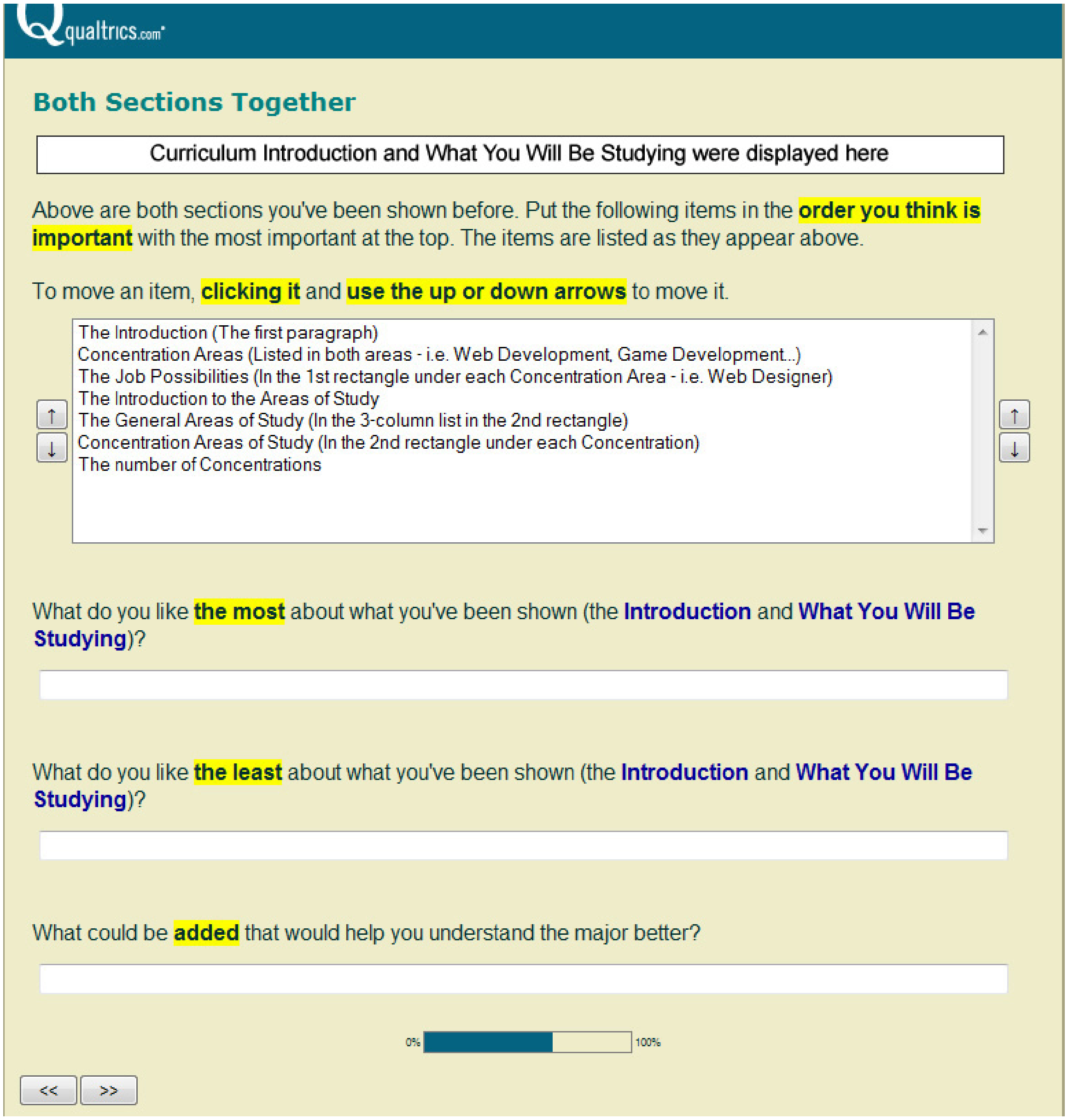
Introduction (The first 3 paragraphs)
Course Number (The 1st column. Examples: CS 101, CS 110...)
Course Name (The 2nd column. Example: Introduction to Computer Science)
Course Credits (The 3rd column. Example: 3)

What do you like **the most** about what you've been shown (the **Introduction** and **What You Will Be Studying**)?

What do you like **the least** about what you've been shown (the **Introduction** and **What You Will Be Studying**)?

What could be **added** that would help you understand the major better?

**Figure 5.10:** Both the Introduction and the "What You Will Be Studying" Sections of the Typical Curriculum in the First Survey Instrument



Both Sections Together

Curriculum Introduction and What You Will Be Studying were displayed here

Above are both sections you've been shown before. Put the following items in the **order you think is important** with the most important at the top. The items are listed as they appear above.

To move an item, **clicking it** and **use the up or down arrows** to move it.

The Introduction (The first paragraph)
Concentration Areas (Listed in both areas - i.e. Web Development, Game Development...)
The Job Possibilities (In the 1st rectangle under each Concentration Area - i.e. Web Designer)
The Introduction to the Areas of Study
The General Areas of Study (In the 3-column list in the 2nd rectangle)
Concentration Areas of Study (In the 2nd rectangle under each Concentration)
The number of Concentrations

What do you like **the most** about what you've been shown (the **Introduction** and **What You Will Be Studying**)?

What do you like **the least** about what you've been shown (the **Introduction** and **What You Will Be Studying**)?

What could be **added** that would help you understand the major better?

**Figure 5.11:** Both the Introduction and the "What You Will Be Studying" Sections of the Job-Focused Curriculum in the First Survey Instrument

the order you think is important with the most important at the top. The items are listed as they appear above.

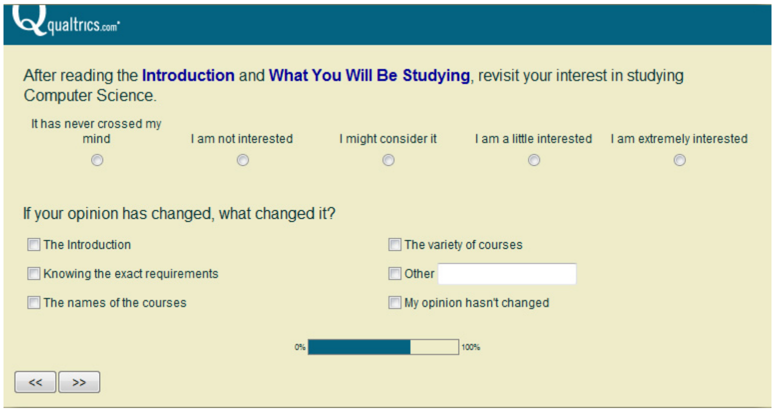
The lists for this question differ between the Typical Curriculum and Job-Focused Curriculum. The question is designed as an ordering question where students select an entry and position it higher or lower in the list. The purpose of the question is to determine the importance of each segment of the curriculum in the minds of the students.

The questions that follow are open-ended questions to determine the positive aspects of what they have seen as well as what could be improved upon. The last open-ended question is designed to determine what is missing that would help students understand the major better.

- What do you like the most about what you've been shown (the Introduction and What You Will Be Studying)?
- What do you like the least about what you've been shown (the Introduction and What You Will Be Studying)?
- What could be added that would help you understand the major better?

After students evaluate both sections together, they are presented with a page that asks them to reflect once again on their interest in studying Computer Science. These questions are presented prior to the Technology and Demographic blocks and revisit the interest question posed at the beginning of the survey and attempts to ascertain the reason a student may have changed their opinion (See Figures 5.12 and 5.13).

- After reading the Introduction and What You Will Be Studying, revisit your interest in studying Computer Science.
- If your opinion has changed, what changed it?



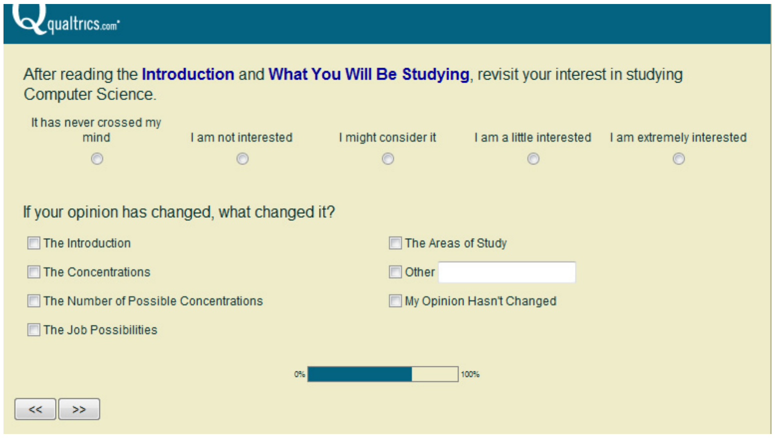
After reading the **Introduction** and **What You Will Be Studying**, revisit your interest in studying Computer Science.

| It has never crossed my mind | I am not interested | I might consider it | I am a little interested | I am extremely interested |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

If your opinion has changed, what changed it?

☐ The Introduction
☐ Knowing the exact requirements
☐ The names of the courses
☐ The variety of courses
☐ Other
☐ My opinion hasn't changed

Figure 5.12: Students reflect on their interest in Studying Computer Science for the Typical Curriculum in the First Survey Instrument



After reading the **Introduction** and **What You Will Be Studying**, revisit your interest in studying Computer Science.

| It has never crossed my mind | I am not interested | I might consider it | I am a little interested | I am extremely interested |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

If your opinion has changed, what changed it?

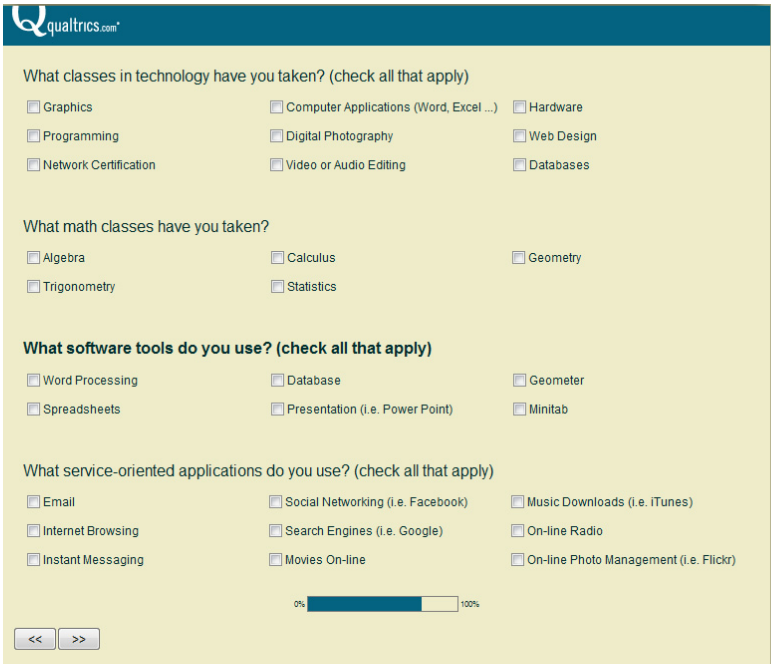
☐ The Introduction
☐ The Concentrations
☐ The Number of Possible Concentrations
☐ The Job Possibilities
☐ The Areas of Study
☐ Other
☐ My Opinion Hasn't Changed

Figure 5.13: Students reflect on their interest in Studying Computer Science for the Job-Focused Curriculum in the First Survey Instrument

The second question, "If your opinion has changed, what changed it?" provides a list of areas of the curriculum that may have affected the student's interest. The lists between the Typical Curriculum and Job-Focused Curriculum differ since they relate to the specific curricula.

### *Technology Block*

The technology block provides questions similar to those found on the High School Student Technology survey.



What classes in technology have you taken? (check all that apply)

☐ Graphics
☐ Programming
☐ Network Certification
☐ Computer Applications (Word, Excel ...)
☐ Digital Photography
☐ Video or Audio Editing
☐ Hardware
☐ Web Design
☐ Databases

What math classes have you taken?

☐ Algebra
☐ Trigonometry
☐ Calculus
☐ Statistics
☐ Geometry

**What software tools do you use? (check all that apply)**

☐ Word Processing
☐ Spreadsheets
☐ Database
☐ Presentation (i.e. Power Point)
☐ Geometer
☐ Minitab

What service-oriented applications do you use? (check all that apply)

☐ Email
☐ Internet Browsing
☐ Instant Messaging
☐ Social Networking (i.e. Facebook)
☐ Search Engines (i.e. Google)
☐ Movies On-line
☐ Music Downloads (i.e. iTunes)
☐ On-line Radio
☐ On-line Photo Management (i.e. Flickr)

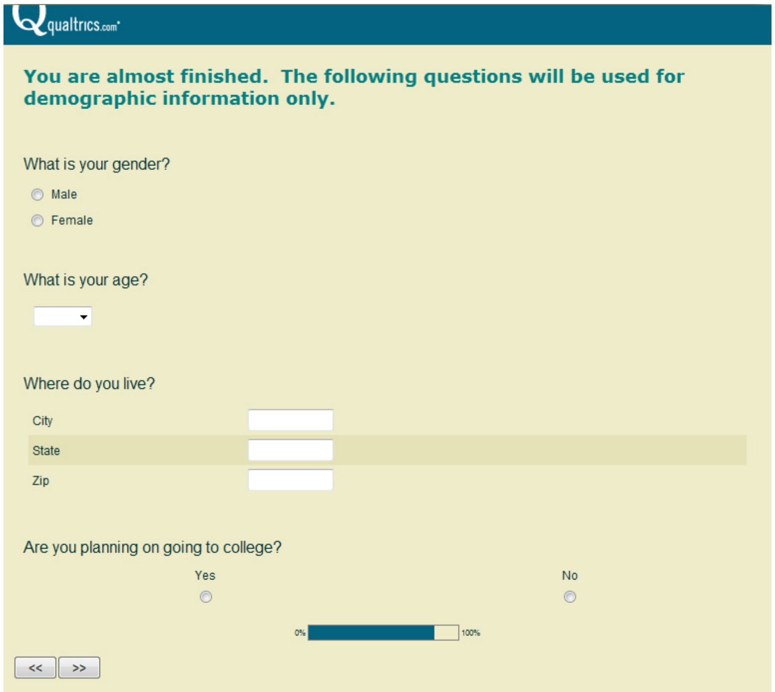
**Figure 5.14:** Technology Block in the First Survey Instrument

- What classes in technology have you taken (check all that apply)?
- What math classes have you taken?
- What software tools do you use (check all that apply)?
- What service-oriented applications do you use (check all that apply)?

### *Demographic Block*

The demographic block provides information about each participant (See Figure 5.15). The last question is posed to determine the student's perceived level of engagement in the survey (See Figure 5.16).

- What is your gender?



**You are almost finished. The following questions will be used for demographic information only.**

What is your gender?

○ Male

○ Female

What is your age?

Where do you live?

| | |
|---|---|
| City | |
| State | |
| Zip | |

Are you planning on going to college?

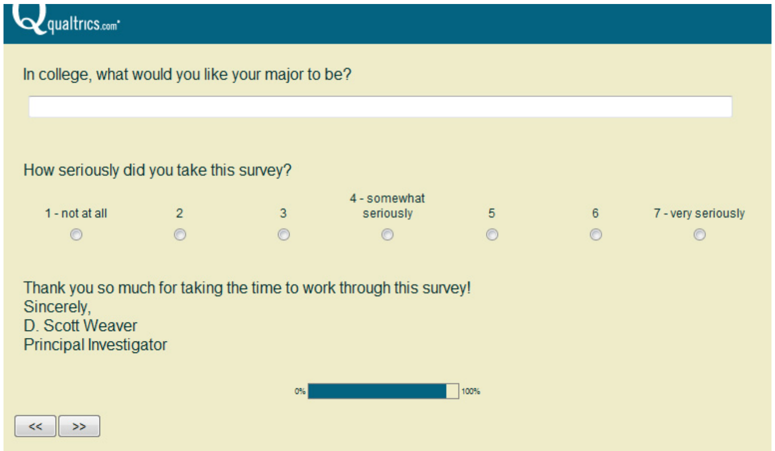
| Yes | No |
|---|---|
| ○ | ○ |

**Figure 5.15:** Technology Block in the First Survey Instrument

- What is your age?
- Where do you live (City, State, Zip)?
- Are you planning on going to college?
- In college, what would you like your major to be?
- How seriously did you take this survey?

### *5.1.2 The Second Survey Instrument*

The second survey instrument was designed to compare student reaction to the Typical Curriculum and the Student-Focused Curriculum. It contained four blocks, the Introduction block, the Typical Curriculum block, the Student-Focused Curriculum block, and the Demographic and Closure block. The individual curricular surveys shared the Introduction, and Demographics and Closure blocks.



In college, what would you like your major to be?

How seriously did you take this survey?

| 1 - not at all | 2 | 3 | 4 - somewhat seriously | 5 | 6 | 7 - very seriously |
|---|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Thank you so much for taking the time to work through this survey!
Sincerely,
D. Scott Weaver
Principal Investigator

**Figure 5.16:** Technology Block in the First Survey Instrument

Figure 5.17 shows the survey flow graphically. The Introduction block introduced the students to the survey. After the introduction, the Qualtrics.com software randomly chose either the Typical Curriculum block or the Student-Focused Curriculum block for each participant so that each participant evaluated only one of the two curricula. No participant evaluated both. An option that the Qualtrics.com software offers is to balance the number of participants for each of the curricular blocks. This was chosen to keep the sample size close, a problem found in the first survey instrument. After a participant completed the Curriculum block provided, the Demographic and Closure block would be presented. After the completion of the Demographic and Closure block, the survey was completed.

### Introduction Block

The Introduction block, shared by both surveys, thanks the students for participating, encourages honest opinions, indicates the approximate time the survey requires, and provided the assurance that the information given would be confidential (See Figure 5.18).

### Curricular Blocks

These Curricular blocks are similar and are broken into two subsections to allow the

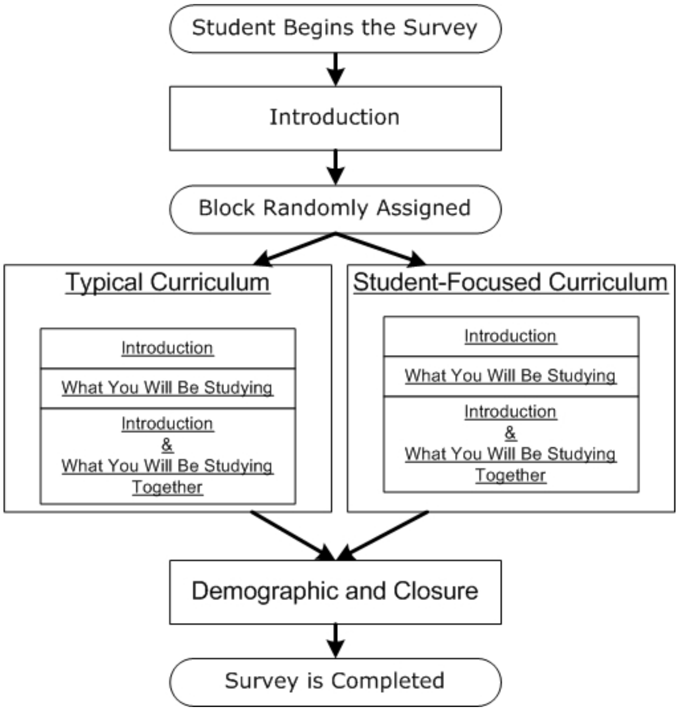
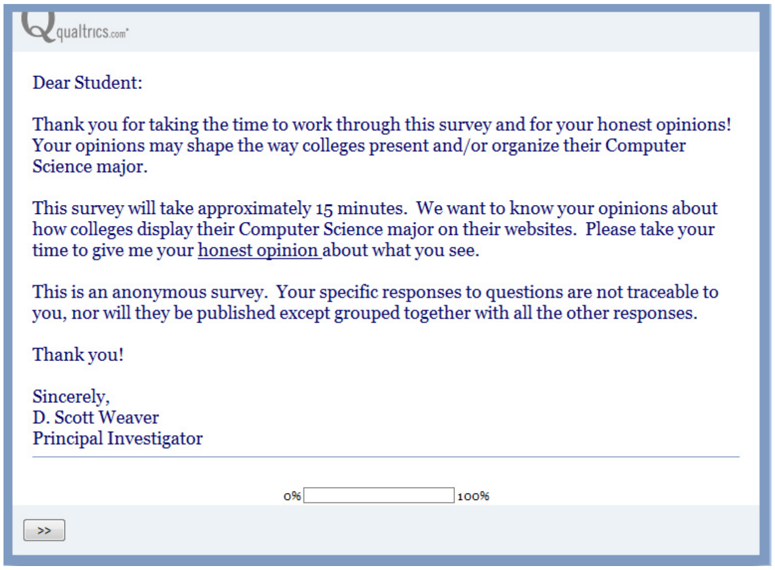


**Figure 5.17:** Survey Flow for the Second Survey Instrument



Dear Student:

Thank you for taking the time to work through this survey and for your honest opinions! Your opinions may shape the way colleges present and/or organize their Computer Science major.

This survey will take approximately 15 minutes. We want to know your opinions about how colleges display their Computer Science major on their websites. Please take your time to give me your honest opinion about what you see.

This is an anonymous survey. Your specific responses to questions are not traceable to you, nor will they be published except grouped together with all the other responses.

Thank you!

Sincerely,
D. Scott Weaver
Principal Investigator

**Figure 5.18:** Introduction Block in the Second Survey Instrument

students to evaluate different parts of the curriculum. The first subsection presents the Introduction to the curriculum and asks questions about what the participant is seeing. The second subsection presents the required courses and asks related questions. Since many of the questions in the Typical Curriculum and Student-Focused Curriculum blocks are similar, they will be explained together.

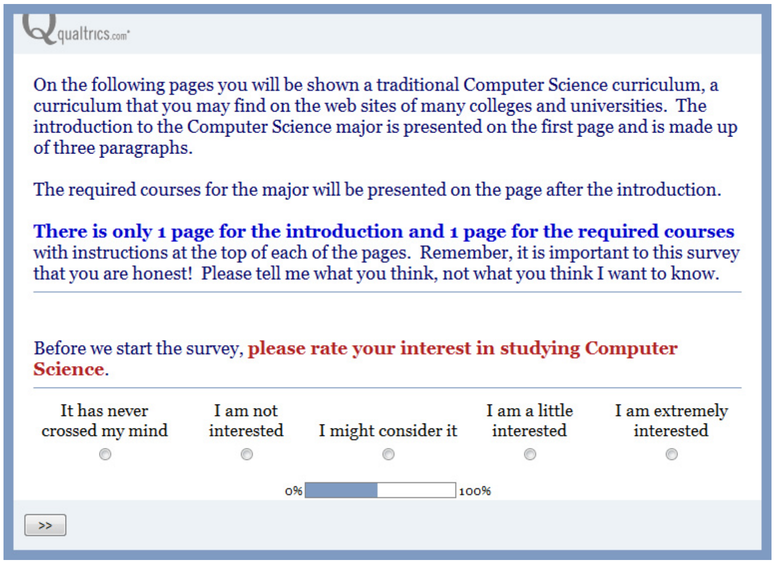
### *Introduction subsection*

The Introduction subsection begins with a description of what the participant can expect to see in the following survey pages. For the Typical Curriculum the description is as follows (See Figure 5.19):

> "On the following pages you will be shown a traditional Computer Science curriculum, a curriculum that you may find on the web sites of many colleges and universities. The introduction to the Computer Science major is presented on the first page and is made up of three paragraphs."
>
> "The required courses for the major will be presented on the page after the introduction."
>
> "There is only 1 page for the introduction and 1 page for the required courses with instructions at the top of each of the pages. Remember, it is important to this survey that you are honest! Please tell me what you think, not what you think I want to know."

The Student-Focused description is as follows (See Figure 5.20):

> "On the following pages you will be shown a Computer Science curriculum. The introduction to the Computer Science major is presented on the first page. The introduction starts with a description of



On the following pages you will be shown a traditional Computer Science curriculum, a curriculum that you may find on the web sites of many colleges and universities. The introduction to the Computer Science major is presented on the first page and is made up of three paragraphs.

The required courses for the major will be presented on the page after the introduction.

**There is only 1 page for the introduction and 1 page for the required courses** with instructions at the top of each of the pages. Remember, it is important to this survey that you are honest! Please tell me what you think, not what you think I want to know.

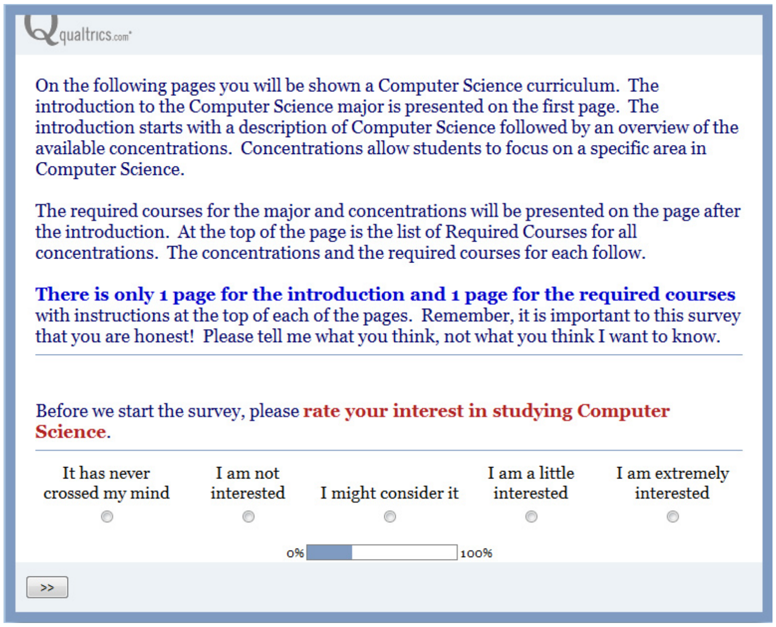
Before we start the survey, **please rate your interest in studying Computer Science**.

| It has never crossed my mind | I am not interested | I might consider it | I am a little interested | I am extremely interested |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

**Figure 5.19:** The Introduction to the Typical Curriculum in the Second Survey Instrument

> Computer Science followed by an overview of the available concentrations. Concentrations allow students to focus on a specific area in Computer Science."
>
> "The required courses for the major and concentrations will be presented on the page after the introduction. At the top of the page is the list of required courses for all concentrations. The concentrations and the required courses for each follow."
>
> "There is only 1 page for the introduction and 1 page for the required courses with instructions at the top of each of the pages. Remember, it is important to this survey that you are honest! Please tell me what you think, not what you think I want to know."

After the descriptions, the student is presented the initial interest question, "Before we start the survey, please rate your interest in studying Computer Science." The purpose of this question is to establish the participant's initial interest in studying computer science. It is then compared to a similar question at the end of the survey.



On the following pages you will be shown a Computer Science curriculum. The introduction to the Computer Science major is presented on the first page. The introduction starts with a description of Computer Science followed by an overview of the available concentrations. Concentrations allow students to focus on a specific area in Computer Science.

The required courses for the major and concentrations will be presented on the page after the introduction. At the top of the page is the list of Required Courses for all concentrations. The concentrations and the required courses for each follow.

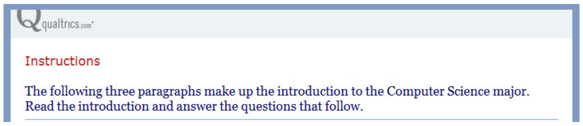
**There is only 1 page for the introduction and 1 page for the required courses** with instructions at the top of each of the pages. Remember, it is important to this survey that you are honest! Please tell me what you think, not what you think I want to know.

Before we start the survey, please **rate your interest in studying Computer Science**.

| It has never crossed my mind | I am not interested | I might consider it | I am a little interested | I am extremely interested |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

Figure 5.20: The Introduction to the Student-Focused Curriculum in the Second Survey Instrument

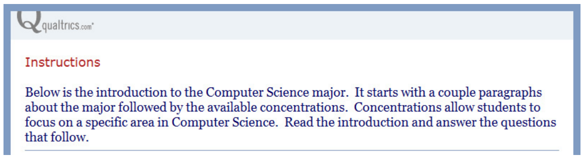
On the page after that initial question, the participant is provided with short instructions followed by the curricular introduction (See Figures 5.21 and 5.22). A section of statements is presented and the student is asked to indicate their level of agreement for each statement. The participant is provided with five levels of agreement based on the Likert scale, “Strongly Disagree”, “Disagree”, “Neither Agree nor Disagree”, “Agree”, and “Strongly Agree” (See Figures 5.23 and 5.24).



Instructions

The following three paragraphs make up the introduction to the Computer Science major. Read the introduction and answer the questions that follow.

Figure 5.21: The Instructions for Evaluating the Typical Curriculum Introduction in the Second Survey Instrument



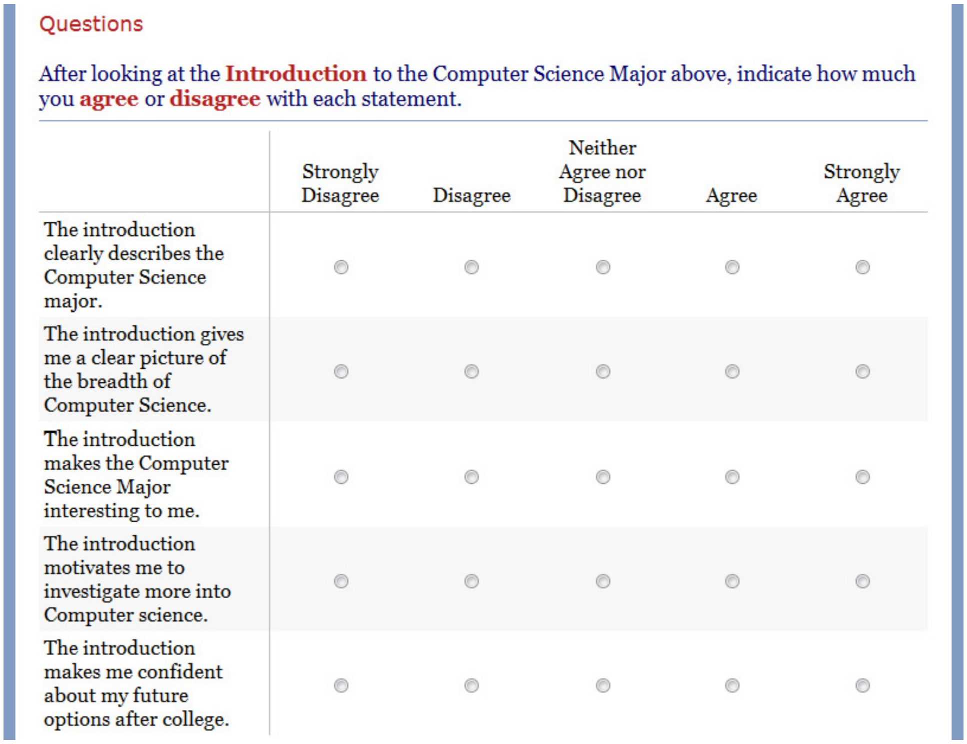
Instructions

Below is the introduction to the Computer Science major. It starts with a couple paragraphs about the major followed by the available concentrations. Concentrations allow students to focus on a specific area in Computer Science. Read the introduction and answer the questions that follow.

Figure 5.22: The Instructions for Evaluating the Student-Focused Curriculum Introduction in the Second Survey Instrument

- After looking at the Introduction of the Computer Science Major above, indicate how much you agree or disagree with each statement.

- The Introduction clearly describes the Computer Science major.
- The Introduction gives me a clear picture of the breadth of Computer science.
- The Introduction makes the Computer Science major interesting to me.
- The Introduction motivates me to investigate more into Computer Science.
- The Introduction makes me confident about my future options after college.



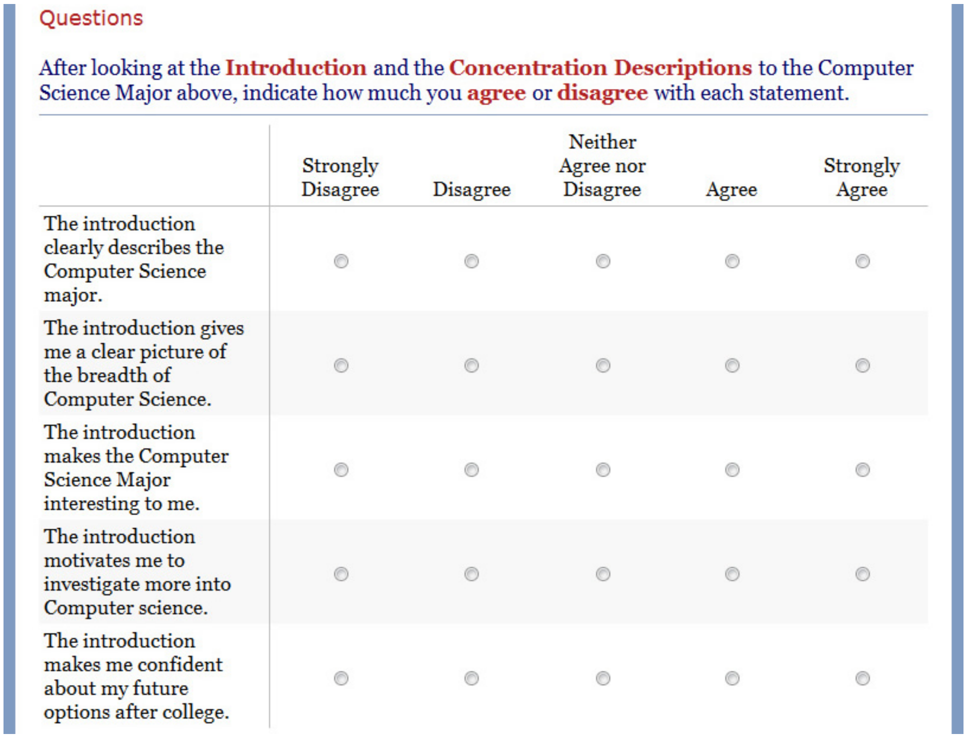
Questions

After looking at the **Introduction** to the Computer Science Major above, indicate how much you **agree** or **disagree** with each statement.

| | Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |
|---|---|---|---|---|---|
| The introduction clearly describes the Computer Science major. | ○ | ○ | ○ | ○ | ○ |
| The introduction gives me a clear picture of the breadth of Computer Science. | ○ | ○ | ○ | ○ | ○ |
| The introduction makes the Computer Science Major interesting to me. | ○ | ○ | ○ | ○ | ○ |
| The introduction motivates me to investigate more into Computer science. | ○ | ○ | ○ | ○ | ○ |
| The introduction makes me confident about my future options after college. | ○ | ○ | ○ | ○ | ○ |

**Figure 5.23:** Rating the Typical Curriculum Introduction in the Second Survey Instrument

The purpose of the participant rating their agreement level to each statement is to determine the effectiveness of the introduction in motivating the participant to investigate the Computer Science major further. The following question attempts to



Questions

After looking at the **Introduction** and the **Concentration Descriptions** to the Computer Science Major above, indicate how much you **agree** or **disagree** with each statement.

| | Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |
|---|---|---|---|---|---|
| The introduction clearly describes the Computer Science major. | ○ | ○ | ○ | ○ | ○ |
| The introduction gives me a clear picture of the breadth of Computer Science. | ○ | ○ | ○ | ○ | ○ |
| The introduction makes the Computer Science Major interesting to me. | ○ | ○ | ○ | ○ | ○ |
| The introduction motivates me to investigate more into Computer science. | ○ | ○ | ○ | ○ | ○ |
| The introduction makes me confident about my future options after college. | ○ | ○ | ○ | ○ | ○ |

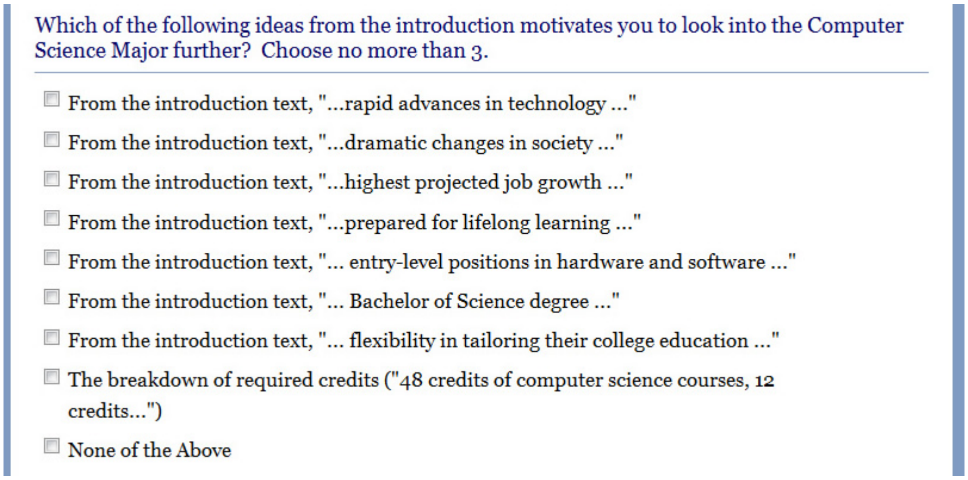
**Figure 5.24:** Rating the Student-Focused Curriculum Introduction in the Second Survey Instrument

identify what part of the introduction was motivating for the participant. Since the curricula are different, the list of options differs (See Figures 5.25 and 5.26).

- Which of the following ideas from the introduction motivates you to look into the Computer Science major further? Chose no more than 3.

### *Required Courses subsection*

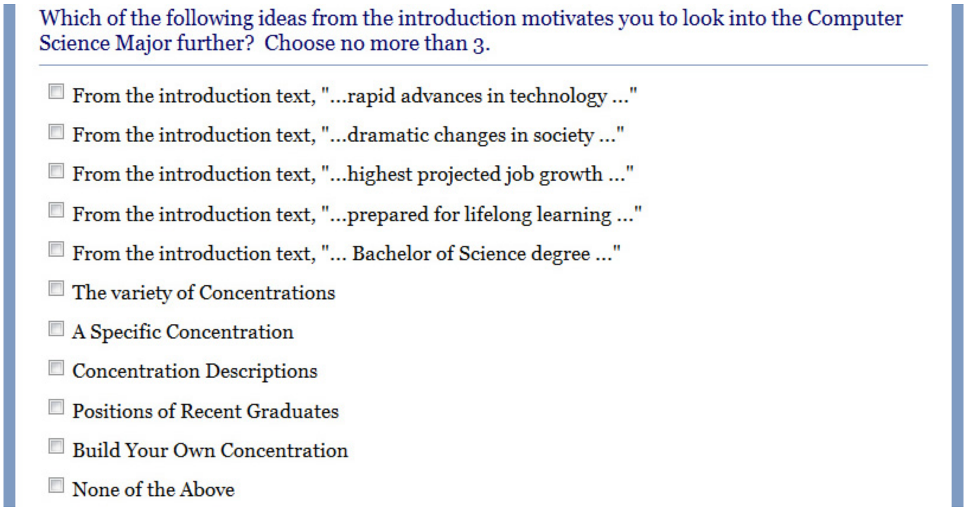
The Required Courses subsection provides brief instructions followed by the requirements for the curriculum being evaluated. For the Typical Curriculum the required course list is presented. For the Student-Focused Curriculum, the core required courses are presented followed by the required courses for each of the six concentrations. The following questions are common to both curricular surveys. The options differ when referring to required courses for the Typical Curriculum versus core requirement details for the Student-Focused Curriculum.



Which of the following ideas from the introduction motivates you to look into the Computer Science Major further? Choose no more than 3.

☐ From the introduction text, "...rapid advances in technology ..."
☐ From the introduction text, "...dramatic changes in society ..."
☐ From the introduction text, "...highest projected job growth ..."
☐ From the introduction text, "...prepared for lifelong learning ..."
☐ From the introduction text, "... entry-level positions in hardware and software ..."
☐ From the introduction text, "... Bachelor of Science degree ..."
☐ From the introduction text, "... flexibility in tailoring their college education ..."
☐ The breakdown of required credits ("48 credits of computer science courses, 12 credits...")
☐ None of the Above

**Figure 5.25:** Motivating Ideas from the Typical Curriculum Introduction in the Second Survey Instrument



Which of the following ideas from the introduction motivates you to look into the Computer Science Major further? Choose no more than 3.

☐ From the introduction text, "...rapid advances in technology ..."
☐ From the introduction text, "...dramatic changes in society ..."
☐ From the introduction text, "...highest projected job growth ..."
☐ From the introduction text, "...prepared for lifelong learning ..."
☐ From the introduction text, "... Bachelor of Science degree ..."
☐ The variety of Concentrations
☐ A Specific Concentration
☐ Concentration Descriptions
☐ Positions of Recent Graduates
☐ Build Your Own Concentration
☐ None of the Above

**Figure 5.26:** Motivating Ideas from the Student-Focused Curriculum Introduction in the Second Survey Instrument

The first question asks the participant to rate their agreement level for each of five statements. Once again the participant is provided with five levels of agreement based on the Likert scale, “Strongly Disagree”, “Disagree”, “Neither Agree nor Disagree”, “Agree”, and “Strongly Agree” (See Figures 5.27 and 5.28).

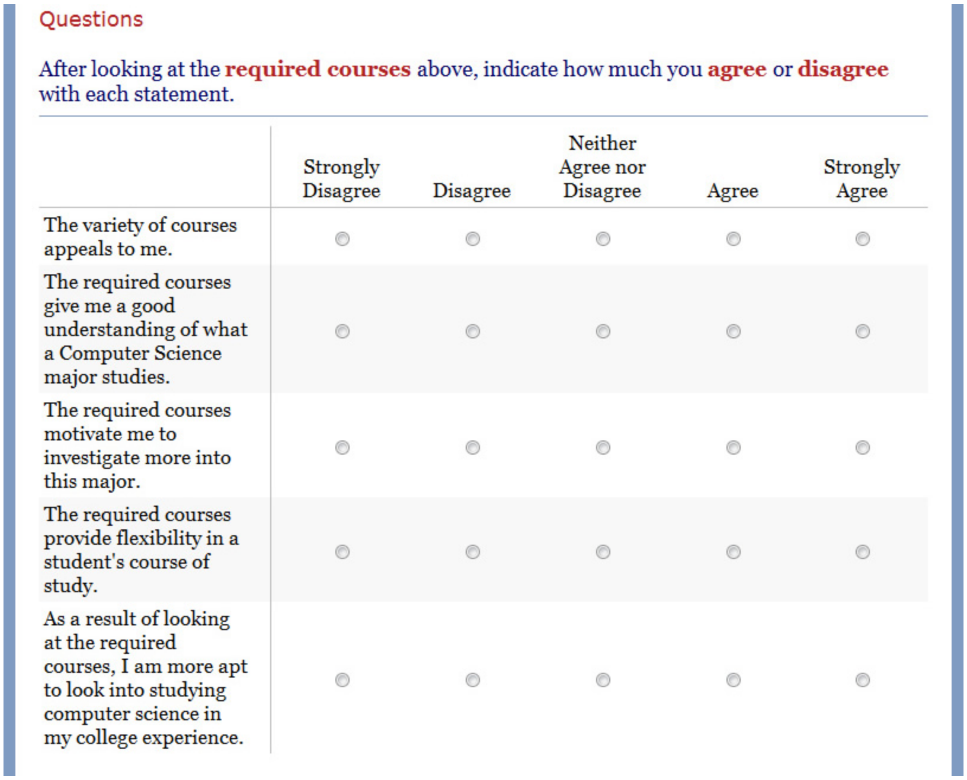
- “After looking at the required courses above, indicate how much you agree or disagree with each statement.”

  **The following are the statements in the Typical Curriculum survey** (See Figure 5.27)

  - The variety of courses appeals to me.”
  - The required courses give me a good understanding of what a Computer Science major studies.
  - The required courses motivate me to investigate more into this major.
  - The required courses provide flexibility in a student’s course of study.
  - As a result of looking at the required courses, I am more apt to look into studying computer science in my college experience.

  **The following are the statements in the Student-Focused Curriculum survey** (See Figure 5.28)

  - The variety of courses and concentrations appeals to me.”
  - The core requirements and concentration details give me a good understanding of what a Computer Science major studies.
  - The core requirements and concentration details motivate me to investigate more into this major.
  - The core requirements and concentration details provide flexibility in a student’s course of study.



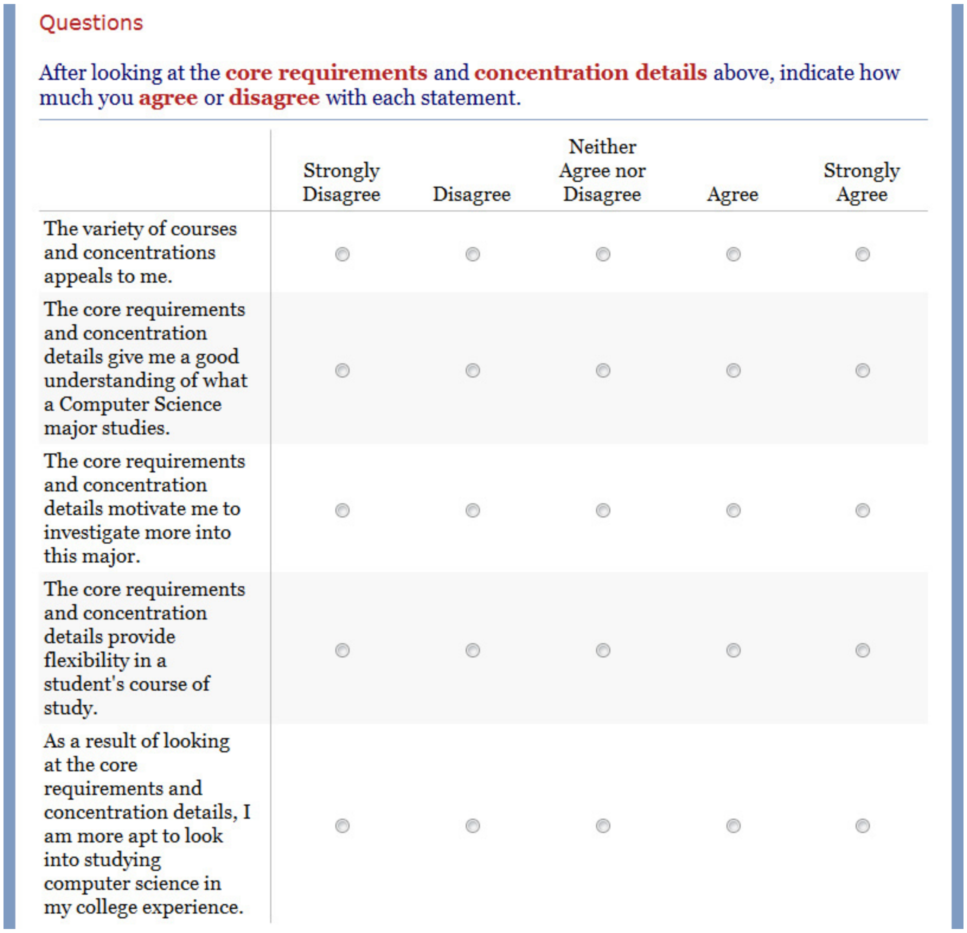
Questions

After looking at the **required courses** above, indicate how much you **agree** or **disagree** with each statement.

| | Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |
|---|---|---|---|---|---|
| The variety of courses appeals to me. | ○ | ○ | ○ | ○ | ○ |
| The required courses give me a good understanding of what a Computer Science major studies. | ○ | ○ | ○ | ○ | ○ |
| The required courses motivate me to investigate more into this major. | ○ | ○ | ○ | ○ | ○ |
| The required courses provide flexibility in a student's course of study. | ○ | ○ | ○ | ○ | ○ |
| As a result of looking at the required courses, I am more apt to look into studying computer science in my college experience. | ○ | ○ | ○ | ○ | ○ |

**Figure 5.27:** Rating the Typical Curriculum Required Courses in the Second Survey Instrument

- ○ As a result of looking at the core requirements and concentration details, I am more apt to look into studying computer science in my college experience.



Questions

After looking at the **core requirements** and **concentration details** above, indicate how much you **agree** or **disagree** with each statement.

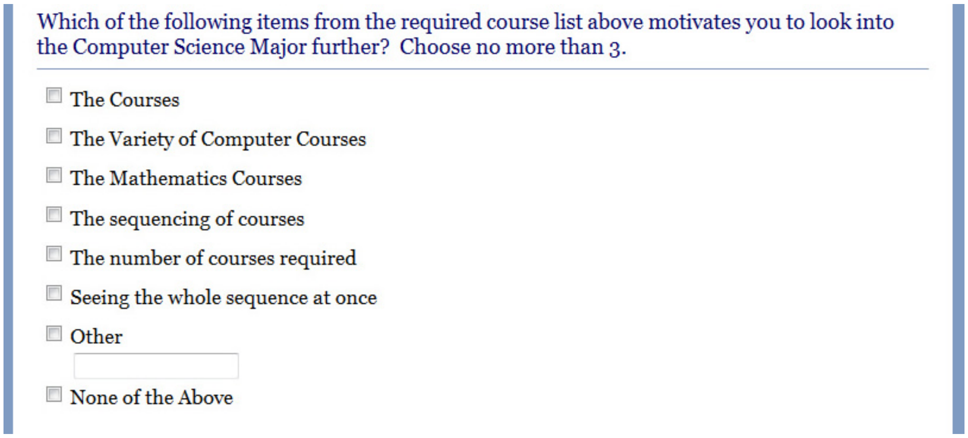
| | Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |
|---|---|---|---|---|---|
| The variety of courses and concentrations appeals to me. | ○ | ○ | ○ | ○ | ○ |
| The core requirements and concentration details give me a good understanding of what a Computer Science major studies. | ○ | ○ | ○ | ○ | ○ |
| The core requirements and concentration details motivate me to investigate more into this major. | ○ | ○ | ○ | ○ | ○ |
| The core requirements and concentration details provide flexibility in a student's course of study. | ○ | ○ | ○ | ○ | ○ |
| As a result of looking at the core requirements and concentration details, I am more apt to look into studying computer science in my college experience. | ○ | ○ | ○ | ○ | ○ |

**Figure 5.28:** Rating the Student-Focused Curriculum Required Courses in the Second Survey Instrument

The next question attempts to identify the part of the required course list that was motivating for the participant. Since the curricula are different, the list of options differs (See Figures 5.29 and 5.30).

**The Typical Curriculum survey asked:** (See Figure 5.29)

- Which of the following items from the required course list above motivates you to look into the Computer Science Major further? Choose no more than 3.



Which of the following items from the required course list above motivates you to look into the Computer Science Major further? Choose no more than 3.

☐ The Courses

☐ The Variety of Computer Courses

☐ The Mathematics Courses

☐ The sequencing of courses

☐ The number of courses required

☐ Seeing the whole sequence at once

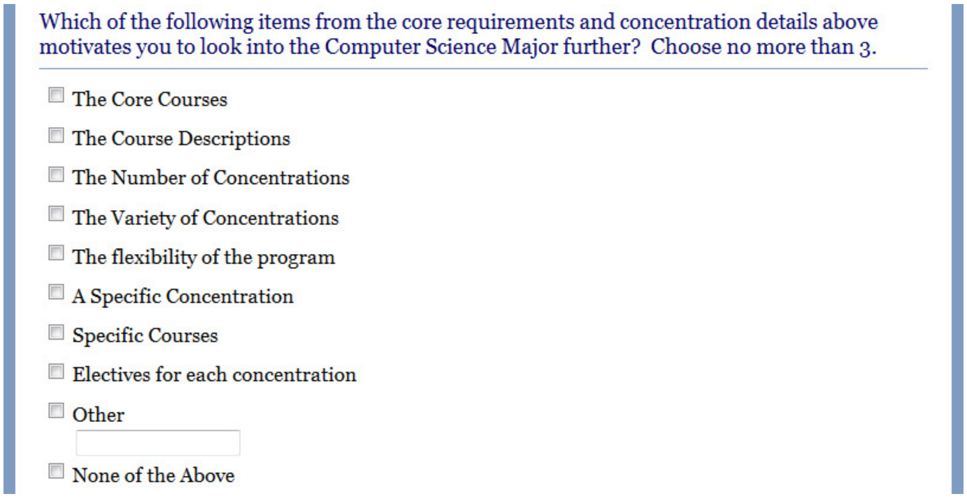
☐ Other

☐ None of the Above

**Figure 5.29:** Motivating Ideas from the Typical Curriculum Required Courses in the Second Survey Instrument

**The Student-Focused Curriculum survey asked:** (See Figure 5.30)

- Which of the following items from the core requirements and concentration details above motivates you to look into the Computer Science Major further? Choose no more than 3.



Which of the following items from the core requirements and concentration details above motivates you to look into the Computer Science Major further? Choose no more than 3.

☐ The Core Courses

☐ The Course Descriptions

☐ The Number of Concentrations

☐ The Variety of Concentrations

☐ The flexibility of the program

☐ A Specific Concentration

☐ Specific Courses

☐ Electives for each concentration

☐ Other

☐ None of the Above

**Figure 5.30:** Motivating Ideas from the Student-Focused Curriculum Required Courses in the Second Survey Instrument

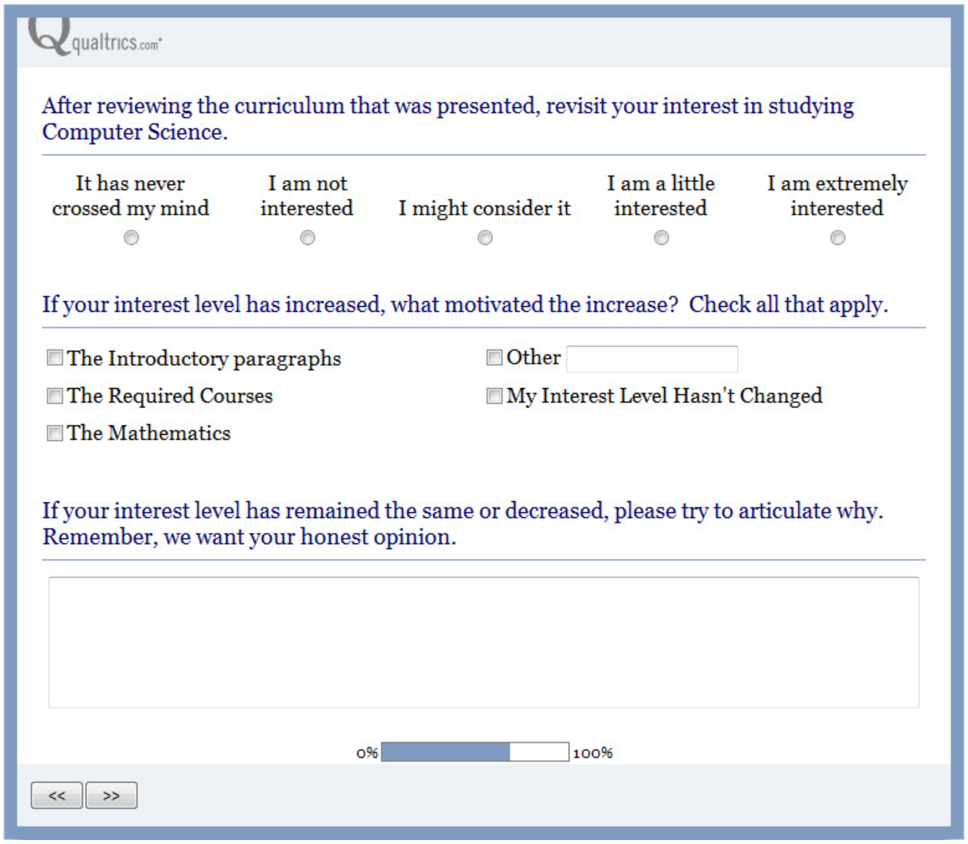
The next page in the survey asks three questions related to the participant's interest prior to proceeding to the Demographic block. The first question revisits the interest question posed at the beginning of the survey and asks the participant to revisit his/her interest in studying Computer Science. The second question provides a list of areas of the curriculum that may have affected the student's interest. The lists between the Typical Curriculum and Student-Focused Curriculum differ since they relate to the specific curricula (See Figures 5.31 and 5.32). The third question is an open-ended question designed to focus on the reason behind a participant's interest level remaining the same or dropping.

- After reviewing the curriculum that was presented, revisit your interest in studying Computer Science.
- If your interest level has increased, what motivated the increase? Check all that apply.
- If your interest level has remained the same or decreased, please try to articulate why. Remember, we want your honest opinion.

### Demographic Block

The demographic block provides information about each participant. The last question is posed to determine the student's perceived level of engagement in the survey (See Figures 5.33 and 5.34).

- What is your gender?
- What is your age?
- Where do you live (City, State, Zip)?
- Are you planning on going to college?
- In college, what would you like your major to be?



After reviewing the curriculum that was presented, revisit your interest in studying Computer Science.

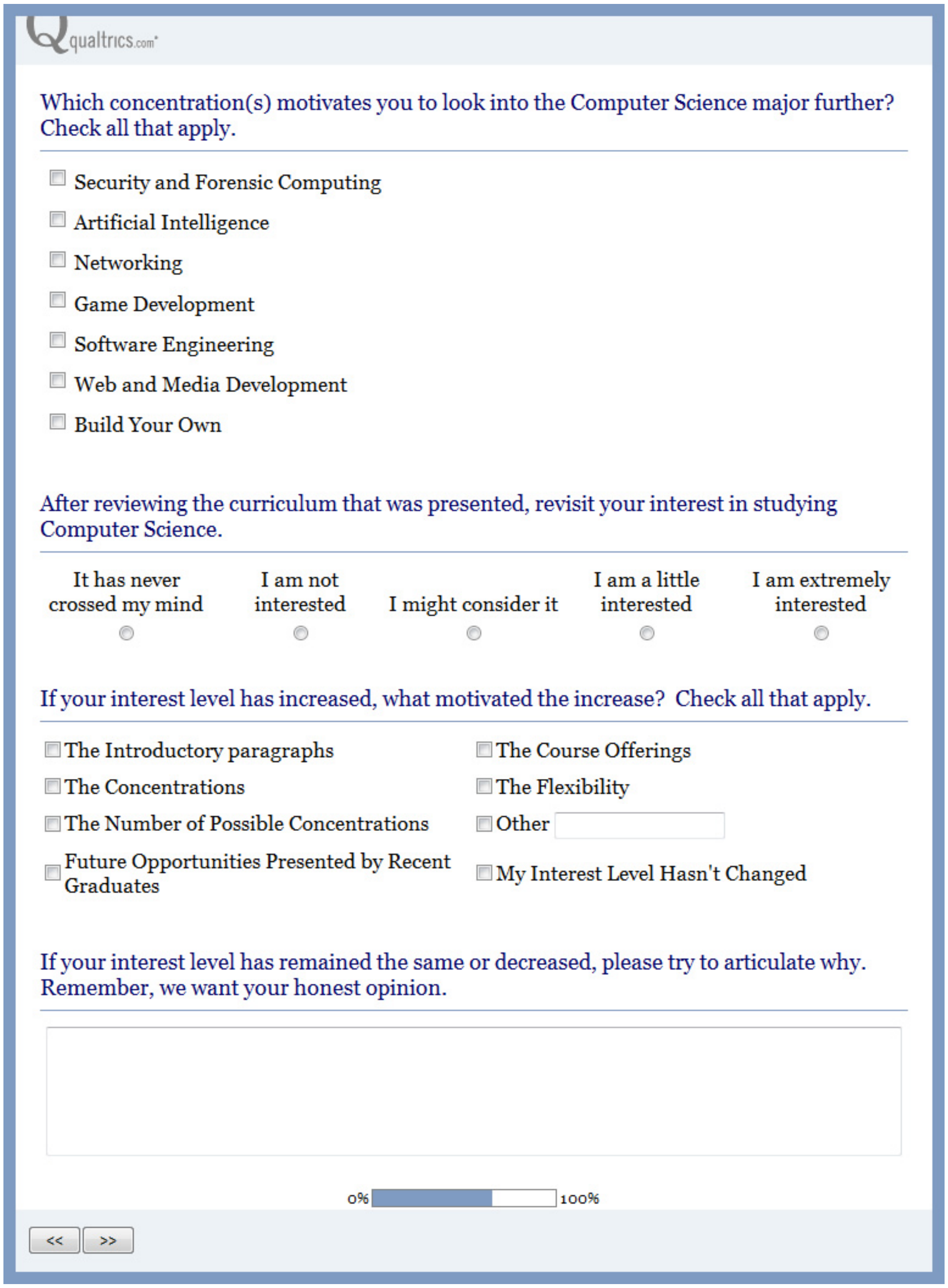
| It has never crossed my mind | I am not interested | I might consider it | I am a little interested | I am extremely interested |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

If your interest level has increased, what motivated the increase? Check all that apply.

☐ The Introductory paragraphs
☐ The Required Courses
☐ The Mathematics
☐ Other
☐ My Interest Level Hasn't Changed

If your interest level has remained the same or decreased, please try to articulate why. Remember, we want your honest opinion.

**Figure 5.31:** Interest In the Typical Curriculum in the Second Survey Instrument



Which concentration(s) motivates you to look into the Computer Science major further? Check all that apply.

☐ Security and Forensic Computing
☐ Artificial Intelligence
☐ Networking
☐ Game Development
☐ Software Engineering
☐ Web and Media Development
☐ Build Your Own

After reviewing the curriculum that was presented, revisit your interest in studying Computer Science.

| It has never crossed my mind | I am not interested | I might consider it | I am a little interested | I am extremely interested |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

If your interest level has increased, what motivated the increase? Check all that apply.

☐ The Introductory paragraphs
☐ The Concentrations
☐ The Number of Possible Concentrations
☐ Future Opportunities Presented by Recent Graduates
☐ The Course Offerings
☐ The Flexibility
☐ Other
☐ My Interest Level Hasn't Changed

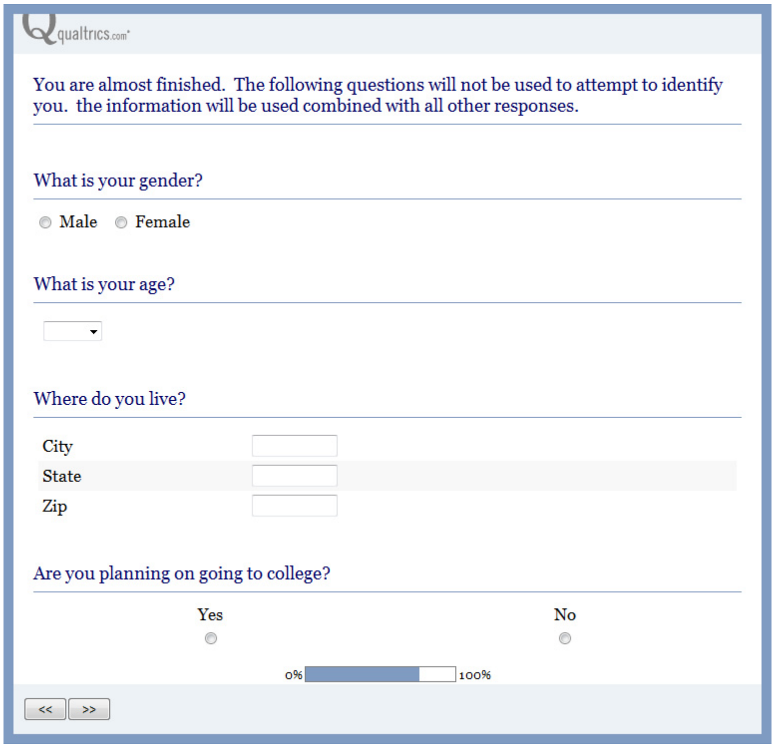
If your interest level has remained the same or decreased, please try to articulate why. Remember, we want your honest opinion.

**Figure 5.32:** Interest In the Student-Focused Curriculum in the Second Survey Instrument

- Have you looked at any college curriculum online?
- Has looking at the college curriculum online influenced you toward a major?
- What Advanced Placement courses have you taken or are currently taking? Check all that apply.
    - Biology
    - Calculus AB or BC
    - Chemistry
    - Computer Science
    - Physics B or C
    - Statistics
    - Other
- How seriously did you take this survey?

### *5.1.3 Selection of Participants*

For the first survey instrument, the participants were invited to participate from several groups which include students from Mechanicsburg Area High School who participated in the focus groups, students from Mechanicsburg Area High School enrolled in Advanced Placement Computer Science, and high school students across the United States whose teachers participated in the Advanced Placement Computer Science reading in 2008. Invitations were sent out via email with the students who participated in the focus groups emailed directly. Teachers of other students were emailed with instructions on how their students could participate.



You are almost finished. The following questions will not be used to attempt to identify you. the information will be used combined with all other responses.

What is your gender?

○ Male ○ Female

What is your age?

Where do you live?

City
State
Zip

Are you planning on going to college?

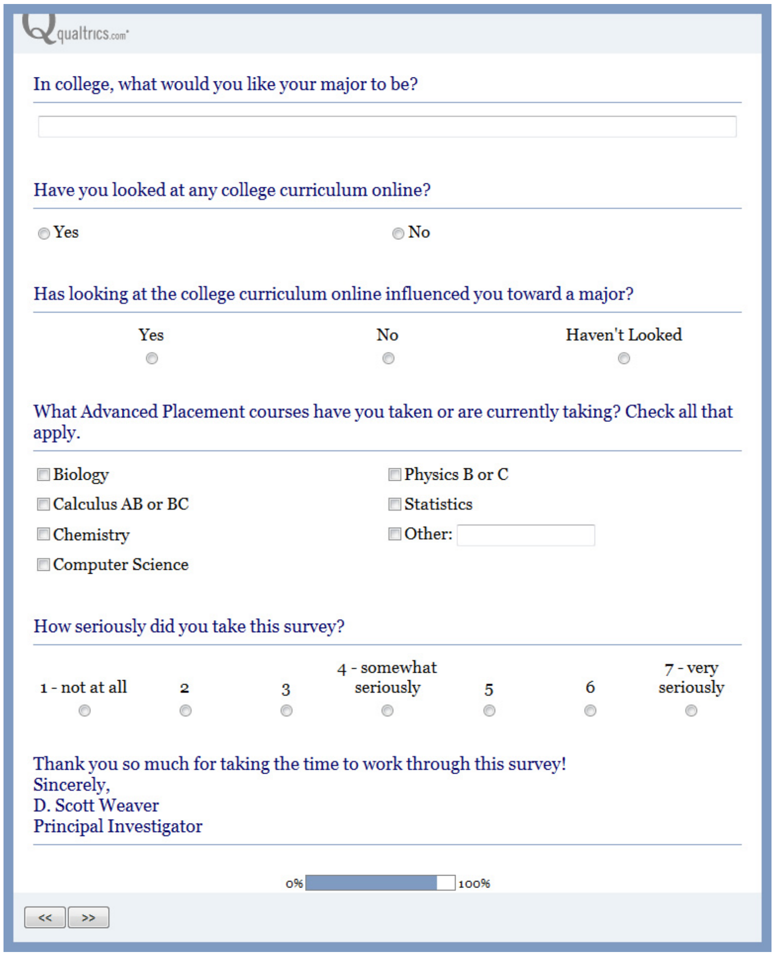
| Yes | No |
|---|---|
| ○ | ○ |

**Figure 5.33:** Interest In the Typical Curriculum in the Second Survey Instrument

The second survey instrument was conducted a year after the first survey instrument, and therefore, had different student populations. For the second survey instrument, participants were invited from similar groups including students from Mechanicsburg Area High School enrolled in Advanced Placement Computer science courses and Business Applications course, and high school students across the United States whose teachers participated in the Advanced Placement Computer Science reading in 2008. All participants were contacted through their teachers who were sent emails soliciting their help and providing instructions on how their students could participate in the surveys.

### *5.1.4 Privacy and Confidentiality*

In soliciting help for the surveys, the teachers emailed had indicated a willingness to participate in the research in an informal survey passed around during the



In college, what would you like your major to be?

Have you looked at any college curriculum online?

○ Yes ○ No

Has looking at the college curriculum online influenced you toward a major?

| Yes | No | Haven't Looked |
|---|---|---|
| ○ | ○ | ○ |

What Advanced Placement courses have you taken or are currently taking? Check all that apply.

☐ Biology
☐ Calculus AB or BC
☐ Chemistry
☐ Computer Science
☐ Physics B or C
☐ Statistics
☐ Other:

How seriously did you take this survey?

| 1 - not at all | 2 | 3 | 4 - somewhat seriously | 5 | 6 | 7 - very seriously |
|---|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Thank you so much for taking the time to work through this survey!
Sincerely,
D. Scott Weaver
Principal Investigator

**Figure 5.34:** Interest In the Student-Focused Curriculum in the Second Survey Instrument

Advanced Placement Computer Science reading in 2008. The Mechanicsburg Area High School teachers involved in the other research activities indicated they were willing to participate in the following surveys. In the first survey instrument, the individual students emailed had participated in a focus group and was informed that they would participate in a final survey, unless they chose not to. Therefore, the emails should not be viewed as an unauthorized intrusion that violates the individual's privacy.

The Qualtrics.com software administered the surveys and did not require any form of login, thus providing anonymity. The questions within the survey were designed to be answered without identifying information and therefore could not be used in any way to identify specific individuals. Therefore, the conducting of the surveys did not violate the participant's confidentiality.

### *5.1.5 Distribution, Response Management, and Administration*

Email was the main tool in soliciting participants for the survey tools. The email for Advanced Placement teachers was sent to people in the researcher's contact list. Thirty teachers were contacted for both survey instruments. Each email contained a target deadline for the completion of the survey.

During the second survey instrument, the researcher received several replies indicating that the teacher's students could not participate in the survey until after the Advanced Placement exam, which fell after the proposed deadline, therefore, deadline was moved beyond the exam date.

### *5.1.6 Pilot*

Both survey instruments were piloted by two sets of Messiah College students. The first survey instrument was piloted by 15 students, the second by 6 students. The students were encouraged to focus on the ease of use and understandability of the surveys. The purpose of the pilot was to eliminate ambiguity, estimate the time required to take the survey, shorten the survey where necessary, rework troubled areas, and clarify questions posed throughout the survey. Revisions were made based on the feedback given.

### *5.1.7 Initial Release*

The second survey instrument was initially released to the students at Mechanicsburg Area High School in the Advanced Placement Computer Science and Business Applications courses. The purpose for the initial release was to ensure that the survey was functioning properly, questions were understandable, and no unforeseen problems occurred. The feedback from the researcher's contacts ensured this was so. All other contacts were emailed two days later to participate in the surveys.

## 5.2 Results of the First Curricular Presentation Surveys

The complete survey can be found in Appendix I. The previous section described the procedures used to develop the surveys. The first survey instrument was developed to compare student reaction to a Typical Computer Science Curriculum versus a Job-Focused Curriculum and combined a survey for the Typical Computer Science Curriculum and a survey for the Job-Focused Curriculum. Sixty-nine students participated in this instrument. Thirty-three students took the Typical

Curriculum survey and twenty-nine finished it, nineteen took the Job-Focused survey and six finished it.

The target population for each survey instrument was high school students. The first survey was administered after many of the students had already left school for summer vacation; therefore, the sample sizes are small.

### *5.2.1 Typical Computer Science Curriculum Survey Responses*

#### Initial Interest Question

The first question posed to participants prior to seeing any portion of the curriculum asks about their initial interest in studying Computer Science (See Table 5.1). The last question posed after the participants have evaluated the curriculum asked them to revisit their interest in studying Computer Science (See Table 5.11). The purpose is to determine if their interest level has changed based on the curriculum they have been evaluating. Below are the results of the first interest question.

**Question 1**: Before we start the survey, please rate your interest in studying Computer Science.

| Level | Responses |
|---|---|
| It has never crossed my mind (1) | 4 |
| I am not interested (2) | 15 |
| I might consider it (3) | 6 |
| I am a little interested (4) | 4 |
| I am extremely interested (5) | 4 |

**Table 5.1:** Typical Curriculum: Students' Initial Interest in Studying Computer Science

**Curriculum Introduction** The survey displays the introduction to the Typical Curriculum shown in Figure 1.5 followed by several questions asking the participant's opinions about the introduction.

**Question 1**: After looking at the Introduction above, how well do you think you understand what this major is about?

The majority of students, 67%, understand the major a little bit based on the Introduction (See Table 5.2). Ten students, 30%, indicate the Introduction makes understanding the major extremely clear.

| Understand the Major | Responses |
|---|---|
| I don't understand it at all (1) | 1 |
| I understand it a little bit (2) | 22 |
| It is extremely clear (3) | 10 |
| Average based on choice values 1-3 | 2.273 |

**Table 5.2:** Typical Curriculum: Responses to the Introduction Fostering Understanding about the Major

**Question 2**: After looking at the Introduction above, how well do you think you understand what jobs you could apply for after graduation?

The majority of the students, 73%, indicate they have a general idea of the jobs that could be applied for after graduation (See Table 5.3).

| Understand Job Availability | Responses |
|---|---|
| I have no idea (1) | 3 |
| I have a general idea (2) | 24 |
| It is extremely clear (3) | 6 |
| Average based on choice values 1-3 | 2.090 |

**Table 5.3:** Typical Curriculum: Responses to the Introduction Fostering Understanding about Jobs

### What You Will Be Studying

Following the Introduction, the survey displays the “What You Will Be Studying” section (See Figure 1.6) and asks participants questions relating to what they have been presented.

**Question 1**: After looking at What You Will Be Studying above, how well do you think you understand what you will be studying?

About 48% of the students have a little understanding of what they will be studying after looking at the “What You Will Be Studying” section, whereas 52% indicate it is extremely clear (See Table 5.4).

| Understanding What Will Be Studied | Responses |
|---|---|
| I don’t understand at all (1) | 0 |
| I understand a little bit (2) | 16 |
| It is extremely clear (3) | 17 |
| Average based on choice values 1-3 | 2.515 |

**Table 5.4:** Typical Curriculum: Responses to What You Will Be Studying Fostering Understanding in What is Studied

**Question 2**: Which courses look interesting (check all that apply)?

The courses that over half of the students indicate look interesting include Computer Graphics, 74%, Artificial Intelligence, 71%, and Computer Architecture, 50% (See Table 5.5). However, the question does not address what the students think the courses are about.

**Question 3**: How important is knowing the exact courses and course names you will be taking?

The majority of the students, 70%, indicate that it is extremely important to know the exact courses and course names in what they will be studying (See Table 5.6).

**Question 4**: How important is it to you to know the required course list?

Most of the students, 82%, responded that it is extremely important to know the required courses for your major (See Table 5.7). Only 18% replied that it was only a little bit important. No one indicated it had no importance.

| Courses | Response | % |
|---|---|---|
| Computer Graphics (14) | 25 | 74% |
| Artificial Intelligence (17) | 24 | 71% |
| Computer Architecture (10) | 17 | 50% |
| Software Engineering (15) | 15 | 44% |
| Programming Languages (9) | 13 | 38% |
| Algorithms and Complexity (5) | 13 | 38% |
| Introduction to Computer Science (1) | 12 | 35% |
| Programming I (2) | 11 | 32% |
| Computer Hardware (8) | 9 | 26% |
| Operating Systems (11) | 9 | 26% |
| Data Structures (4) | 8 | 24% |
| Programming II (3) | 7 | 21% |
| Computer Org. & Assembly Lang. (6) | 7 | 21% |
| System Programming Concepts (7) | 6 | 18% |
| Database Concepts (13) | 6 | 18% |
| Computer Science Capstone (12) | 4 | 12% |
| Compiler Design (18) | 5 | 15% |
| Data Comm. & Networking (16) | 4 | 12% |

**Table 5.5:** Typical Curriculum: Interest in Courses Listed in Rank Order

| Importance of knowing Exact Courses | Responses |
|---|---|
| It is not important (1) | 2 |
| It is a little bit important (2) | 8 |
| It is extremely important (3) | 23 |
| Average based on choice values 1-3 | 2.636 |

**Table 5.6:** Typical Curriculum: Importance of Exact Course List and Course Names

| Importance of knowing Required Course List | Responses |
|---|---|
| It is not important (1) | 0 |
| It is a little bit important (2) | 6 |
| It is extremely important (3) | 27 |
| Average based on choice values 1-3 | 2.818 |

**Table 5.7:** Typical Curriculum: Importance of Required Course List

### Both Sections Together

After the section “What You Will Be Studying,” the survey presents both sections together and asks participants questions about the curriculum as a whole.

**Question 1**: Above are both sections you've been shown before. Put the following items in the order you think is important with the most important at the top. The items are listed as they appear above.

Students indicated their ranking of the items within the curriculum presented that were important in Table 5.8.

| Section Importance | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Introduction (The first 3 paragraphs) (1) | 27 | 2 | 4 | 1 |
| Course Number (The 1st column) (2) | 0 | 15 | 5 | 14 |
| Course Name (The 2nd column) (3) | 7 | 11 | 15 | 1 |
| Course Credits (The 3rd column) (4) | 0 | 6 | 10 | 18 |

**Table 5.8:** Typical Curriculum: Importance of Items in the Curriculum

The Borda method is used to analyze data from questions that seek priority ordering or rank ordering. Table 5.9 provides the Borda data and score indicating the Introduction being the most important part of the Typical Curriculum followed by course name, course number and course credits.

| Rank | Section Importance | 1 | 2 | 3 | 4 | Borda Score |
|---|---|---|---|---|---|---|
| 1 | Introduction (The first 3 paragraphs) (1) | 104 | 6 | 8 | 1 | 119 |
| 2 | Course Name (The 2nd column) (2) | 28 | 33 | 30 | 1 | 90 |
| 3 | Course Number (The 1st column) (3) | 0 | 42 | 10 | 14 | 66 |
| 4 | Course Credits (The 3rd column) (4) | 0 | 18 | 20 | 18 | 55 |

**Table 5.9:** Typical Curriculum: Importance of Items in the Curriculum Ranked by Borda Scores

However, in analyzing the data, thirteen responses prioritize the data in the order it was presented, which makes those results suspect. Table 5.10 removes the suspected rank entries and shows the recomputed Borda scores. The first and second items have not changed, but the third and fourth have switched places.

| Rank | Section Importance | 1 | 2 | 3 | 4 | Borda Score |
|---|---|---|---|---|---|---|
| 1 | Introduction (The first 3 paragraphs) (1) | 52 | 6 | 8 | 1 | 67 |
| 2 | Course Name (The 2nd column) (2) | 28 | 33 | 2 | 1 | 64 |
| 4 | Course Credits (The 3rd column) (3) | 0 | 18 | 20 | 4 | 42 |
| 3 | Course Number (The 1st column) (4) | 0 | 3 | 10 | 14 | 27 |

**Table 5.10:** Typical Curriculum: Importance of Items in the Curriculum Ranked by Borda Scores with Suspect Responses Removed

The following questions were open ended. The responses have been summarized below.

**Question 2**: What do you like the most about what you've been shown (the Introduction and What You Will Be Studying)?

1. The course list is simple and understandable. 18 responses referred to this in some fashion.
2. The introduction is clear and sparks interest. Nine responses referred to this.
3. The format of the presented curriculum. Three responses.
4. Job opportunities and flexibility of the curriculum both had a single response.

**Question 3**: What do you like the least about what you've been shown (the Introduction and What You Will Be Studying)?

1. Ten of the participants refer to the introduction as boring, bland, and not very descriptive.
2. Nine participants indicated that there are no specifics or descriptions to the courses listed and that they did not understand what the courses meant.

3. Five responses referred to the “What You Will Be Studying” section being overwhelming, or identified a specific course they did not like.
4. Three responses felt the curriculum was too difficult.
5. Two responses indicated the course numbers have no meaning.

**Question 4**: What could be added that would help you understand the major better?

1. Twenty responses indicate course details and descriptions are necessary.
2. Seven indicated job opportunities would be helpful, with one indicating jobs held by previous majors would be helpful.

**Question 5**: After reading the Introduction and What You Will Be Studying, revisit your interest in studying Computer Science.

There was a slight increase in interest level after taking the Typical Curriculum survey. Two students who previously indicated studying Computer Science had never crossed their mind indicated they are not interested (6%) indicating what they observed within the curriculum helped them realize that Computer Science is not something they have interest in studying. However, the interest level of several others increased (See Table 5.11).

Table 5.12 show the changes in interest levels from the beginning of the survey to the end. The interest level of nine students increased, the interest level of twenty-two students remained the same, and the interest level of three students declined. Though this appears a positive result, sixteen of the thirty-four students (47%) remain within the “not interested” area while only nine (26%) are within the

| Interest Level | Previous Interest Level | Current Interest Level |
|---|---|---|
| It has never crossed my mind (1) | 4 | 2 |
| I am not interested (2) | 15 | 14 |
| I might consider it (3) | 6 | 9 |
| I am a little interested (4) | 4 | 5 |
| I am extremely interested (5) | 4 | 4 |

**Table 5.11:** Typical Curriculum: Students' Interest Level in Studying Computer Science After Taking the Survey

interested area. The data suggests that the students are still not interested in Computer Science based on the Typical Curriculum.

| | |
|---|---|
| Positive Change | 9 (26%) |
| No Change | 22 (65%) |
| Negative Change | 3 ( 9%) |

**Table 5.12:** Typical Curriculum: Change in Interest Level

### *5.2.2 Job-Focused Curriculum Responses*

#### Initial Interest Question

The first question posed to participants prior to seeing any portion of the curriculum asked about their initial interest in studying Computer Science. The last question posed after the participants have evaluated the curriculum asked them to revisit their interest in studying Computer Science. The purpose was to determine if their interest level has changed based on the curriculum they have been evaluating. Below are the results of the first interest question.

**Question 1**: Before we start the survey, please rate your interest in studying Computer Science.

Almost half of the students taking the Job-Focused Curriculum survey (47%)

indicated they were not interested in studying Computer Science (See Table 5.13). 16% indicated they were a little bit interested in studying Computer Science while 21% indicated an extreme interest.

| Interest Level | Responses |
|---|---|
| It has never crossed my mind (1) | 0 |
| I am not interested (2) | 9 |
| I might consider it (3) | 3 |
| I am a little interested (4) | 3 |
| I am extremely interested (5) | 4 |

**Table 5.13:** Job-Focused: Students' Initial Interest Level in Studying Computer Science

### Curriculum Introduction

The survey displays the introduction to the Job-Focused Curriculum (See Figure 3.2) followed by several questions asking the participant's opinions about the introduction.

**Question 1**: After looking at the Introduction above, how well do you think you understand what this major is about?

After looking at the Introduction to the Job-Focused Curriculum, 63% of the students indicated they had a general idea of what he major was all about, 32% indicated the Introduction made it extremely clear, while the rest, 5%, indicated the Introduction did not help them understand what the major was about (See Table 5.14).

**Question 2**: After looking at the Introduction above, how well do you think you understand what jobs you could apply for after graduation?

The majority of the students, 84%, thought that the Introduction provided a general idea of what jobs could be applied for after graduation (See Table 5.15).

| Understand the Major | Responses |
|---|---|
| I don't understand it at all (1) | 1 |
| I understand it a little bit (2) | 12 |
| It is extremely clear (3) | 6 |
| Average based on choice values 1-3 | 2.263 |

**Table 5.14:** Job-Focused: Responses to the Introduction Fostering Understanding about the Major

| Understand Job Availability | Responses |
|---|---|
| I have no idea (1) | 1 |
| I have a general idea (2) | 16 |
| It is extremely clear (3) | 2 |
| Average based on choice values 1-3 | 2.053 |

**Table 5.15:** Job-Focused: Responses to the Introduction Fostering Understanding about Jobs

**Question 3**: Which concentrations look interesting to you (check all that apply or None of the Above)?

Only one concentration, Game Development, looked interesting to half the students taking the survey. Three others, Web Development, 42%, Security, 38%, and Software Engineering and Application Development, 33%, were interesting to over a third of the students (See Table 5.16).

| Answer | Response | % |
|---|---|---|
| Game Development (2) | 12 | 50% |
| Web Development (1) | 10 | 42% |
| Security (4) | 9 | 38% |
| Software Engineering, Application Development (6) | 8 | 33% |
| Database (5) | 5 | 21% |
| Theory and Analysis (8) | 5 | 21% |
| Networking (3) | 3 | 13% |
| Technology Infrastructure (7) | 3 | 13% |
| None of the Above (9) | 3 | 13% |

**Table 5.16:** Job-Focused: Interest in Concentrations Listed in Rank Order

**Question 4**: Put the concentrations you chose in the order of interest to you with the most interesting at the top.

The students were asked to put the concentrations that they chose for Question 3 in order of interest. To determine the aggregate rank, the Borda method was used to evaluate the results of this question. The top four that were chosen in Question 3 were also the top four in rank order (See Table 5.17).

| Concentration | Borda Value |
|---|---|
| Game Development (1) | 95 |
| Web Development (2) | 72 |
| Security (3) | 63 |
| Software Engineering, Application Development (4) | 51 |
| Theory and Analysis (5) | 29 |
| Database (6) | 16 |
| Technology Infrastructure (7) | 13 |
| Networking (8) | 10 |

**Table 5.17:** Job-Focused: Interest in Concentrations Listed by Borda Value

### What You Will Be Studying

Following the Introduction, the survey displays the "What You Will Be Studying" section (See Figure 3.3) and asks participants questions relating to what they have been presented.

**Question 1**: After looking at What You Will Be Studying above, how well do you think you understand what you will be studying?

Over half the students, 53%, chose the middle option, indicating they understand what they would be studying based on the "What You Will Be Studying" section (See Table 5.18). Another 42% indicate they believe that section makes it extremely clear.

| Importance of knowing Exact Courses | Responses |
|---|---|
| I don't understand at all (1) | 1 |
| I understand a little bit (2) | 10 |
| It is extremely clear (3) | 8 |
| Average based on choice values 1-3 | 2.368 |

**Table 5.18:** Job-Focused: Responses to What You Will Be Studying Fostering Understanding in What is Studied

**Question 2**: How important is knowing the exact courses and course names you will be taking?

The majority of the students, 63%, indicate that knowing the exact courses and course names of what they would be studying is extremely important (See Table 5.19) which is similar to those taking the Typical Curriculum survey (70%) (See Table 5.6).

| Importance of knowing Exact Courses | Responses |
|---|---|
| It is not important (1) | 3 |
| It is a little bit important (2) | 4 |
| It is extremely important (3) | 12 |
| Average based on choice values 1-3 | 2.474 |

**Table 5.19:** Job-Focused: Importance of Exact Course List and Course Names

**Question 3**: How important is it to you to know the required course list?

The majority of the students, 78%, indicated that it is extremely important to know the required courses for your major (See Table 5.20) which again is similar to those taking the Typical Curriculum survey, 82% (See Table 5.7). Only two students, 11%, indicated it is not important at all while the other two indicated it has a little importance. In other words, most students looking at a curriculum need to know what courses they are required to take.

| Importance of knowing Required Course List | Responses |
|---|---|
| Not important at all (1) | 2 |
| A little bit important (2) | 2 |
| Extremely important (3) | 15 |
| Average based on choice values 1-3 | 2.684 |

**Table 5.20:** Job-Focused: Importance of Required Course List

### Both Sections Together

After the section "What You Will Be Studying," the survey presents both sections together and asks participants questions about the curriculum as a whole.

**Question 1**: Above are both sections you've been shown before. Put the following items in the order you think is important with the most important at the top. The items are listed as they appear above.

| Curricular Item | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| The Introduction (The first paragraph) | 14 | 0 | 0 | 1 | 0 | 2 | 2 |
| Concentration Areas (Listed in both areas -i.e. Web Development, Game Development...) | 2 | 10 | 3 | 1 | 3 | 0 | 0 |
| The Job Possibilities (In the 1st rectangle under each Concentration Area - i.e. Web Designer) | 2 | 3 | 7 | 3 | 1 | 0 | 3 |
| The Introduction to the Areas of Study | 1 | 5 | 3 | 8 | 2 | 0 | 0 |
| The General Areas of Study (In the 3-column list in the 2nd rectangle) | 0 | 1 | 2 | 4 | 9 | 2 | 1 |
| Concentration Areas of Study (In the 2nd rectangle under each Concentration) | 0 | 0 | 3 | 1 | 1 | 13 | 1 |
| The number of Concentrations | 0 | 0 | 1 | 1 | 3 | 2 | 12 |

**Table 5.21:** Job-Focused: Importance of Items in the Curriculum

Table 5.21 presents the number of responses for each of the ranking levels for each curricular items. To determine proper ranking order, the Borda method was employed. The Borda method is used to analyze data from questions that seek priority ordering or rank ordering. Table 5.22 provides the Borda data and score indicating the Introduction being the most important part of the Job-Focused Curriculum followed by course name, course number and course credits.

| Curricular Item | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Borda Score |
|---|---|---|---|---|---|---|---|---|
| The Introduction (The first paragraph) | 98 | 0 | 0 | 4 | 0 | 4 | 2 | 108 |
| Concentration Areas (Listed in both areas - i.e. Web Development, Game Development...) | 14 | 60 | 15 | 4 | 9 | 0 | 0 | 102 |
| The Introduction to the Areas of Study | 7 | 30 | 15 | 32 | 6 | 0 | 0 | 90 |
| The Job Possibilities (In the 1st rectangle under each Concentration Area - i.e. Web Designer) | 14 | 18 | 35 | 12 | 3 | 0 | 3 | 85 |
| The General Areas of Study (In the 3-column list in the 2nd rectangle) | 0 | 6 | 10 | 16 | 27 | 4 | 1 | 64 |
| Concentration Areas of Study (In the 2nd rectangle under each Concentration) | 0 | 0 | 15 | 4 | 3 | 26 | 1 | 49 |
| The number of Concentrations | 0 | 0 | 5 | 4 | 9 | 4 | 12 | 34 |

**Table 5.22:** Job-Focused Curriculum: Importance of Items in the Curriculum Ranked by Borda score

The following questions were open ended. The responses have been summarized below.

**Question 2**: What do you like the most about what you've been shown (the Introduction and What You Will Be Studying)?

1. Five responses indicated the concentration areas were helpful in knowing what one might study.
2. Four responses indicated the layout and format were easy to read and organized.
3. Four responses indicated the Areas of Study section was helpful.

**Question 3**: What do you like the least about what you've been shown (the Introduction and What You Will Be Studying)?

1. Six responses indicated more detail was needed. Specifically for concentrations and job opportunities.
2. One indicated columns were confusing.

**Question 4**: What could be added that would help you understand the major better?

1. Five responses indicated job descriptions would be helpful.
2. Four responses indicated course descriptions would clarify what one would be studying.
3. Two responses indicated concentration descriptions would be helpful.

**Question 5**: After reading the Introduction and What You Will Be Studying, revisit your interest in studying Computer Science.

| Interest Level | Previous Interest Level | Current Interest Level |
|---|---|---|
| It has never crossed my mind (1) | 0 | 0 |
| I am not interested (2) | 9 | 10 |
| I might consider it (3) | 3 | 2 |
| I am a little interested (4) | 3 | 3 |
| I am extremely interested (5) | 4 | 4 |

**Table 5.23:** Job-Focused: Students' Interest Level in Studying Computer Science After Taking the Survey

Table 5.24 show the changes in interest levels from the beginning of the survey to the end. The interest level of one student increased, the interest level of fifteen students remained the same, and the interest level of two students declined. The results indicate that more students are not interested (53%) than are interested (37%). The data suggests that students are still not interested in Computer Science based on the Job-Focused Curriculum.

| | |
|---|---|
| Positive Change | 1 ( 6%) |
| No Change | 15 (83%) |
| Negative Change | 2 ( 11%) |

**Table 5.24:** Job-Focused: Change in Interest Level

### *5.2.3 Technology Information*

The first question in the technology section, "What classes in technology have you taken? (check all that apply)," is to get an idea of the knowledge level of the participants. Computer Applications such as Word and Excel and Programming are two courses that over half the students have taken.

| Technology Course | Response | % |
|---|---|---|
| Computer Applications (Word, Excel ...) | 27 | 63% |
| Programming | 22 | 51% |
| Graphics | 9 | 21% |
| Digital Photography | 8 | 19% |
| Web Design | 7 | 16% |
| Video or Audio Editing | 6 | 14% |
| Hardware | 4 | 9% |
| Databases | 2 | 5% |
| Network Certification | 0 | 0% |

**Table 5.25:** First Survey Instrument: Technology Courses Students have Taken

The second question, "What math classes have you taken?" provides information about the level of mathematical exposure of the participants. Over 50% of those participating have taken Algebra, Geometry, and Trigonometry.

| Math Course | Response | % |
|---|---|---|
| Algebra | 52 | 98% |
| Geometry | 50 | 94% |
| Trigonometry | 29 | 55% |
| Calculus | 16 | 30% |
| Statistics | 7 | 13% |

**Table 5.26:** First Survey Instrument: Math Courses Students have Taken

The third question, "What software tools do you use? (Check all that apply)" reinforces the fact that 63% of those participating have taken a course on computer applications. Over 63% of participants use word processing, spreadsheet, and presentation software.

| Software Tool | Response | % |
|---|---|---|
| Word Processing | 50 | 98% |
| Presentation (i.e. Power Point) | 46 | 90% |
| Spreadsheets | 32 | 63% |
| Database | 11 | 22% |
| Geometer | 4 | 8% |
| Minitab | 0 | 0% |

**Table 5.27:** First Survey Instrument: Software Tool Students Use

The last technology related question reinforces the characteristics of this Y-Generation. "What service-oriented applications do you use? (Check all that apply)"

### *5.2.4 Demographics of the First Survey Instrument*

Of those that participated, 23 were male and 30 were female. The ages ranged from 14 to 21 with the median age being 17. Nine states were represented in this survey: California, Colorado, Georgia, Illinois, Kentucky, Ohio, Oregon, Pennsylvania, and Vermont.

| Service-Oriented Application | Response | % |
|---|---|---|
| Email | 53 | 100% |
| Search Engines (i.e. Google) | 52 | 98% |
| Internet Browsing | 49 | 92% |
| Social Networking (i.e. Facebook) | 47 | 89% |
| Music Downloads (i.e. iTunes) | 45 | 85% |
| Instant Messaging | 40 | 75% |
| Movies On-line | 34 | 64% |
| On-line Radio | 23 | 43% |
| On-line Photo Management (i.e. Flickr) | 15 | 28% |

**Table 5.28:** First Survey Instrument: Service-Oriented Application Students Use

| State | Participants | Percent |
|---|---|---|
| California | 17 | 44% |
| Colorado | 5 | 13% |
| Georgia | 4 | 10% |
| Illinois | 1 | 3% |
| Kentucky | 2 | 5% |
| Ohio | 2 | 5% |
| Oregon | 1 | 3% |
| Pennsylvania | 18 | 46% |
| Vermont | 1 | 3% |

**Table 5.29:** First Survey Instrument: State Representation

All of those taking the survey indicated they are planning on going to college. Of those planning on attending college, intended majors include Archaeology (1), Architecture (2), Art (1), Biology (3), Business (5), Chemistry (1), Computer and Information Science (5), Criminal Justice (1), Culinary Arts (1), Education (2), Engineering (6), Graphic Design (1), Humanities (1), Mathematics (1), Music (2), Nursing (2), Physics (2), Political Science (1), Pre-Med (1), Psychology (3), Science (1), Social Work (1), Spanish (1), and Sports (1). This indicates that the participants in the second survey instrument have a wide range of interests and not all are looking to go into Computer Science.

### *5.2.5 Summary of the First Survey Instrument*

Though the survey had a relatively low participation rate, there were several lessons learned that were applied to the second survey instrument, specifically the Student-Focused Curriculum. First, it became evident that students expect to see a list of required courses. 70% of the students in the Typical survey and 63% of the students in the Job-Focused survey indicated that it is extremely important to know the exact courses they will be taking. 82% of the students in the Typical survey and 79% of the students in the Job-Focused survey indicated that having a required course list is extremely important. The Job-Focused Curriculum did not present specific courses, but study areas. This appears to have confused or overwhelmed students, which may have caused the post interest level to remain the same or drop.

In both surveys, descriptions were identified as lacking, specifically course descriptions. Participants in the Job-Focused survey also indicated that concentration details were needed.

Several other comments from the Typical survey influenced the development of the Student-Focused Curriculum. One comment shared by several participants indicated that course numbers have no meaning and therefore, were left out of the Student-Focused Curriculum. Another comment made by seven participants was that some information on job opportunities and those jobs held by previous graduates would be helpful. This also was included in the Student-Focused Curriculum.

Several comments from the Job-Focused survey also influenced or reinforced ideas for the development of the Student-Focused Curriculum. Five participants indicated concentrations were important which reinforced the idea of having them in the Student-Focused Curriculum. One indicated that the columns were distracting and caused confusion. Therefore, columns were not used in the Student-Focused Curriculum.

## 5.3 Results of the Second Curricular Presentation Surveys

The complete survey can be found in Appendix I. The previous section described the procedures used to develop the surveys. The second survey instrument was developed to compare a Typical Curriculum to a Student-Focused Curriculum and combined a survey for the Typical Computer Science Curriculum and a survey for the Student-Focused Curriculum. 177 high school students participated in this instrument. Eighty-five students started the Typical Curriculum survey and Eighty-one completed it. 92 students started the Student-Focused Curriculum survey and 83 completed it. The completion rate was 92.66%.

### *5.3.1 Typical Computer Science Survey Responses*

As in the first survey instrument, the first question posed to the participant prior to seeing any portion of the curriculum asks about their initial interest in studying Computer Science (See Table 5.30). The last question posed after the participant evaluated the curriculum asked them to revisit their interest in studying Computer Science (See Table 5.35). The purpose is to determine if their interest level has changed based on the curriculum they have been evaluating. Below are the results of the first interest question for the Typical Curriculum Survey.

**Question 1**: Before we start the survey, please rate your interest in studying Computer Science.

| Interest Level | Responses |
|---|---|
| It has never crossed my mind (1) | 3 |
| I am not interested (2) | 12 |
| I might consider it (3) | 24 |
| I am a little interested (4) | 21 |
| I am extremely interested (5) | 21 |

**Table 5.30:** Second Survey Typical Curriculum: Students' Initial Interest in Studying Computer Science

### Curriculum Introduction

The survey displays the introduction to the Typical Curriculum followed by a question asking the participant to indicate their agreement level to several statements.

**Question 1**: After looking at the Introduction to the Computer Science Major above, indicate how much you agree or disagree with each statement (The results are displayed in Table 5.31).

**Question 2**: Which of the following ideas from the introduction motivates you to look into the Computer Science Major further? Choose no more than 3 (The results are displayed in Table 5.32).

### What You Will Be Studying

Following the Introduction, the survey displays the Typical Curriculum's Required Courses section and once again asks the participants to indicate their level of agreement to five statements (See Figure 5.23).

**Question 1**: After looking at the required courses above, indicate how much you agree or disagree with each statement (The results are displayed in Table 5.33).

**Question 2**: Which of the following items from the required course list above

| Statement | Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree | Mean |
|---|---|---|---|---|---|---|
| The Introduction clearly describes the Computer Science major. | 3 | 16 | 18 | 33 | 11 | 3.407 |
| The Introduction gives me a clear picture of the breadth of Computer Science. | 3 | 15 | 20 | 35 | 8 | 3.370 |
| The Introduction makes the Computer Science Major interesting to me. | 6 | 17 | 27 | 26 | 5 | 3.086 |
| The Introduction motivates me to investigate more into Computer science. | 7 | 22 | 25 | 20 | 7 | 2.975 |
| The Introduction makes me confident about my future options after college. | 4 | 17 | 19 | 26 | 15 | 3.383 |

**Table 5.31:** Second Survey Typical Curriculum: Student Agreement Level of Statements Related to the Curriculum Introduction

motivates you to look into the Computer Science Major further? Choose no more than 3 (The results are displayed in Table 5.34).

This question provided the opportunity for the participant to add their own option. The added options include, “Working with hardware and software” and “Ability to choose” (two of the four were off-task).

**Question 3**: After reading the Introduction and What You Will Be Studying, revisit your interest in studying Computer Science (The results are displayed in Table 5.35).

Table 5.36 show the changes in interest levels from the beginning of the survey to

| Item in the Introduction | Response | % |
|---|---|---|
| From the introduction text, "...highest projected job growth ..." | 48 | 59% |
| From the introduction text, "...rapid advances in technology ..." | 32 | 40% |
| From the introduction text, "...flexibility in tailoring their college education ..." | 26 | 32% |
| From the introduction text, "...prepared for lifelong learning ..." | 16 | 20% |
| The breakdown of required credits("48 credits of computer science courses, 12credits...") | 13 | 16% |
| From the introduction text, "...dramatic changes in society ..." | 12 | 15% |
| From the introduction text, "...entry-level positions in hardware and software ..." | 9 | 11% |
| From the introduction text, "...Bachelor of Science degree ..." | 9 | 11% |
| None of the Above | 13 | 16% |

**Table 5.32:** Second Survey Typical Curriculum: Importance of Items in the Introduction that Fosters Motivation

the end. The interest level of three students increased, the interest level of fifty-seven students remained the same, and the interest level of seventeen students declined. Three quarters of the interest level of the students remained the same while 22% dropped. The data suggests that the Typical Curriculum does not inspire a majority students (96%) to pursue Computer Science and actually causes disinterest in many (22%).

Several of the questions following the post interest question attempted to determine what caused changes in interest.

**Question 4**: If your interest level has increased, what motivated the increase? Check all that apply (The results are displayed in Table 5.37).

This question provided the opportunity for the participant to add their own option. The only option added by participants whose interest level increased was, "How atrocious Computer Science is!" which brings into question the validity of the student's response to the question regarding their interest level. There were other

| Statement | Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree | Mean |
|---|---|---|---|---|---|---|
| The variety of courses appeals to me. | 11 | 9 | 17 | 27 | 16 | 3.350 |
| The required courses give me a good understanding of what a Computer Science major studies. | 1 | 0 | 12 | 42 | 25 | 4.125 |
| The required courses motivate me to investigate more into this major. | 11 | 18 | 25 | 16 | 10 | 2.950 |
| The required courses provide flexibility in a student's course of study. | 8 | 20 | 26 | 22 | 4 | 2.925 |
| As a result of looking at the required courses, I am more apt to look into studying computer science in my college experience. | 11 | 18 | 22 | 24 | 5 | 2.925 |

**Table 5.33:** Second Survey Typical Curriculum: Student Agreement Level of Statements Related to the Required Course List

| Item in the Required Course List | Response | % |
|---|---|---|
| The Variety of Computer Courses | 31 | 38% |
| The Courses | 24 | 30% |
| The Mathematics Courses | 22 | 27% |
| Seeing the whole sequence at once | 17 | 21% |
| The sequencing of courses | 8 | 10% |
| The number of courses required | 8 | 10% |
| Other | 4 | 5% |
| None of the Above | 20 | 25% |

**Table 5.34:** Second Survey Typical Curriculum: Importance of Items in the Required Course List that Fosters Motivation

| Interest Level | Previous Interest Level | Current Interest Level |
|---|---|---|
| It has never crossed my mind (1) | 3 | 2 |
| I am not interested (2) | 12 | 20 |
| I might consider it (3) | 24 | 24 |
| I am a little interested (4) | 21 | 17 |
| I am extremely interested (5) | 21 | 18 |

**Table 5.35:** Second Survey Typical Curriculum: Students' Interest Level in Studying Computer Science After Taking the Survey

| | |
|---|---|
| Positive Change | 3 ( 4%) |
| No Change | 57 (74%) |
| Negative Change | 17 (22%) |

**Table 5.36:** Typical Curriculum: Change in Interest Level

additional opinions added to this question. However, these opinions were from participants whose interest level *actually dropped*. The majority of the participants evaluating the Typical Curriculum showed no increased interest.

| Reasons | Response |
|---|---|
| The Mathematics | 2 |
| The Introductory paragraphs | 1 |
| The Required Courses | 1 |
| Other | 1 |

**Table 5.37:** Second Survey Typical Curriculum: Students' Reasons for Increase in Interest

The following question was open ended attempting to get at the reasons behind student's interest remaining the same or dropping.

**Question 5**: If your interest level has remained the same or decreased, please try to articulate why. Remember, we want your honest opinion.

- 11 responses indicated the participant is not interested in Computer Science with 3 of them adding that the subject is boring.

- 7 participants are already interested.
- 4 participants refer to the mathematics requirement being too difficult
- 2 individuals indicated the course descriptions were not helpful.
- 2 individuals indicated they have already decided their major.
- 2 individuals indicated they have other interests.
- 2 identify the programming requirement as being problematic.
- 1 indicated that AP Computer Science has turned him/her off.
- 1 acknowledged that the curriculum has caused the drop in interest.
- 1 indicated it looked too difficult.

One student summed up the Hypothesis of this research by saying, “This curriculum seems to be ‘standard’ for practically every college/university. Nothing added new knowledge or peaked my interest further.”

### *5.3.2 Student-Focused Computer Science Survey Responses*

As in all the other surveys, the first question posed to the participant prior to seeing any portion of the curriculum asked about their initial interest in studying Computer Science. The last question posed after the participant evaluated the curriculum asked them to revisit their interest in studying Computer Science. The purpose was to determine if their interest level had changed based on the curriculum they had been evaluating. Below are the results of the first interest question for the Student-Focused Curriculum Survey.

| Interest Level | Responses |
|---|---|
| It has never crossed my mind (1) | 4 |
| I am not interested (2) | 13 |
| I might consider it (3) | 19 |
| I am a little interested (4) | 18 |
| I am extremely interested (5) | 29 |

**Table 5.38:** Student-Focused: Students' Initial Interest in Studying Computer Science

**Question 1**: Before we start the survey, please rate your interest in studying Computer Science (The results are displayed in Table 5.38).

### Curriculum Introduction

The survey displays the introduction to the Student-Focused Curriculum which consists of two paragraphs introducing the major and a list of concentration, each containing a description and jobs in which recent graduates are currently involved. This is followed by a question asking the participant to indicate their agreement level to several statements.

**Question 1**: After looking at the Introduction to the Computer Science Major above, indicate how much you agree or disagree with each statement (The results are displayed in Table 5.39).

**Question 2**: Which of the following ideas from the introduction motivates you to look into the Computer Science Major further? Choose no more than 3 (The results are displayed in Table 5.40).

| Statement | Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree | Mean |
|---|---|---|---|---|---|---|
| The Introduction clearly describes the Computer Science major. | 7 | 5 | 15 | 43 | 13 | 3.602 |
| The Introduction gives me a clear picture of the breadth of Computer Science. | 3 | 5 | 18 | 39 | 18 | 3.771 |
| The Introduction makes the Computer Science Major interesting to me. | 6 | 12 | 24 | 29 | 12 | 3.349 |
| The Introduction motivates me to investigate more into Computer science. | 8 | 18 | 25 | 24 | 8 | 3.072 |
| The Introduction makes me confident about my future options after college. | 8 | 10 | 25 | 30 | 10 | 3.289 |

**Table 5.39:** Student-Focused: Student Agreement Level of Statements Related to the Curriculum Introduction

### What You Will Be Studying

Following the Introduction, the survey displays the Student-Focused Curriculum's Required Courses section. This section is made up of the Core Requirements followed by each concentration and their requirements (for complete details, see Appendix I). After observing the Required Courses section, participants are again asked to indicate their level of agreement to five statements.

**Question 1**: After looking at the required courses above, indicate how much you agree or disagree with each statement (The results are displayed in Table 5.41).

**Question 2**: Which of the following items from the required course list above

| Answer | Response | % |
|---|---|---|
| From the introduction text, "...rapid advances in technology ..." | 24 | 29% |
| From the introduction text, "...dramatic changes in society ..." | 11 | 13% |
| From the introduction text, "...highest projected job growth ..." | 40 | 48% |
| From the introduction text, "...prepared for lifelong learning ..." | 14 | 17% |
| From the introduction text, "...Bachelor of Science degree ..." | 4 | 5% |
| The variety of Concentrations | 25 | 30% |
| A Specific Concentration | 12 | 14% |
| Concentration Descriptions | 12 | 14% |
| Positions of Recent Graduates | 18 | 22% |
| Build Your Own Concentration | 13 | 16% |
| None of the Above | 12 | 14% |

**Table 5.40:** Student-Focused: Importance of Items in the Introduction that Fosters Motivation

motivates you to look into the Computer Science Major further? Choose no more than 3 (The results are displayed in Table 5.42).

This question provided the opportunity for the participant to add their own option. The added options include, "Computer technology" and "Editing movies."

**Question 3**: Which concentration(s) motivates you to look into the Computer Science major further? Check all that apply (The results are displayed in Table 5.43).

**Question 4**: After reading the Introduction and What You Will Be Studying, revisit your interest in studying Computer Science (The results are displayed in Table 5.44).

Table 5.45 show the changes in interest levels from the beginning of the survey to the end. The interest level of nineteen students increased, the interest level of fifty-three students remained the same, and the interest level of eleven students declined. The Student-Focused Curriculum increased the interest level of almost twice as many students (23%) than of those whose interest level decreased (13%).

| Statement | Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree | Mean |
|---|---|---|---|---|---|---|
| The variety of courses and concentrations appeals to me. | 6 | 11 | 14 | 31 | 18 | 3.550 |
| The core requirements and concentration details give me a good understanding of what a Computer Science major studies. | 4 | 6 | 8 | 44 | 20 | 3.854 |
| The core requirements and concentration details motivate me to investigate more into this major. | 6 | 14 | 27 | 25 | 10 | 3.232 |
| The core requirements and concentration details provide flexibility in a student's course of study. | 6 | 9 | 24 | 34 | 9 | 3.378 |
| As a result of looking at the core requirements and concentration details, I am more apt to look into studying computer science in my college experience. | 7 | 19 | 25 | 19 | 12 | 3.122 |

**Table 5.41:** Student-Focused: Student Agreement Level of Statements Related to the "What You Will Be Studying" Section

The data seems to suggest that a Student-Focused curriculum can inspire students to pursue a Computer Science major.

The questions following the post interest question focus on the reasons participants have changed their interest.

**Question 5**: If your interest level has increased, what motivated the increase? Check all that apply (The results are displayed in Table 5.46).

| Answer | Response | % |
|---|---|---|
| The Core Courses | 14 | 17% |
| The Course Descriptions | 26 | 31% |
| The Number of Concentrations | 18 | 22% |
| The Variety of Concentrations | 28 | 34% |
| The flexibility of the program | 25 | 30% |
| A Specific Concentration | 20 | 24% |
| Specific Courses | 17 | 20% |
| Electives for each concentration | 14 | 17% |
| Other | 2 | 2% |
| None of the Above | 13 | 16% |

**Table 5.42:** Student-Focused: Importance of Items in the Required Course List that Fosters Motivation

| Concentration | Student's Indicating Interest | % of Responses |
|---|---|---|
| Security and Forensic Computing | 7 | 8% |
| Artificial Intelligence | 11 | 13% |
| Networking | 6 | 7% |
| Game Development | 13 | 16% |
| Software Engineering | 10 | 12% |
| Web and Media Development | 7 | 8% |
| Build Your Own | 5 | 6% |

**Table 5.43:** Student-Focused: Responses Related to Concentrations that Motivate Students to Look into Computer Science

| Interest Level | Previous Interest Level | Current Interest Level |
|---|---|---|
| It has never crossed my mind (1) | 4 | 5 |
| I am not interested (2) | 13 | 13 |
| I might consider it (3) | 19 | 14 |
| I am a little interested (4) | 18 | 21 |
| I am extremely interested (5) | 29 | 30 |

**Table 5.44:** Student-Focused: Students' Interest Level in Studying Computer Science After Taking the Survey

This question also provided the opportunity for the participant to add their own reasons for their increased interest level. The added reasons include, "Course

| | |
|---|---|
| Positive Change | 19 (23%) |
| No Change | 53 (64%) |
| Negative Change | 11 (13%) |

**Table 5.45:** Student-Focused Curriculum: Change in Interest Level

| Answer | Response | % |
|---|---|---|
| The Introductory paragraphs | 7 | 37% |
| The Concentrations | 10 | 53% |
| The Number of Possible Concentrations | 12 | 63% |
| Future Opportunities Presented by Recent Graduates | 14 | 74% |
| The Course Offerings | 18 | 95% |
| The Flexibility | 13 | 68% |
| Other | 4 | 21% |

**Table 5.46:** Student-Focused: Students' Reasons for Increase in Interest

descriptions increased my interest," "Survey made me realize all the opportunities in this career field that I did not realize existed" and "I was not aware that the field of Computer Science had so many different options to go into. The variety and number of possible concentrations increased my interest level in computer science." Two indicated specific items in the curriculum: "Computer Technology" and "Game Development."

The only responses included in Table 5.46, were those from participants whose *interest level increased.* The percentages reflect the percent the response is out of the number of participants whose interest increased. The Student-Focused Curriculum *influenced 19 participants and increased their interest level.* The following question is an open ended question attempting to get at the reasons behind student's interest remaining the same or dropping.

**Question 6**: If your interest level has remained the same or decreased, please try to articulate why. Remember, we want your honest opinion.

Those whose interest level had remained the same indicated the following as reasons for remaining the same:

- Seven participants indicated they are already interested in Computer Science; therefore, the survey did not change their interest level.
- Five participants indicated they have already chosen a different major; therefore, their interest level has not changed.
- Three participants indicated they are just not interested in Computer Science.
- Some of the single responses include, “it looks difficult,” “the information is overwhelming,” “the Mathematics requirement,” and “not good at it.”

Those whose interest level had dropped indicated the following as reasons for dropping their interest level:

- Two participants indicated they are just not interested in Computer Science.
- The single responses include “different major chosen” and “the amount of courses required for each concentration.”

As mentioned previously, one student summed up the positive aspects of the Student-Focused Curriculum, “I was not aware that the field of Computer Science had so many different options to go into. The variety and number of possible concentrations increased my interest level in computer science.”

#### 5.3.2.1 Demographics of the Second Survey Instrument

Of those that participated, 116 were male and 46 were female. The ages ranged from 14 to 21 with the median age being 17. Nine states were represented in this survey: California, Colorado, Illinois, Maine, New Jersey, Ohio, Pennsylvania, Tennessee, and Texas.

| State | Participants | Percent |
|---|---:|---:|
| California | 13 | 8% |
| Colorado | 10 | 6% |
| Illinois | 20 | 13% |
| Maine | 6 | 4% |
| New Jersey | 14 | 9% |
| Ohio | 6 | 4% |
| Pennsylvania | 42 | 27% |
| Tennessee | 10 | 6% |
| Texas | 36 | 23% |

**Table 5.47:** Second Survey Instrument: State Representation

Of those taking the survey 156 or 97% indicated they are planning on going to college. Of those planning on attending college, intended majors include Accounting (2), Actuarial Science (1), Art (3), Biology (3), Business (5), Chemistry (2), Child Care (1), Computer and Information Science (34), Criminal Justice (1), Economics (1), Engineering (34), English (1), Environmental Science (1), Fashion Retail Management (1), Health (2), History (1), International Affairs (1), Journalism (1), Law (1), Linguistics (1), Mathematics (4), Media (1), Medical (4), Music (2), Nursing (1), Physics (3), Political Science (1), Psychology (4), Science (4), Sociology (1), Spanish (1), and Sports (1). This indicates that the participants in the second survey instrument have a wide range of interests and not all are looking to go into Computer Science.

Of the 156 planning to attend college, 94 (60%) have looked at a college curriculum. Of these 94, 67 (71%) indicate that looking at the college curriculum online influenced their decision for a major.

Participants have taken a variety of AP courses. Just over half the participants, 59%, have taken AP Computer Science (See Table 5.48). Those not listed include Chinese, Economics, English, Environmental Science, European History, Government, Music, Psychology, and Spanish.

| Answer | Response | % |
|---|---|---|
| Biology | 28 | 17% |
| Calculus AB or BC | 61 | 37% |
| Chemistry | 29 | 18% |
| Computer Science | 97 | 59% |
| Physics B or C | 37 | 23% |
| Statistics | 23 | 14% |
| Other: | 61 | 37% |

**Table 5.48:** Second Survey Instrument: AP Courses Students have Taken

### *5.3.3 Summary of the Second Survey Instrument*

#### Summary of the Typical Curriculum Survey

Over 50% (59%) of participants in the Typical survey indicate that the motivating factor in the introductory paragraphs is the information from the Bureau of Labor Statistics that computer and technology related fields claim some of the highest projected job growth in the United States.

After looking at the required course list, 53% indicate they agree or strongly agree with “the variety of courses is appealing” and 84% agree or strongly agree that “the required courses give them a good understanding of what a Computer Science major studies.” However, when asked about motivating factors, only 30% indicated that the courses were a motivating factor, and only 38% indicated that the variety of computer courses was a motivating factor.

### Summary of the Student-Focused Curriculum Survey

Over 50% of participants in the Student-Focused survey indicated that the variety of courses and concentrations is appealing (61%), the core requirements and concentration details give a good understanding of what a Computer Science major studies (78%), and the core requirements and concentration details provide flexibility in a student's course of study (52%). However, no item from the required course list motivated more than 34% of the participants. Yet when asked what motivated an increase in their interest level, 95% of those whose interest increased indicated the course offerings as being the motivating factor. In addition, 74% indicated the future opportunities presented by recent graduates, 68% indicated the flexibility, and 63% indicated the number of possible concentrations whereas 53% indicated the concentrations themselves.

Therefore, when presented with a Computer Science curriculum, it is important to tailor the curriculum to the appropriate audience, namely prospective students.

# Chapter 6

# Summary and Reflection

The goal of research was to investigate the attitudes and perceptions of today's high school students toward computer-related curricula presented on the World Wide Web. The motivation for this study lies in the drop in enrollment of students pursuing computing-related majors and the need to challenge higher education to change the way it communicates courses of study.

My intent for this research is to provide direction and motivation to higher education to focus on communicating effectively with those for whom they are providing a service. It is also my intent to draw the attention of computing education researchers toward high school students. Without including those who are about to pursue a higher education in further study, researchers will continue to address the needs of those already involved in Computer Science.

The results of this research reflect the attitudes and perceptions of a limited population of students. The limited population comes from a specific high school, college, and those over whom Advanced Placement Computer Science teachers have influence. The students involved have developed opinions based on their life experience and their educational experience in the schools they attend.

This research shows evidence that in designing the presentation of Computer Science as a Student-Focused Curriculum, the opinions of college students had effected the interest level of high school students across the United States. That observation provides an opportunity for researchers to look toward new avenues of opinion in designing research.

## 6.1 Addressing the Hypotheses

The following hypotheses were stated in Chapter 1 and are addressed in this chapter.

1. When presented with a more relevant Computer Science curriculum than a typical curriculum today, students will be encouraged and motivated to enroll in the major.
2. Colleges and Universities have not changed the way they display Computer Science curriculum over the last ten years. When compared with earlier course catalogs, courses will have been added, but names of standard courses will remain the same.
3. When asked about information technology, students react positively, enjoying its use.
4. College Computer Science curricula do not correlate with job postings found on job search web sites nor with what is considered to be important areas in computing.

### *6.1.1 Computer Science Curricular Presentation*

**When presented with a more relevant Computer Science curriculum than a typical curriculum today, students will be encouraged and motivated to enroll in the major.**

This hypothesis is supported by the Final Curriculum Presentation surveys. When presented with a typical curriculum, student interest dropped from an average of 3.556 on a scale of 1 to 5 to 3.358. The statistical T-Test, using a level of significance of 0.05, demonstrates that the drop is statistically significant with a p-value of 0.021. 21% of the interest levels of the student participants dropped and 70% remained the same. Put into real terms, 21 out of every 100 students that look into a Computer Science program that presents a typical curriculum may walk away from pursuing Computer Science as a major in college. It is interesting to note that the decline in the number of Computer Science and Computer Engineering degrees in 2008 was 20%. The largest drop in enrollment over the last ten years was between the years 2004 and 2005 when enrollment dropped 21%.

On a positive note, though the statistical T-Test did not demonstrate statistical significance in the change, the interest level of those presented with the Student-Focused curriculum rose from 3.663 to 3.669. 25% of the interest levels of the student participants rose while 61% remained the same. This means that 25 out of every 100 students has a little more interest in pursuing Computer Science as a major after looking at an attempt at a relevant curriculum.

These results validate the hypothesis that when presented with a more culturally relevant Computer Science curriculum, students will be encouraged and motivated to enroll in the major. One limitation to this study was the survey instrument itself. The ”culturally relevant” curriculum presented to the student was not interactive. It was static and long. One could argue that the length of the curriculum may have disinterested students. If the curriculum could have been presented in a form familiar to students, a form that is dynamic, they could have investigated parts of the curriculum that intrigued them and ignored the portions that may have distracted them. If that hypothesis were explored and found to be true, the interest level of students might rise significantly more than shown in this research.

### *6.1.2 College and University Curricular Presentation*

**Colleges and Universities have not changed the way they display Computer Science curriculum over the last ten years. When compared with earlier course catalogs, courses will have been added, but names of standard courses will remain the same.**

This hypothesis is supported by the Curriculum Study that showed that 62% of the curriculum reviewed that had at least ten years of archived curricula available remained the same as that of ten years ago. 68% of the curriculum reviewed that had at least five years of archived curricula available remained the same as that of five years ago.

The Curriculum Study was not exhaustive and was not intended to indicate that the actual curriculum itself employed by the college or university is not up-to-date. The study focused on the presentation of the curriculum that prospective students might find. The content of the curricular courses was not evaluated except to correlate courses between schools.

### *6.1.3 Students and Technology*

**When asked about information technology, students react positively, enjoying its use.**

This hypothesis is supported by the High School Student Technology Survey, the High School Student Focus Groups, as well as the Curriculum Presentation Surveys. The focus of this hypothesis was not specific to computers, but more broad to technology as a whole. 92% of students who took part in the Technology Survey own a computer whether it be a desktop or laptop computer. 94% have cell phones and 79% use an MP3 player of some kind. In the section on technology terms, 73% indicated iPhones as being exciting. This indicates not only an acceptance to, but an embrace of newer technology.

In the High School Student Focus Groups, students indicated the benefits of technology ranging from communication to storing information. When discussing what excites them about computers, those that participated discussed communication; communication with the world around them; convenient communication as well as multiple possibilities to communicate. They also indicated the usefulness of computers as tools to help them with tasks they were performing from editing movies to help with homework.

In the Curriculum Presentation surveys, some of the open-ended responses from students evaluating the Typical Curriculum indicated they did not understand the curriculum; that they were overwhelmed or felt the curriculum was too difficult. Some indicated the curriculum was boring. This from students who typically enjoy using technology.

### *6.1.4 Curriculum and Job Postings*

**College Computer Science curricula do not correlate with job postings found on job search web sites nor with what is considered to be important areas in computing.**

This hypothesis was supported by the Curriculum Study in conjunction with the Technology Job Review. In searching for jobs, technology jobs are categorized into different opportunities, unlike the Typical Computer Science Curriculum. Though the hypothesis was found to be true, it may not be correct to assume that changing the terminology used in Computer Science curricula to those used in job advertisements will be beneficial. In fact, when presented with a curriculum that focused on job terminology, though the interest level remained above 3, which is the average in the range of 1 to 5, it still dropped slightly.

Companies have the luxury of focusing terminology to only those individuals who may understand it. When looking for someone to work in a specialized field, a company does not care to help those who do not understand the terminology in that specialized field, they simply care to find the person who does know it. Companies do not attempt to educate through job advertisement, they are looking for specific people. Colleges and Universities do not have that luxury. In the past when computers were a novelty, students enrolled in programs possibly due to the novelty.

## 6.2 Contribution to Knowledge

This dissertation explored the attitudes and perceptions of high school students toward technology, computers, and the study of Computer Science in college. The purpose of this study was not to identify the attitudes and perceptions of today's generation of high school students, but to use the attitudes and perceptions of the sample population to evaluate the effectiveness of how the Computer Science curriculum is currently being presented on the World Wide Web. This study shows that high school and college students' perceptions can contribute to improving the presentation of a curriculum on a college or university web site.

The data collected in this study specific to the presentation of the Computer Science curriculum, based on student responses, reveals the following:

- Concentrations help define the Computer Science curriculum. Though the ACM suggest five distinct computing disciplines, Computer Science (CS), Information Technology (IT), Information Systems (IS), Computer Engineering (CE), and Software Engineering (SE) [98], students do not perceive a difference between them [48]. Therefore, presenting a single computing major with concentrations that differentiate the distinct computing disciplines will lead prospective students to one major through which they can explore which specialty or concentration is of more interest to them.

- Providing language in the curricular presentation that provides real-world application interests students.

- Students are attracted to opportunities to use what they are learning outside of the classroom whether it is in clubs, organizations, or volunteer opportunities. Therefore, offering those opportunities as part of their educational experience will generate interest in the major.

- Connecting the technology high school students are familiar with to a computing curriculum will increase interest.

## 6.3 Other Avenues of Research

The goal of this research was to investigate the attitudes and perceptions of today's high school students toward computer-related curricula presented on the World Wide Web. The purpose of this research was not to develop the model curricular presentation that inspires students, but to show that, when presented a more relevant curriculum student interest increases. This research could be expanded to explore other methods of presenting the curriculum that might further increase interest. As stated earlier, presenting the curriculum in a dynamic fashion might increase student interest.

During this investigation it became clear that some of the problems of attracting high school students to major in Computer Science stem from their experience with computer-related courses in high school. One avenue of further research would focus on high school computing curricula. What courses do high schools offer? Which are required? Do the courses that are required provide a broad overview of the computing field or a single aspect of computing? It would be interesting to investigate the number of graduates from different high schools that end up majoring in computer science and comparing the computing curricula of those with high enrollment rates to determine how they are inspiring students to continue with Computer Science. One hypothesis would be that those schools with a computing curriculum that gives the students a broad view of what can be studied in computer science will have more students enrolling in computer science in college. Those schools with curricula that misname courses, calling a Microsoft Applications course Computer Science, will have fewer students enrolling in computer science in college.

Another avenue of further research would be to develop a high school computer science course that would provide students with a broad overview of the possibilities of studying computer science. The course would add examples where value is added back to the community. One may conjecture that students would be excited about the course and would want to study computer science further in their college career. This course would also incorporate external speakers and/or field trips to expose students to people who do computer-related jobs. This would address the stereotype of geeks sitting in cubicles staring at a computer monitor all day.

Another avenue of further research would involve investigating the support high school computing teachers receive in teaching the latest technology. Teachers who receive a high level of support in teaching the latest technology might inspire students to pursue a computing major. In the High School Student Focus Group study in this research, students indicated teachers being an influence in their choice of college major. Though this study did not pursue that further, it could be conjectured that those teachers excited about their field have a positive influence on their students.

The results of this dissertation show that for today's generation, the computer is no longer a novelty but an appliance. Therefore, simply indicating the existence of a Computer-related major isn't enough. Colleges and University Computer Science professors need to communicate the current novelty of Computer Science in a way this generation will respond to.

# Appendix A

# Computer Science Programs

**Abilene Christian University**

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CS 111 | Introduction to Computer Science | R |
| CS 115 | Introduction To Programming | R |
| CS 120 | Programming I | R |
| CS 130 | Programming Ii: Data Structures | R |
| CS 220 | Computer Organization | R |
| CS 230 | Object-oriented Programming | R |
| CS 315 | Mobile Computing I | E |
| CS 316 | Mobile Computing II | E |
| CS 320 | Database Programming And Design | E |
| CS 330 | The Human-computer Interface | E |
| CS 332 | Design And Analysis Of Algorithms | E |
| CS 341 | Numerical Methods | E |
| CS 352 | Programming Languages | E |
| CS 356 | Operating Systems | E |
| CS 365 | Theory Of Computation | E |
| CS 374 | Software Engineering | E |
| CS 376 | Software Testing And Quality Assurance | E |
| CS 381 | Computer Graphics | E |
| CS 420 | Networks And Distributed Computing | E |
| CS 442 | Numerical Analysis | E |
| CS 467 | Introduction To Artificial Intelligence | E |
| CS 474 | Object-oriented Design | E |
| CS 495 | Senior Seminar | R |
| IT 220 | Introduction to Databases and Database Management Systems | R |
| IT 221 | Fundamentals of Networking and Data Communications | R |

**Table A.1:** Courses for the Computer Science major at Abilene Christian University

### Amherst College

| Registration ID | Course Name | Req Ind |
|---|---|---|
| 11 | Introduction To Computer Science I | R |
| 12 | Introduction To Computer Science II | R |
| 16 | Computer Systems I | R |
| 20 | Data Structures And Algorithms I | R |
| 23 | Programming Language Paradigms | C |
| 24 | Artificial Intelligence | C |
| 26 | Computer Systems II | R |
| 28 | Networks And Cryptography | C |
| 30 | Data Structures And Algorithms II | R |
| 34 | Applied Algorithms | C |
| 37 | Compiler Design | C |
| 38 | Theoretical Foundations Of Computer Science | C |
| 39 | Advanced Operating Systems | C |
| 40 | Seminar In Computer Science | C |
| 5 | Demystifying The Internet | E |
| 77 | Senior Departmental Honors | C |
| 97 | Special Topics | C |

**Table A.2:** Courses for the Computer Science major at Amherst College

**Bethel University**

| Registration ID | Course Name | Req Ind |
|---|---|---|
| COS100 | Introduction To Programming | R |
| COS105 | Computer Science 1 | R |
| COS205 | Scientific Computing | E |
| COS212 | Computer Science 2 | R |
| COS214 | Computer Systems | R |
| COS216 | Data Structures And Objects | R |
| COS301 | Operating Systems And Computer Architecture | R |
| COS313 | Database Systems | R |
| COS318 | Web Programming | R |
| COS337 | K Behavioral Robotics | E |
| COS344 | Numerical Methods | C |
| COS371 | Organization Of Programming Languages | R |
| COS376 | Operations Research | C |
| COS377 | Software Engineering | R |
| COS386 | Data Communications And | R |
| COS389 | Artificial Intelligence | R |
| COS490 | Topics In Computer Science | R |

**Table A.3:** Courses for the Computer Science major at Bethel University

### Brigham Young University

| Registration ID | Course Name | Req Ind |
|---|---|---|
| C S 100 | Fundamentals Of Computing And Information | E |
| C S 124 | Introduction To Computer Systems | R |
| C S 142 | Introduction To Computer Programming | R |
| C S 235 | Data Structures And Algorithms | R |
| C S 236 | Discrete Structures | R |
| C S 240 | Advanced Programming Concepts | R |
| C S 252 | Introduction To Computational Theory | R |
| C S 312 | Algorithm Analysis | R |
| C S 330 | Concepts Of Programming Languages | R |
| C S 340 | Software Design And Testing | R |
| C S 345 | Operating Systems Design | R |
| C S 360 | Internet Programming | R |
| C S 404 | Ethics And Computers In Society | R |
| C S 405 | Creating And Managing A Software Business | E |
| C S 412 | Linear Programming And Convex Optimization | E |
| C S 418 | Bioinformatics | E |
| C S 428 | Software Engineering | E |
| C S 431 | Algorithmic Languages And Compilers | E |
| C S 450 | Introduction To Digital Signal And Image Processing | E |
| C S 452 | Database Modeling Concepts | E |
| C S 453 | Fundamentals Of Information Retrieval | E |
| C S 455 | Computer Graphics | E |
| C S 456 | Introduction To User Interface Software | E |
| C S 460 | Computer Communications And Networking | E |
| C S 462 | Large-scale Distributed System Design | E |
| C S 465 | Computer Security | E |
| C S 470 | Introduction To Artificial Intelligence | E |
| C S 476 | Introduction To Data Mining | E |
| C S 478 | Tools For Machine Learning And Data Mining | E |
| C S 479 | Natural Language Processing | E |
| C S 484 | Parallel Processing | E |

**Table A.4:** Courses for the Computer Science major at Brigham Young University

### Bucknell University

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CSCI 180 | Introduction To A Microcomputer Environment | E |
| CSCI 202 | Computing For Scientists | E |
| CSCI 203 | Introduction To Computer Science I | R |
| CSCI 204 | Introduction To Computer Science II | R |
| CSCI 206 | Computer Organization And Programming | R |
| CSCI 208 | Programming Language Design | R |
| CSCI 240 | Computers And Society | R |
| CSCI 278 | Computer Science Individual Study | E |
| CSCI 305 | Introduction To Database | C |
| CSCI 311 | Algorithms And Data Structures | R |
| CSCI 315 | Operating Systems Design | R |
| CSCI 320 | Computer Architecture | C |
| CSCI 331 | Compiler Optimization | C |
| CSCI 334 | Graphs, Their Algorithms, And Software Engineering | C |
| CSCI 335 | Web Information Retrieval | C |
| CSCI 341 | Theory Of Computation I | R |
| CSCI 350 | Introduction To Analysis Of Algorithms | C |
| CSCI 355 | Distributed Computing | C |
| CSCI 362 | Computer And Network Security | C |
| CSCI 363 | Computer Networks | C |
| CSCI 367 | Computer Graphics | C |
| CSCI 376 | Computer Science Honors Thesis | C |
| CSCI 378 | Individual Study In Computer Science | C |
| CSCI 379 | Topics In Computer Science | C |
| CSCI 475 | Senior Design I | C |
| CSCI 476 | Senior Design II | C |
| CSCI 479 | Capstone Computer Science Design | R |

**Table A.5:** Courses for the Computer Science major at Bucknell University

## California Berkely, University of

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CS 10 | The Beauty And Joy Of Computing | E |
| CS 149 | Introduction To Embedded Systems | E |
| CS 150 | Components And Design Techniques For Digital Systems | C |
| CS 152 | Computer Architecture And Engineering | C |
| CS 160 | User Interface Design And Development | C |
| CS 161 | Computer Security | C |
| CS 162 | Operating Systems And System Programming | R |
| CS 164 | Programming Languages And Compilers | C |
| CS 169 | Software Engineering | C |
| CS 170 | Efficient Algorithms And Intractable Problems | R |
| CS 172 | Computability And Complexity | E |
| CS 174 | Combinatorics And Discrete Probability | E |
| CS 182 | The Neural Basis Of Thought And Language | E |
| CS 184 | Foundations Of Computer Graphics | C |
| CS 186 | Introduction To Database Systems | C |
| CS 188 | Introduction To Artificial Intelligence | C |
| CS 194 | Special Topics | E |
| CS 195 | Social Implications Of Computer Technology | E |
| CS 3 | Introduction To Symbolic Programming | E |
| CS 61A | The Structure And Interpretation Of Computer Programs | R |
| CS 61B | Data Structures | R |
| CS 61C | Machine Structures | R |
| CS 70 | Discrete Mathematics And Probability Theory | R |
| CS 84 | Sophomore Seminar | E |
| CS 98 | Directed Group Study | E |
| CS 99 | Individual Study And Research For Undergraduates | E |
| CS 9A | Matlab For Programmers | E |
| CS 9B | Pascal For Programmers | E |
| CS 9C | C For Programmers | E |
| CS 9D | Scheme And Functional Programming For Programmers | E |
| CS 9E | Productive Use Of The Unix Environment | E |
| CS 9F | C++ For Programmers | E |
| CS 9G | Java For Programmers | E |
| CS 9H | Python For Programmers | E |
| CS C191 | Quantum Information Science And Technology | E |

**Table A.6:** Courses for the Computer Science major at California Berkely, University of

### California Berkely, University of (page 2)

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CS C195 | Social Implications Of Computer Technology | E |
| CS H195 | Honors Social Implications Of Computer Technology | E |
| CS H196A-H196B | Senior Honors Thesis Research | E |

**Table A.7:** Courses for the Computer Science major at California Berkely, University of (Page 2)

### Calvin College

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CS104 | Applied C++ | E |
| CS106 | Introduction To Scientific Computation And Modeling. | E |
| CS108 | Introduction To Computing | R |
| CS112 | Introduction To Data Structures | R |
| CS195 | Introductory Computing Seminar | R |
| CS212 | Data Structures And Algorithms | R |
| CS214 | Programming Language Concepts | R |
| CS216 | Programming Challenges | E |
| CS232 | Operating Systems And Networking | R |
| CS262 | Software Engineering | R |
| CS295 | Computing Seminar | R |
| CS312 | Logic, Computability And Complexity | C |
| CS320 | Advanced Computer Architecture | C |
| CS324 | Cross Cultural Engagement Across The Digital Divide | E |
| CS332 | Advanced Computer Networks | C |
| CS342 | Database Management Systems | C |
| CS344 | Artificial Intelligence | C |
| CS352 | Computer Graphics | C |
| CS372 | Numerical Analysis | C |
| CS374 | High Performance Computing | C |
| CS382 | Special Topics In Computer Science: Compiler Design | C |
| CS384 | Perspectives On Computing | R |
| CS386 | Computer Security | C |
| CS390 | Independent Study | E |
| CS394 | Senior Internship In Computing | E |
| CS396 | Senior Project In Computing | R |
| CS398 | Senior Project In Computing II | R |

**Table A.8:** Courses for the Computer Science major at Calvin College

### Carnegie Mellon University

| Registration ID | Course Name | Req Ind |
|---|---|---|
| 15-050 | Study Abroad | E |
| 15-075 | Computer Science Co-op | E |
| 15-090 | Computer Science Practicum | E |
| 15-100 | Introductory/intermediate Programming | E |
| 15-105 | Principles Of Computation | E |
| 15-111 | Intermediate/advanced Programming | R |
| 15-123 | Effective Programming In C And Unix | R |
| 15-211 | Fundamental Data Structures And Algorithms | R |
| 15-212 | Principles Of Programming | R |
| 15-213 | Introduction To Computer Systems | R |
| 15-221 | Technical Communication For Computer Scientists | E |
| 15-251 | Great Theoretical Ideas In Computer Science | R |
| 15-295 | Special Topic: Competition Programming And Problem Solving | E |
| 15-312 | Foundations Of Programming Languages | E |
| 15-313 | Foundations Of Software Engineering | E |
| 15-317 | Constructive Logic | E |
| 15-321 | Research Methods For Experimental Computer Science | E |
| 15-322 | Introduction To Computer Music | E |
| 15-323 | Music Systems And Information Processing | E |
| 15-354 | Computational Discrete Mathematics | E |
| 15-355 | Modern Computer Algebra | E |
| 15-359 | Special Topic: Probability And Computing | E |
| 15-381 | Artificial Intelligence: Representation And Problem Solving | E |
| 15-384 | Robotic Manipulation | E |
| 15-385 | Computer Vision | E |
| 15-386 | Computational Neuroscience: Visual Computation In Biological Systems | E |
| 15-390 | Entrepreneurship For Computer Science | E |
| 15-391 | Technology Consulting In The Community | E |
| 15-392 | Special Topic: Secure Programming | E |
| 15-410 | Operating System Design And Implementation | E |
| 15-411 | Compiler Design | E |
| 15-412 | Operating System Practicum | E |
| 15-413 | Software Engineering | E |
| 15-414 | Bug Catching: Automated Program Verification and Testing | E |

**Table A.9:** Courses for the Computer Science major at Carnegie Mellon University

**Carnegie Mellon University (page 2)**

| Registration ID | Course Name | Req Ind |
|---|---|---|
| 15-415 | Database Applications | E |
| 15-418 | Parallel Computer Architecture and Programming | E |
| 15-421 | Web Commerce, Security and Privacy | E |
| 15-437 | Web Applications Development | E |
| 15-441 | Computer Networks | E |
| 15-451 | Algorithm Design And Analysis | R |
| 15-453 | Formal Languages And Automata | E |
| 15-462 | Computer Graphics | E |
| 15-463 | Computational Photography | E |
| 15-464 | Technical Animation | E |
| 15-465 | Animation Art And Technology | E |
| 15-466 | Computer Game Programming | E |
| 15-482 | Human Language Technologies | E |
| 15-485 | Computational Perception | E |
| 15-490 | Special Topic: Computational Neuroscience | E |

**Table A.10:** Courses for the Computer Science major at Carnegie Mellon University (Page 2)

### Cedarville University

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CS-1210 | C++ Programming | R |
| CS-1220 | Object-oriented Design Using C++ | R |
| CS-2210 | Data Structures Using Java | R |
| CS-3210 | Programming Language Survey | R |
| CS-3310 | Operating Systems | R |
| CS-3410 | Algorithms | R |
| CS-3510 | Compiler Theory And Practice | R |
| CS-3610 | Database Organization And Design | R |
| CS-3920 | Computer Science Internship | C |
| CS-3950 | Topics In Computer Science | C |
| CS-3980 | Independent Study In Computer Science | C |
| CS-4220 | Web Applications | R |
| CS-4320 | Network Security | C |
| CS-4410 | Parallel Computing | C |
| CS-4710 | Computer Graphics | C |
| CS-4810 | Software Engineering I | R |
| CS-4820 | Software Engineering II | R |
| CS-4950 | Advanced Topics In Computer Science | C |
| CS-4980 | Independent Study In Computer Science | C |

**Table A.11:** Courses for the Computer Science major at Cedarville University

### Christian Brothers University

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CS 171 | Introduction To Computer Science | R |
| CS 172 | Fundamentals Of Computer Science | R |
| CS 234 | Data Structures | R |
| CS 240 | Introduction To Bioinformatics | E |
| CS 295 | Data Communications And | R |
| CS 360 | Object Oriented Design | R |
| CS 370 | Operating Systems | R |
| CS 400 | Internship In Computer Science | R |
| CS 440 | Algorithms | R |
| CS 460 | Topics In Computer Science | E |
| CS 471 | Data Base Design | R |
| CS 481 | Computer Science Project I | R |
| CS 482 | Computer Science Project II | R |

**Table A.12:** Courses for the Computer Science major at Christian Brothers University

## Cornell University

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CS 1109 | Fundamental Programming Concepts | E |
| CS 1110 | Introduction To Computing Using Java | C |
| CS 1112 | Introduction To Computing Using Matlab | C |
| CS 1114 | Introduction To Computing Using Matlab And Robotics | C |
| CS 1130 | Transition To Object-oriented Programming | E |
| CS 1132 | Transition To Matlab | E |
| CS 1300 | Introduction To Programming Web Applications | E |
| CS 1610 | Computing In The Arts | E |
| CS 1620 | Visual Imaging In The Electronic Age | E |
| CS 1710 | Introduction To Cognitive Science | E |
| CS 2022 | Introduction To C | E |
| CS 2024 | C++ Programming | E |
| CS 2026 | Introduction To C# | E |
| CS 2042 | Unix Tools | E |
| CS 2044 | Advanced Unix Programming And Tools | E |
| CS 2110 | Object-oriented Programming And Data Structures | C |
| CS 2800 | Discrete Structures | R |
| CS 2850 | Networks | E |
| CS 3110 | Data Structures And Functional Programming | R |
| CS 3410 | Systems Programming | C |
| CS 3420 | Computer Organization | C |
| CS 3740 | Computational Linguistics | E |
| CS 3758 | Autonomous Mobile Robots | E |
| CS 3810 | Introduction to Theory of Computing | E |
| CS 4110 | Programming Languages and Logics | R |
| CS 4120 | Introduction to Compilers | E |
| CS 4121 | Practicum in Compilers | C |
| CS 4210 | Numerical Analysis and Differential Equations | E |
| CS 4220 | Numerical Analysis: Linear and Nonlinear Problems | E |
| CS 4300 | Information Retrieval | E |
| CS 4302 | Web Information Systems | E |
| CS 4320 | Introduction to Database Systems | E |
| CS 4321 | Practicum in Database Systems | C |
| CS 4410 | Operating Systems | E |
| CS 4411 | Practicum in Operating Systems | C |
| CS 4420 | Computer Architecture | E |

**Table A.13:** Courses for the Computer Science major at Cornell University

### Cornell University (page 2)

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CS 4450 | Computer Networks | C |
| CS 4520 | Introduction to Bioinformatics | E |
| CS 4620 | Computer Graphics I | E |
| CS 4621 | Computer Graphics Practicum | C |
| CS 4670 | Introduction to Computer Vision | E |
| CS 4700 | Foundations of Artificial Intelligence | E |
| CS 4701 | Practicum in Artificial Intelligence | C |
| CS 4740 | Introduction to Natural Language Processing | E |
| CS 4758 | Robot Learning | E |
| CS 4759 | Autonomous Mobile Robots | E |
| CS 4780 | Machine Learning | E |
| CS 4782 | Probabilistic Graphical Models | E |
| CS 4812 | Quantum Computation | E |
| CS 4820 | Introduction to Analysis of Algorithms | R |
| CS 4830 | Introduction to Cryptography | E |
| CS 4850 | Mathematical Foundations for the Information Age | E |
| CS 4860 | Applied Logic | E |

**Table A.14:** Courses for the Computer Science major at Cornell University (Page 2)

## Duke University

| Registration ID | Course Name | Req Ind |
|---|---|---|
| 1 | Principles Of Computer Science | E |
| 100 | Program Design And Analysis II | R |
| 102 | Discrete Math For Computer Science | R |
| 104 | Computer Organization And Programming | R |
| 108 | Software Design And Implementation | R |
| 110 | Introduction To Operating Systems | R |
| 111 | Introduction To Computer Modeling | E |
| 114 | Introduction To Computer Networks | E |
| 116 | Introduction To Database Systems | E |
| 120L | Introduction To Switching Theory And Logic Design | E |
| 122S | Constructing Immersive Virtual Worlds | E |
| 124 | Computer Graphics | E |
| 130 | Introduction To The Design And Analysis Of Algorithms | R |
| 140 | Mathematical Foundations Of Computer Science | R |
| 148 | Logic And Its Applications | E |
| 149S | Problem Solving Seminar | E |
| 150 | Introduction To Numerical Methods And Analysis | R |
| 150S | Introduction To Numerical Methods And Analysis | E |
| 160 | Introduction To Computational Genomics | E |
| 170 | Introduction To Artificial Intelligence | E |
| 173 | Computational Microeconomics | E |
| 181S | Computer Science Seminar | E |
| 182S | Technical And Social Analysis Of Information And The Internet | E |
| 189S | Computer Science Education Research Seminar | E |
| 18S | Introduction To Problem Solving | E |
| 190 | Duke-administered Study Abroad: Advanced Special Topics In Computer Science | E |
| 191 | Research Independent Study | E |
| 192 | Research Independent Study | E |
| 193 | Independent Study | E |
| 195 | Computer Science Internship | E |
| 196 | Topics In Computer Science | E |
| 196S | Topics In Computer Science | E |
| 197 | Topics In Computer Science | E |
| 210 | Operating Systems | E |

**Table A.15:** Courses for the Computer Science major at Duke University

## Duke University (page 2)

| Registration ID | Course Name | Req Ind |
|---|---|---|
| 212 | Distributed Information Systems | E |
| 214 | Computer Networks And Distributed Systems | E |
| 215 | Wireless Networking And Mobile Computing | E |
| 216 | Data-intensive Computing Systems | E |
| 219 | Statistical Data Mining | E |
| 220 | Advanced Computer Architecture I | E |
| 221 | Advanced Computer Architecture II | E |
| 225 | Fault-tolerant And Testable Computer Systems | E |
| 226 | Probability For Electrical And Computer Engineers | E |
| 230 | Design And Analysis Of Algorithms | E |
| 232 | Approximation Algorithms | E |
| 234 | Computational Geometry | E |
| 235 | Topics In Data Compression | E |
| 236 | Computational Topology | E |
| 237 | Randomized Algorithms | E |
| 240 | Computational Complexity | E |
| 250 | Numerical Analysis | E |
| 258 | Introduction To Computational Science | E |
| 261 | Computational Sequence Biology | E |
| 262 | Computational Systems Biology | E |
| 263 | Algorithms In Structural Biology And Biophysics | E |
| 263B | Computational Structural Biology | E |
| 264 | Nonlinear Dynamics | E |
| 270 | Artificial Intelligence | E |
| 271 | Machine Learning | E |
| 274 | Introduction To Computer Vision | E |
| 296 | Advanced Topics In Computer Science | E |
| 297 | Advanced Topics In Computer Science | E |
| 4 | Programming And Problem Solving | E |
| 49S | First-year Seminar | E |
| 4FCS | Introduction To Computational Genomics And Computer Science | E |
| 6 | Introduction To Computer Science | E |
| 6L | Introduction To Computer Science | E |
| 72 | Artificial Life, Culture, And Evolution | E |
| 82 | Technical And Social Analysis Of Information And The Internet | E |

**Table A.16:** Courses for the Computer Science major at Duke University (Page 2)

**Duke University (page 3)**

| Registration ID | Course Name | Req Ind |
|---|---|---|
| 89S | Computer Science Education Research Seminar | E |
| 90 | Duke-administered Study Abroad: Special Topics In Computer Science | E |
| 96 | Topics In Computer Science | E |
| 96S | Topics In Computer Science | E |
| 97S | Minds And Computers: Foundations Of Artificial Intelligence | E |

**Table A.17:** Courses for the Computer Science major at Duke University (Page 3)

### Eastern Mennonite University

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CS 110 | Introduction To Computer Science | E |
| CS 120 | Introduction To Programming: Visual Basic | E |
| CS 220 | Intermediate Programming: Java | R |
| CS 230 | Networking And Data Communications | R |
| CS 250 | Architecture And Operating Systems | R |
| CS 270 | Databases And Information Management | R |
| CS 320 | Data Structures | R |
| CS 333 | Topics In Computing | E |
| CS 340 | Analysis Of Algorithms | R |
| CS 350 | System Administration | E |
| CS 370 | Software Engineering | E |
| CS 420 | Programming Languages | R |
| CS 470 | Project Management | E |
| CS 488 | Computer Science Internship | E |
| CS 499 | Independent Study/Research | E |

**Table A.18:** Courses for the Computer Science major at Eastern Mennonite University

## Hendrix College

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CSCI 115 | Computing And The Internet | E |
| CSCI 135 | Robotics Explorations Studio | E |
| CSCI 150 | Foundations Of Computer Science I | R |
| CSCI 151 | Foundations Of Computer Science II | R |
| CSCI 230 | Computing Systems Organization | R |
| CSCI 250 | Programming Practicum | R |
| CSCI 280 | Algorithms & Problem Solving Paradigms | R |
| CSCI 330 | Computer Architecture | C |
| CSCI 335 | Artificial Intelligence | C |
| CSCI 340 | Database Systems | C |
| CSCI 350 | Software Engineering | C |
| CSCI 360 | Survey Of Programming Languages | C |
| CSCI 380 | Theory Of Computation | C |
| CSCI 385 | Scientific Computing | C |
| CSCI 397 | Cross-disciplinary Project | C |
| CSCI 410 | Technical Communication And Analysis | R |
| CSCI 420 | Operating Systems And Concurrent Computing | C |
| CSCI 490 | Advanced Topics In Computer Science | C |
| CSCI 497 | Senior Seminar | C |

**Table A.19:** Courses for the Computer Science major at Hendrix College

### Illinois, University of

| Registration ID | Course Name | Req Ind |
|---|---|---|
| 100 | Freshman Orientation | E |
| 101 | Intro Computing: Engrg & Sci | E |
| 105 | Intro Computing: Non-tech | E |
| 110 | Programming Laboratory | E |
| 125 | Intro To Computer Science | R |
| 173 | Discrete Structures | R |
| 196 | Freshman Honors | E |
| 199 | Undergraduate Open Seminar | E |
| 210 | Ethical & Professional Issues | E |
| 225 | Data Structures | R |
| 231 | Computer Architecture I | R |
| 232 | Computer Architecture II | R |
| 241 | System Programming | R |
| 242 | Programming Studio | R |
| 296 | Honors Course | E |
| 357 | Numerical Methods I | R |
| 373 | Theory Of Computation | R |
| 397 | Individual Study | E |
| 398 | Special Topics | E |
| 410 | Text Information Systems | E |
| 411 | Database Systems | E |
| 412 | Introduction To Data Mining | E |
| 414 | Multimedia Systems | E |
| 418 | Interactive Computer Graphics | E |
| 419 | Production Computer Graphics | E |
| 420 | Parallel Progrmg: Sci & Engrg | E |
| 421 | Progrmg Languages & Compilers | E |
| 422 | Programming Language Design | E |
| 423 | Operating Systems Design | E |
| 424 | Real-time Systems | E |
| 425 | Distributed Systems | E |
| 426 | Compiler Construction | E |
| 427 | Software Engineering I | E |
| 428 | Software Engineering II | E |
| 429 | Software Engineering Ii, Acp | E |
| 431 | Embedded Systems | E |
| 433 | Computer System Organization | E |
| 438 | Communication Networks | E |

**Table A.20:** Courses for the Computer Science major at Illinois, University of

### Illinois, University of (page 2)

| Registration ID | Course Name | Req Ind |
|---|---|---|
| 440 | Artificial Intelligence | E |
| 446 | Machine Learning | E |
| 450 | May Not Receive Additional | E |
| 450 | Numerical Analysis | E |
| 457 | Numerical Methods II | R |
| 460 | Security Laboratory | E |
| 461 | Computer Security I | E |
| 463 | Computer Security II | E |
| 465 | User Interface Design | E |
| 466 | Introduction To Bioinformatics | E |
| 473 | Fundamental Algorithms | E |
| 475 | Formal Models Of Computation | E |
| 476 | Program Verification | E |
| 477 | Formal Software Devel Methods | E |
| 491 | Seminar | E |
| 492 | Senior Project I | E |
| 493 | Or Cs 494. Cs 492 Combined With Cs 493 Fulfills The Advanced Composition Requirement. No Graduate | E |
| 493 | Senior Project Ii, Acp | E |
| 494 | Senior Project II | E |
| 498 | Special Topics | E |
| 499 | Senior Thesis | E |

**Table A.21:** Courses for the Computer Science major at Illinois, University of (Page 2)

### Johns Hopkins University

| Registration ID | Course Name | Req Ind |
|---|---|---|
| 600.101 | Computer Fluency | E |
| 600.102 | Cs Foundations | E |
| 600.104 | Computer Ethicstheory And Practice | R |
| 600.105 | M&ms: Freshman Experience | E |
| 600.106 | Pre-programming: Algorithmic Thinking | E |
| 600.107 | Introduction To Programming In Java | R |
| 600.108 | Introduction To Programming Lab | E |
| 600.120 | Intermediate Programming | R |
| 600.145 | Introduction To Computer-integrated Surgery | E |
| 600.146 | Introduction To Medical Imaging | E |
| 600.161 | Exploring Vision In The Real World | E |
| 600.202 | Introduction To Public Health And Biomedical Informatics | E |
| 600.211 | Unix Systems Programming | E |
| 600.226 | Data Structures | R |
| 600.245 | Foundations Of Computer Integrated Surgery | E |
| 600.255 | Introduction To Video Game Design | E |
| 600.256 | Introduction To Video Game Design Lab | E |
| 600.271 | Automata And Computation Theory | R |
| 600.315 | Database Systems | E |
| 600.316 | Transaction Processing Systems | E |
| 600.318 | Operating Systems | E |
| 600.319 | Storage Systems | E |
| 600.320 | Parallel Programming | E |
| 600.321 | Object-oriented Software Engineering | C |
| 600.324 | Network Security | E |
| 600.325 | Declarative Methods | E |
| 600.328 | Compilers And Interpreters | E |
| 600.333 | Computer System Fundamentals | R |
| 600.335 | Artificial Intelligence | E |
| 600.336 | Algorithms For Sensor-based Robotics | E |
| 600.337 | Distributed Systems | E |
| 600.341 | Basics Of Applied Cryptography | E |
| 600.344 | Computer Network Fundamentals | E |
| 600.355 | Video Game Design Project | E |
| 600.357 | Computer Graphics | E |
| 600.361 | Computer Vision | E |
| 600.363 | Introduction To Algorithms | E |

**Table A.22:** Courses for the Computer Science major at Johns Hopkins University

### Johns Hopkins University (page 2)

| Registration ID | Course Name | Req Ind |
|---|---|---|
| 600.392 | Senior Design Project | C |

**Table A.23:** Courses for the Computer Science major at Johns Hopkins University (Page 2)

## Kentucky, University of

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CS 100 | The Computer Science Profession | R |
| CS 101 | Introduction To Computing I | E |
| CS 115 | Introduction To Computer Programming | R |
| CS 215 | Introduction To Program Design, Abstraction, And Problem Solving | R |
| CS 216 | Introduction To Software Engineering | R |
| CS 221 | First Course In Computer Science For Engineers | E |
| CS 275 | Discrete Mathematics | R |
| CS 315 | Algorithm Design And Analysis | R |
| CS 316 | Web Programming | E |
| CS 321 | Introduction To Numerical Methods | R |
| CS 335 | Graphics And Multimedia | E |
| CS 340 | Applicable Algebra | E |
| CS 375 | Logic And Theory Of Computing | R |
| CS 380 | Microcomputer Organization | R |
| CS 383 | Introduction To Embedded Systems | E |
| CS 395 | Independent Work In Computer Science | E |
| CS 422 | Numerical Solutions Of Equations | E |
| CS 470G | Introduction to Operating Systems | R |
| CS 499 | Senior Design Project | R |

**Table A.24:** Courses for the Computer Science major at Kentucky, University of

### Kettering University

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CE 210 | Digital Systems I | R |
| CE 320 | Microcomputers I | R |
| CS-101 | Computing And Algorithms I | R |
| CS-102 | Computing And Algorithms II | R |
| CS-202 | Systems Programming Concepts | R |
| CS-203 | Computing & Algorithms III | R |
| CS-211 | Discrete Mathematics | R |
| CS-300 | The Computing Professional | R |
| CS-312 | Theory Of Computation | R |
| CS-320 | Computer Graphics | E |
| CS-331 | Programming Language Design | E |
| CS-341 | Web Software Tools | E |
| CS-385 | Introduction To Game Design | E |
| CS-415 | Cryptography | E |
| CS-420 | Multimedia Design | E |
| CS-425 | Parallel Models And Algorithms | E |
| CS-431 | Compiler Design And Construction | E |
| CS-435 | Functional Languages And Parsing | R |
| CS-451 | Operating Systems | R |
| CS-455 | Computer And Network Security | E |
| CS-458 | Computer And Network Forensics | E |
| CS-459 | Secure Software | E |
| CS-461 | Database Systems | E |
| CS-465 | Information Retrieval And Data Mining | E |
| CS-471 | Software Engineering | R |
| CS-481 | Artificial Intelligence | E |
| CS-485 | Advanced Game Development | E |
| CS-541 | Web Technology | E |
| CS-571 | Software Requirements Engineering | E |

**Table A.25:** Courses for the Computer Science major at Kettering University

## Linfield College

| Registration ID | Course Name | Req Ind |
|---|---|---|
| COMP-101 | Fundamentals Of Information Systems Tec | E |
| COMP-120 | Microcomputer Applications | E |
| COMP-121 | Introduction To The Internet And World Wide Web | E |
| COMP-131 | Computers In Modern Society | E |
| COMP-152 | Programming & Object Structures | E |
| COMP-160 | Introduction To Programming: Functions | R |
| COMP-161 | Beginning Programming: Objects | R |
| COMP-180 | Intermediate Programming: Data Abstractions | R |
| COMP-181 | Intermediate Programming: Algorithm Design And Analysis | R |
| COMP-250 | Database Program Development | E |
| COMP-260 | Database Management Systems | R |
| COMP-270 | Advanced Topics In Algorithms, Complexity And Intelligent Systems | R |
| COMP-302 | Software Engineering | E |
| COMP-305 | Software Engineering | R |
| COMP-310 | Networks And Web Application Development | E |
| COMP-330 | Operating Systems And Networking | R |
| COMP-375 | Computer Graphics And Animation | R |
| COMP-377 | Computer Architecture | R |
| COMP-400 | Applied Software Development Project | E |
| COMP-450 | Database Administration | E |
| COMP-480 | Independent Study | E |
| COMP-485 | Advanced Topics In Computer Science | R |
| COMP-487 | Software Engineering Internship | E |
| COMP-490 | Capstone Project | R |

**Table A.26:** Courses for the Computer Science major at Linfield College

**Lyndon State College**

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CIS 1050 | Computer Operation Systems And Spreadsheets | E |
| CIS 1060 | Introduction To Databases | E |
| CIS 1090 | Object Oriented Problem Solving | R |
| CIS 1090 | Object Oriented Problem Solving, Is Strongly Recommended Before Taking This Course | E |
| CIS 1210 | Concepts Of Word Processing | E |
| CIS 1220 | Concepts Of The Internet And Www | E |
| CIS 1240 | Simple Computer Graphics | E |
| CIS 1247 | Concepts Of Desktop Publishing | E |
| CIS 1310 | Methods Of Computer Presentations | E |
| CIS 2011 | Visual Basic Programming | E |
| CIS 2032 | C++ Programming | R |
| CIS 2060 | Programming With Fortran | E |
| CIS 2101 | Introduction To Unix | E |
| CIS 2141 | Programming Internet And Web Applications Part I | R |
| CIS 2142 | Advanced Visual Basic | R |
| CIS 2271 | Java Programming | R |
| CIS 2271 | Java Programming, Is Strongly Recommended Before Taking This Course | E |
| CIS 2279 | Introduction To Perl Programming | E |
| CIS 2290 | Introduction To Python | E |
| CIS 2330 | Database Systems | R |
| CIS 2990 | Portfolio | E |
| CIS 3050 | Algorithms And Data Structures | R |
| CIS 3110 | Networking | R |
| CIS 3120 | Programming Internet And Web Applications Part II | E |
| CIS 3810 | Cooperative Field Work | E |
| CIS 4040 | Computer Security | R |
| CIS 4060 | Advanced Web Tools | E |
| CIS 4120 | Systems Analysis And Design | R |
| CIS 4710 | Special Studies In Computer Science | E |
| CIS 4810 | Internship In Computer Science | R |
| CIS 4990 | Portfolio | R |

**Table A.27:** Courses for the Computer Science major at Lyndon State College

## Lyon College

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CSC 110 | Programming With Visual Basic | E |
| CSC 120 | Computer Information Systems | E |
| CSC 140 | Introduction To Programming I | R |
| CSC 145 | Introduction To Programming II | R |
| CSC 235 | Data Structures And Algorithms I | R |
| CSC 245 | Introduction To Digital Logic | E |
| CSC 255 | Computer Architecture With Assembly Language | R |
| CSC 260 | Data Structures And Algorithms II | R |
| CSC 304 | Project In Software Design And Engineering | E |
| CSC 310 | Mathematical Foundations Of Computer Science | R |
| CSC 320 | Programming Languages | R |
| CSC 330 | Database Theory And Application | E |
| CSC 380 | Parallel Programming | E |
| CSC 410 | Data Communications And Networks | E |
| CSC 415 | Numerical Analysis | E |
| CSC 420 | Operating Systems | R |
| CSC 450 | Independent Study | E |
| CSC 482 | Special Topics In Computer Science | E |

**Table A.28:** Courses for the Computer Science major at Lyon College

### Maine at Fort Kent, University of

| Registration ID | Course Name | Req Ind |
|---|---|---|
| Cos 103 | Introduction To Information Technology | E |
| Cos 111 | Introduction To Computer Science | R |
| Cos 125 | Internet Fundamentals And Webpage Design | C |
| Cos 130 | Desktop Publishing | E |
| Cos 206 | Survey Of Information Assurance And Security | C |
| Cos 233 | Macromedia Flash Development | E |
| Cos 260 | Introduction To Programming | R |
| Cos 272 | Computer Graphic Art | E |
| Cos 310 | Computer Programming – Fortran | C |
| Cos 320 | Computer Programming – Cobol | C |
| Cos 325 | Computer Programming – C++ | C |
| Cos 327 | Computer Programming – Visualbasic | C |
| Cos 333 | Systems Analysis And Design | C |
| Cos 338 | Networking | C |
| Cos 346 | Databases | C |
| Cos 360 | Computer Organization/assembly Language | C |
| Cos 370 | Operating Systems | E |
| Cos 381 | Internet/intranet Programming | E |
| Cos 397 | Computer Management Internship | E |
| Cos 420 | Internet And Intranet Architecture | E |
| Cos 430 | Cryptography | E |

**Table A.29:** Courses for the Computer Science major at Maine at Fort Kent, University of

## Massachusetts Amherst, University of

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CMPSCI 105 | Computer Literacy (r2) | E |
| CMPSCI 120 | Introduction To Problem Solving With The Internet | E |
| CMPSCI 121 | Introduction To Problem Solving With Computers (r2) | R |
| CMPSCI 187 | Programming With Data Structures (r2) | R |
| CMPSCI 201 | Architecture And Assembly Language | R |
| CMPSCI 220 | Programming Methodology | C |
| CMPSCI 240 | Reasoning About Uncertainty | C |
| CMPSCI 250 | Introduction To Computation | C |
| CMPSCI 287 | Programming Language Paradigms | E |
| CMPSCI 291 | Computer Systems Principles | C |
| CMPSCI 305 | Social Issues In Computing | R |
| CMPSCI 311 | Introduction To Algorithms | E |
| CMPSCI 320 | Introduction To Software Engineering | E |
| CMPSCI 365 | Digital Forensics | E |
| CMPSCI 377 | Operating Systems | E |
| CMPSCI 383 | Artificial Intelligence | E |
| CMPSCI 401 | Formal Language Theory | E |
| CMPSCI 446 | Search Engines | E |
| CMPSCI 453 | Computer Networks | E |
| CMPSCI 520 | Software Engineering: Synthesis And Development | E |
| CMPSCI 529 | Software Engineering Project Management | E |

**Table A.30:** Courses for the Computer Science major at Massachusetts Amherst, University of

### Michigan State University

| Registration ID | Course Name | Req Ind |
|---|---|---|
| 101 | Computing Concepts And Competencies | E |
| 131 | Technical Computing And Problem Solving | E |
| 231 | Introduction To Programming I | R |
| 232 | Introduction To Programming II | R |
| 240 | Informatics | E |
| 260 | Discrete Structures In Computer Science | R |
| 290 | Independent Study In Computer Science | E |
| 291 | Selected Topics In Computer Science | E |
| 320 | Computer Organization And Architecture | R |
| 331 | Algorithms And Data Structures | R |
| 335 | Object-oriented Software Design | R |
| 410 | Operating Systems | R |
| 420 | Computer Architecture | C |
| 422 | Computer Networks | C |
| 425 | Introduction To Computer Security | C |
| 429 | Interdisciplinary Topics In Cybersecurity | E |
| 435 | Software Engineering | C |
| 440 | Introduction To Artificial Intelligence | C |
| 444 | Information Technology Project Management | E |
| 450 | Translation Of Programming Languages | C |
| 452 | Organization Of Programming Languages | C |
| 460 | Computability And Formal Language Theory | C |
| 471 | Media Processing And Multimedia Computing | C |
| 472 | Computer Graphics | C |
| 475 | Introduction To Computational Linguistics | C |
| 480 | Database Systems | C |
| 484 | Information Retrieval | C |
| 490 | Independent Study In Computer Science | E |
| 491 | Selected Topics In Computer Science | E |
| 498 | Collaborative Design (w) | R |

**Table A.31:** Courses for the Computer Science major at Michigan State University

**Midwestern State University**

| Registration ID | Course Name | Req Ind |
|---|---|---|
| 1013 | Computer Concepts And Applications | E |
| 1023 | Computing For Science Majors | E |
| 1033 | Introductory Topics In Computing | E |
| 1043 | Computer Science I | R |
| 1053 | Computer Science II | R |
| 2084 | Introduction To Computer Architecture | R |
| 2133 | Data Structures | R |
| 3023 | Logic Design | R |
| 3233 | Theory Of Computation | R |
| 3493 | Internet Programming | E |
| 3533 | Numerical Analysis | E |
| 4103 | Introduction To Operating Systems | R |
| 4113 | Software Engineering | R |
| 4123 | Data Base Management Systems | E |
| 4143 | Topics In Contemporary Programming Languages | R |
| 4213 | Introduction To Computer Graphics | E |
| 4223 | Introduction To Simulation | E |
| 4233 | Artificial Intelligence | E |
| 4313 | Interactive 3d Game Graphics | E |
| 4433 | Computer Communications And Networks | E |
| 4453 | Computer Architecture | E |
| 4773 | Internship In Computer Science | E |
| 4883 | Topics In Computer Science | E |
| 4991 | Seminar In Social Responsibility 1 Semester Hour Prerequisite: Must Be In Last Year Prior To Graduation | R |
| 4993 | Independent Study 3 Semester Hours Prerequisite: Consent Of The Chair | E |

**Table A.32:** Courses for the Computer Science major at Midwestern State University

## Nevada, Reno, University of

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CS 105 | Introduction To Computing | R |
| CS 135 | Computer Science I | R |
| CS 202 | Computer Science II | R |
| CS 241 | Introduction To Computer Methods For Engineers | E |
| CS 281 | Introduction To Computer Game Development | E |
| CS 282 | Simulation Physics | E |
| CS 302 | Data Structures | R |
| CS 320 | Interaction Design | E |
| CS 326 | Programming Languages, Concepts And Implementation | R |
| CS 330 | Design Patterns | E |
| CS 365 | Mathematics Of Computer Science | R |
| CS 381 | The Game Development Pipeline | E |
| CS 382 | Introduction To Artificial Intelligence | E |
| CS 415 | Parallel Computing | E |
| CS 420 | Human-computer Interaction | E |
| CS 425 | Software Engineering | R |
| CS 426 | Senior Projects In Computer Science | R |
| CS 446 | Principles Of Operating Systems | R |
| CS 447 | Computer Systems Administration | E |
| CS 450 | Fundamentals Of Integrated Computer Security | E |
| CS 456 | Automata And Formal Languages | R |
| CS 457 | Database Management Systems | E |
| CS 460 | Compiler Construction | E |
| CS 466 | Numerical Methods I | E |
| CS 467 | Numerical Methods II | E |
| CS 474 | Image Processing And Interpretation | E |
| CS 477 | Analysis Of Algorithms | R |
| CS 479 | Pattern Recognition | E |
| CS 480 | Computer Graphics | E |
| CS 481 | Advanced Computer Game Design | E |
| CS 482 | Artificial Intelligence | E |
| CS 483 | Artificial Intelligence Programming | E |
| CS 485 | Computer Vision | E |
| CS 486 | Advanced Computer Vision | E |
| CS 491 | Topics | E |
| CS 493 | Directed Study In Computer Science | E |
| CS 494 | Internship In Computer Science | E |

**Table A.33:** Courses for the Computer Science major at Nevada, Reno, University of

### New Mexico Institute of Mining and Technology

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CSE 101 | Introduction To Computer Science And Information Technology | R |
| CSE 113 | Introduction To Programming | R |
| CSE 122 | Algorithms And Data Structures | R |
| CSE 213 | Introduction To Object Oriented Programming | R |
| CSE 221 | Computer System Organization | R |
| CSE 222 | Systems Programming | R |
| CSE 321 | Internet And Web Programming | E |
| CSE 324 | Principles Of Programming Languages | R |
| CSE 325 | Principles Of Operating Systems | R |
| CSE 326 | Software Engineering | R |
| CSE 328 | Secure Software Construction | E |
| CSE 331 | Computer Architecture | R |
| CSE 342 | Formal Languages And Automata | R |
| CSE 344 | Design And Analysis Of Algorithms | R |
| CSE 351 | Modeling And Simulation Technologies For Information Systems | E |
| CSE 353 | Data And Computer Communication | R |
| CSE 373 | Introduction To Database Systems | E |
| CSE 382 | Legal, Ethical, and Social Issues of Information Technology | R |
| CSE 423 | Compiler Writing | R |
| CSE 441 | Cryptography And Applications | E |
| CSE 451 | Introduction To Parallel Processing | E |
| CSE 453 | Computer Networks And The Internet | E |
| CSE 454 | Computer Graphics | E |
| CSE 463 | Information Assurance | E |
| CSE 464 | Introduction To Soft Computing | E |
| CSE 476 | Visualization | E |
| CSE 489 | Special Topics In Computer Science | E |

**Table A.34:** Courses for the Computer Science major at New Mexico Institute of Mining and Technology

### Northern Arizona University

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CS 110 | Introduction To Computer Science | E |
| CS 112 | Introduction To The World Wide Web And Internet | E |
| CS 122 | Programming For Engineering And Science | E |
| CS 122H | Programming For Engineering And Science - Honors | E |
| CS 122L | Programming For Engineering And Science Lab | E |
| CS 123 | Programming In Fortran | E |
| CS 126 | Computer Science I | R |
| CS 136 | Computer Science II | R |
| CS 199 | Special Topics | E |
| CS 200 | Introduction To Computer Organization | R |
| CS 212 | Web Programming | E |
| CS 248 | Foundations Of Computer Science | E |
| CS 249 | Data Structures | R |
| CS 299 | Special Topics | E |
| CS 301 | Social And Ethical Issues In Computer Science | R |
| CS 315 | Automata Theory | R |
| CS 345 | Principles Of Database Systems | E |
| CS 386 | Software Engineering | R |
| CS 389 | Cooperative Education | E |
| CS 396 | Principles Of Languages | R |
| CS 399 | Special Topics | E |
| CS 408 | Fieldwork Experience | E |
| CS 413 | Virtual Worlds | E |
| CS 421 | Algorithms | R |
| CS 430 | Computer Graphics | E |
| CS 445 | Data Mining | E |
| CS 450 | Introduction To Parallel Computing | E |
| CS 460 | Computer Networks | E |
| CS 470 | Introduction To Intelligent Systems | E |
| CS 476C | Applied Capstone Design | E |
| CS 477 | Advanced User Interfaces | E |
| CS 480 | Operating Systems | R |
| CS 481 | Compilers | E |
| CS 485 | Undergraduate Research | E |
| CS 486C | Capstone Experience | R |
| CS 497 | Independent Study | E |
| CS 499 | Contemporary Developments | E |

**Table A.35:** Courses for the Computer Science major at Northern Arizona University

### Oberlin College

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CSCI 150 | Principles Of Computer Science I | R |
| CSCI 151 | Principles Of Computer Science II | R |
| CSCI 210 | Computer Organization | R |
| CSCI 215 | Cryptology | E |
| CSCI 241 | Systems Programming | E |
| CSCI 259 | Computer Animation | E |
| CSCI 261 | Introduction To Game Design | E |
| CSCI 275 | Programming Abstractions | R |
| CSCI 280 | Introduction To Algorithms | R |
| CSCI 307 | Programming Languages | E |
| CSCI 311 | Database Systems | E |
| CSCI 317 | Computer Architecture | E |
| CSCI 331 | Compilers | E |
| CSCI 333 | Natural Language Processing | E |
| CSCI 341 | Operating Systems | E |
| CSCI 342 | Computer Networks | E |
| CSCI 343 | Computer And Information Security | E |
| CSCI 357 | Computer Graphics | E |
| CSCI 364 | Artificial Intelligence | E |
| CSCI 365 | Advanced Algorithms | E |
| CSCI 383 | Theory Of Computer Science | R |
| CSCI 401 | Honors | E |

**Table A.36:** Courses for the Computer Science major at Oberlin College

## Oklahoma State University

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CS 1003 | Computer Proficiency | E |
| CS 1103 | Computer Programming | E |
| CS 1113 | Computer Science I | E |
| CS 2133 | Computer Science II | E |
| CS 2301 | Fortran Programming | E |
| CS 2331 | Sas Programming | E |
| CS 2351 | Unix Programming | E |
| CS 2433 | C/c++ Programming | R |
| CS 2570 | Special Problems In Computer Science | E |
| CS 3030 | Industrial Practice In Computer Science | E |
| CS 3363 | Organization Of Programming Languages | R |
| CS 3373 | Advanced Object-oriented Programming For Windowing Environments | E |
| CS 3423 | Introduction To Database Systems | E |
| CS 3443 | Computer Systems | R |
| CS 3513 | Numerical Methods For Digital Computers | R |
| CS 3570 | Special Problems In Computer Science | E |
| CS 3613 | Theoretical Foundations Of Computing | R |
| CS 3653 | Discrete Mathematics For Computer Science | R |
| CS 4113 | Techniques Of Computer Science For Science And Engineering | E |
| CS 4143 | Computer Graphics | E |
| CS 4154 | Computer Science Migration | E |
| CS 4173 | Video Game Development | E |
| CS 4183 | Video Game Design | E |
| CS 4243 | Algorithms And Processes In Computer Security | E |
| CS 4273 | Software Engineering | E |
| CS 4283 | Computer Networks | E |
| CS 4323 | Design And Implementation Of Operating Systems I | R |
| CS 4343 | Data Structures And Algorithm Analysis I | R |
| CS 4443 | Compiler Writing I | E |
| CS 4513 | Numerical Mathematics: Analysis | E |
| CS 4883 | Computer Networks | R |

**Table A.37:** Courses for the Computer Science major at Oklahoma State University

### Oregon State University

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CS 101 | Computers: Applications And Implications | E |
| CS 151 | Introduction To C Programming | E |
| CS 160 | Computer Science Orientation | R |
| CS 161 | Introduction To Computer Science I | R |
| CS 162 | Introduction To Computer Science II | R |
| CS 195 | Introduction To Web Authoring | E |
| CS 199 | Selected Topics | E |
| CS 261 | Data Structures | R |
| CS 262 | Programming Projects In C++ | E |
| CS 271 | Computer Architecture And Assembly Language | R |
| CS 275 | Introduction To Databases | R |
| CS 295 | Intermediate Web Authoring | E |
| CS 311 | Operating Systems I | R |
| CS 312 | Linux System Administration | E |
| CS 321 | Introduction To Theory Of Computation | E |
| CS 325 | Analysis Of Algorithms | R |
| CS 331 | Introduction To Artificial Intelligence | E |
| CS 352 | Introduction To Usability Engineering | R |
| CS 361 | Software Engineering I | R |
| CS 362 | Software Engineering II | R |
| CS 372 | Introduction To Computer Networks | R |
| CS 381 | Programming Language Fundamentals | R |
| CS 391 | H Social And Ethical Issues In Computer Science | E |
| CS 391 | Social And Ethical Issues In Computer Science | R |
| CS 395 | Interactive Multimedia | E |
| CS 401 | Research | E |
| CS 403 | Thesis | E |
| CS 405 | Reading And Conference | E |
| CS 406 | Projects | E |
| CS 407 | Seminar | E |
| CS 410 | Occupational Internship | E |
| CS 411 | Operating Systems II | R |
| CS 419 | H Selected Topics In Computer Science | E |
| CS 419 | Selected Topics In Computer Science | E |
| CS 420 | Graph Theory With Applications To Computer Science | E |
| CS 434 | Machine Learning And Data Mining | E |
| CS 440 | Database Management Systems | E |

**Table A.38:** Courses for the Computer Science major at Oregon State University

### Oregon State University (page 2)

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CS 450 | Introduction To Computer Graphics | E |
| CS 461 | Senior Software Engineering Project | R |
| CS 462 | Senior Software Engineering Project | R |
| CS 463 | Senior Software Engineering Project | R |
| CS 472 | Computer Architecture | E |
| CS 475 | Introduction To Parallel Computing | E |
| CS 476 | Advanced Computer Networking | E |
| CS 480 | Translators | E |
| CS 495 | Interactive Multimedia Projects | E |

**Table A.39:** Courses for the Computer Science major at Oregon State University (Page 2)

### Pace University

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CS 108 | Introduction To Computer Science | E |
| CS 109 | Introduction To Computing Using C++ | E |
| CS 113 | Mathematical Structures For Computer Science | E |
| CS 121 | Computer Programming I | R |
| CS 122 | Computer Programming II | R |
| CS 150 | The Internet And Web Authoring | E |
| CS 152 | Internet Programming I | E |
| CS 154 | Internet Programming II | E |
| CS 156 | Scripting Languages | E |
| CS 199V | Topic: Formal Discrete Structures | E |
| CS 232 | Computer Organization | R |
| CS 241 | Data Structures And Algorithms I | R |
| CS 242 | Data Structures And Algorithms II | R |
| CS 271 | Fundamentals Of Unix And C Programming | R |
| CS 295 | Computer Science Internship | E |
| CS 301 | Computer Science Internship | E |
| CS 312 | Research Methods In Computers And Society | E |
| CS 320 | Introduction To Xml Application Development | E |
| CS 321 | Introduction To Game Programming | E |
| CS 324 | Application Development With | E |
| CS 325 | Introduction To Data Mining | E |
| CS 326 | Intro To Computer Vision Pattern Recognition | E |
| CS 331 | Security In Computing | E |
| CS 344 | Internet Computing With Distributed Components | E |
| CS 351 | Automata And Computability | E |
| CS 361 | Programming Languages And Implementation | E |
| CS 371 | Operating Systems And Architecture I | E |
| CS 372 | Operating Systems And Architecture II | E |
| CS 383 | Computer Graphics | E |
| CS 385 | Artificial Intelligence I | E |
| CS 387 | Database Design | E |
| CS 388 | Data Communications | E |
| CS 389 | Software Engineering | E |
| CS 396M | Topic: Formal Software Development | E |
| CS 397A | Topic: Software Design | E |
| CS 397B | Topic: Social Choice And Computer Science | E |
| CS 397D | Financial Computing | E |
| CS 397E | Topic: Enterprise System Integration With Web Service | E |

**Table A.40:** Courses for the Computer Science major at Pace University

### Pace University (page 2)

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CS 397F | Directed Readings In Computer Science | E |
| CS 397J | Topic: Parallel And Distributed Computing | E |
| CS 397K | Topic: Internet Computing With Distributed Systems | E |
| CS 397L | Advanced Problem Solving Using Lego Robotics | E |
| CS 397M | Topic: Computer Game Engineering | E |
| CS 397N | Topic: Technology Entrepreneurship | E |
| CS 397P | Engineering Designs In 3-d Worlds | E |
| CS 397R | Topic: Robotics | E |
| CS 397S | Topic:mobile Application Development | E |
| CS 397U | Topic: Linux System Programming | E |
| CS 397W | Mobile Phone Programming & Entrepreneurship | E |
| CS 397Y | Topic: Windows System Programming | E |
| CS 397Z | Topic: Visual Computing | E |
| CS 483 | Computer Graphics II | E |
| CS 488 | Computer Networks And The Internet | R |
| CS 490 | Independent Study In Computer Science | E |

**Table A.41:** Courses for the Computer Science major at Pace University (Page 2)

## Pittsburgh Bradford, University of

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CS 0101 | Introduction To Computer Science | R |
| CS 0102 | Introduction To Information Structures | R |
| CS 0103 | Integrated Business Microcomputing | E |
| CS 0106 | Computational Methods | E |
| CS 0112 | Intro To 3d Modeling And Animation | E |
| CS 0161 | The Technology Of Computing 3 | E |
| CS 0162 | Survey Of Information Technology | E |
| CS 0163 | Introduction To Web Programming | E |
| CS 0165 | Networking I | E |
| CS 0166 | Networking II | E |
| CS 0190 | Practicum In Fortran | E |
| CS 0191 | Practicum In C | E |
| CS 0192 | Practicum In C++ | E |
| CS 0193 | Practicum In Unix | E |
| CS 0194 | Practicum In Java | E |
| CS 0195 | Practicum In Mathematica | E |
| CS 0196 | Practicum In Perl | E |
| CS 0197 | Directed Study Computer Science | E |
| CS 0198 | Practicum In Python | E |
| CS 0199 | Practicum In C# | E |
| CS 0201 | Concepts Of Computer Science | R |
| CS 0203 | Data Structure | R |
| CS 0205 | Programming Applications | E |
| CS 0209 | Introduction To Web Databases | E |
| CS 0230 | Crime In The Digital Age | E |
| CS 0235 | Microcontroller Architecture Programming | R |
| CS 0240 | Introduction To Informatics | E |
| CS 0250 | Special Topics | E |
| CS 0261 | Computer Security | E |
| CS 0262 | Systems Administration | E |
| CS 0263 | Survivability And Information Assurance | E |
| CS 1303 | Programming Languages | E |
| CS 1304 | Introduction To Simulation | E |
| CS 1307 | Database Management | E |
| CS 1312 | Unix Operating System | E |
| CS 1314 | Network Computing | E |
| CS 1315 | Software Maintenance And Enhancement | E |
| CS 1316 | Computational Linear Algebra | E |

**Table A.42:** Courses for the Computer Science major at Pittsburgh Bradford, University of

### Pittsburgh Bradford, University of (page 2)

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CS 1320 | User Interface Design | E |
| CS 1330 | Social And Ethical Impact Of Computing | R |
| CS 1332 | Digital Logic | E |
| CS 1342 | Computer Organization | E |
| CS 1401 | Principles Of Software Engineering | E |
| CS 1405 | Advanced Database Management | E |
| CS 1410 | Computer Visualization | E |
| CS 1415 | Data Mining | E |
| CS 1450 | Topics In Computer Science | E |
| CS 1452 | Capstone: Computer Science | R |
| CS 1497 | Directed Study: Computer Science | E |
| CS 1498 | Directed Research: Computer Science | E |
| CS 1499 | Internship | E |

**Table A.43:** Courses for the Computer Science major at Pittsburgh Bradford, University of (Page 2)

## Princeton University

| Registration ID | Course Name | Req Ind |
|---|---|---|
| COS109 | Computers In Our World | E |
| COS116 | The Computational Universe | E |
| COS126 | General Computer Science | R |
| COS217 | Introduction To Programming Systems | R |
| COS226 | Algorithms And Data Structures | R |
| COS318 | Operating Systems | C |
| COS320 | Compiling Techniques | C |
| COS323 | Computing For The Physical And Social Sciences | C |
| COS325 | Transforming Reality By Computer | C |
| COS333 | Advanced Programming Techniques | C |
| COS340 | Reasoning About Computation | C |
| COS342 | Introduction to Graph Theory | C |
| COS397 | Junior Independent Work | C |
| COS398 | Junior Independent Work | C |
| COS402 | Artificial Intelligence | C |
| COS423 | Theory Of Algorithms | C |
| COS424 | Interacting with Data | C |
| COS425 | Database And Information Management Systems | C |
| COS426 | Computer Graphics | C |
| COS429 | Computer Vision | C |
| COS432 | Information Security | C |
| COS433 | Cryptography | C |
| COS435 | Information Retrieval, Discovery, And Delivery | C |
| COS436 | Human-computer Interface Technology | C |
| COS441 | Programming Languages | C |
| COS444 | Internet Auctions: Theory And Practice | C |
| COS451 | Computational Geometry | C |
| COS455 | Introduction to Genomics and Computational Molecular Biology | C |
| COS461 | Computer Networks | C |
| COS471 | Computer Architecture and Organization | C |
| COS479 | Pervasive Information Systems | C |
| COS487 | Theory Of Computation | C |
| COS494 | Special Topics In Artificial Intelligence | E |
| COS495 | Special Topics In Computer Science | E |
| COS497 | Senior Independent Work | C |
| COS498 | Senior Independent Work | C |

**Table A.44:** Courses for the Computer Science major at Princeton University

**Rhode Island College**

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CSCI 101 | Introduction To Computers | E |
| CSCI 102 | Introduction To Visual Basic Programming | E |
| CSCI 157 | Introduction To Algorithmic Thinking | E |
| CSCI 201 | Computer Programming I | R |
| CSCI 203 | Advanced Visual Basic Programming | C |
| CSCI 221 | Computer Programming II | R |
| CSCI 301 | Introduction to Java Programming | C |
| CSCI 302 | C++ Programming | C |
| CSCI 305 | Functional Programming | C |
| CSCI 312 | Computer Organization And Architecture I | R |
| CSCI 313 | Computer Organization And Architecture II | R |
| CSCI 315 | Information Structures | R |
| CSCI 325 | Organization Of Programming Languages | R |
| CSCI 401 | Software Engineering | R |
| CSCI 415 | Software Testing | C |
| CSCI 422 | Introduction To Computation Theory | R |
| CSCI 423 | Analysis Of Algorithms | R |
| CSCI 427 | Introduction To Artificial Intelligence | C |
| CSCI 435 | Operating Systems And Computer Architecture | R |
| CSCI 437 | Introduction To Data And Computer Communications | C |
| CSCI 455 | Introduction To Database Systems | C |

**Table A.45:** Courses for the Computer Science major at Rhode Island College

### Rochester, University of

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CSC 108 | Computer Applications For The Humanities | E |
| CSC 109 | Computer Applications For The Sciences | E |
| CSC 161 | Or Equivalent | E |
| CSC 171 | The Science Of Programming | R |
| CSC 172 | The Science Of Data Structures | R |
| CSC 173 | Computation And Formal Systems | R |
| CSC 190 | Issues In Computing | E |
| CSC 200 | Undergraduate Problem Seminar | R |
| CSC 210 | Web Programming | E |
| CSC 242 | Artificial Intelligence | R |
| CSC 244 | Logical Foundations Of Artificial Intelligence | E |
| CSC 246 | Mathematical Foundations Of Artificial Intelligence | E |
| CSC 247 | Natural Language Processing | E |
| CSC 248 | Statistical Speech And Language Processing | E |
| CSC 249 | Machine Vision | E |
| CSC 252 | Computer Organization | R |
| CSC 254 | Programming Language Design & Implementation | R |
| CSC 255 | Advanced Programming Systems | E |
| CSC 256 | Operating Systems | E |
| CSC 257 | Computer Networks | E |
| CSC 258 | Parallel And Distributed Systems | E |
| CSC 260 | Topics In Natural Language Dialog Systems | E |
| CSC 280 | Computer Models And Limitations | R |
| CSC 281 | Cryptography | E |
| CSC 282 | Design And Analysis Of Efficient Algorithms | R |
| CSC 284 | Advanced Algorithms | E |
| CSC 286 | Computational Complexity | E |
| CSC 287 | Randomized, Parallel, And Other Advanced Modes Of Computation | E |
| CSC 290 | Topics In Computer Science | E |
| CSC 391 | Independent Study In Computer Science | E |
| CSC 391H | Honors Independent Study In Computer Science | E |
| CSC 393 | Senior Project | E |
| CSC 395 | Research In Computer Science | E |

**Table A.46:** Courses for the Computer Science major at Rochester, University of

## South Dakota School of Mines and Technology

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CSC 105 | Introduction To Computers | E |
| CSC 150 | Computer Science I | R |
| CSC 210 | Web Authoring | E |
| CSC 250 | Computer Science II | R |
| CSC 251 | Finite Structures | R |
| CSC 284 | Database Processing | E |
| CSC 291 | Independent Study | E |
| CSC 292 | Topics | E |
| CSC 300 | Data Structures | R |
| CSC 314 | Assembly Language | R |
| CSC 317 | Computer Organization And Architecture | R |
| CSC 372 | Analysis Of Algorithms | R |
| CSC 391 | Independent Study | E |
| CSC 392 | Topics | E |
| CSC 410 | Parallel Computing | E |
| CSC 412 | Cryptography | E |
| CSC 415 | Introduction To Robotics | E |
| CSC 416 | Introduction To Autonomous Systems | E |
| CSC 421 | Graphical User Interfaces | R |
| CSC 433 | Computer Graphics | E |
| CSC 440 | Advanced Digital Systems | E |
| CSC 445 | Intro To Theory Of Computation | E |
| CSC 447 | Artificial Intelligence | E |
| CSC 448 | Machine Learning | E |
| CSC 449 | Pattern Recognition | E |
| CSC 456 | Operating Systems | R |
| CSC 461 | Programming Languages | R |
| CSC 463 | Data Communications | E |
| CSC 464 | Introduction To Digital Image Processing And Computer Vision | E |
| CSC 465 | Senior Design I | R |
| CSC 467 | Senior Design II | R |
| CSC 470 | Software Engineering | R |
| CSC 476 | Theory Of Compilers | E |
| CSC 484 | Database Management Systems | R |
| CSC 491 | Independent Study | E |
| CSC 492 | Topics | E |
| CSC 498 | Undergraduate Research/scholarship | E |

**Table A.47:** Courses for the Computer Science major at South Dakota School of Mines and Technology

**Southern California, University of**

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CSCI 101L | Fundamentals Of Computer Programming | R |
| CSCI 102L | Data Structures | R |
| CSCI 106Lx | Introduction To Computer Engineering/computer Science | E |
| CSCI 110 | Introduction To Digital Logic | E |
| CSCI 180 | Survey Of Digital Games And Their Technologies | E |
| CSCI 200L | Object-oriented Programming | R |
| CSCI 201L | Principles Of Software Development | R |
| CSCI 271 | Discrete Methods In Computer Science | R |
| CSCI 281 | Pipelines For Games And Interactives | E |
| CSCI 300 | Introduction To Intelligent Agents Using Science Fiction | E |
| CSCI 303 | Design And Analysis Of Algorithms | R |
| CSCI 320 | Digital Media Basics For Multimedia | E |
| CSCI 351 | Programming And Multimedia On The World Wide Web | E |
| CSCI 352L | Computer Organization And Architecture | E |
| CSCI 355x | Software Design For Engineers | E |
| CSCI 357 | Basic Organization Of Computer Systems | E |
| CSCI 377 | Introduction To Software Engineering | R |
| CSCI 380 | Video Game Programming | E |
| CSCI 390 | Special Problems | E |
| CSCI 402 | Operating Systems | R |
| CSCI 410x | Translation Of Programming Languages | E |
| CSCI 445 | Introduction To Robotics | E |
| CSCI 450 | Introduction To Computer Networks | E |
| CSCI 452L | Game Hardware Architectures | E |
| CSCI 454L | Introduction To Systems Design Using Microprocessors | E |
| CSCI 455x | Introduction To Programming Systems Design | E |
| CSCI 457 | Computer Systems Organization | E |
| CSCI 458 | Numerical Methods | E |
| CSCI 459 | Computer Systems And Applications Modeling Fundamentals | E |
| CSCI 460 | Introduction To Artificial Intelligence | E |
| CSCI 464 | Foundations Of Exotic Computation | E |
| CSCI 477 | Design And Construction Of Large Software Systems | R |
| CSCI 480 | Computer Graphics | E |

**Table A.48:** Courses for the Computer Science major at Southern California, University of

### Southern California, University of (page 2)

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CSCI 485 | File And Database Management | E |
| CSCI 486 | Serious Games Development | E |
| CSCI 487 | Programming Game Engines | E |
| CSCI 490x | Directed Research | E |
| CSCI 491abL | Final Game Project | E |

**Table A.49:** Courses for the Computer Science major at Southern California, University of (Page 2)

### Stevens Institute of Technology

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CS 105 | Introduction To Scientific Computing | E |
| CS 115 | Introduction To Computer Science | R |
| CS 135 | Discrete Structures | E |
| CS 146 | Introduction To Web Programming And Project Development | R |
| CS 181 | Introduction To Computer Science Honors I | E |
| CS 182 | Introduction To Computer Science Honors II | E |
| CS 284 | Data Structures | R |
| CS 334 | Automata And Computation | E |
| CS 347 | Software Development Process | R |
| CS 383 | Computer Organization And Programming | R |
| CS 385 | Algorithms | R |
| CS 392 | Systems Programming | R |
| CS 423 | Software Engineering Practice I | R |
| CS 424 | Software Engineering Practice II | R |
| CS 442 | Database Management Systems | R |
| CS 465 | Selected Topics In Computer Science | E |
| CS 488 | Computer Architecture | R |
| CS 492 | Operating Systems | R |
| CS 496 | Principles Of Programming Languages | R |
| CS 497 | Independent Study | E |
| CS 498 | Senior Research I | E |
| CS 499 | Senior Research II | E |
| CS 506 | Introduction to IT Security | R |
| CS 511 | Concurrent Programming | R |

**Table A.50:** Courses for the Computer Science major at Stevens Institute of Technology

## Texas A & M

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CSCE 110 | Programming I | E |
| CSCE 111 | Introduction To Computer Science Concepts And Programming | E |
| CSCE 113 | Intermediate Programming And Design | E |
| CSCE 121 | Introduction To Program Design And Concepts | R |
| CSCE 181 | Introduction To Computing | R |
| CSCE 203 | Introduction To Computing | E |
| CSCE 206 | Structured Programming In C | E |
| CSCE 211 | Data Structures And Their Implementations | E |
| CSCE 221 | Data Structures And Algorithms | R |
| CSCE 222 | Discrete Structures For Computing | R |
| CSCE 285 | Directed Studies | E |
| CSCE 289 | Special Topics In | E |
| CSCE 291 | Research | E |
| CSCE 310 | Database Systems | E |
| CSCE 311 | Analysis Of Algorithms | E |
| CSCE 312 | Computer Organization | R |
| CSCE 313 | Introduction To Computer Systems | R |
| CSCE 314 | Programming Languages | R |
| CSCE 315 | Programming Studio | R |
| CSCE 321 | Computer Architecture | E |
| CSCE 332 | Programming Language Design | E |
| CSCE 350 | Computer Architecture And Design | E |
| CSCE 410 | Operating Systems | E |
| CSCE 411 | Design And Analysis Of Algorithms | R |
| CSCE 420 | Artificial Intelligence | E |
| CSCE 431 | Software Engineering | E |
| CSCE 433 | Formal Languages And Automata | E |
| CSCE 434 | Compiler Design | E |
| CSCE 436 | Computer-human Interaction | E |
| CSCE 438 | Distributed Objects Programming | E |
| CSCE 440 | Quantum Algorithms | E |
| CSCE 441 | Computer Graphics | E |
| CSCE 442 | Scientific Programming | E |
| CSCE 444 | Structures Of Interactive Information | E |
| CSCE 452 | Robotics And Spatial Intelligence | E |
| CSCE 456 | Real-time Computing | E |
| CSCE 462 | Microcomputer Systems | E |

**Table A.51:** Courses for the Computer Science major at Texas A & M

### Texas A & M (page 2)

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CSCE 463 | Networks And Distributed Processing | E |
| CSCE 469 | Advanced Computer Architecture | E |
| CSCE 470 | Information Storage And Retrieval | E |
| CSCE 481 | Seminar | R |
| CSCE 482 | Senior Capstone Design | R |
| CSCE 483 | Computer Systems Design | E |
| CSCE 485 | Directed Studies | E |
| CSCE 489 | Special Topics | E |
| CSCE 491 | Research | E |

**Table A.52:** Courses for the Computer Science major at Texas A & M (Page 2)

### Texas Arlington, University of

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CSE 1104 | Introduction To Engineering | R |
| CSE 1105 | Introduction To Computer Science And Engineering | R |
| CSE 1301 | Computer Literacy | E |
| CSE 1310 | Introduction To Computers & Programming | E |
| CSE 1311 | Introductory Programming For Engineers & Scientists | E |
| CSE 1320 | Intermediate Programming | R |
| CSE 1325 | Object-oriented & Event-driven Programming | R |
| CSE 1392 | Special Topics | E |
| CSE 2140 | Digital Logic Lab | E |
| CSE 2312 | Computer Organization & Architecture | R |
| CSE 2315 | Discrete Structures | R |
| CSE 2320 | Algorithms & Data Structures | R |
| CSE 2321 | Data Structures For Non-engineers | E |
| CSE 2392 | Special Topics | E |
| CSE 3302 | Programming Languages | R |
| CSE 3310 | Fundamentals Of Software Engineering | R |
| CSE 3315 | Theoretical Concepts In Computer Science And Engineering | R |
| CSE 3316 | Professional Practices | R |
| CSE 3320 | Operating Systems | R |
| CSE 3330 | Database Systems And File Structures | R |
| CSE 3340 | Computational Methods In Computer Engineering | E |
| CSE 3392 | Special Topics | E |
| CSE 3442 | Embedded Systems I | E |
| CSE 4191 | Individual Projects | E |
| CSE 4303 | Computer Graphics | E |
| CSE 4305 | Compilers For Algorithmic Languages | E |
| CSE 4308 | Artificial Intelligence I | R |
| CSE 4309 | Artificial Intelligence II | E |
| CSE 4311 | Object-oriented Software Engineering | E |
| CSE 4313 | Introduction To Signal Processing | E |
| CSE 4316 | Computer System Design Project I | R |
| CSE 4317 | Computer System Design Project II | R |
| CSE 4321 | Software Testing & Maintenance | E |
| CSE 4322 | Software Project Management | E |
| CSE 4323 | Quantitative Computer Architecture | E |
| CSE 4331 | Database Implementation And Theory | E |

**Table A.53:** Courses for the Computer Science major at Texas Arlington, University of

### Texas Arlington, University of (page 2)

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CSE 4340 | Mobile Systems Engineering | E |
| CSE 4342 | Embedded Systems II | E |
| CSE 4344 | Computer Network Organization | E |
| CSE 4348 | Multimedia Systems | E |
| CSE 4351 | Parallel Processing | E |
| CSE 4360 | Autonomous Robot Design And Programming | E |
| CSE 4361 | Software Design Patterns | E |
| CSE 4391 | Individual Projects | E |
| CSE 4392 | Special Topics | E |

**Table A.54:** Courses for the Computer Science major at Texas Arlington, University of (Page 2)

## Virginia Polytechnic Institute and State University

| Registration ID | Course Name | Req Ind |
|---|---|---|
| 1004 | Computer Literacy | E |
| 1044 | Introduction To Programming In C | E |
| 1054 | Introduction To Programming In Java | E |
| 1104 | Introduction To Computer Science | E |
| 1114 | Introduction To Software Design Fundamental Concepts Of Programming From An Object-oriented Perspective | R |
| 1124 | Introduction To Media Computation | R |
| 1204 | Internet And System Software | E |
| 1344 | Programming In C | E |
| 1604 | Introduction To The Internet | E |
| 1614 | Introduction To Living In The Knowledge Society (likes) | E |
| 1704 | Introduction To Data Structures And Software Engineering | E |
| 1705 | Introduction To Object-oriented Development | E |
| 1944 | Computer Science First Year Seminar | E |
| 2104 | Introduction To Problem Solving In Computer Science | R |
| 2114 | Software Design And Data Structures | R |
| 2204 | Unix | E |
| 2304 | Self Study In A Programming System | E |
| 2504 | Introduction To Computer Organization | E |
| 2505 | Introduction To Computer Organization I | R |
| 2506 | Introduction To Computer Organization II | R |
| 2604 | Data Structures And File Management | E |
| 2605 | Data Structs & Oo Development | E |
| 2704 | Object-oriented Software Design And Construction | E |
| 3114 | Data Structures And Algorithms | R |
| 3204 | Operating Systems | E |
| 3214 | Computer Systems | R |
| 3304 | Comparative Languages | R |
| 3604 | Professionalism In Computing | R |
| 3704 | Intermediate Software Design And Engineering | E |
| 3724 | Introduction To Human-computer Interaction | E |
| 3744 | Intro Gui Programming/graphics | E |
| 3824 | Introduction To Computational Biology And Bioinformatics | E |
| 4004 | Data And Information Structures | E |

**Table A.55:** Courses for the Computer Science major at Virginia Polytechnic Institute and State University

**Virginia Polytechnic Institute and State University (page 2)**

| Registration ID | Course Name | Req Ind |
|---|---|---|
| 4014 | Principles Of Computer Architecture And Operating Systems | E |
| 4104 | Data And Algorithm Analysis | C |
| 4114 | Introduction To Formal Languages And Automata Theory | C |
| 4124 | Theory Of Computation | C |
| 4204 | Computer Graphics | E |
| 4214 | Simulation And Modeling | E |
| 4224 | Performance Evaluation Of Computer Systems | E |
| 4234 | Parallel Computation | E |
| 4244 | Internet Software Development | E |
| 4254 | Computer Network Architecture And Programming | E |
| 4284 | Systems & Networking Capstone | E |
| 4304 | Compiler Design And Implementation | E |
| 4604 | Introduction To Data Base Management Systems | E |
| 4624 | Multimedia, Hypertext And Information Access | E |
| 4634 | Design Of Information | E |
| 4644 | Creative Computing Studio | E |
| 4704 | Software Engineering | E |
| 4804 | Introduction To Artificial Intelligence | E |

**Table A.56:** Courses for the Computer Science major at Virginia Polytechnic Institute and State University (Page 2)

## Virginia's College at Wise, University of

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CSC 1010 | Object Oriented Programming | E |
| CSC 1100 | Computer Literacy | E |
| CSC 1180 | Foundations Of Computer Programming In C/c++ | R |
| CSC 1350 | Computer Network Assembly | E |
| CSC 2180 | Data Structures | R |
| CSC 2220 | Programming In Java | C |
| CSC 2230 | Programming In C# | C |
| CSC 2300 | Software Engineering | R |
| CSC 3050 | Digital Logic | C |
| CSC 3180 | Introduction To Algorithms | R |
| CSC 3250 | Unix Systems | C |
| CSC 3260 | Introduction To Human - Computer Interaction | C |
| CSC 3300 | Fundamentals Of Computer Science | E |
| CSC 3380 | Introduction To Numerical Methods | E |
| CSC 3400 | Database Design And Applications | R |
| CSC 3600 | Operations Research | E |
| CSC 3710 | Discrete Structures | E |
| CSC 3750 | Web Technologies | C |
| CSC 4000 | Operating Systems: Theory And Practice | R |
| CSC 4110 | Advanced Database Systems | C |
| CSC 4150 | Introduction To Robotics And Artificial Intelligence | C |
| CSC 4200 | Programming Languages | R |
| CSC 4300 | Computer Architecture | R |
| CSC 4350 | Computer Networks | R |
| CSC 4380 | Information Security | C |
| CSC 4400 | Computer Graphics | E |
| CSC 4450 | Introduction To Compilers | E |
| CSC 4500 | Modeling And Simulation | E |
| CSC 4600 | Information Characteristics | C |
| CSC 4700 | Special Studies In Computer Science | E |
| CSC 4990 | Computer Science Seminar | R |

**Table A.57:** Courses for the Computer Science major at Virginia's College at Wise, University of

### West Virginia University Institute of Technology

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CS 100 | Computer Science | E |
| CS 101 | Intro To Computer Applications | E |
| CS 112 | Computer Science For Engineers | E |
| CS 115 | Discrete Structures | R |
| CS 121 | Computer Science 1 | R |
| CS 122 | Computer Science 2 | R |
| CS 201 | Data Structures | R |
| CS 221 | Analysis Of Algorithms | R |
| CS 222 | Intro Software Engineering | R |
| CS 225 | C# | E |
| CS 231 | Introduction To Computer Organization | R |
| CS 251 | Operations Workshop I | R |
| CS 261 | Ascs Projects | E |
| CS 263 | Introduction To Networking | R |
| CS 264 | Data Base Management | E |
| CS 265 | Introduction To Computer Languages | E |
| CS 266 | E-commerce | E |
| CS 270 | Linux | E |
| CS 279 | Sophomore Seminar | R |
| CS 293 | Special Topics | E |
| CS 310 | Principles Of Programming Languages | R |
| CS 322 | System Analysis And Design Methodology | R |
| CS 324 | Database Management | R |
| CS 350 | Computer System Concepts | R |
| CS 365 | Computer Languages | E |
| CS 370 | Microcontrollers | E |
| CS 410 | Compiler Construction | R |
| CS 450 | Operating Systems Structures | E |
| CS 454 | Cryptology | E |
| CS 456 | Digital Image Processing | E |
| CS 461 | Senior Project | R |
| CS 470 | Introduction To Computer Graphics | E |
| CS 472 | Artificial Intelligence | E |
| CS 479 | Advanced CS Math | R |

**Table A.58:** Courses for the Computer Science major at West Virginia University Institute of Technology

**William Penn University**

| Registration ID | Course Name | Req Ind |
|---|---|---|
| APCS 110 | Microcomputer Applications | E |
| APCS 112 | Computer Applications For Communications | E |
| APCS 114 | Computer Applications For Business | E |
| APCS 205 | Algorithms & Programming | R |
| APCS 215 | Visual Programming | E |
| APCS 220 | Computer Organization & Digital Circuits | R |
| APCS 225 | File Processing (cobol) | E |
| APCS 242 | Computer & Network Management | R |
| APCS 265 | System Analysis And Design Methods | R |
| APCS 305 | Programming Techniques | R |
| APCS 310 | Operating Systems & Networks | E |
| APCS 311 | Networking | E |
| APCS 312 | Operating Systems | R |
| APCS 326 | Database Management Information Systems | R |
| APCS 336 | Current Topics In Applied Computer Science (web Programming) | R |
| APCS 342 | Installation/troubleshooting Practicum | E |
| APCS 344 | Training Practicum | E |
| APCS 345 | Numerical Analysis Methods | R |
| APCS 346 | Information & Security Assurance | E |
| APCS 350 | Data Structures & Algorithm Analysis | R |
| APCS 355 | Testing & Quality Assurance | E |
| APCS 360 | Software Engineering Project | R |
| APCS 370 | Systems Implementation | E |
| APCS 390 | Professional Development Seminar | R |
| APCS 395 | Professional Development Seminar II | R |

**Table A.59:** Courses for the Computer Science major at William Penn University

## Wisconsin, University of

| Registration ID | Course Name | Req Ind |
|---|---|---|
| COMP SCI 202 | Introduction To Computation | E |
| COMP SCI 240 | Introduction To Discrete Mathematics | R |
| COMP SCI 250 | Digital Society: The Impact Of Computers And Computer Technology | E |
| COMP SCI 252 | Introduction To Computer Engineering | E |
| COMP SCI 298 | Directed Study In Computer Science | E |
| COMP SCI 302 | Introduction To Programming | R |
| COMP SCI 304 | Group Meeting | E |
| COMP SCI 310 | Problem Solving Using Computers | E |
| COMP SCI 352 | Digital System Fundamentals | R |
| COMP SCI 354 | Machine Organization And Programming | R |
| COMP SCI 367 | Introduction To Data Structures | R |
| COMP SCI 368 | Topics Course Learning A New Programming Language | E |
| COMP SCI 371 | Technology Of Computer-based Business Systems | E |
| COMP SCI 412 | Introduction To Numerical Methods | C |
| COMP SCI 416 | Foundations of Scientific Computing | C |
| COMP SCI 425 | Introduction to Combinatorial Optimization | C |
| COMP SCI 471 | Introduction To Computational Statistics | E |
| COMP SCI 475 | Introduction To Combinatorics | E |
| COMP SCI 513 | Numerical Linear Algebra | C |
| COMP SCI 514 | Numerical Analysis | C |
| COMP SCI 520 | Introduction To Theory Of Computing | C |
| COMP SCI 525 | Linear Programming Methods | C |
| COMP SCI 533 | Image Processing | E |
| COMP SCI 536 | Introduction To Programming Languages And Compilers | C |
| COMP SCI 537 | Introduction To Operating Systems | C |
| COMP SCI 538 | Introduction to the Theory and Design of Programming Languages | C |
| COMP SCI 539 | Introduction To Artificial Neural Network And Fuzzy Systems | E |
| COMP SCI 540 | Introduction To Artificial Intelligence | E |
| COMP SCI 547 | Computer Systems Modeling Fundamentals | C |
| COMP SCI 552 | Introduction To Computer Architecture | C |
| COMP SCI 559 | Computer Graphics | C |
| COMP SCI 564 | Database Management Systems: Design And Implementation | C |

**Table A.60:** Courses for the Computer Science major at Wisconsin, University of

## Wisconsin, University of (page 2)

| Registration ID | Course Name | Req Ind |
|---|---|---|
| COMP SCI 576 | Introduction To Bioinformatics | E |
| COMP SCI 577 | Introduction To Algorithms | C |
| COMP SCI 640 | Introduction To Computer Networks | C |
| COMP SCI 642 | Introduction To Information Security | E |

**Table A.61:** Courses for the Computer Science major at Wisconsin, University of (Page 2)

### Worcester Polytechnic

| Registration ID | Course Name | Req Ind |
|---|---|---|
| CS 1101 | Introduction To Program Design | C |
| CS 1102 | Accelerated Introduction To Program Design | C |
| CS 2011 | Introduction To Machine Organization And Assembly Language | E |
| CS 2022 | Discrete Mathematics | E |
| CS 2102 | Object-oriented Design Concepts | R |
| CS 2118 | Object-oriented Design Concepts For Business Applications | E |
| CS 2223 | Algorithms | E |
| CS 2301 | Systems Programming For Non-majors | E |
| CS 2303 | Systems Programming Concepts | R |
| CS 3013 | Operating Systems | C |
| CS 3041 | Human-computer Interaction | C |
| CS 3043 | Social Implications Of Information Processing | C |
| CS 3133 | Foundations Of Computer Science | C |
| CS 3431 | Database Systems I | C |
| CS 3516 | Computer Networks | E |
| CS 3733 | Software Engineering | C |
| CS 4032 | Numerical Methods for Linear and Nonlinear Systems | E |
| CS 4033 | Numerical Methods for Calculus and Differential Equations | E |
| CS 4120 | Analysis Of Algorithms | C |
| CS 4123 | Theory Of Computation | C |
| CS 4233 | Object-oriented Analysis And Design | C |
| CS 4241 | Webware: Computational Technology For Network Information Systems | E |
| CS 4341 | Introduction To Artificial Intelligence | E |
| CS 4401 | Software Security Engineering | E |
| CS 4432 | Database Systems II | E |
| CS 4445 | Data Mining And Knowledge Discovery In Databases | E |
| CS 4513 | Distributed Computing Systems | C |
| CS 4515 | Computer Architecture | C |
| CS 4516 | Computer Networks | C |
| CS 4533 | Techniques Of Programming Language Translation | C |
| CS 4536 | Programming Languages | C |
| CS 4731 | Computer Graphics | E |
| CS 4732 | Computer Animation | E |

**Table A.62:** Courses for the Computer Science major at Worcester Polytechnic

# Appendix B

# Key Course List

### Advanced Database Systems

| Course Name | College or University | Req Ind |
|---|---|---|
| Advanced Database Systems | Virginia's College at Wise, University of | C |

**Table B.1:** Example of Advanced Database Systems

### Algorithm Analysis

| Course Name | College or University | Req Ind |
|---|---|---|
| Algorithm Analysis | Brigham Young University | R |
| Algorithms & Problem Solving Paradigms | Hendrix College | R |
| Computing And Algorithms I | Kettering University | R |
| Intermediate Programming: Algorithm Design And Analysis | Linfield College | R |
| Introduction To Algorithms | Wisconsin, University of | C |
| Introduction To Analysis Of Algorithms | Bucknell University | C |
| Theory Of Algorithms | Princeton University | C |

**Table B.2:** Example of Algorithm Analysis

### Algorithms II

| Course Name | College or University | Req Ind |
|---|---|---|
| Computing And Algorithms II | Kettering University | R |

**Table B.3:** Example of Algorithms II

### Algorithms III

| Course Name | College or University | Req Ind |
|---|---|---|
| Computing & Algorithms III | Kettering University | R |

**Table B.4:** Example of Algorithms III

### Algorithms and Complexity

| Course Name | College or University | Req Ind |
|---|---|---|
| Advanced Topics In Algorithms, Complexity And Intelligent Systems | Linfield College | R |
| Algorithm Design And Analysis | Carnegie Mellon University | R |
| Algorithm Design And Analysis | Kentucky, University of | R |
| Algorithms | Stevens Institute of Technology | R |
| Algorithms | Northern Arizona University | R |
| Algorithms | Christian Brothers University | R |
| Algorithms | Cedarville University | R |
| Algorithms & Programming | William Penn University | R |
| Analysis Of Algorithms | West Virginia University Institute of Technology | R |
| Analysis Of Algorithms | Oregon State University | R |
| Analysis Of Algorithms | Eastern Mennonite University | R |
| Analysis Of Algorithms | Worcester Polytechnic | C |
| Analysis Of Algorithms | Nevada, Reno, University of | R |
| Analysis Of Algorithms | South Dakota School of Mines and Technology | R |
| Analysis Of Algorithms | Rhode Island College | R |
| Applied Algorithms | Amherst College | C |

**Table B.5:** Example of Algorithms and Complexity

### Algorithms and Complexity (Page 2)

| Course Name | College or University | Req Ind |
|---|---|---|
| Data And Algorithm Analysis | Virginia Polytechnic Institute and State University | C |
| Design And Analysis Of Algorithms | Texas A & M | R |
| Design And Analysis Of Algorithms | Southern California, University of | R |
| Design And Analysis Of Algorithms | New Mexico Institute of Mining and Technology | R |
| Design And Analysis Of Efficient Algorithms | Rochester, University of | R |
| Efficient Algorithms And Intractable Problems | California Berkely, University of | R |
| Introduction To Algorithms | Virginia's College at Wise, University of | R |
| Introduction To Algorithms | Oberlin College | R |
| Introduction to Analysis of Algorithms | Cornell University | R |
| Introduction To Computational Theory | Brigham Young University | R |
| Introduction To The Design And Analysis Of Algorithms | Duke University | R |
| Introduction To Theory Of Computing | Wisconsin, University of | C |
| Logic, Computability And Complexity | Calvin College | C |
| Theory Of Computation | Kettering University | R |
| Theory Of Computation | Hendrix College | C |

**Table B.6:** Example of Algorithms and Complexity(Page 2)

### Artificial Intelligence

| Course Name | College or University | Req Ind |
|---|---|---|
| Artificial Intelligence | Amherst College | C |
| Artificial Intelligence | Bethel University | R |
| Artificial Intelligence | Princeton University | C |
| Artificial Intelligence | Calvin College | C |
| Artificial Intelligence | Rochester, University of | R |
| Artificial Intelligence | Hendrix College | C |
| Artificial Intelligence I | Texas Arlington, University of | R |
| Introduction To Artificial Intelligence | Michigan State University | C |
| Introduction To Artificial Intelligence | California Berkely, University of | C |
| Introduction To Artificial Intelligence | Rhode Island College | C |
| Introduction To Robotics And Artificial Intelligence | Virginia's College at Wise, University of | C |
| Practicum in Artificial Intelligence | Cornell University | C |

**Table B.7:** Example of Artificial Intelligence

### Assembly Language Programming

| Course Name | College or University | Req Ind |
|---|---|---|
| Assembly Language | South Dakota School of Mines and Technology | R |

**Table B.8:** Example of Assembly Language Programming

### Automata Theory

| Course Name | College or University | Req Ind |
|---|---|---|
| Automata Theory | Northern Arizona University | R |
| Introduction To Formal Languages And Automata Theory | Virginia Polytechnic Institute and State University | C |
| Theory Of Computation | Princeton University | C |
| Theory Of Computation | Worcester Polytechnic | C |

**Table B.9:** Example of Automata Theory

### Combinatorics

| Course Name | College or University | Req Ind |
|---|---|---|
| Introduction to Combinatorial Optimization | Wisconsin, University of | C |

**Table B.10:** Example of Combinatorics

### Compiler Design

| Course Name | College or University | Req Ind |
|---|---|---|
| Compiler Construction | West Virginia University Institute of Technology | R |
| Compiler Design | Amherst College | C |
| Compiler Optimization | Bucknell University | C |
| Compiler Theory And Practice | Cedarville University | R |
| Compiler Writing | New Mexico Institute of Mining and Technology | R |
| Compiling Techniques | Princeton University | C |
| Introduction To Programming Languages And Compilers | Wisconsin, University of | C |
| Practicum in Compilers | Cornell University | C |
| Special Topics In Computer Science: Compiler Design | Calvin College | C |
| Techniques Of Programming Language Translation | Worcester Polytechnic | C |
| Translation Of Programming Languages | Michigan State University | C |

**Table B.11:** Example of Compiler Design

### Computational Geometry

| Course Name | College or University | Req Ind |
|---|---|---|
| Computational Geometry | Princeton University | C |

**Table B.12:** Example of Computational Geometry

### Computational Linguistics

| Course Name | College or University | Req Ind |
|---|---|---|
| Introduction To Computational Linguistics | Michigan State University | C |

**Table B.13:** Example of Computational Linguistics

### Computational Theory

| Course Name | College or University | Req Ind |
|---|---|---|
| Automata And Computation Theory | Johns Hopkins University | R |
| Computation And Formal Systems | Rochester, University of | R |
| Introduction To Computation Theory | Rhode Island College | R |
| Theoretical Concepts In Computer Science And Engineering | Texas Arlington, University of | R |
| Theoretical Foundations Of Computer Science | Amherst College | C |
| Theoretical Foundations Of Computing | Oklahoma State University | R |
| Theory Of Computation | Midwestern State University | R |
| Theory Of Computation | Illinois, University of | R |
| Theory Of Computation | Virginia Polytechnic Institute and State University | C |
| Theory Of Computation I | Bucknell University | R |
| Theory Of Computer Science | Oberlin College | R |

**Table B.14:** Example of Computational Theory

### Computer Architecture

| Course Name | College or University | Req Ind |
|---|---|---|
| Advanced Computer Architecture | Calvin College | C |
| Architecture And Assembly Language | Massachusetts Amherst, University of | R |
| Architecture And Operating Systems | Eastern Mennonite University | R |
| Computer Architecture | Michigan State University | C |
| Computer Architecture | Linfield College | R |
| Computer Architecture | Worcester Polytechnic | C |
| Computer Architecture | Stevens Institute of Technology | R |
| Computer Architecture | Virginia's College at Wise, University of | R |
| Computer Architecture | Bucknell University | C |
| Computer Architecture | Hendrix College | C |
| Computer Architecture | New Mexico Institute of Mining and Technology | R |
| Computer Architecture And Assembly Language | Oregon State University | R |
| Computer Architecture And Engineering | California Berkely, University of | C |
| Computer Architecture and Organization | Princeton University | C |
| Computer Architecture I | Illinois, University of | R |
| Computer Architecture With Assembly Language | Lyon College | R |
| Computer Organization And Architecture II | Rhode Island College | R |
| Introduction To Computer Architecture | Midwestern State University | R |

**Table B.15:** Example of Computer Architecture

### Computer Architecture (Page 2)

| Course Name | College or University | Req Ind |
|---|---|---|
| Introduction To Computer Architecture | Wisconsin, University of | C |
| Introduction To Computer Organization II | Virginia Polytechnic Institute and State University | R |

**Table B.16:** Example of Computer Architecture(Page 2)

### Computer Architecture II

| Course Name | College or University | Req Ind |
|---|---|---|
| Computer Architecture II | Illinois, University of | R |

**Table B.17:** Example of Computer Architecture II

### Computer Graphics

| Course Name | College or University | Req Ind |
|---|---|---|
| Computer Graphics | Michigan State University | C |
| Computer Graphics | Wisconsin, University of | C |
| Computer Graphics | Princeton University | C |
| Computer Graphics | Cedarville University | C |
| Computer Graphics | Calvin College | C |
| Computer Graphics | Bucknell University | C |
| Computer Graphics And Animation | Linfield College | R |
| Computer Graphics Practicum | Cornell University | C |
| Foundations Of Computer Graphics | California Berkely, University of | C |

**Table B.18:** Example of Computer Graphics

### Computer Models

| Course Name | College or University | Req Ind |
|---|---|---|
| Computer Models And Limitations | Rochester, University of | R |

**Table B.19:** Example of Computer Models

### Computer Organization and Assembly Language

| Course Name | College or University | Req Ind |
|---|---|---|
| Computer Organization | Abilene Christian University | R |
| Computer Organization | Pace University | R |
| Computer Organization | Cornell University | C |
| Computer Organization | Rochester, University of | R |
| Computer Organization | Texas A & M | R |
| Computer Organization | Oberlin College | R |
| Computer Organization & Architecture | Texas Arlington, University of | R |
| Computer Organization & Digital Circuits | William Penn University | R |
| Computer Organization And Architecture | Michigan State University | R |
| Computer Organization And Architecture | South Dakota School of Mines and Technology | R |
| Computer Organization And Architecture I | Rhode Island College | R |
| Computer Organization And Programming | Duke University | R |
| Computer Organization And Programming | Stevens Institute of Technology | R |
| Computer Organization And Programming | Bucknell University | R |

**Table B.20:** Example of Computer Organization and Assembly Language

**Computer Organization and Assembly Language (Page 2)**

| Course Name | College or University | Req Ind |
|---|---|---|
| Computer Organization/assembly Language | Maine at Fort Kent, University of | C |
| Introduction To Computer Organization | Northern Arizona University | R |
| Introduction To Computer Organization | West Virginia University Institute of Technology | R |
| Introduction To Computer Organization I | Virginia Polytechnic Institute and State University | R |

**Table B.21:** Example of Computer Organization and Assembly Language(Page 2)

### Computer Science Capstone

| Course Name | College or University | Req Ind |
|---|---|---|
| Capstone Computer Science Design | Bucknell University | R |
| Capstone Experience | Northern Arizona University | R |
| Capstone Project | Linfield College | R |
| Capstone: Computer Science | Pittsburgh Bradford, University of | R |
| Computer Science Project I | Christian Brothers University | R |
| Computer Science Seminar | Virginia's College at Wise, University of | R |
| Professional Development Seminar | William Penn University | R |
| Seminar In Social Responsibility | Midwestern State University | R |
| Senior Capstone Design | Texas A & M | R |
| Senior Design I | South Dakota School of Mines and Technology | R |
| Senior Design Project | Johns Hopkins University | C |
| Senior Design Project | Kentucky, University of | R |
| Senior Project | West Virginia University Institute of Technology | R |
| Senior Project In Computing | Calvin College | R |
| Senior Projects In Computer Science | Nevada, Reno, University of | R |
| Senior Seminar | Abilene Christian University | R |
| Senior Software Engineering Project | Oregon State University | R |

**Table B.22:** Example of Computer Science Capstone

### Computer Science Capstone II

| Course Name | College or University | Req Ind |
|---|---|---|
| Computer Science Project II | Christian Brothers University | R |
| Senior Design II | South Dakota School of Mines and Technology | R |
| Senior Project In Computing II | Calvin College | R |
| Senior Software Engineering Project | Oregon State University | R |

**Table B.23:** Example of Computer Science Capstone II

### Computer Science Capstone III

| Course Name | College or University | Req Ind |
|---|---|---|
| Senior Software Engineering Project | Oregon State University | R |

**Table B.24:** Example of Computer Science Capstone III

### Computer Science Honors Thesis

| Course Name | College or University | Req Ind |
|---|---|---|
| Computer Science Honors Thesis | Bucknell University | C |

**Table B.25:** Example of Computer Science Honors Thesis

### Computer Vision

| Course Name | College or University | Req Ind |
|---|---|---|
| Computer Vision | Princeton University | C |

**Table B.26:** Example of Computer Vision

### Computing for Other Majors

| Course Name | College or University | Req Ind |
|---|---|---|
| Computing For The Physical And Social Sciences | Princeton University | C |

**Table B.27:** Example of Computing for Other Majors

### Cross-disciplinary Project

| Course Name | College or University | Req Ind |
|---|---|---|
| Cross-disciplinary Project | Hendrix College | C |

**Table B.28:** Example of Cross-disciplinary Project

### Cryptography

| Course Name | College or University | Req Ind |
|---|---|---|
| Cryptography | Princeton University | C |

**Table B.29:** Example of Cryptography

### Data Communications and Networking

| Course Name | College or University | Req Ind |
|---|---|---|
| Advanced Computer Networks | Calvin College | C |
| Computer & Network Management | William Penn University | R |
| Computer Networks | Michigan State University | C |

**Table B.30:** Example of Data Communications and Networking

### Data Communications and Networking (Page 2)

| Course Name | College or University | Req Ind |
|---|---|---|
| Computer Networks | Princeton University | C |
| Computer Networks | Cornell University | C |
| Computer Networks | Worcester Polytechnic | C |
| Computer Networks | Oklahoma State University | R |
| Computer Networks | Virginia's College at Wise, University of | R |
| Computer Networks | Bucknell University | C |
| Computer Networks And The Internet | Pace University | R |
| Data And Computer Communication | New Mexico Institute of Mining and Technology | R |
| Data Communications And Computer Networks | Bethel University | R |
| Data Communications And Networking | Christian Brothers University | R |
| Fundamentals of Networking and Data Communications | Abilene Christian University | R |
| Introduction To Computer Networks | Wisconsin, University of | C |
| Introduction To Computer Networks | Oregon State University | R |
| Introduction To Data And Computer Communications | Rhode Island College | C |
| Introduction To Networking | West Virginia University Institute of Technology | R |
| Networking | Lyndon State College | R |
| Networking | Maine at Fort Kent, University of | C |
| Networking And Data Communications | Eastern Mennonite University | R |
| Networks And Cryptography | Amherst College | C |

**Table B.31:** Example of Data Communications and Networking(Page 2)

### Data Structures

| Course Name | College or University | Req Ind |
|---|---|---|
| Data Structure | Pittsburgh Bradford, University of | R |
| Data Structures | Midwestern State University | R |
| Data Structures | Illinois, University of | R |
| Data Structures | Johns Hopkins University | R |
| Data Structures | West Virginia University Institute of Technology | R |
| Data Structures | Christian Brothers University | R |
| Data Structures | Northern Arizona University | R |
| Data Structures | Oregon State University | R |
| Data Structures | Stevens Institute of Technology | R |
| Data Structures | Nevada, Reno, University of | R |
| Data Structures | Eastern Mennonite University | R |
| Data Structures | California Berkely, University of | R |
| Data Structures | Virginia's College at Wise, University of | R |
| Data Structures | South Dakota School of Mines and Technology | R |
| Data Structures | Southern California, University of | R |
| Data Structures And Functional Programming | Cornell University | R |
| Data Structures And Objects | Bethel University | R |
| Data Structures Using Java | Cedarville University | R |
| Introduction To Data Structures | Wisconsin, University of | R |
| Introduction To Data Structures | Calvin College | R |
| Programming With Data Structures | Massachusetts Amherst, University of | R |

**Table B.32:** Example of Data Structures

### Data Structures (Page 2)

| Course Name | College or University | Req Ind |
|---|---|---|
| Software Design And Data Structures | Virginia Polytechnic Institute and State University | R |
| The Science Of Data Structures | Rochester, University of | R |

**Table B.33:** Example of Data Structures(Page 2)

### Data Structures And Algorithms

| Course Name | College or University | Req Ind |
|---|---|---|
| Algorithms & Data Structures | Texas Arlington, University of | R |
| Algorithms And Data Structures | Michigan State University | R |
| Algorithms And Data Structures | Lyndon State College | R |
| Algorithms And Data Structures | Princeton University | R |
| Algorithms And Data Structures | Bucknell University | R |
| Algorithms And Data Structures | New Mexico Institute of Mining and Technology | R |
| Data Structures & Algorithm Analysis | William Penn University | R |
| Data Structures And Algorithm Analysis I | Oklahoma State University | R |
| Data Structures And Algorithms | Virginia Polytechnic Institute and State University | R |
| Data Structures And Algorithms | Brigham Young University | R |
| Data Structures And Algorithms | Calvin College | R |
| Data Structures And Algorithms | Texas A & M | R |
| Data Structures And Algorithms I | Amherst College | R |
| Data Structures And Algorithms I | Pace University | R |
| Data Structures And Algorithms I | Lyon College | R |
| Fundamental Data Structures And Algorithms | Carnegie Mellon University | R |

**Table B.34:** Example of Data Structures And Algorithms

### Data Structures And Algorithms II

| Course Name | College or University | Req Ind |
|---|---|---|
| Data Structures And Algorithms II | Amherst College | R |
| Data Structures And Algorithms II | Pace University | R |
| Data Structures And Algorithms II | Lyon College | R |

**Table B.35:** Example of Data Structures And Algorithms II

### Data Structures and Algorithms Using OO

| Course Name | College or University | Req Ind |
|---|---|---|
| Introduction To Computer Science II | Bucknell University | R |

**Table B.36:** Example of Data Structures and Algorithms Using OO

### Database Concepts

| Course Name | College or University | Req Ind |
|---|---|---|
| Data Base Design | Christian Brothers University | R |
| Database And Information Management Systems | Princeton University | C |
| Database Design And Applications | Virginia's College at Wise, University of | R |
| Database Management | West Virginia University Institute of Technology | R |
| Database Management Information Systems | William Penn University | R |
| Database Management Systems | Linfield College | R |

**Table B.37:** Example of Database Concepts

### Database Concepts (Page 2)

| Course Name | College or University | Req Ind |
|---|---|---|
| Database Management Systems | Stevens Institute of Technology | R |
| Database Management Systems | Calvin College | C |
| Database Management Systems | South Dakota School of Mines and Technology | R |
| Database Management Systems: Design And Implementation | Wisconsin, University of | C |
| Database Organization And Design | Cedarville University | R |
| Database Systems | Michigan State University | C |
| Database Systems | Lyndon State College | R |
| Database Systems | Bethel University | R |
| Database Systems | Hendrix College | C |
| Database Systems And File Structures | Texas Arlington, University of | R |
| Database Systems I | Worcester Polytechnic | C |
| Databases | Maine at Fort Kent, University of | C |
| Databases And Information Management | Eastern Mennonite University | R |
| Introduction To Database | Bucknell University | C |
| Introduction To Database Systems | California Berkely, University of | C |
| Introduction To Database Systems | Rhode Island College | C |
| Introduction To Databases | Oregon State University | R |
| Introduction to Databases and Database Management Systems | Abilene Christian University | R |
| Practicum in Database Systems | Cornell University | C |

**Table B.38:** Example of Database Concepts(Page 2)

### Discrete Mathematics

| Course Name | College or University | Req Ind |
|---|---|---|
| Discrete Math For Computer Science | Duke University | R |
| Discrete Mathematics | Kentucky, University of | R |
| Discrete Mathematics | Kettering University | R |
| Discrete Mathematics And Probability Theory | California Berkely, University of | R |
| Discrete Mathematics For Computer Science | Oklahoma State University | R |
| Discrete Methods In Computer Science | Southern California, University of | R |
| Discrete Structures | Illinois, University of | R |
| Discrete Structures | Brigham Young University | R |
| Discrete Structures | West Virginia University Institute of Technology | R |
| Discrete Structures | Cornell University | R |
| Discrete Structures | Texas Arlington, University of | R |
| Discrete Structures For Computing | Texas A & M | R |
| Discrete Structures In Computer Science | Michigan State University | R |
| Introduction To Computation | Massachusetts Amherst, University of | C |
| Introduction To Discrete Mathematics | Wisconsin, University of | R |

**Table B.39:** Example of Discrete Mathematics

## Distributed Computing

| Course Name | College or University | Req Ind |
|---|---|---|
| Distributed Computing | Bucknell University | C |
| Distributed Computing Systems | Worcester Polytechnic | C |

**Table B.40:** Example of Distributed Computing

## Finite Structures

| Course Name | College or University | Req Ind |
|---|---|---|
| Finite Structures | South Dakota School of Mines and Technology | R |

**Table B.41:** Example of Finite Structures

## Functional Programming

| Course Name | College or University | Req Ind |
|---|---|---|
| Functional Programming | Rhode Island College | C |

**Table B.42:** Example of Functional Programming

## Genomics and Computational Molecular Biology

| Course Name | College or University | Req Ind |
|---|---|---|
| Introduction to Genomics and Computational Molecular Biology | Princeton University | C |

**Table B.43:** Example of Genomics and Computational Molecular Biology

### Graph Theory

| Course Name | College or University | Req Ind |
|---|---|---|
| Graphs, Their Algorithms, And Software Engineering | Bucknell University | C |
| Introduction to Graph Theory | Princeton University | C |

**Table B.44:** Example of Graph Theory

### Great Theoretical Ideas In Computer Science

| Course Name | College or University | Req Ind |
|---|---|---|
| Great Theoretical Ideas In Computer Science | Carnegie Mellon University | R |

**Table B.45:** Example of Great Theoretical Ideas In Computer Science

### High Performance Computing

| Course Name | College or University | Req Ind |
|---|---|---|
| High Performance Computing | Calvin College | C |

**Table B.46:** Example of High Performance Computing

### Honors

| Course Name | College or University | Req Ind |
|---|---|---|
| Senior Departmental Honors | Amherst College | C |

**Table B.47:** Example of Honors

### Human Computer Interface

| Course Name | College or University | Req Ind |
|---|---|---|
| Graphical User Interfaces | South Dakota School of Mines and Technology | R |
| Human-computer Interaction | Worcester Polytechnic | C |
| Human-computer Interface Technology | Princeton University | C |
| Introduction To Human - Computer Interaction | Virginia's College at Wise, University of | C |
| Introduction To Usability Engineering | Oregon State University | R |
| User Interface Design And Development | California Berkely, University of | C |

**Table B.48:** Example of Human Computer Interface

### Independent Study

| Course Name | College or University | Req Ind |
|---|---|---|
| Independent Study In Computer Science | Cedarville University | C |
| Individual Study In Computer Science | Bucknell University | C |
| Junior Independent Work | Princeton University | C |
| Junior Independent Work | Princeton University | C |
| Senior Independent Work | Princeton University | C |
| Senior Independent Work | Princeton University | C |

**Table B.49:** Example of Independent Study

### Independent Study II

| Course Name | College or University | Req Ind |
|---|---|---|
| Independent Study In Computer Science | Cedarville University | C |

**Table B.50:** Example of Independent Study II

### Information Retrieval

| Course Name | College or University | Req Ind |
|---|---|---|
| Information Characteristics | Virginia's College at Wise, University of | C |
| Information Retrieval | Michigan State University | C |
| Information Retrieval, Discovery, And Delivery | Princeton University | C |

**Table B.51:** Example of Information Retrieval

### Information Structures

| Course Name | College or University | Req Ind |
|---|---|---|
| Information Structures | Rhode Island College | R |
| Introduction To Information Structures | Pittsburgh Bradford, University of | R |

**Table B.52:** Example of Information Structures

### Interacting with Data

| Course Name | College or University | Req Ind |
|---|---|---|
| Interacting with Data | Princeton University | C |

**Table B.53:** Example of Interacting with Data

### Internet Auctions: Theory And Practice

| Course Name | College or University | Req Ind |
|---|---|---|
| Internet Auctions: Theory And Practice | Princeton University | C |

**Table B.54:** Example of Internet Auctions: Theory And Practice

### Internship

| Course Name | College or University | Req Ind |
|---|---|---|
| Computer Science Internship | Cedarville University | C |
| Internship In Computer Science | Lyndon State College | R |
| Internship In Computer Science | Christian Brothers University | R |
| Programming Practicum | Hendrix College | R |

**Table B.55:** Example of Internship

### Introduction To Computing Using Matlab

| Course Name | College or University | Req Ind |
|---|---|---|
| Introduction To Computing Using Matlab | Cornell University | C |
| Introduction To Computing Using Matlab And Robotics | Cornell University | C |

**Table B.56:** Example of Introduction To Computing Using Matlab

### Introduction To Engineering

| Course Name | College or University | Req Ind |
|---|---|---|
| Introduction To Engineering | Texas Arlington, University of | R |

**Table B.57:** Example of Introduction To Engineering

### Introduction To Programming

| Course Name | College or University | Req Ind |
|---|---|---|
| Advanced Visual Basic | Lyndon State College | R |
| Introduction to Java Programming | Rhode Island College | C |
| Introduction To Programming | Abilene Christian University | R |
| Introduction To Programming: Functions | Linfield College | R |

**Table B.58:** Example of Introduction To Programming

## Introduction to Computer Science

| Course Name | College or University | Req Ind |
|---|---|---|
| Computer Science 1 | Bethel University | R |
| Computer Science Orientation | Oregon State University | R |
| Concepts Of Computer Science | Pittsburgh Bradford, University of | R |
| Foundations Of Computer Science I | Hendrix College | R |
| Fundamentals Of Computer Science | Christian Brothers University | R |
| General Computer Science | Princeton University | R |
| Intro To Computer Science | Illinois, University of | R |
| Introduction To Computer Science | Maine at Fort Kent, University of | R |
| Introduction to Computer Science | Abilene Christian University | R |
| Introduction To Computer Science | Stevens Institute of Technology | R |
| Introduction To Computer Science And Engineering | Texas Arlington, University of | R |
| Introduction To Computer Science And Information Technology | New Mexico Institute of Mining and Technology | R |
| Introduction To Computer Science I | Amherst College | R |
| Introduction To Computer Science I | Bucknell University | R |
| Introduction To Computing | Nevada, Reno, University of | R |
| Introduction To Computing | Calvin College | R |
| Introduction To Computing | Texas A & M | R |
| Principles Of Computer Science I | Oberlin College | R |

**Table B.59:** Example of Introduction to Computer Science

## Linear Programming

| Course Name | College or University | Req Ind |
|---|---|---|
| Linear Programming Methods | Wisconsin, University of | C |

**Table B.60:** Example of Linear Programming

## Logic Design

| Course Name | College or University | Req Ind |
|---|---|---|
| Digital Logic | Virginia's College at Wise, University of | C |
| Logic And Theory Of Computing | Kentucky, University of | R |
| Logic Design | Midwestern State University | R |

**Table B.61:** Example of Logic Design

## Machine Organization

| Course Name | College or University | Req Ind |
|---|---|---|
| Machine Organization And Programming | Wisconsin, University of | R |
| Machine Structures | California Berkely, University of | R |

**Table B.62:** Example of Machine Organization

## Mathematics Of Computer Science

| Course Name | College or University | Req Ind |
|---|---|---|
| Mathematical Foundations Of Computer Science | Duke University | R |
| Mathematical Foundations Of Computer Science | Lyon College | R |
| Mathematics Of Computer Science | Nevada, Reno, University of | R |

**Table B.63:** Example of Mathematics Of Computer Science

### Media Computing

| Course Name | College or University | Req Ind |
|---|---|---|
| Introduction To Media Computation | Virginia Polytechnic Institute and State University | R |
| Media Processing And Multimedia Computing | Michigan State University | C |

**Table B.64:** Example of Media Computing

### Microcomputers

| Course Name | College or University | Req Ind |
|---|---|---|
| Microcomputer Organization | Kentucky, University of | R |
| Microcomputers I | Kettering University | R |

**Table B.65:** Example of Microcomputers

### Microcontroller Architecture Programming

| Course Name | College or University | Req Ind |
|---|---|---|
| Microcontroller Architecture Programming | Pittsburgh Bradford, University of | R |

**Table B.66:** Example of Microcontroller Architecture Programming

## Numerical Methods

| Course Name | College or University | Req Ind |
|---|---|---|
| Advanced CS Math | West Virginia University Institute of Technology | R |
| Introduction To Numerical Methods | Wisconsin, University of | C |
| Introduction To Numerical Methods | Kentucky, University of | R |
| Introduction To Numerical Methods And Analysis | Duke University | R |
| Numerical Analysis | Wisconsin, University of | C |
| Numerical Analysis | Calvin College | C |
| Numerical Analysis Methods | William Penn University | R |
| Numerical Linear Algebra | Wisconsin, University of | C |
| Numerical Methods | Bethel University | C |
| Numerical Methods For Digital Computers | Oklahoma State University | R |
| Numerical Methods I | Illinois, University of | R |

**Table B.67:** Example of Numerical Methods

## Numerical Methods II

| Course Name | College or University | Req Ind |
|---|---|---|
| Numerical Methods II | Illinois, University of | R |

**Table B.68:** Example of Numerical Methods II

### Object Oriented Programming

| Course Name | College or University | Req Ind |
|---|---|---|
| Introduction To Object Oriented Programming | New Mexico Institute of Mining and Technology | R |
| Object Oriented Design | Christian Brothers University | R |
| Object Oriented Problem Solving | Lyndon State College | R |
| Object-oriented & Event-driven Programming | Texas Arlington, University of | R |
| Object-oriented Design Concepts | Worcester Polytechnic | R |
| Object-oriented Design Using C++ | Cedarville University | R |
| Object-oriented Programming | Abilene Christian University | R |
| Object-oriented Programming | Southern California, University of | R |
| Object-oriented Programming And Data Structures | Cornell University | C |
| Object-oriented Software Design | Michigan State University | R |

**Table B.69:** Example of Object Oriented Programming

### Object-Oriented Design

| Course Name | College or University | Req Ind |
|---|---|---|
| Foundations Of Computer Science II | Hendrix College | R |
| Object-oriented Analysis And Design | Worcester Polytechnic | C |
| Object-oriented Software Engineering | Johns Hopkins University | C |

**Table B.70:** Example of Object-Oriented Design

### Operating Systems

| Course Name | College or University | Req Ind |
|---|---|---|
| Advanced Operating Systems | Amherst College | C |
| Design And Implementation Of Operating Systems I | Oklahoma State University | R |
| Introduction To Operating Systems | Duke University | R |
| Introduction To Operating Systems | Midwestern State University | R |
| Introduction To Operating Systems | Wisconsin, University of | C |
| Introduction to Operating Systems | Kentucky, University of | R |
| Operating Systems | Michigan State University | R |
| Operating Systems | William Penn University | R |
| Operating Systems | Princeton University | C |
| Operating Systems | Worcester Polytechnic | C |
| Operating Systems | Christian Brothers University | R |
| Operating Systems | Northern Arizona University | R |
| Operating Systems | Stevens Institute of Technology | R |
| Operating Systems | Cedarville University | R |
| Operating Systems | Kettering University | R |
| Operating Systems | Lyon College | R |
| Operating Systems | South Dakota School of Mines and Technology | R |
| Operating Systems | Southern California, University of | R |
| Operating Systems | Texas Arlington, University of | R |
| Operating Systems And Computer Architecture | Bethel University | R |
| Operating Systems And Computer Architecture | Rhode Island College | R |
| Operating Systems And Concurrent Computing | Hendrix College | C |

**Table B.71:** Example of Operating Systems

### Operating Systems (Page 2)

| Course Name | College or University | Req Ind |
|---|---|---|
| Operating Systems And Networking | Linfield College | R |
| Operating Systems And Networking | Calvin College | R |
| Operating Systems And System Programming | California Berkely, University of | R |
| Operating Systems Design | Brigham Young University | R |
| Operating Systems Design | Bucknell University | R |
| Operating Systems I | Oregon State University | R |
| Operating Systems: Theory And Practice | Virginia's College at Wise, University of | R |
| Practicum in Operating Systems | Cornell University | C |
| Principles Of Operating Systems | Nevada, Reno, University of | R |
| Principles Of Operating Systems | New Mexico Institute of Mining and Technology | R |

**Table B.72:** Example of Operating Systems(Page 2)

### Operating Systems II

| Course Name | College or University | Req Ind |
|---|---|---|
| Operating Systems II | Oregon State University | R |

**Table B.73:** Example of Operating Systems II

### Operations Research

| Course Name | College or University | Req Ind |
|---|---|---|
| Operations Research | Bethel University | C |

**Table B.74:** Example of Operations Research

### Operations Workshop I

| Course Name | College or University | Req Ind |
|---|---|---|
| Operations Workshop I | West Virginia University Institute of Technology | R |

**Table B.75:** Example of Operations Workshop I

### Parallel Computing

| Course Name | College or University | Req Ind |
|---|---|---|
| Parallel Computing | Cedarville University | C |

**Table B.76:** Example of Parallel Computing

### Perspectives On Computing

| Course Name | College or University | Req Ind |
|---|---|---|
| Perspectives On Computing | Calvin College | R |

**Table B.77:** Example of Perspectives On Computing

### Pervasive Information Systems

| Course Name | College or University | Req Ind |
|---|---|---|
| Pervasive Information Systems | Princeton University | C |

**Table B.78:** Example of Pervasive Information Systems

### Portfolio

| Course Name | College or University | Req Ind |
|---|---|---|
| Portfolio | Lyndon State College | R |

**Table B.79:** Example of Portfolio

### Problems Solving

| Course Name | College or University | Req Ind |
|---|---|---|
| Introduction To Problem Solving In Computer Science | Virginia Polytechnic Institute and State University | R |
| Introduction To Problem Solving With Computers | Massachusetts Amherst, University of | R |

**Table B.80:** Example of Problems Solving

### Program Design

| Course Name | College or University | Req Ind |
|---|---|---|
| Introduction To Program Design | Worcester Polytechnic | C |
| Introduction To Program Design And Concepts | Texas A & M | R |
| Introduction To Program Design, Abstraction, And Problem Solving | Kentucky, University of | R |
| Program Design And Analysis II | Duke University | R |

**Table B.81:** Example of Program Design

### Program Design II

| Course Name | College or University | Req Ind |
|---|---|---|
| Accelerated Introduction To Program Design | Worcester Polytechnic | C |

**Table B.82:** Example of Program Design II

### Programming I

| Course Name | College or University | Req Ind |
|---|---|---|
| Beginning Programming: Objects | Linfield College | R |
| C Programming | Oklahoma State University | R |
| C++ Programming | Lyndon State College | R |
| C++ Programming | Cedarville University | R |
| Computer Programming I | Pace University | R |
| Computer Programming I | Rhode Island College | R |
| Computer Science 1 | West Virginia University Institute of Technology | R |
| Computer Science I | Midwestern State University | R |
| Computer Science I | Northern Arizona University | R |
| Computer Science I | Nevada, Reno, University of | R |
| Computer Science I | South Dakota School of Mines and Technology | R |
| Concurrent Programming | Stevens Institute of Technology | R |
| Foundations Of Computer Programming In C/(No Suggestions) | Virginia's College at Wise, University of | R |
| Fundamentals Of Computer Programming | Southern California, University of | R |
| Introduction To Computer Programming | Brigham Young University | R |
| Introduction To Computer Programming | Kentucky, University of | R |
| Introduction To Computer Science | Pittsburgh Bradford, University of | R |
| Introduction To Computer Science | Christian Brothers University | R |
| Introduction To Computer Science I | Oregon State University | R |
| Introduction To Computing Using Java | Cornell University | C |

**Table B.83:** Example of Programming I

### Programming I (Page 2)

| Course Name | College or University | Req Ind |
|---|---|---|
| Introduction To Programming | Wisconsin, University of | R |
| Introduction To Programming | Maine at Fort Kent, University of | R |
| Introduction To Programming | Bethel University | R |
| Introduction To Programming | New Mexico Institute of Mining and Technology | R |
| Introduction To Programming I | Michigan State University | R |
| Introduction To Programming I | Lyon College | R |
| Introduction To Programming In Java | Johns Hopkins University | R |
| Introduction To Programming Systems | Princeton University | R |
| Principles Of Programming | Carnegie Mellon University | R |
| Programming Abstractions | Oberlin College | R |
| Programming I | Abilene Christian University | R |
| Programming Techniques | William Penn University | R |
| The Science Of Programming | Rochester, University of | R |

**Table B.84:** Example of Programming I(Page 2)

### Programming II

| Course Name | College or University | Req Ind |
|---|---|---|
| Advanced Programming Concepts | Brigham Young University | R |
| Advanced Programming Techniques | Princeton University | C |
| Computer Programming – C++ | Maine at Fort Kent, University of | C |
| Computer Programming II | Pace University | R |
| Computer Programming II | Rhode Island College | R |

**Table B.85:** Example of Programming II

**Programming II (Page 2)**

| Course Name | College or University | Req Ind |
|---|---|---|
| Computer Science 2 | Bethel University | R |
| Computer Science 2 | West Virginia University Institute of Technology | R |
| Computer Science II | Midwestern State University | R |
| Computer Science II | Northern Arizona University | R |
| Computer Science II | Nevada, Reno, University of | R |
| Computer Science II | South Dakota School of Mines and Technology | R |
| Intermediate Programming | Johns Hopkins University | R |
| Intermediate Programming | Texas Arlington, University of | R |
| Intermediate Programming: Data Abstractions | Linfield College | R |
| Intermediate Programming: Java | Eastern Mennonite University | R |
| Intermediate/advanced Programming | Carnegie Mellon University | R |
| Introduction To Computer Science II | Amherst College | R |
| Introduction To Computer Science II | Oregon State University | R |
| Introduction To Programming II | Michigan State University | R |
| Introduction To Programming II | Lyon College | R |
| Java Programming | Lyndon State College | R |
| Principles Of Computer Science II | Oberlin College | R |
| Programming Ii: Data Structures | Abilene Christian University | R |
| Programming In Java | Virginia's College at Wise, University of | C |

**Table B.86:** Example of Programming II(Page 2)

### Programming Languages

| Course Name | College or University | Req Ind |
|---|---|---|
| Comparative Languages | Virginia Polytechnic Institute and State University | R |
| Computability And Formal Language Theory | Michigan State University | C |
| Concepts Of Programming Languages | Brigham Young University | R |
| Formal Languages And Automata | New Mexico Institute of Mining and Technology | R |
| Foundations Of Computer Science | Worcester Polytechnic | C |
| Functional Languages And Parsing | Kettering University | R |
| Introduction to the Theory and Design of Programming Languages | Wisconsin, University of | C |
| Organization Of Programming Languages | Michigan State University | C |
| Organization Of Programming Languages | Bethel University | R |
| Organization Of Programming Languages | Oklahoma State University | R |
| Organization Of Programming Languages | Rhode Island College | R |
| Principles Of Languages | Northern Arizona University | R |
| Principles Of Programming Languages | West Virginia University Institute of Technology | R |
| Principles Of Programming Languages | Stevens Institute of Technology | R |
| Programming Language Concepts | Calvin College | R |
| Programming Language Fundamentals | Oregon State University | R |
| Programming Language Paradigms | Amherst College | C |

**Table B.87:** Example of Programming Languages

### Programming Languages (Page 2)

| Course Name | College or University | Req Ind |
|---|---|---|
| Programming Language Survey | Cedarville University | R |
| Programming Languages | Princeton University | C |
| Programming Languages | Eastern Mennonite University | R |
| Programming Languages | Lyon College | R |
| Programming Languages | Virginia's College at Wise, University of | R |
| Programming Languages | South Dakota School of Mines and Technology | R |
| Programming Languages | Texas A & M | R |
| Programming Languages | Texas Arlington, University of | R |
| Programming Languages And Compilers | California Berkely, University of | C |
| Programming Languages and Logics | Cornell University | R |
| Programming Languages, Concepts And Implementation | Nevada, Reno, University of | R |
| Survey Of Programming Languages | Hendrix College | C |
| Topics In Contemporary Programming Languages | Midwestern State University | R |

**Table B.88:** Example of Programming Languages(Page 2)

### Programming Languages II

| Course Name | College or University | Req Ind |
|---|---|---|
| Automata And Formal Languages | Nevada, Reno, University of | R |
| Principles Of Programming Languages | New Mexico Institute of Mining and Technology | R |
| Programming Language Design | Bucknell University | R |
| Programming Language Design & Implementation | Rochester, University of | R |
| Programming Languages | Worcester Polytechnic | C |

**Table B.89:** Example of Programming Languages II

### Programming Methodology

| Course Name | College or University | Req Ind |
|---|---|---|
| Programming Methodology | Massachusetts Amherst, University of | C |

**Table B.90:** Example of Programming Methodology

### Programming Studio

| Course Name | College or University | Req Ind |
|---|---|---|
| Programming Studio | Illinois, University of | R |
| Programming Studio | Texas A & M | R |

**Table B.91:** Example of Programming Studio

### Programming in Another Language

| Course Name | College or University | Req Ind |
|---|---|---|
| Advanced Visual Basic Programming | Rhode Island College | C |
| C++ Programming | Rhode Island College | C |
| Computer Programming – Cobol | Maine at Fort Kent, University of | C |
| Computer Programming – Fortran | Maine at Fort Kent, University of | C |
| Computer Programming – Visual Basic | Maine at Fort Kent, University of | C |
| Programming In C# | Virginia's College at Wise, University of | C |

**Table B.92:** Example of Programming in Another Language

### Reasoning About Computation And Uncertainty

| Course Name | College or University | Req Ind |
|---|---|---|
| Reasoning About Computation | Princeton University | C |
| Reasoning About Uncertainty | Massachusetts Amherst, University of | C |

**Table B.93:** Example of Reasoning About Computation And Uncertainty

### Scientific Computing

| Course Name | College or University | Req Ind |
|---|---|---|
| Foundations of Scientific Computing | Wisconsin, University of | C |
| Scientific Computing | Hendrix College | C |

**Table B.94:** Example of Scientific Computing

### Security

| Course Name | College or University | Req Ind |
|---|---|---|
| Computer And Network Security | Bucknell University | C |
| Computer Security | Lyndon State College | R |
| Computer Security | California Berkely, University of | C |
| Computer Security | Calvin College | C |
| Information Security | Princeton University | C |
| Information Security | Virginia's College at Wise, University of | C |
| Introduction To Computer Security | Michigan State University | C |
| Introduction to IT Security | Stevens Institute of Technology | R |
| Network Security | Cedarville University | C |

**Table B.95:** Example of Security

### Seminar

| Course Name | College or University | Req Ind |
|---|---|---|
| Introductory Computing Seminar | Calvin College | R |
| Seminar | Texas A & M | R |
| Seminar In Computer Science | Amherst College | C |
| Senior Seminar | Hendrix College | C |
| Undergraduate Problem Seminar | Rochester, University of | R |

**Table B.96:** Example of Seminar

### Seminar II

| Course Name | College or University | Req Ind |
|---|---|---|
| Computing Seminar | Calvin College | R |
| Professional Development Seminar II | William Penn University | R |

**Table B.97:** Example of Seminar II

### Senior Design I

| Course Name | College or University | Req Ind |
|---|---|---|
| Collaborative Design | Michigan State University | R |
| Senior Design I | Bucknell University | C |

**Table B.98:** Example of Senior Design I

### Senior Design II

| Course Name | College or University | Req Ind |
|---|---|---|
| Senior Design II | Bucknell University | C |

**Table B.99:** Example of Senior Design II

### Social and Ethical Issues in Computer Science

| Course Name | College or University | Req Ind |
|---|---|---|
| Computer Ethics Theory And Practice | Johns Hopkins University | R |
| Computers And Society | Bucknell University | R |
| Ethics And Computers In Society | Brigham Young University | R |
| Legal, Ethical, and Social Issues of Information Technology | New Mexico Institute of Mining and Technology | R |
| Social And Ethical Impact Of Computing | Pittsburgh Bradford, University of | R |
| Social And Ethical Issues In Computer Science | Northern Arizona University | R |
| Social And Ethical Issues In Computer Science | Oregon State University | R |
| Social Implications Of Information Processing | Worcester Polytechnic | C |
| Social Issues In Computing | Massachusetts Amherst, University of | R |

**Table B.100:** Example of Social and Ethical Issues in Computer Science

### Software Design

| Course Name | College or University | Req Ind |
|---|---|---|
| Software Design And Implementation | Duke University | R |
| Software Design And Testing | Brigham Young University | R |

**Table B.101:** Example of Software Design

### Software Development

| Course Name | College or University | Req Ind |
|---|---|---|
| Principles Of Software Development | Southern California, University of | R |
| Software Development Process | Stevens Institute of Technology | R |

**Table B.102:** Example of Software Development

### Software Engineering

| Course Name | College or University | Req Ind |
|---|---|---|
| Fundamentals Of Software Engineering | Texas Arlington, University of | R |
| Intro Software Engineering | West Virginia University Institute of Technology | R |
| Introduction To Software Design | Virginia Polytechnic Institute and State University | R |
| Introduction To Software Engineering | Kentucky, University of | R |
| Introduction To Software Engineering | Southern California, University of | R |
| Software Engineering | Midwestern State University | R |
| Software Engineering | Michigan State University | C |
| Software Engineering | Linfield College | R |
| Software Engineering | Bethel University | R |
| Software Engineering | California Berkely, University of | C |
| Software Engineering | Worcester Polytechnic | C |
| Software Engineering | Northern Arizona University | R |
| Software Engineering | Nevada, Reno, University of | R |
| Software Engineering | Kettering University | R |
| Software Engineering | Calvin College | R |

**Table B.103:** Example of Software Engineering

### Software Engineering (Page 2)

| Course Name | College or University | Req Ind |
|---|---|---|
| Software Engineering | Virginia's College at Wise, University of | R |
| Software Engineering | South Dakota School of Mines and Technology | R |
| Software Engineering | Hendrix College | C |
| Software Engineering | Rhode Island College | R |
| Software Engineering | New Mexico Institute of Mining and Technology | R |
| Software Engineering I | Oregon State University | R |
| Software Engineering I | Cedarville University | R |
| Software Engineering Practice I | Stevens Institute of Technology | R |
| Software Engineering Project | William Penn University | R |

**Table B.104:** Example of Software Engineering(Page 2)

### Software Engineering II

| Course Name | College or University | Req Ind |
|---|---|---|
| Software Engineering II | Oregon State University | R |
| Software Engineering II | Cedarville University | R |
| Software Engineering Practice II | Stevens Institute of Technology | R |

**Table B.105:** Example of Software Engineering II

### Software Systems

| Course Name | College or University | Req Ind |
|---|---|---|
| Design And Construction Of Large Software Systems | Southern California, University of | R |

Table B.106: Example of Software Systems

### Software Testing

| Course Name | College or University | Req Ind |
|---|---|---|
| Software Testing | Rhode Island College | C |

Table B.107: Example of Software Testing

### Sophomore Seminar

| Course Name | College or University | Req Ind |
|---|---|---|
| Sophomore Seminar | West Virginia University Institute of Technology | R |

Table B.108: Example of Sophomore Seminar

### Structure of Programs

| Course Name | College or University | Req Ind |
|---|---|---|
| The Structure And Interpretation Of Computer Programs | California Berkely, University of | R |

**Table B.109:** Example of Structure of Programs

### Survey Of Information Assurance And Security

| Course Name | College or University | Req Ind |
|---|---|---|
| Survey Of Information Assurance And Security | Maine at Fort Kent, University of | C |

**Table B.110:** Example of Survey Of Information Assurance And Security

### Systems

| Course Name | College or University | Req Ind |
|---|---|---|
| Components And Design Techniques For Digital Systems | California Berkely, University of | C |
| Computer System Concepts | West Virginia University Institute of Technology | R |
| Computer System Fundamentals | Johns Hopkins University | R |
| Computer Systems | Virginia Polytechnic Institute and State University | R |
| Computer Systems I | Amherst College | R |
| Computer Systems Modeling Fundamentals | Wisconsin, University of | C |
| Digital System Fundamentals | Wisconsin, University of | R |
| Digital Systems I | Kettering University | R |
| Introduction To Computer Systems | Brigham Young University | R |
| System Analysis And Design Methodology | West Virginia University Institute of Technology | R |
| System Analysis And Design Methods | William Penn University | R |
| Systems Analysis And Design | Maine at Fort Kent, University of | C |

**Table B.111:** Example of Systems

### Systems II

| Course Name | College or University | Req Ind |
|---|---|---|
| Computer System Design Project II | Texas Arlington, University of | R |
| Computer Systems II | Amherst College | R |

**Table B.112:** Example of Systems II

### Systems Programming

| Course Name | College or University | Req Ind |
|---|---|---|
| Computer System Design Project I | Texas Arlington, University of | R |
| Computer System Organization | New Mexico Institute of Mining and Technology | R |
| Computer Systems | Bethel University | R |
| Computer Systems | Oklahoma State University | R |
| Computer Systems Principles | Massachusetts Amherst, University of | C |
| Computing Systems Organization | Hendrix College | R |
| Effective Programming In C And Unix | Carnegie Mellon University | R |
| Introduction To Computer Systems | Carnegie Mellon University | R |
| Introduction To Computer Systems | Texas A & M | R |
| System Programming | Illinois, University of | R |
| Systems Analysis And Design | Lyndon State College | R |
| Systems Programming | Cornell University | C |
| Systems Programming | Stevens Institute of Technology | R |
| Systems Programming | New Mexico Institute of Mining and Technology | R |
| Systems Programming Concepts | Worcester Polytechnic | R |
| Systems Programming Concepts | Kettering University | R |

**Table B.113:** Example of Systems Programming

### Technical Communication And Analysis

| Course Name | College or University | Req Ind |
|---|---|---|
| Technical Communication And Analysis | Hendrix College | R |

**Table B.114:** Example of Technical Communication And Analysis

### The Computing Professional

| Course Name | College or University | Req Ind |
|---|---|---|
| Professional Practices | Texas Arlington, University of | R |
| Professionalism In Computing | Virginia Polytechnic Institute and State University | R |
| The Computer Science Profession | Kentucky, University of | R |
| The Computing Professional | Kettering University | R |

**Table B.115:** Example of The Computing Professional

### Topics In Computer Science

| Course Name | College or University | Req Ind |
|---|---|---|
| Advanced Topics In Computer Science | Linfield College | R |
| Advanced Topics In Computer Science | Cedarville University | C |
| Advanced Topics In Computer Science | Hendrix College | C |
| Current Topics In Applied Computer Science (web Programming) | William Penn University | R |
| Special Topics | Amherst College | C |
| Topics In Computer Science | Bethel University | R |
| Topics In Computer Science | Cedarville University | C |
| Topics In Computer Science | Bucknell University | C |

**Table B.116:** Example of Topics In Computer Science

### Transforming Reality By Computer

| Course Name | College or University | Req Ind |
|---|---|---|
| Transforming Reality By Computer | Princeton University | C |

**Table B.117:** Example of Transforming Reality By Computer

### Unix Programming

| Course Name | College or University | Req Ind |
|---|---|---|
| Fundamentals Of Unix And C Programming | Pace University | R |

**Table B.118:** Example of Unix Programming

### Unix Systems

| Course Name | College or University | Req Ind |
|---|---|---|
| Unix Systems | Virginia's College at Wise, University of | C |

**Table B.119:** Example of Unix Systems

### Web Information Retrieval

| Course Name | College or University | Req Ind |
|---|---|---|
| Web Information Retrieval | Bucknell University | C |

**Table B.120:** Example of Web Information Retrieval

### Web Programming

| Course Name | College or University | Req Ind |
|---|---|---|
| Internet Fundamentals And Webpage Design | Maine at Fort Kent, University of | C |
| Internet Programming | Brigham Young University | R |
| Introduction To Web Programming And Project Development | Stevens Institute of Technology | R |
| Programming Internet And Web Applications Part I | Lyndon State College | R |
| Web Applications | Cedarville University | R |
| Web Programming | Bethel University | R |

**Table B.121:** Example of Web Programming

### Web Technologies

| Course Name | College or University | Req Ind |
|---|---|---|
| Web Technologies | Virginia's College at Wise, University of | C |

**Table B.122:** Example of Web Technologies

# Appendix C

# Job Search Categories

## C.1 Dice

Dice, “The Career Hub for Tech Insiders [5]” “is a career website for technology and engineering professionals [5]”. This site is dedicated to technology jobs. This site allows the user to browse jobs by skill rather than by category like many of the other job search web sites. The following are the all the skills dice offers:

| | | | |
|---|---|---|---|
| .Net | .Net Developer | ASP.net | Business Analyst |
| C | CCNA | Cisco | Cobol |
| Data Architect | Data Warehouse | DB2 | Desktop Support |
| Engineering | ETL | HTML | Informatica |
| Integration | J2EE | Java | JavaScript |
| Linux | LoadRunner | Oracle | Oracle DBA |
| PeopleSoft | Perl | PHP | PMP |
| Project Manager | QA | SAP | SharePoint |
| Siebel | Software Development | Software Engineer | |
| SQL | SQL DBA | SQL Server | Systems Administrator |
| Systems Analyst | Technical Support | Unix | VB.net |
| VMWare | Web Developer | Weblogic | WebSphere |
| Windows | XML | | |

**Table C.1:** Dice Skills List [6]

## C.2 Snag a Job

Snagajob.com, developed by Shawn Boyer, began in 1999 as a favor for a friend. It allows users to search for part-time and full-time hourly jobs [12]. Snagajob only has one computer related category called “Computers & Technology [13]”. Once in the category, snagajob.com lists the companies and the number of jobs available, allowing the user to choose the company to find what computer-related jobs are available.

## C.3 Simply Hired

Based in Silicon Valley, SimplyHired’s goal is to make finding a job “a simple yet effective, enjoyable journey [10]”. SimplyHired displays 50 categories, eight of which are directly computer-related.

| | | |
|---|---|---|
| IT | Systems | QA |
| Internet | Networking | DBA |
| Technology | Software | |

**Table C.2:** Simply Hired Computer-Related Categories [11]

## C.4 Monster

Monster has been providing job-search opportunities for over 10 years in over 50 countries [9]. In its job search, Monster allows the user to narrow the search by selecting from State, Industry, Category, Posting Date, Career Level, Years of Experience, Education Level, and Job Type [8]. There are two main computer-related categories, “Biotech/R&D/Science” and “IT/Software Development [8]”.

## C.5 Career Builder

CareerBuilder.com offers 72 categories of jobs, six of which are computer-related.

| | |
|---|---|
| Biotechnology | Computer Hardware |
| Computer Software | Internet - ECommerce |
| Telecommunications | Wireless |

**Table C.3:** Career Builder Computer-Related Categories [4]

## C.6 Yahoo Hot Jobs

Yahoo Hot Jobs offers 42 categories of jobs, five of which are computer-related.

| | |
|---|---|
| Internet | QA and Quality Control |
| Software Engineer | Technology |
| Telecommunication | |

**Table C.4:** Yahoo Hot Jobs Computer-Related Categories

# Appendix D

# Technology Survey

# Technology Survey

## Purpose of study

The purpose of this study is to understand the perceptions and attitudes you, high school seniors have toward technology and studying computing how those perceptions and attitudes were formed.

## Description of study procedures

There are two levels of participation. The first level of participation is filling out this survey. Filling out this survey constitutes your consent to this level of participation.

The second level is to participate in a focus group to be held after school. The focus group will last approximately 90 minutes. Immediately following the focus group you will have an opportunity to ask questions of a college professor regarding college and possible technology majors. After all the focus groups have been held, a final questionnaire will be given. After that you will be entered in a drawing to win an iPod Nano.

Your name will only appear on this cover sheet and will be retained by the guidance counselor. All information will be kept private. You will not be identified in any publication or presentation of the study findings. All documents from this study will be kept confidential.

Your decision whether or not to participate is completely up to you. If you decide to participate, you are free to withdraw at any time. You may also choose not to answer questions on the questionnaires. I may also choose to withdraw from this study if it is in your best interest.

## Contact persons

If you have any questions related to the research please contact:
Principal Investigator: Scott Weaver
Email: sweaver@messiah.edu
Phone: 717-766-2511 x3785

Please check one of the following.

☐ I am not willing to participate in a focus group.

☐ I am willing to participate in a focus group. Check all the dates below that you are available. If you want a friend with you, write their name down.

- ☐ Mon, February 9
- ☐ Tue, February 10
- ☐ Wed, February 11
- ☐ Tue, February 17
- ☐ Wed, February 18
- ☐ Thu, February 19
- ☐ Mon, February 23
- ☐ Tue, February 24
- ☐ Wed, February 25

Name: ______________________________ Friend: ______________________________

# Technology Survey

1. The following information will be kept confidential and is only used for statistical purposes.

   Gender ☐ Male ☐ Female Age ___

## Interests in High School

2. What are your 2 favorite classes in High School?

3. What are your 2 least favorite classes in High School?

## Use of technology

4. What technology do you use regularly? (check all that apply)

   ☐ iPod or other MP3 player
   ☐ cell phone
   ☐ computer/laptop
   ☐ other: ______________________________

5. What technology would you love to use/own if you could?

6. What is the main thing you use computers for?

7. How many computers does your family have at home?

8. What are your favorite websites? Circle the one you think is the coolest.

9. What classes in technology have you? (check all that apply)

   ☐ Keyboarding
   ☐ Programming
   ☐ Use of the Internet
   ☐ Computer Applications (Word, Excel …)
   ☐ Graphics
   ☐ Network Certification
   ☐ Databases
   ☐ Multi-Media / Digital Photo.
   ☐ Hardware
   ☐ Web Design
   ☐ Other: ________________

10. What have you learned about computers that you've picked up on your own? (check all that apply)

   ☐ Upgrading my computer hardware (additional memory, graphics cards, etc.)
   ☐ Upgrading my computer software (new version of Operating System, Browser..)
   ☐ Application program installation
   ☐ Set up home network
   ☐ Programming
   ☐ Other ________________________
   ☐ Website development
   ☐ Installed new Operating System
   ☐ None

# Technology Survey

11. What would you love to learn about computers?

12. What would you like your major to be in college? List your top 2 choices at this point in your life.

13. Quickly read each term in the list below and react based on your first impression whether you think the term "Boring", "Neutral", or "Exciting" or don't know what it is.

| Term | Boring | Neutral | Exciting | What's This? |
|---|---|---|---|---|
| iPhone | | | | |
| Programming | | | | |
| Game Development | | | | |
| Virtual Machine | | | | |
| Networking | | | | |
| Graphics | | | | |
| Phishing | | | | |
| Open Source | | | | |
| Wiki / Blog | | | | |
| Linux | | | | |
| Security | | | | |
| Bandwidth | | | | |
| Firewall | | | | |
| E-commerce | | | | |
| Flashdrive | | | | |
| Spyware | | | | |
| Voice Over IP | | | | |
| Web Development | | | | |
| Robotics | | | | |
| Artificial Intelligence | | | | |

# Appendix E

# Interview Guide

# Understanding Attitudes and Perceptions of the Next Generation toward Technology

## Interview Guide

Version 2.0

Scott Weaver

February 17, 2009

# 1 Introduction

Enrollment has been dropping in the computing majors and reasons have been proposed based around the fear of not being able to land a job due to the dot-com bust, out-sourcing, and job scarcity [3]. However, according to the Bureau of Labor and Statistics, jobs in computing will increase in the next ten years [2, 1]. So what are the real reasons for the drop in enrollment? What are the perceptions of high school students that keep them from choosing computing as a major?

High school students and their parents are the primary stake holders from which to learn. Understanding their perceptions of computing majors and how studying computing fits into their world view is key to understanding this decline in enrollment. Without their input, the reasons for the drop in computing majors over the last five years [4] will continue to be guesswork.

# 2 The Purpose

The purpose of this study is to understand the perceptions and attitudes high school students have toward technology and how those perceptions and attitudes were formed.

## 3 Questions

- Thank you for your willingness to participate in this focus group. My goal is to understand what you think and believe about technology and computing. Because I want to know what YOU think, there are no wrong answers. I will be recording our conversations simply to be able to look for patterns and insights over all the focus groups I'll be conducting. This is all confidential, nothing you say today will be connected with you in my research, so please feel free to be totally honest about your feelings and thoughts during our conversation.

  1: **OPENING:** Tell us your name and what your favorite website or computer game is.
  2: **INTRODUCTION:** Describe the benefits of using technology and computers.
  3: **TRANSITION:** In your view, what is the difference between technology and computing? Which term is more appealing? Is there another term that fits better?
  4: **TRANSITION:** When you think about computing, what comes to mind?

- View of computers in general

  1: **KEY:** What excites you about computers?
  2: **KEY:** What has been your greatest disappointment in using computers?
  3: **KEY:** If you could change anything about computers and computing, what would you change?

- Job Opportunities in Computing

  1: **KEY:** What kind of jobs do you think are available to those who major in computing?
  2: **KEY:** If you studied computing in college, what do you think your job opportunities will be when you graduate?
  3: **KEY:** If you got a job using technology of some sort, what would your dream job look like?
  4: **KEY:** What do you think you need to study to get a "computing" job?

- Initial thoughts of Majoring in Computing

  1: **KEY:** Have you thought about what you'd like to major in when you go to college?
  2: **KEY:** What aspects of that major interest or intrigue you?
  3: **KEY:** Have you looked at any college websites to learn about their majors? What were your impressions of the website?
  4: **KEY:** Have you looked at any computing majors online? What were your impressions about the majors?

- Majoring in Computing

1: **KEY:** When you think about majoring in computing what comes to mind?
2: **KEY:** What do you hear people say about majoring in computing?
3: **KEY:** Who would you say is the person who has influenced you the most?
4: **KEY:** What are your thoughts about going to college and majoring in computing?
5: **KEY:** If you could make your own computing major, what would it look like?
6: **KEY:** How would you explain the computing major you just created to interest your friends or gain approval from someone in your family?

- Wrap-up regarding computing

1: **KEY:** Tell me up to five positive things about computing, no matter how small the positive thing is.
2: **KEY:** Tell me up to five negative things about computing, no matter how small the positive thing is.

- Ending

1: **ENDING:** Of all the things we've discussed, what is the most important disconnect you see between your perceptions of technology and computing and the idea of majoring in computing in college?

- **Note to Self**: Summarize the discussion in under 3 minutes...

1: **Summary:** Is this an adequate summary?
2: **Summary:** Did I correctly describe what was said?
3: **Summary:** How well does that capture what was said here?
4: **FINAL:** Have we missed anything?
5: **FINAL:** Is there anything that we should have talked about but didn't?

# References

[1] Arlene Dohm and Lynn Shniper. Occupational employment projections to 2016. `http://www.bls.gov/opub/mlr/2007/11/art5full.pdf`, November 2007.

[2] Eric B. Figueroa and Rose A. Woods. Industry output and employment projections to 2016. `http://www.bls.gov/opub/mlr/2007/11/art4full.pdf`, November 2007.

[3] John Sargent. An overview of past and projected employment changes in the professional it occupations. `http://www.cra.org/CRN/issues/0403.pdf`, May 2004.

[4] Stuart Zweben. 2006-2007 taulbee survey. `http://www.cra.org/CRN/articles/may08/taulbee.html`, May 2008.

# Appendix F

## Recruitment Script

Good morning. It's great to see you this morning. How many of you enjoy using technology, raise your hand. You may have a cell phone, maybe an iPhone or an iPod. You may enjoy playing your Wii or looking at the new gadgets in some of the new cars. Great.

Now, how many of you enjoy computers? You enjoy using them, you may even have installed software or upgraded the hardware.

That's great, I have a good group here today. I need your help. My name is Scott Weaver and I teach at Messiah College. I'm doing research on what you think about technology. What do you like and dislike. What do you think about computers or about studying computers.

The first way you can help is by filling out the survey that was handed to you on your way in. If you didn't get one, raise your hand and we'll be sure to get you one.

The second way is to give me your opinions in a group of 6-10 other students. These focus groups will be held after school, so I'll supply the pizza and soda if you participate. You only need to participate in one group. Because this is important to me and is taking some of your time, I will also enter your name into a drawing for an iPod Nano. It's that important to me to hear what you have to say.

These focus group will last approximately 90 minutes, after which I will stick around and answer any questions you may have about college or computer and technology related fields.

There is a place on the front of your survey to indicate that you are willing to participate in one of these focus groups. If you do, please check all the dates you could participate. If you want to make sure you are in the group with a friend, write your friends name down, but still indicate all the dates you are available. I can only do one group a day.

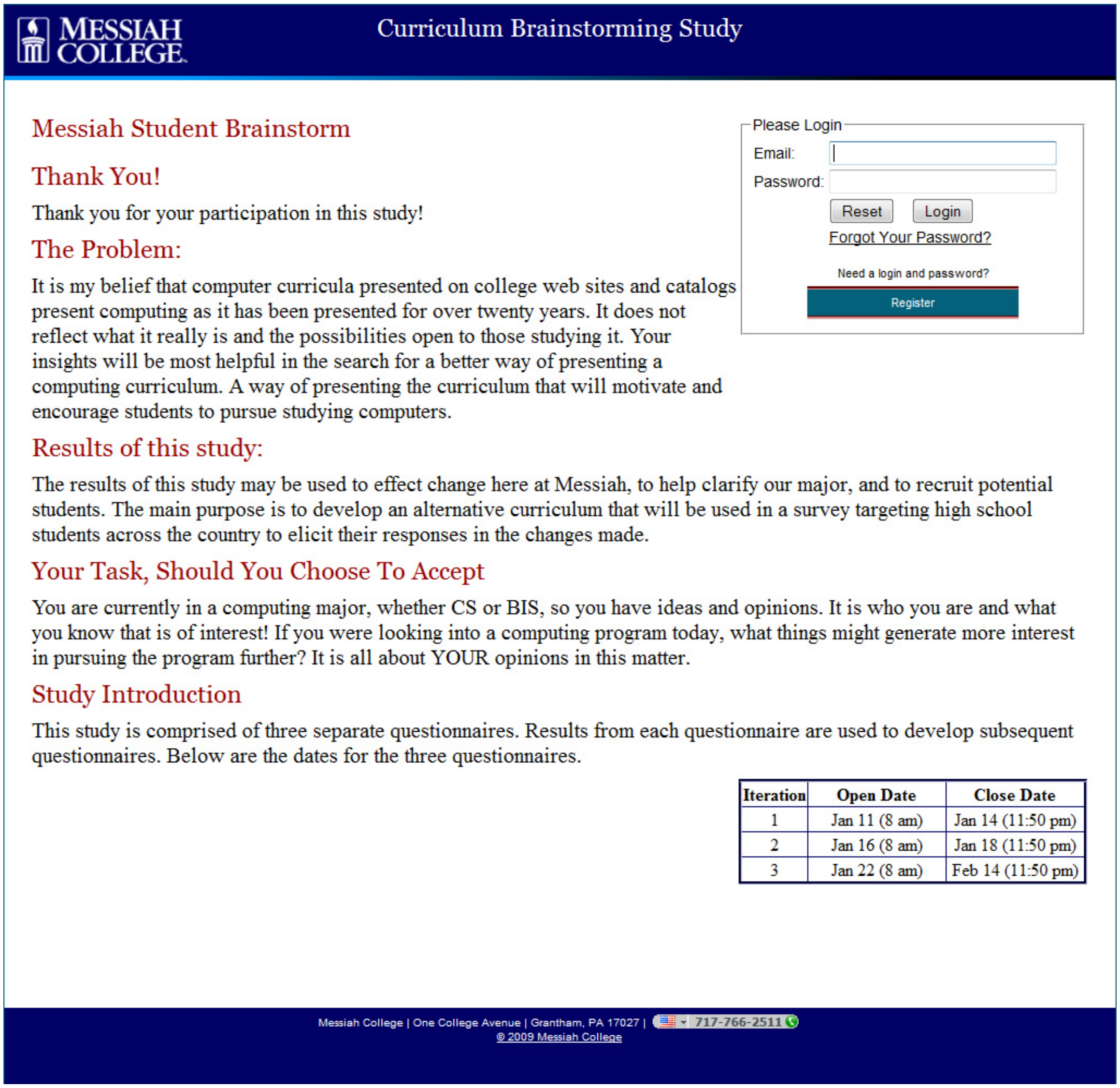
Take the next few minutes to complete your survey and we'll be around to collect them. Thank you so much.

# Appendix G

# Sample Delphi Session

## G.1 Delphi Study Introduction Screen

The welcome screen thanked the students for participating in the study. It presented the problem and how the results of the study would be used. It then provided instructions on how to proceed. At the bottom of the welcome screen was displayed the dates of the three Iterations.



Curriculum Brainstorming Study

Messiah Student Brainstorm

Thank You!

Thank you for your participation in this study!

The Problem:

It is my belief that computer curricula presented on college web sites and catalogs present computing as it has been presented for over twenty years. It does not reflect what it really is and the possibilities open to those studying it. Your insights will be most helpful in the search for a better way of presenting a computing curriculum. A way of presenting the curriculum that will motivate and encourage students to pursue studying computers.

Results of this study:

The results of this study may be used to effect change here at Messiah, to help clarify our major, and to recruit potential students. The main purpose is to develop an alternative curriculum that will be used in a survey targeting high school students across the country to elicit their responses in the changes made.

Your Task, Should You Choose To Accept

You are currently in a computing major, whether CS or BIS, so you have ideas and opinions. It is who you are and what you know that is of interest! If you were looking into a computing program today, what things might generate more interest in pursuing the program further? It is all about YOUR opinions in this matter.

Study Introduction

This study is comprised of three separate questionnaires. Results from each questionnaire are used to develop subsequent questionnaires. Below are the dates for the three questionnaires.

| Iteration | Open Date | Close Date |
|---|---|---|
| 1 | Jan 11 (8 am) | Jan 14 (11:50 pm) |
| 2 | Jan 16 (8 am) | Jan 18 (11:50 pm) |
| 3 | Jan 22 (8 am) | Feb 14 (11:50 pm) |

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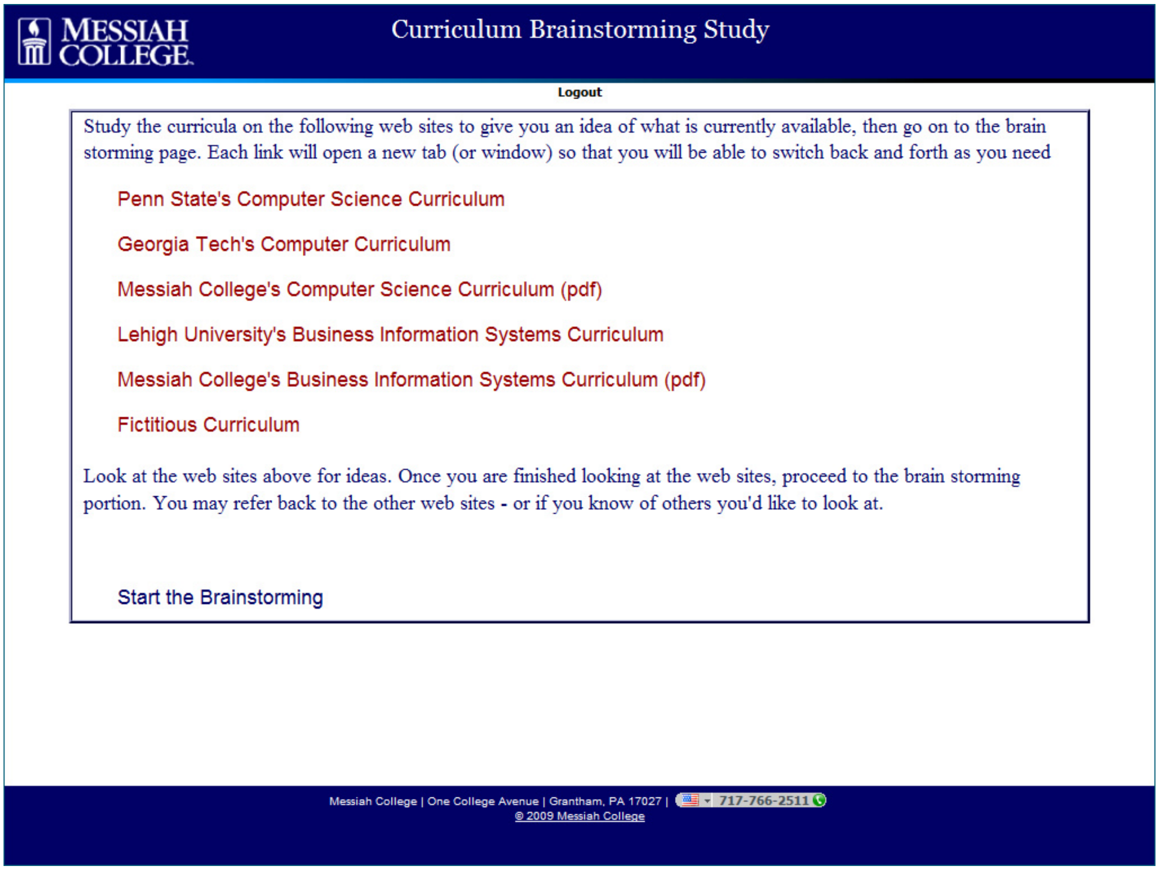
## G.2 Delphi Study Iteration One

The first screen of Iteration One asked the students to examine several curricula before brainstorming. The idea behind this was to aid the student in brainstorming ideas.



Curriculum Brainstorming Study

Study the curricula on the following web sites to give you an idea of what is currently available, then go on to the brain storming page. Each link will open a new tab (or window) so that you will be able to switch back and forth as you need

- Penn State's Computer Science Curriculum
- Georgia Tech's Computer Curriculum
- Messiah College's Computer Science Curriculum (pdf)
- Lehigh University's Business Information Systems Curriculum
- Messiah College's Business Information Systems Curriculum (pdf)
- Fictitious Curriculum

Look at the web sites above for ideas. Once you are finished looking at the web sites, proceed to the brain storming portion. You may refer back to the other web sites - or if you know of others you'd like to look at.

Start the Brainstorming

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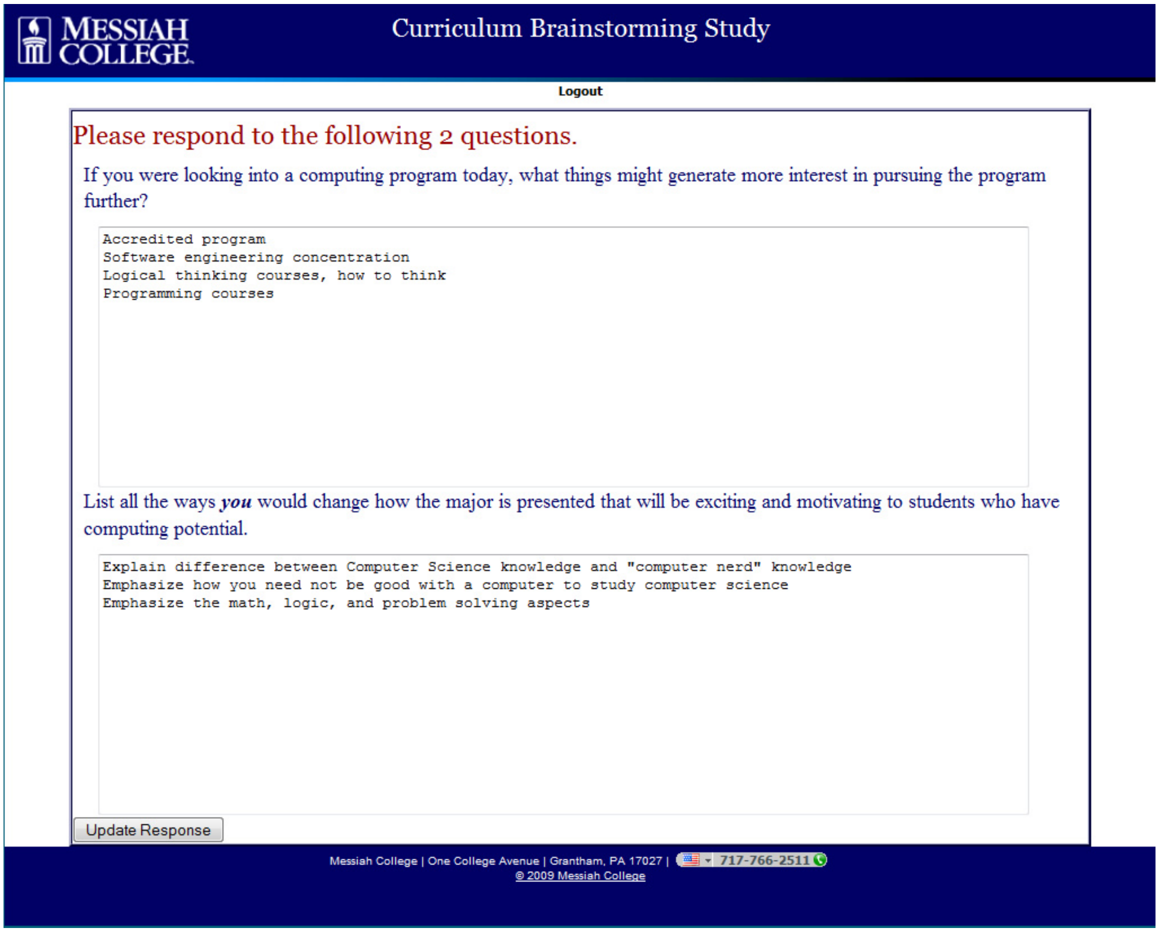
The second screen of Iteration One allowed students to add their brainstorming ideas.



Please respond to the following 2 questions.

If you were looking into a computing program today, what things might generate more interest in pursuing the program further?

```
Accredited program
Software engineering concentration
Logical thinking courses, how to think
Programming courses
```

List all the ways ***you*** would change how the major is presented that will be exciting and motivating to students who have computing potential.

```
Explain difference between Computer Science knowledge and "computer nerd" knowledge
Emphasize how you need not be good with a computer to study computer science
Emphasize the math, logic, and problem solving aspects
```

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## G.3 Delphi Study Iteration Two

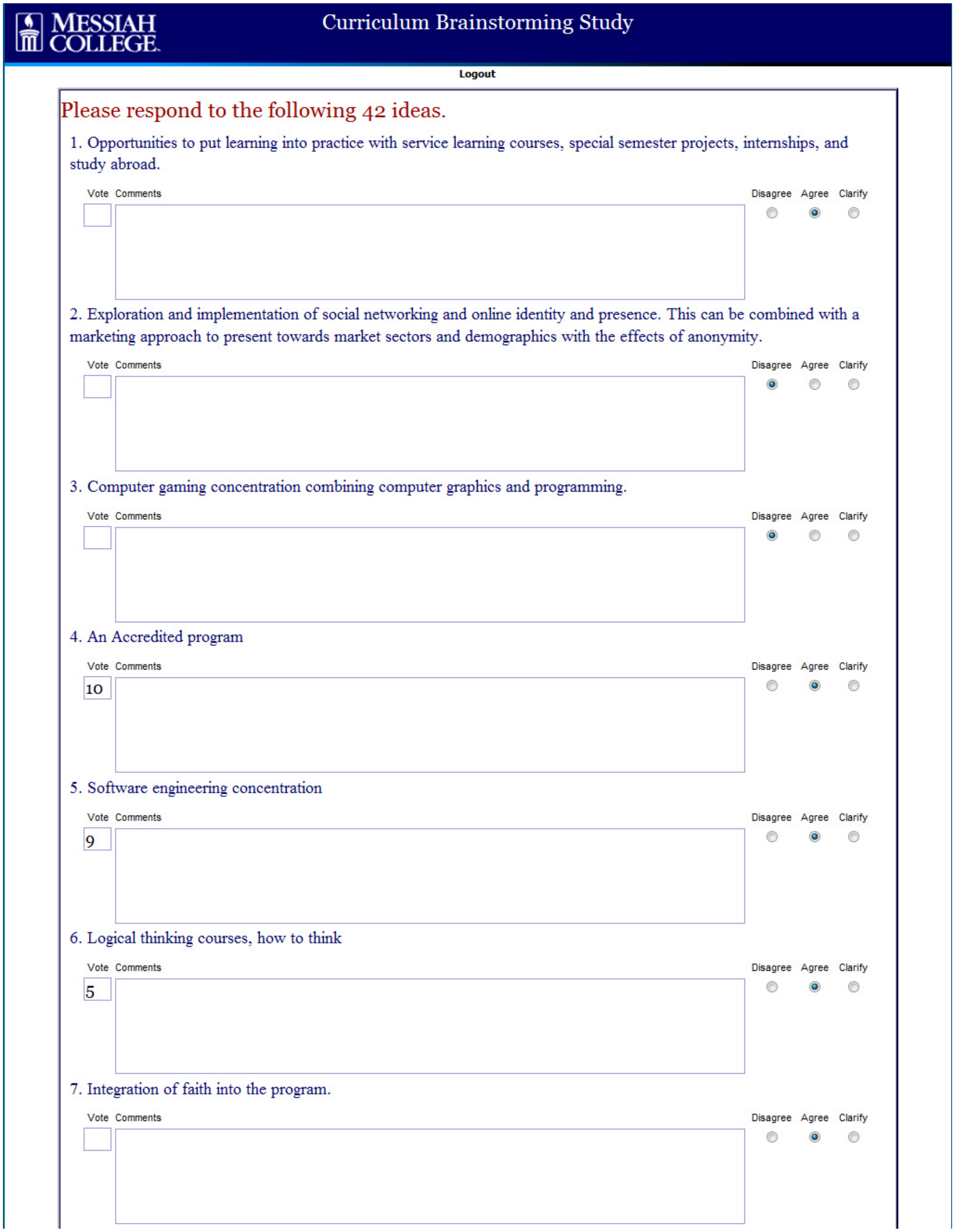
The first screen of Iteration Two provided instructions on what to do with the following screen.

In this iteration, read through all the ***Idea***s and comment on them and indicate whether you Disagree, Agree, or need clarification on the ***Idea***. Choose and keep track of the ***Idea***s you consider the top ten.

Then rate the top 10 you chose by giving the top ***Idea*** a 10 and the next a 9 and so forth. Use the Vote text box. Do not duplicate ratings.

At the end of the form there is a space to add more ***Idea***s that you may have as you read through the list. Add all the extra ***Idea***s you have in the box provided. If it is an ***Idea*** that relates to another ***Idea***, please use the other ***Idea***'s comment box to elaborate instead of adding it as a new ***Idea***.

The second screen provided all the brainstorming ideas and allowed the participant to comment on any idea as well as choose the top ten ideas and rate them from most important (10) to least important (1).



Please respond to the following 42 ideas.

1. Opportunities to put learning into practice with service learning courses, special semester projects, internships, and study abroad.

Vote Comments Disagree ○ Agree ● Clarify ○

2. Exploration and implementation of social networking and online identity and presence. This can be combined with a marketing approach to present towards market sectors and demographics with the effects of anonymity.

Vote Comments Disagree ● Agree ○ Clarify ○

3. Computer gaming concentration combining computer graphics and programming.

Vote Comments Disagree ● Agree ○ Clarify ○

4. An Accredited program

Vote 10 Comments Disagree ○ Agree ● Clarify ○

5. Software engineering concentration

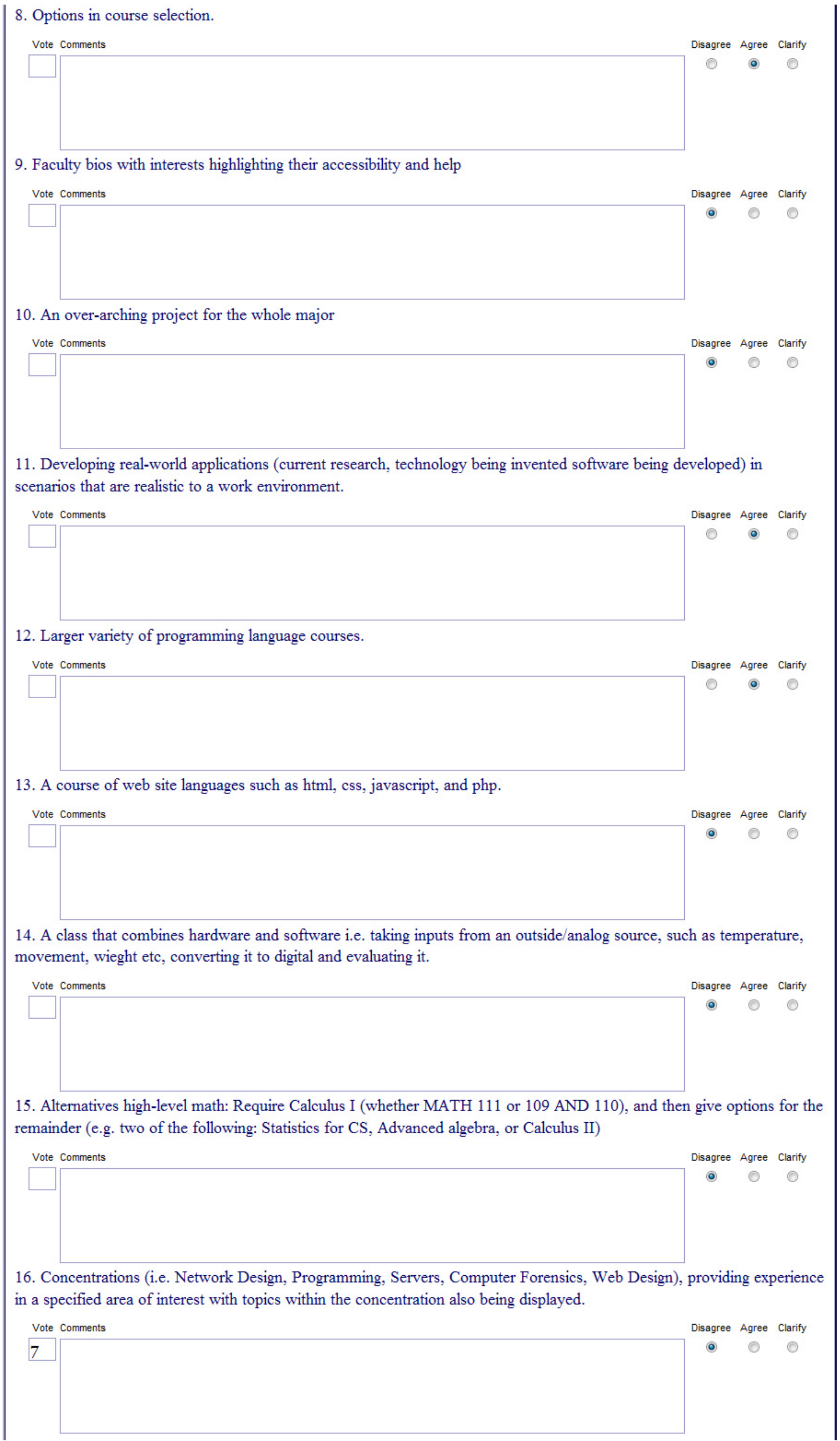
Vote 9 Comments Disagree ○ Agree ● Clarify ○

6. Logical thinking courses, how to think

Vote 5 Comments Disagree ○ Agree ● Clarify ○

7. Integration of faith into the program.

Vote Comments Disagree ○ Agree ● Clarify ○



8. Options in course selection.

Vote Comments — Disagree ○ Agree ● Clarify ○

☐

9. Faculty bios with interests highlighting their accessibility and help

Vote Comments — Disagree ● Agree ○ Clarify ○

☐

10. An over-arching project for the whole major

Vote Comments — Disagree ● Agree ○ Clarify ○

☐

11. Developing real-world applications (current research, technology being invented software being developed) in scenarios that are realistic to a work environment.

Vote Comments — Disagree ○ Agree ● Clarify ○

☐

12. Larger variety of programming language courses.

Vote Comments — Disagree ○ Agree ● Clarify ○

☐

13. A course of web site languages such as html, css, javascript, and php.

Vote Comments — Disagree ● Agree ○ Clarify ○

☐

14. A class that combines hardware and software i.e. taking inputs from an outside/analog source, such as temperature, movement, wieght etc, converting it to digital and evaluating it.

Vote Comments — Disagree ● Agree ○ Clarify ○

☐

15. Alternatives high-level math: Require Calculus I (whether MATH 111 or 109 AND 110), and then give options for the remainder (e.g. two of the following: Statistics for CS, Advanced algebra, or Calculus II)

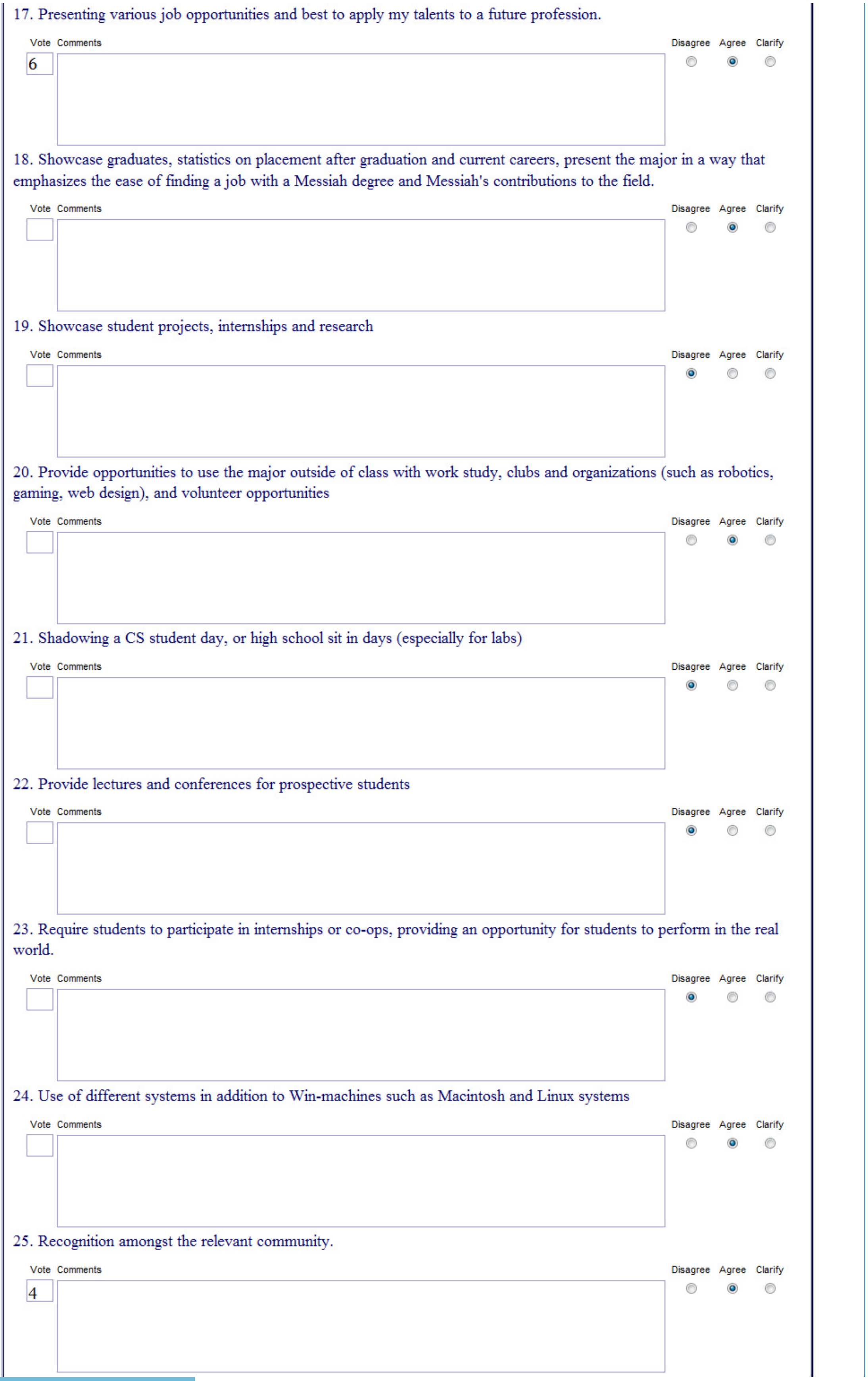
Vote Comments — Disagree ● Agree ○ Clarify ○

☐

16. Concentrations (i.e. Network Design, Programming, Servers, Computer Forensics, Web Design), providing experience in a specified area of interest with topics within the concentration also being displayed.

Vote Comments — Disagree ● Agree ○ Clarify ○

7



17. Presenting various job opportunities and best to apply my talents to a future profession.

Vote: 6
Comments:
Disagree ○ Agree ● Clarify ○

18. Showcase graduates, statistics on placement after graduation and current careers, present the major in a way that emphasizes the ease of finding a job with a Messiah degree and Messiah's contributions to the field.

Vote:
Comments:
Disagree ○ Agree ● Clarify ○

19. Showcase student projects, internships and research

Vote:
Comments:
Disagree ● Agree ○ Clarify ○

20. Provide opportunities to use the major outside of class with work study, clubs and organizations (such as robotics, gaming, web design), and volunteer opportunities

Vote:
Comments:
Disagree ○ Agree ● Clarify ○

21. Shadowing a CS student day, or high school sit in days (especially for labs)

Vote:
Comments:
Disagree ● Agree ○ Clarify ○

22. Provide lectures and conferences for prospective students

Vote:
Comments:
Disagree ● Agree ○ Clarify ○

23. Require students to participate in internships or co-ops, providing an opportunity for students to perform in the real world.

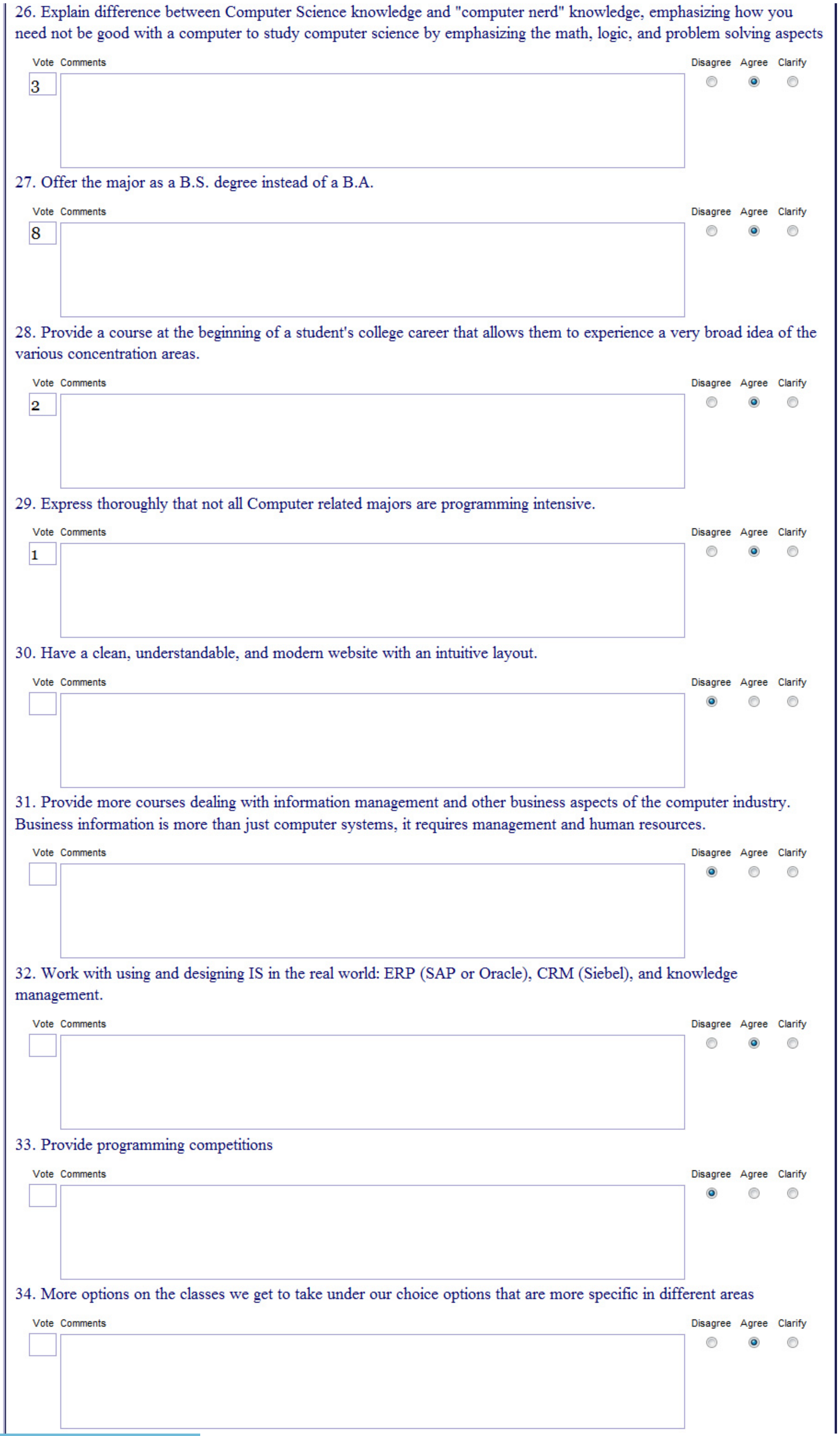
Vote:
Comments:
Disagree ● Agree ○ Clarify ○

24. Use of different systems in addition to Win-machines such as Macintosh and Linux systems

Vote:
Comments:
Disagree ○ Agree ● Clarify ○

25. Recognition amongst the relevant community.

Vote: 4
Comments:
Disagree ○ Agree ● Clarify ○



26. Explain difference between Computer Science knowledge and "computer nerd" knowledge, emphasizing how you need not be good with a computer to study computer science by emphasizing the math, logic, and problem solving aspects

| Vote | Comments | Disagree | Agree | Clarify |
|---|---|---|---|---|
| 3 | | ○ | ● | ○ |

27. Offer the major as a B.S. degree instead of a B.A.

| Vote | Comments | Disagree | Agree | Clarify |
|---|---|---|---|---|
| 8 | | ○ | ● | ○ |

28. Provide a course at the beginning of a student's college career that allows them to experience a very broad idea of the various concentration areas.

| Vote | Comments | Disagree | Agree | Clarify |
|---|---|---|---|---|
| 2 | | ○ | ● | ○ |

29. Express thoroughly that not all Computer related majors are programming intensive.

| Vote | Comments | Disagree | Agree | Clarify |
|---|---|---|---|---|
| 1 | | ○ | ● | ○ |

30. Have a clean, understandable, and modern website with an intuitive layout.

| Vote | Comments | Disagree | Agree | Clarify |
|---|---|---|---|---|
| | | ● | ○ | ○ |

31. Provide more courses dealing with information management and other business aspects of the computer industry. Business information is more than just computer systems, it requires management and human resources.

| Vote | Comments | Disagree | Agree | Clarify |
|---|---|---|---|---|
| | | ● | ○ | ○ |

32. Work with using and designing IS in the real world: ERP (SAP or Oracle), CRM (Siebel), and knowledge management.

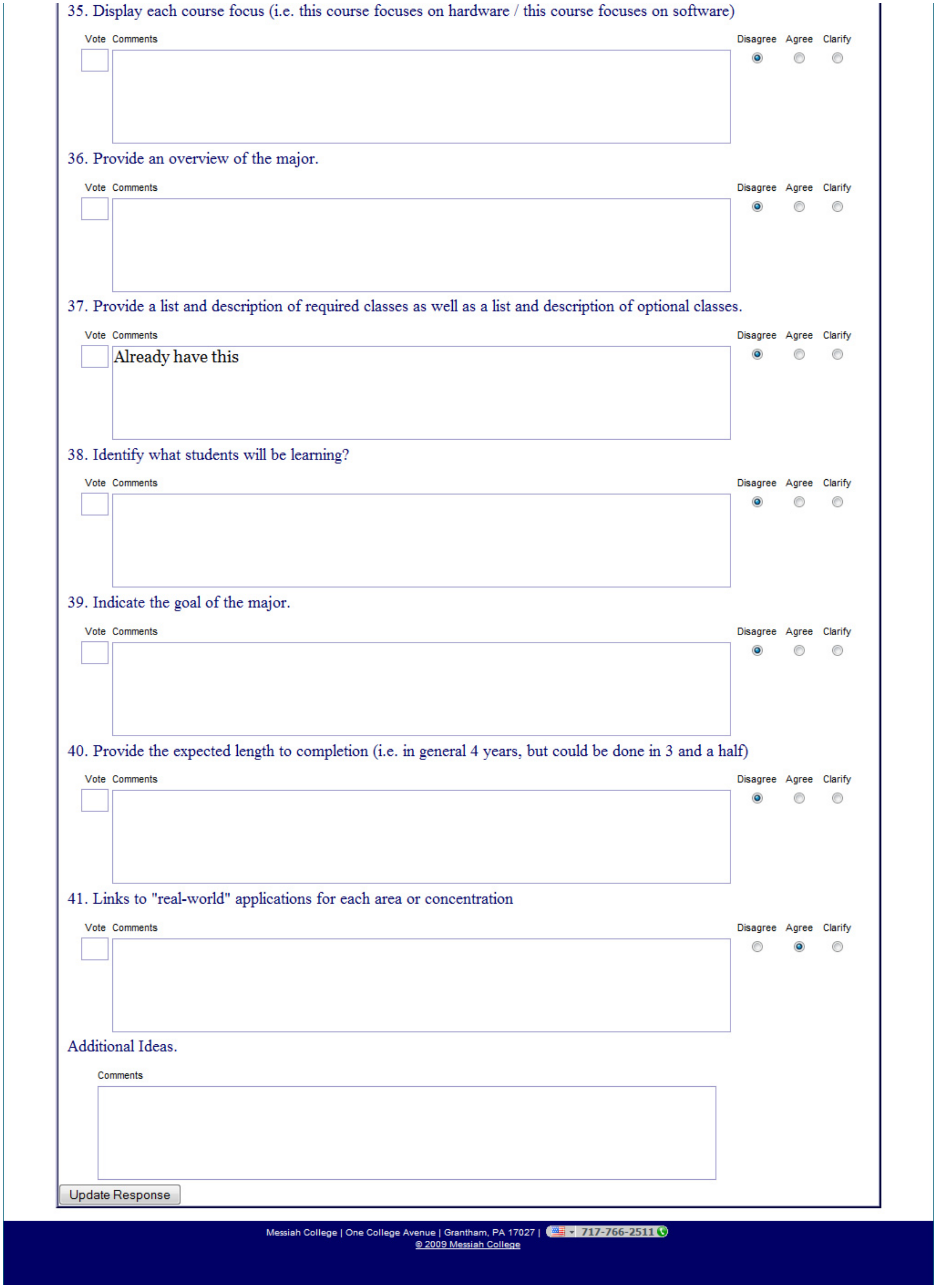
| Vote | Comments | Disagree | Agree | Clarify |
|---|---|---|---|---|
| | | ○ | ● | ○ |

33. Provide programming competitions

| Vote | Comments | Disagree | Agree | Clarify |
|---|---|---|---|---|
| | | ● | ○ | ○ |

34. More options on the classes we get to take under our choice options that are more specific in different areas

| Vote | Comments | Disagree | Agree | Clarify |
|---|---|---|---|---|
| | | ○ | ● | ○ |



35. Display each course focus (i.e. this course focuses on hardware / this course focuses on software)

Vote ☐ Comments

Disagree ● Agree ○ Clarify ○

36. Provide an overview of the major.

Vote ☐ Comments

Disagree ● Agree ○ Clarify ○

37. Provide a list and description of required classes as well as a list and description of optional classes.

Vote ☐ Comments: Already have this

Disagree ● Agree ○ Clarify ○

38. Identify what students will be learning?

Vote ☐ Comments

Disagree ● Agree ○ Clarify ○

39. Indicate the goal of the major.

Vote ☐ Comments

Disagree ● Agree ○ Clarify ○

40. Provide the expected length to completion (i.e. in general 4 years, but could be done in 3 and a half)

Vote ☐ Comments

Disagree ● Agree ○ Clarify ○

41. Links to "real-world" applications for each area or concentration

Vote ☐ Comments

Disagree ○ Agree ● Clarify ○

Additional Ideas.

Comments

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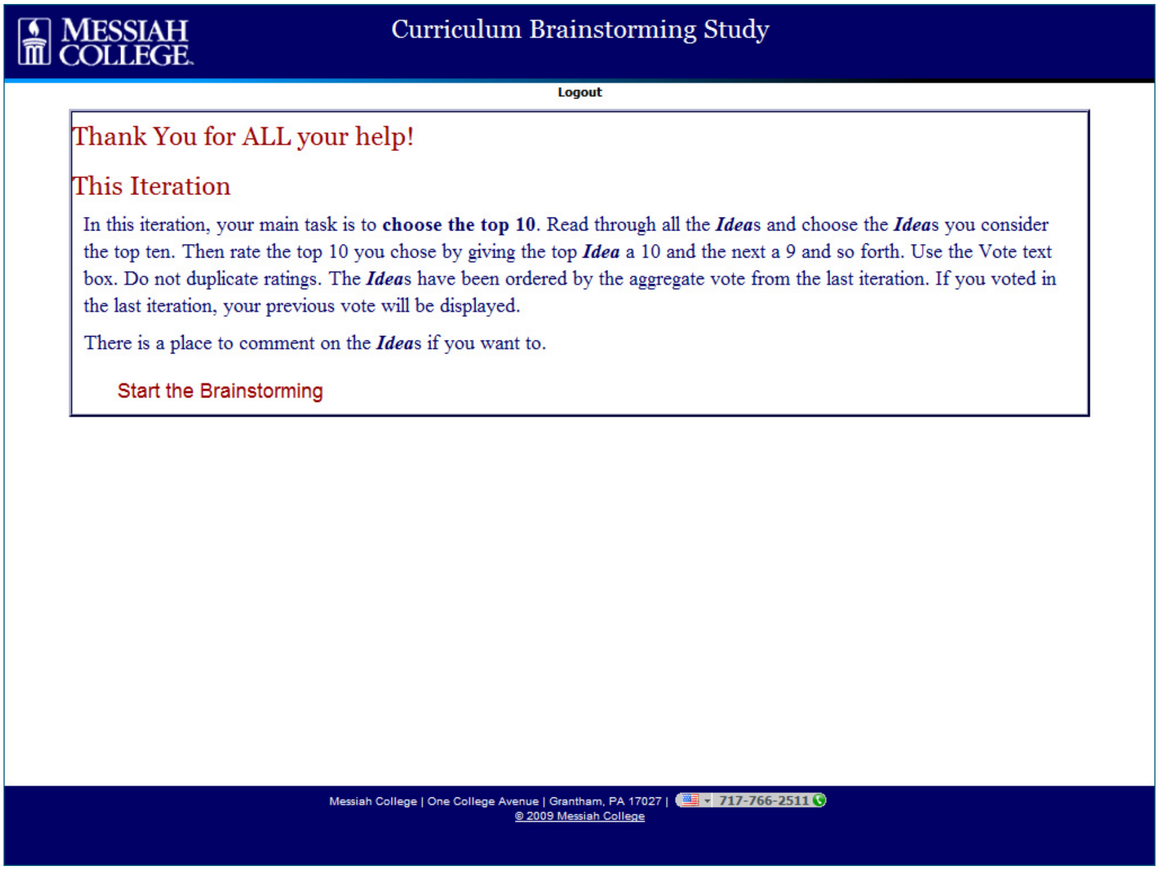
## G.4 Delphi Study Iteration Three

The first screen of Iteration Three thanked the participants and provided instructions on what to do with the following screen.



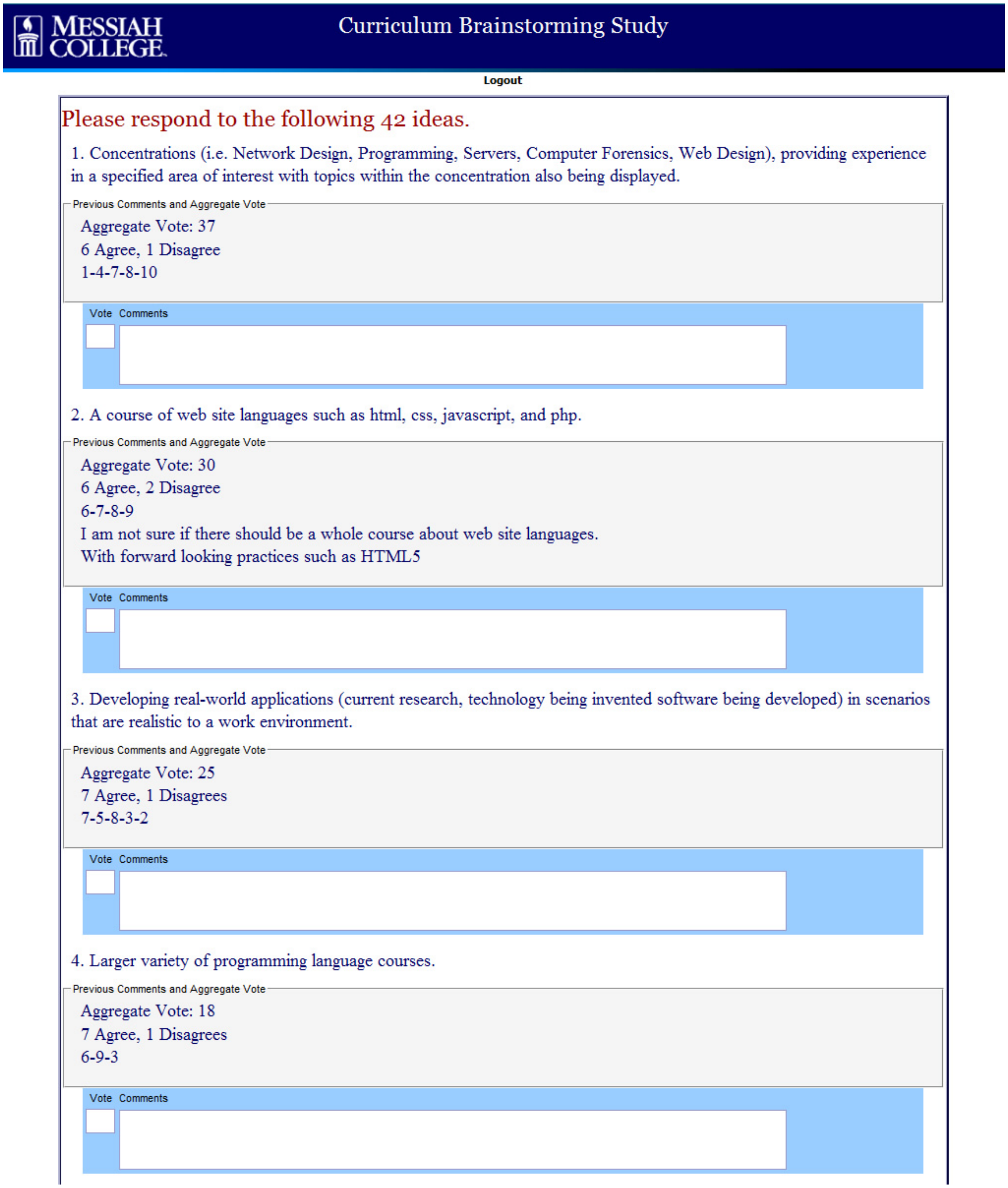
Thank You for ALL your help!

This Iteration

In this iteration, your main task is to **choose the top 10**. Read through all the ***Idea***s and choose the ***Idea***s you consider the top ten. Then rate the top 10 you chose by giving the top ***Idea*** a 10 and the next a 9 and so forth. Use the Vote text box. Do not duplicate ratings. The ***Idea***s have been ordered by the aggregate vote from the last iteration. If you voted in the last iteration, your previous vote will be displayed.

There is a place to comment on the ***Idea***s if you want to.

The second screen provided all the brainstorming ideas and allowed the participant to comment on any idea as well as choose the top ten ideas and rate them from most important (10) to least important (1).



Please respond to the following 42 ideas.

1. Concentrations (i.e. Network Design, Programming, Servers, Computer Forensics, Web Design), providing experience in a specified area of interest with topics within the concentration also being displayed.

Previous Comments and Aggregate Vote

Aggregate Vote: 37
6 Agree, 1 Disagree
1-4-7-8-10

2. A course of web site languages such as html, css, javascript, and php.

Previous Comments and Aggregate Vote

Aggregate Vote: 30
6 Agree, 2 Disagree
6-7-8-9
I am not sure if there should be a whole course about web site languages.
With forward looking practices such as HTML5

3. Developing real-world applications (current research, technology being invented software being developed) in scenarios that are realistic to a work environment.

Previous Comments and Aggregate Vote

Aggregate Vote: 25
7 Agree, 1 Disagrees
7-5-8-3-2

4. Larger variety of programming language courses.

Previous Comments and Aggregate Vote

Aggregate Vote: 18
7 Agree, 1 Disagrees
6-9-3

5. Opportunities to put learning into practice with service learning courses, special semester projects, internships, and study abroad.

Previous Comments and Aggregate Vote

Aggregate Vote: 17
9 Agree, 0 Disagree
10-2-3-2

6. Software engineering concentration

Previous Comments and Aggregate Vote

Aggregate Vote: 15
7 Agree, 1 Disagree
5-9-1

7. Offer the major as a B.S. degree instead of a B.A.

Previous Comments and Aggregate Vote

Aggregate Vote: 15
7 Agree, 1 Disagrees, 1 Needs Clarification
7-8
Definitely! It should be a science instead of an art

8. Presenting various job opportunities and best to apply my talents to a future profession.

Previous Comments and Aggregate Vote

Aggregate Vote: 14
6 Agree, 1 Disagrees, 2 Need Clarification
2-6-6
Already done by Career Center, Dr Weaver, and Holly Myers

9. An over-arching project for the whole major

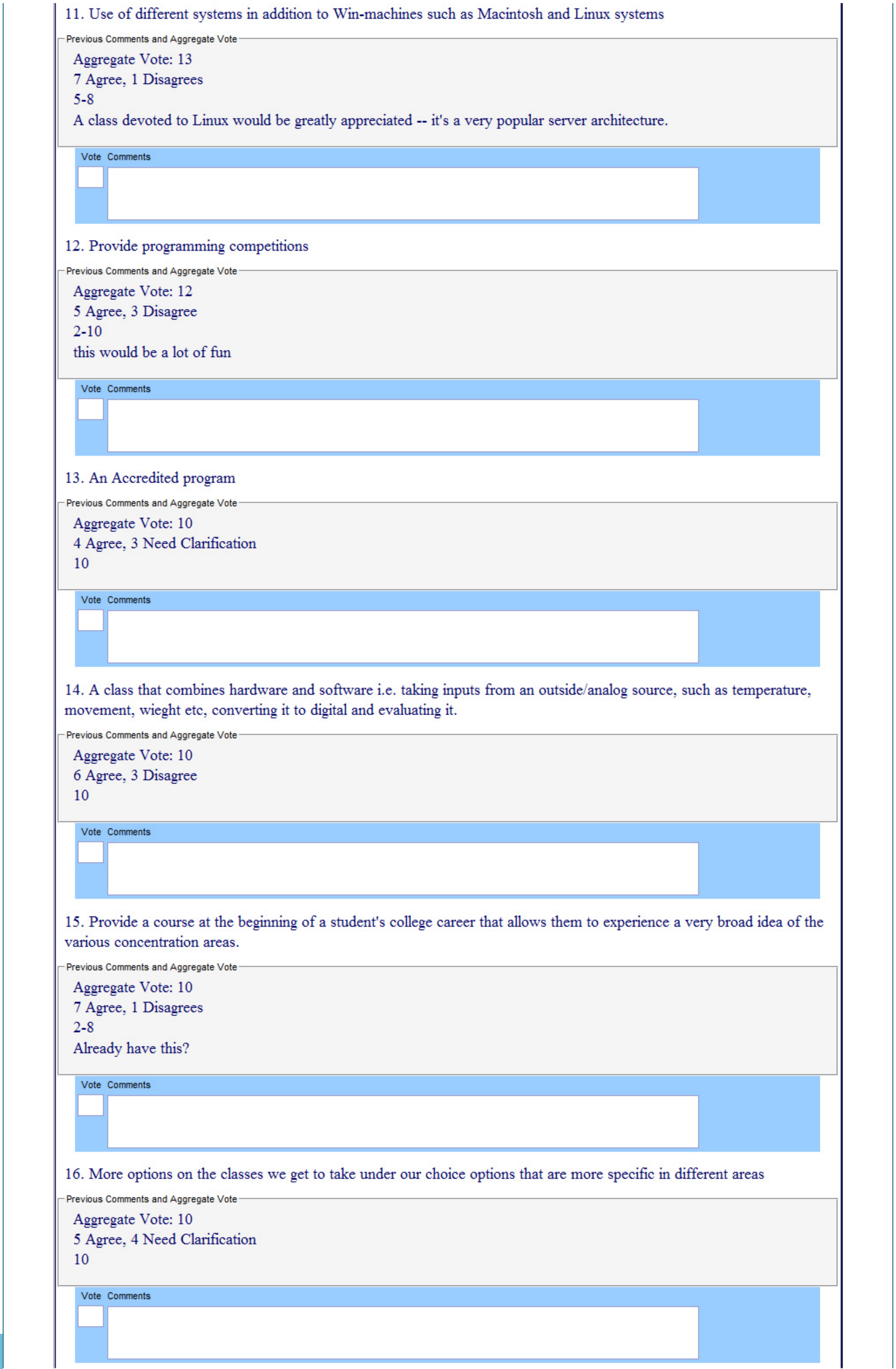
Previous Comments and Aggregate Vote

Aggregate Vote: 13
4 Agree, 1 Disagrees, 2 Needs clarification
6-7

10. Provide opportunities to use the major outside of class with work study, clubs and organizations (such as robotics, gaming, web design), and volunteer opportunities

Previous Comments and Aggregate Vote

Aggregate Vote: 13
9 Agree, 0 Disagree
4-9
Work study would be great volunteer opportunity especially are great for resumes



11. Use of different systems in addition to Win-machines such as Macintosh and Linux systems

Previous Comments and Aggregate Vote

Aggregate Vote: 13
7 Agree, 1 Disagrees
5-8
A class devoted to Linux would be greatly appreciated -- it's a very popular server architecture.

Vote Comments

12. Provide programming competitions

Previous Comments and Aggregate Vote

Aggregate Vote: 12
5 Agree, 3 Disagree
2-10
this would be a lot of fun

Vote Comments

13. An Accredited program

Previous Comments and Aggregate Vote

Aggregate Vote: 10
4 Agree, 3 Need Clarification
10

Vote Comments

14. A class that combines hardware and software i.e. taking inputs from an outside/analog source, such as temperature, movement, wieght etc, converting it to digital and evaluating it.

Previous Comments and Aggregate Vote

Aggregate Vote: 10
6 Agree, 3 Disagree
10

Vote Comments

15. Provide a course at the beginning of a student's college career that allows them to experience a very broad idea of the various concentration areas.

Previous Comments and Aggregate Vote

Aggregate Vote: 10
7 Agree, 1 Disagrees
2-8
Already have this?

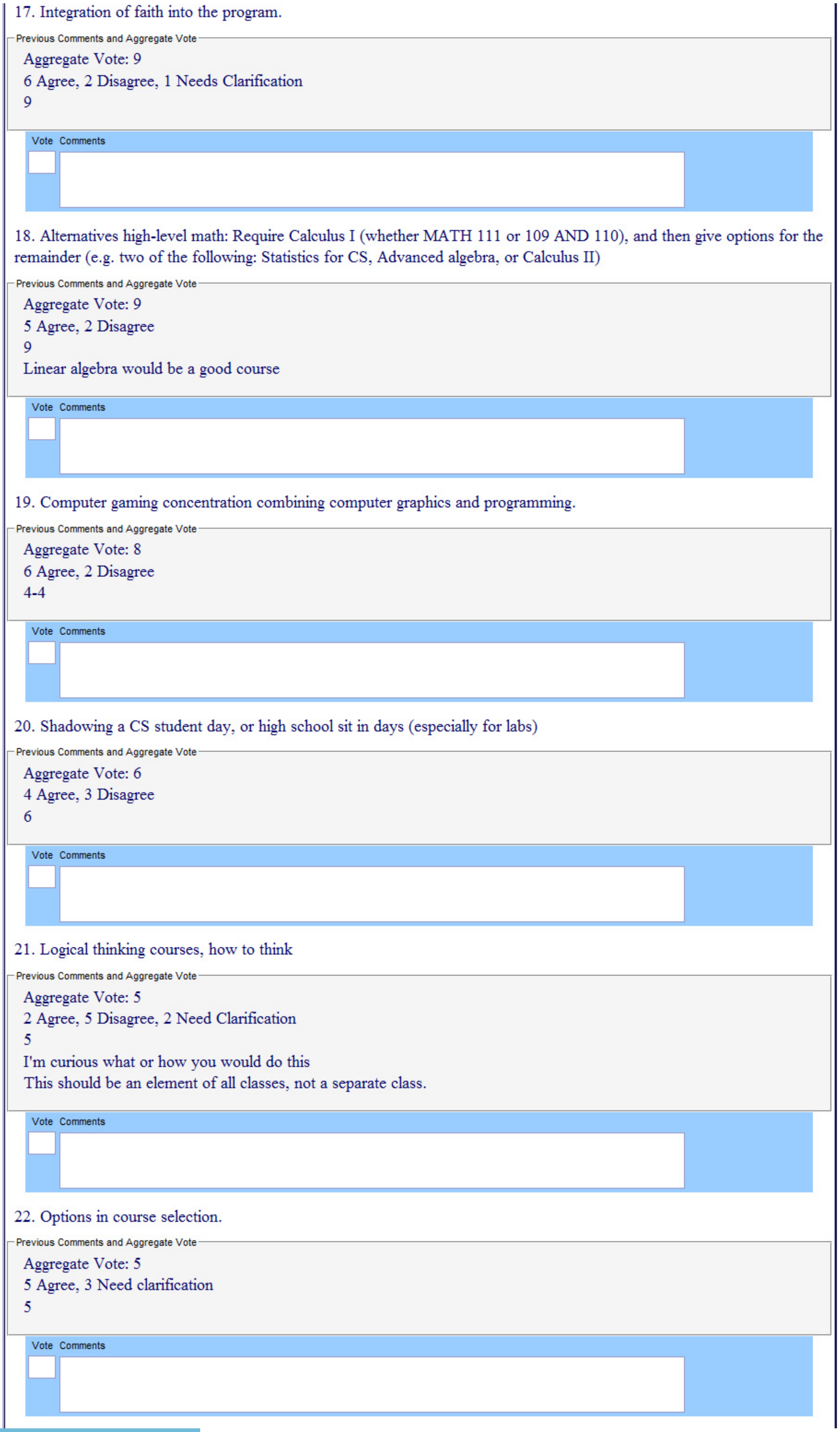
Vote Comments

16. More options on the classes we get to take under our choice options that are more specific in different areas

Previous Comments and Aggregate Vote

Aggregate Vote: 10
5 Agree, 4 Need Clarification
10

Vote Comments



17. Integration of faith into the program.

Previous Comments and Aggregate Vote

Aggregate Vote: 9
6 Agree, 2 Disagree, 1 Needs Clarification
9

Vote Comments
☐

18. Alternatives high-level math: Require Calculus I (whether MATH 111 or 109 AND 110), and then give options for the remainder (e.g. two of the following: Statistics for CS, Advanced algebra, or Calculus II)

Previous Comments and Aggregate Vote

Aggregate Vote: 9
5 Agree, 2 Disagree
9
Linear algebra would be a good course

Vote Comments
☐

19. Computer gaming concentration combining computer graphics and programming.

Previous Comments and Aggregate Vote

Aggregate Vote: 8
6 Agree, 2 Disagree
4-4

Vote Comments
☐

20. Shadowing a CS student day, or high school sit in days (especially for labs)

Previous Comments and Aggregate Vote

Aggregate Vote: 6
4 Agree, 3 Disagree
6

Vote Comments
☐

21. Logical thinking courses, how to think

Previous Comments and Aggregate Vote

Aggregate Vote: 5
2 Agree, 5 Disagree, 2 Need Clarification
5
I'm curious what or how you would do this
This should be an element of all classes, not a separate class.

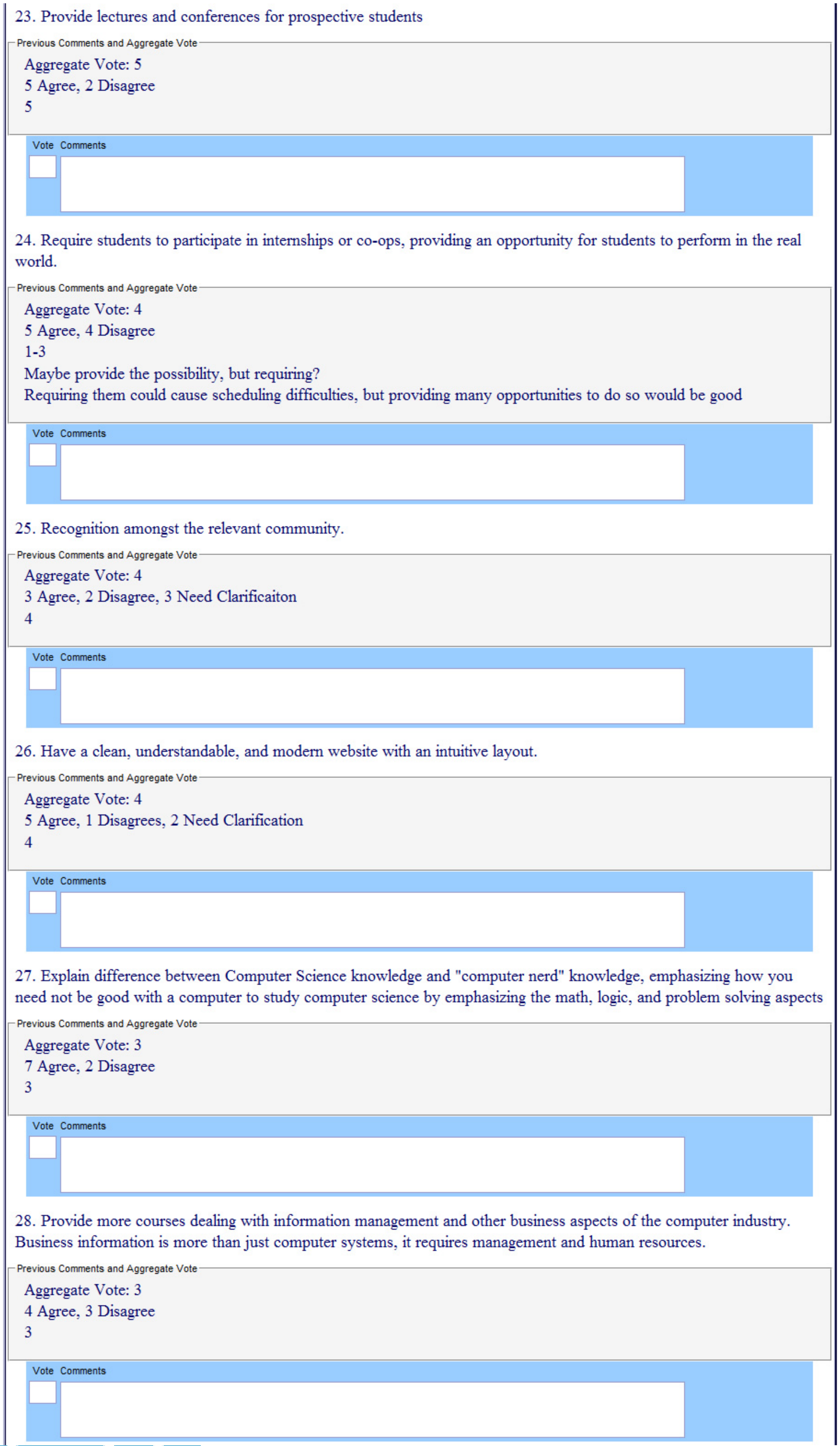
Vote Comments
☐

22. Options in course selection.

Previous Comments and Aggregate Vote

Aggregate Vote: 5
5 Agree, 3 Need clarification
5

Vote Comments
☐



23. Provide lectures and conferences for prospective students

Previous Comments and Aggregate Vote

Aggregate Vote: 5
5 Agree, 2 Disagree
5

Vote Comments

24. Require students to participate in internships or co-ops, providing an opportunity for students to perform in the real world.

Previous Comments and Aggregate Vote

Aggregate Vote: 4
5 Agree, 4 Disagree
1-3
Maybe provide the possibility, but requiring?
Requiring them could cause scheduling difficulties, but providing many opportunities to do so would be good

Vote Comments

25. Recognition amongst the relevant community.

Previous Comments and Aggregate Vote

Aggregate Vote: 4
3 Agree, 2 Disagree, 3 Need Clarificaiton
4

Vote Comments

26. Have a clean, understandable, and modern website with an intuitive layout.

Previous Comments and Aggregate Vote

Aggregate Vote: 4
5 Agree, 1 Disagrees, 2 Need Clarification
4

Vote Comments

27. Explain difference between Computer Science knowledge and "computer nerd" knowledge, emphasizing how you need not be good with a computer to study computer science by emphasizing the math, logic, and problem solving aspects

Previous Comments and Aggregate Vote

Aggregate Vote: 3
7 Agree, 2 Disagree
3

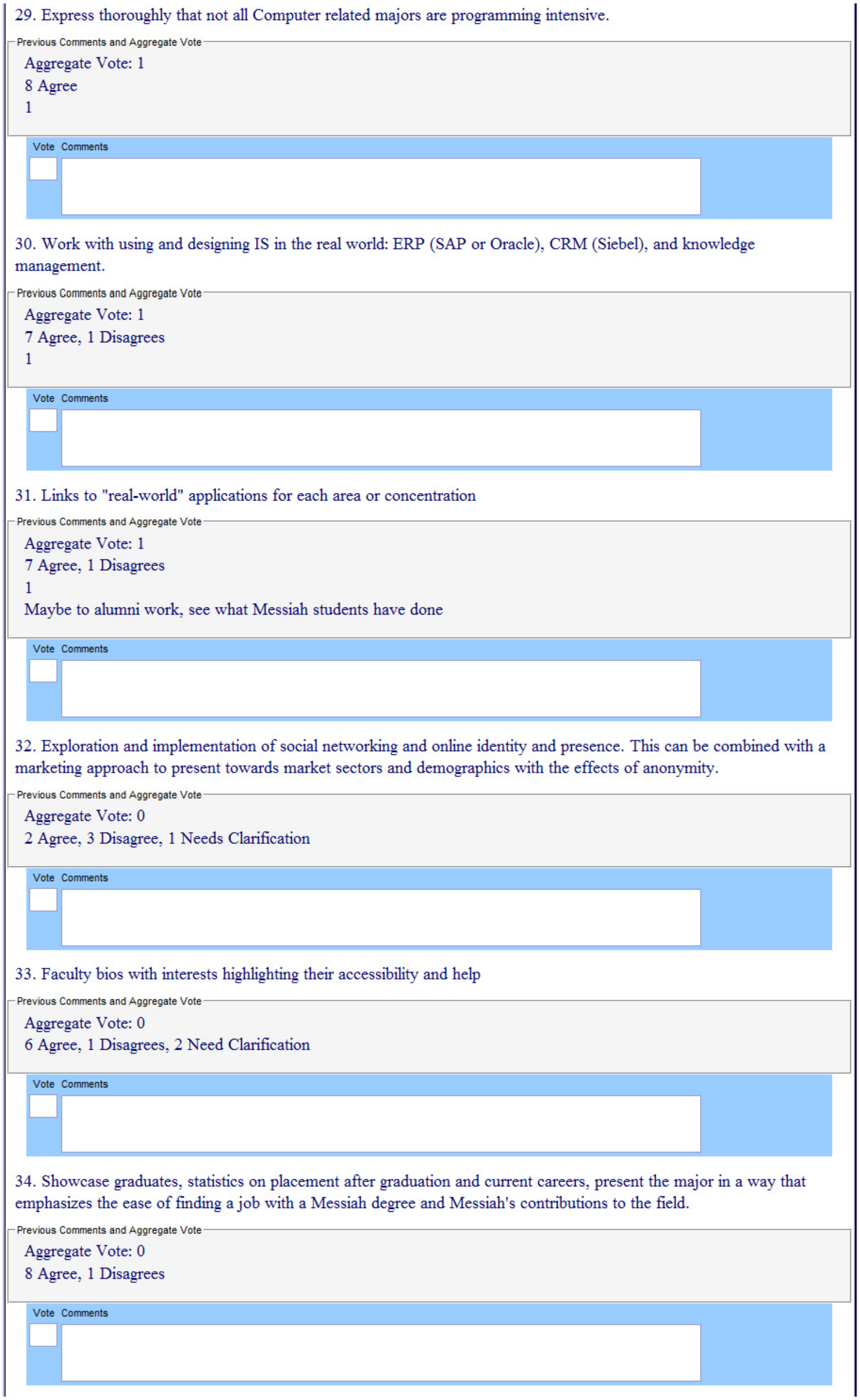
Vote Comments

28. Provide more courses dealing with information management and other business aspects of the computer industry. Business information is more than just computer systems, it requires management and human resources.

Previous Comments and Aggregate Vote

Aggregate Vote: 3
4 Agree, 3 Disagree
3

Vote Comments



29. Express thoroughly that not all Computer related majors are programming intensive.

Previous Comments and Aggregate Vote

Aggregate Vote: 1
8 Agree
1

Vote Comments

☐

30. Work with using and designing IS in the real world: ERP (SAP or Oracle), CRM (Siebel), and knowledge management.

Previous Comments and Aggregate Vote

Aggregate Vote: 1
7 Agree, 1 Disagrees
1

Vote Comments

☐

31. Links to "real-world" applications for each area or concentration

Previous Comments and Aggregate Vote

Aggregate Vote: 1
7 Agree, 1 Disagrees
1
Maybe to alumni work, see what Messiah students have done

Vote Comments

☐

32. Exploration and implementation of social networking and online identity and presence. This can be combined with a marketing approach to present towards market sectors and demographics with the effects of anonymity.

Previous Comments and Aggregate Vote

Aggregate Vote: 0
2 Agree, 3 Disagree, 1 Needs Clarification

Vote Comments

☐

33. Faculty bios with interests highlighting their accessibility and help

Previous Comments and Aggregate Vote

Aggregate Vote: 0
6 Agree, 1 Disagrees, 2 Need Clarification

Vote Comments

☐

34. Showcase graduates, statistics on placement after graduation and current careers, present the major in a way that emphasizes the ease of finding a job with a Messiah degree and Messiah's contributions to the field.

Previous Comments and Aggregate Vote

Aggregate Vote: 0
8 Agree, 1 Disagrees

Vote Comments

☐

35. Showcase student projects, internships and research

Aggregate Vote: 0
6 Agree, 2 Disagree, 1 Needs Clarification

36. Display each course focus (i.e. this course focuses on hardware and this course focuses on software)

Aggregate Vote: 0
5 Agree, 1 Disagrees, 1 Needs Clarification

37. Provide an overview of the major.

Aggregate Vote: 0
4 Agree, 1 Disagrees, 3 Need Clarification

38. Provide a list and description of required classes as well as a list and description of optional classes.

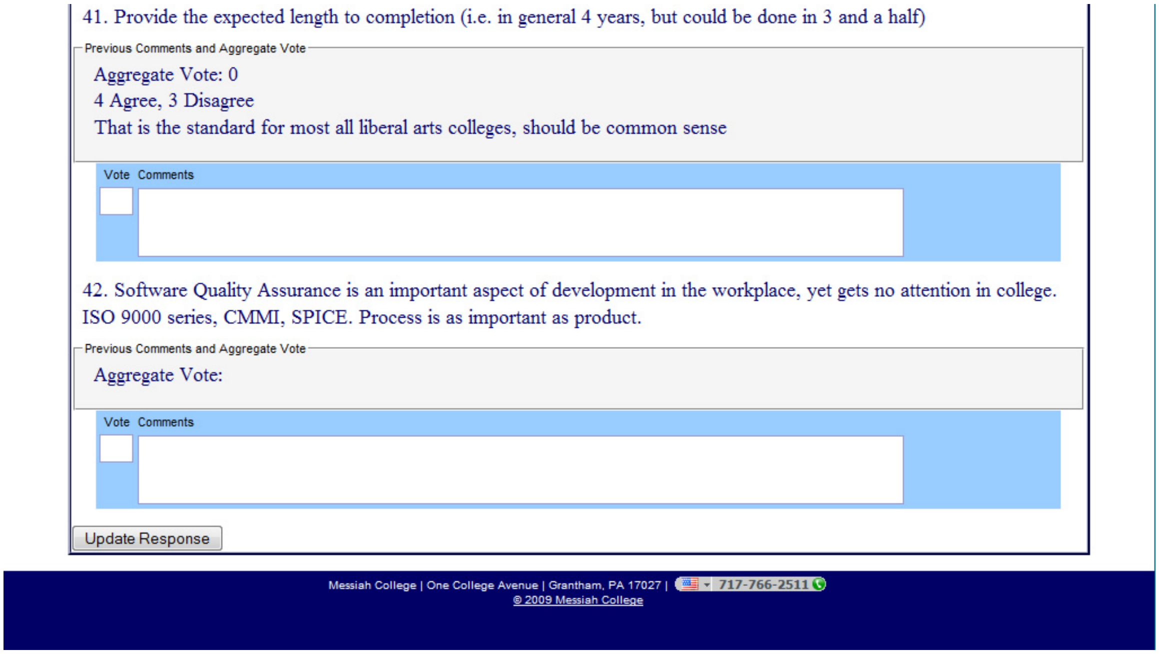
Aggregate Vote: 0
6 Agree, 2 Disagree, 1 Needs Clarification
We already have this.

39. Identify what students will be learning?

Aggregate Vote: 0
3 Agree, 2 Disagree, 3 Need Clarification
There are a course catalog and syllabi

40. Indicate the goal of the major.

Aggregate Vote: 0
4 Agree, 2 Disagree, 1 Needs clarification



41. Provide the expected length to completion (i.e. in general 4 years, but could be done in 3 and a half)

Previous Comments and Aggregate Vote

Aggregate Vote: 0
4 Agree, 3 Disagree
That is the standard for most all liberal arts colleges, should be common sense

42. Software Quality Assurance is an important aspect of development in the workplace, yet gets no attention in college. ISO 9000 series, CMMI, SPICE. Process is as important as product.

Previous Comments and Aggregate Vote

Aggregate Vote:

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# Appendix H

## Student-Focused Curriculum

# Computer Science Major

Over the last decade, rapid advances in technology, specifically digital technology, have led to dramatic changes in society and in the global economy. Computer and technology related fields claim some of the highest projected job growth in the United States! To prepare for this exciting field, students are encouraged to participate in internships; placement aid is provided.

Students are prepared for lifelong learning in this rapidly evolving discipline. Students seeking a Bachelor of Science degree in Computer Science will find a lot of flexibility in tailoring their college education. Because the computing and technology fields are so diverse, this program, accredited by ABET, allows students to focus on a chosen concentration.

## Concentrations

### *Security and Forensic Computing*

Technologically competent criminals exploit new technologies to commit crime. Specialists are needed to thwart criminals by developing secure environments as well as examining digital evidence when a crime has occurred. Recent graduates are currently working as:

- Quality Assurance Project Manager at a large Online News Firm
- Systems Administrator for a large Health Insurance Firm

### *Artificial Intelligence*

Artificial intelligence is used in everything from the Spirit robot sent to mars to collect data to GPS units and cell phones. Specialists are needed to develop products that behave intelligently. The student-run robotics club provides opportunities to apply learning. Recent graduates are currently working as:

- System Engineer developing satellite intelligence for a contracting firm near Washington, DC
- Artificial Intelligence Specialist for a nonprofit scientific society based in California.

### *Networking*

Networking and the Internet have increased the abilities of different technologies such as cars, cell phones and computers to communicate directly with each other. Specialists are needed to design, install, configure and maintain networks to allow devices to do so. Recent graduates are currently working as:

- IT Project Manager for a large networking firm in Kenya, Africa
- Systems and Network Engineer for a financial organization

### *Game Development*

With the ever increasing power of computers and their graphics capabilities, game development has become a global industry. Specialists are needed to focus on all aspects of interactive video game design, developing games like those available for the PS3 and Xbox gaming consoles. The student-run gaming club provides opportunities to test game ideas. Recent graduates are currently working as:

- Flash Game Developer for an online media company
- Project Creative Director for a large gaming company.

### *Software Engineering*

Software Engineers work in all aspects of society designing, implementing and modifying high quality software for many different types of applications. Specialists are needed to provide software solutions to real-world challenges in many settings from airliners to iPhones. Recent graduates are currently working as:

- Solutions Architect for a worldwide contracting firm.
- Director of Software Engineering for a global firm based in Minnesota

### *Web and Media Development*

The Internet is used more and more as a vehicle for commerce and information. As the saying goes, “Knowledge is Power.” Specialists are needed to develop dynamic, interactive web applications for a world dependent on the World Wide Web. The student-run Web Development organization provides web solutions to many non-profit organizations. Recent graduates are currently working as:

- Mobile Application Development Research for a large, global non-profit organization
- Web Designer and Developer for a local web development business

### *Build-Your Own*

Sometimes students are not sure which direction to take. This program allows students to develop a concentration uniquely their own. With the help of their advisor, any student can tailor the Computer Science major to their needs and dreams.

## Core Required Courses

The following are the courses that all Computer Science majors engage in regardless of their chosen concentration.

### Calculus I

Calculus I takes the processes of finding the slope of a line and the area in a closed region and considers them as infinite processes. Students study of how things change and how to model systems in which there is change.

### Discrete Mathematics

Computers deal with discrete objects, those things which can be separated from each other. Students learn the fundamentals of discrete mathematics which can be applied to real-world problems from the placement of cell-phone towers so they won't interfere with each other to the orbits of satellites.

### Introduction to Computer Science

Students are introduced to the various aspects of Computer Science through a general survey course of technology "meccas", the history of various aspects of development in Computer Science, ethical practices in the field and emerging technologies.

### Programming I

Students become familiar with basic programming structures such as loops, conditional statements, variables and methods through weekly lab assignments in the Java programming language.

### Database Concepts

Students explore the fundamental concepts involved in building and maintaining a database using the MySQL and Oracle database management systems, CSS and PHP programming languages. In cooperation with the Intermediate Web Design course, students create a dynamic, database-driven web site.

### Database Applications

Students apply what they have learned in Database Concepts to develop a solution to a real-world need expressed by a non-profit organization. Emphasis is placed on communication and cooperation between multiple teams to design, create, implement and maintain a large-scale application.

### Information Systems

Students explore how information technology is used to support the decision-making process in businesses.

### Senior Capstone

This two-semester course provides a finale to each student's academic career. While preparing for life after college through various professional preparatory activities, students utilize their cumulative knowledge to develop a final project in their chosen concentration. Students are encouraged to seek current needs in the business and non-profit communities for real-world opportunities.

# Concentration Required Courses

## *Security and Forensic Computing*

The following courses are required for the Security Concentration.

### Networking

Students learn the basics of networking and the Internet and how to establish communications between servers as well as the various techniques necessary to create lines of communication between other technological devices.

### Computer and Network Security

Students examine computer systems to determine vulnerabilities then practice hacking into those systems. Students then learn how to build defenses to prevent those attacks. Students are exposed to exploits of different operating systems with an emphasis on Windows, Linux and Macintosh.

### Operating Systems

Students learn the internal structure and manipulation of the Linux, Macintosh, and Windows operating systems with a focus on protection and security.

### Computer Forensics

Students learn how to preserve, identify, extract and document digital evidence in various forms. Current opportunities from local law enforcement agencies allow students to experience real-world forensics.

### Cryptography

Students learn how two people can exchange a message in such a way that no one else can understand it, or cause problems with it. A real-world example is online banking which uses cryptography to ensure online transactions are conducted privately by the authorized person.

### Advanced Network Security

Students develop advanced skills in identifying network security vulnerabilities, conducting risk assessments, preventing, detecting and responding to intrusions and providing for business continuity and disaster recovery. Local businesses provide opportunities for students to use their developing skills to assess security vulnerabilities and risks.

### Biometrics

Students study the use of biological identifiers such as finger prints and the eye’s iris in security applications. Lab projects reinforce topics learned.

### Electives

Students may choose 3 other courses from any concentration to round out their degree.

## *Artificial Intelligence*

The following courses are required for the Artificial Intelligence Concentration.

### Image Processing and Computer Vision

Students learn how to use models of digital image formation, image representation, image enhancement and image understanding to enable machines to make decisions based on the acquired image.

### Introduction to Artificial Intelligence

Students learn how to develop intelligent devices including machine problem solving, game playing, pattern recognition and perception problems, machine learning, expert systems and robotics. Graduate students involved in Artificial Intelligence in industry present their current challenges and real-world projects.

### Pattern Recognition

Students expand their understanding of the structures and problems of digital pattern recognition; helping machines classify data (patterns) based on the machine's prior knowledge or on statistical information extracted from the data (pattern).

### Natural Language Processing

Students examine how computers process and understand natural language with an emphasis on English.

### Expert Systems

Students learn the fundamentals of intelligent data processing through an in depth understanding of various concepts and popular techniques used in the field of data mining.

### Knowledge-Based Software Engineering

Students expand their understanding of expert systems and natural language processing, developing applications to process and understand large amounts of data and provide solutions to human questions. Companies utilizing current methods discussed in class describe their use and development of knowledge-based applications in real-world settings.

### Electives

Students may choose 3 other courses from any concentration to round out their degree.

## *Networking*

The following courses are required for the Networking Concentration.

### Networking

Students learn the basics of networking and the Internet and how to establish communications between servers as well as the various techniques necessary to create lines of communication between other technological devices.

### Wireless Networks and Mobile Computing

Students extend their understanding of networking to wireless and mobile devices including smart phones and pda's learning how to provide access to information anywhere, anyplace, and anytime.

### Distributed Systems

Students explore the issues surrounding applications that are distributed in different locations that do not share the same address space but are working together to solve a problem.

### Computer and Network Security

Students examine computer systems to determine vulnerabilities then practice hacking into those systems. Students then learn how to build defenses to prevent those attacks. Students are exposed to exploits of different operating systems with an emphasis on Windows, Linux and Macintosh.

### Converged Networks

Students examine current and emerging network technologies that have differing architecture to deliver varying information from voice, data, and video/imaging and how to make them work together. Students tour various local Internet Service Provider facilities to observe current, real-world converged networks in operation.

### Advanced Network Security

Students develop advanced skills in identifying network security vulnerabilities, conducting risk assessments, preventing, detecting and responding to intrusions and providing for business continuity and disaster recovery. Local businesses provide opportunities for students to use their developing skills to assess security vulnerabilities and risks.

### Electives

Students may choose 3 other courses from any concentration to round out their degree.

## *Game Development*

The following courses are required for the Game Development Concentration.

### Programming II

Students expand their understanding of programming, focusing on object-oriented structures and methods necessary for software and game development; structures and methods they will use in other graphics and gaming courses.

### 3D Modeling and Animation

Students explore a multitude of techniques in 3D graphics and animation as they master the many tools of 3D Studio Max. Students develop 3D graphics and animations for gaming environments much like those in games for the Xbox and PS3.

### Graphics

Students learn and use a high performance cross-platform real time 3D graphics library used in both game and simulation industries. Students are exposed to the same techniques as Pixar employees in developing animation in movies such as Toy Story and UP. The will also use some of the same tools as developers for the Xbox and PS3.

### Structure of Game Design

Students are introduced to the important techniques used by game programmers and designers from developing a framework for the game to the story line that keeps gamers interested. Students apply tools of the trade to creating a game of their design. Students deconstruct their favorite video game into its developmental stages.

### Data Structures

Students apply the tools necessary to manage data and organize programs in a variety of applications, examining the effectiveness of each tool.

### Introduction to Artificial Intelligence

Students learn how to develop intelligent devices including machine problem solving, game playing, pattern recognition and perception problems, machine learning, expert systems and robotics. Graduate students involved in Artificial Intelligence in industry present their current challenges and real-world projects.

### Electives

Students may choose 3 other courses from any concentration to round out their degree.

## *Software Engineering*

The following courses are required for the Software Engineering Concentration.

### Programming II

Students expand their understanding of programming, focusing on object-oriented structures and methods necessary for software and game development; structures and methods they will use in other graphics and gaming courses.

### Data Structures

Students apply the tools necessary to manage data and organize programs in a variety of applications, examining the effectiveness of each tool.

### Principles and Practices of Software Engineering

Students examine the principles and methods of software engineering from development methodology, software requirements and specifications, software design, testing software quality assurance, and project management. Students are also exposed to a number of popular tools used extensively in industry to support software engineering activities.

### Object Oriented Modeling

Student are provided with the tools and techniques needed to solve complex, real-world software engineering problems in an object-oriented manner, using the most effective elements of the widely used Unified Process. Students develop an Object-Oriented Model to a current, real-world situation provided by local businesses.

### Computer Systems

Students explore machine-level programming and architecture and learn discernment in when and where to use them.

### Distributed Systems

Students explore the issues surrounding applications that are distributed in different locations that do not share the same address space but are working together to solve a problem.

### Electives

Students may choose 3 other courses from any concentration to round out their degree.

## *Web and Media Development*

The following courses are required for the Web and Media Development Concentration.

### Principles of Web Site Design

Students are introduced to the concepts and principles for designing Web sites. They apply design basics to developing a web site using XHTML and Cascading Style Sheets and publish their web site to a web server.

### Web Graphics

Students are introduced to the basic techniques of digital photography manipulation with an emphasis on techniques for working with images for Web design. Students apply their understanding to preparing graphic images for the web in a variety of ways.

### Basic Typography

Students are introduced to the terminology, technology and design aspects of typography and visual communication, developing an understanding of the foundations of typography and its effective use in graphic design.

### Webmasters and Servers

Students explore existing and emerging Web development technologies including specialized Web markup and scripting languages evaluating their effective use in an enterprise Web development environment. Students are exposed to web developers currently using these technologies in solving their real-world challenges.

### Intermediate Web Design

Students combine their knowledge of web design, graphics and typography to create complex page layouts and navigation. They develop scripting and database skills using current scripting languages to deliver dynamic web sites. In cooperation with the Database Concepts course, students create a dynamic, database-driven web site.

### Digital Imaging and Streaming Video

Students are provided hands on projects learning about digital imaging and streaming video.

### E-Commerce

Students explore multi-faceted issues of commerce on the Internet from the customer experience to business expectations with an emphasis on security for both customer and business.

### Electives

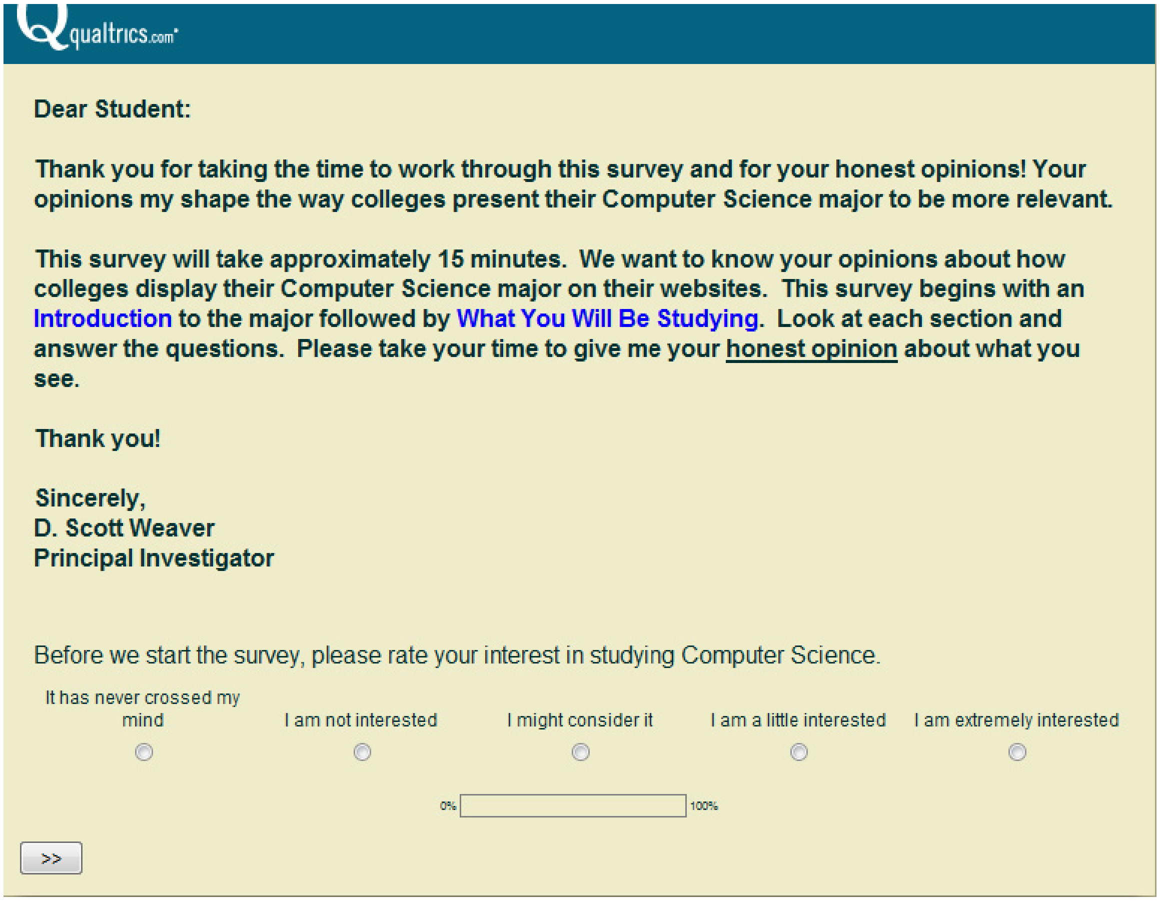
Students may choose 3 other courses from any concentration to round out their degree.

# Appendix I

# Survey Instruments

## I.1 First Survey Instrument

### *I.1.1 Introduction Block*



**Dear Student:**

**Thank you for taking the time to work through this survey and for your honest opinions! Your opinions my shape the way colleges present their Computer Science major to be more relevant.**

**This survey will take approximately 15 minutes. We want to know your opinions about how colleges display their Computer Science major on their websites. This survey begins with an Introduction to the major followed by What You Will Be Studying. Look at each section and answer the questions. Please take your time to give me your honest opinion about what you see.**

**Thank you!**

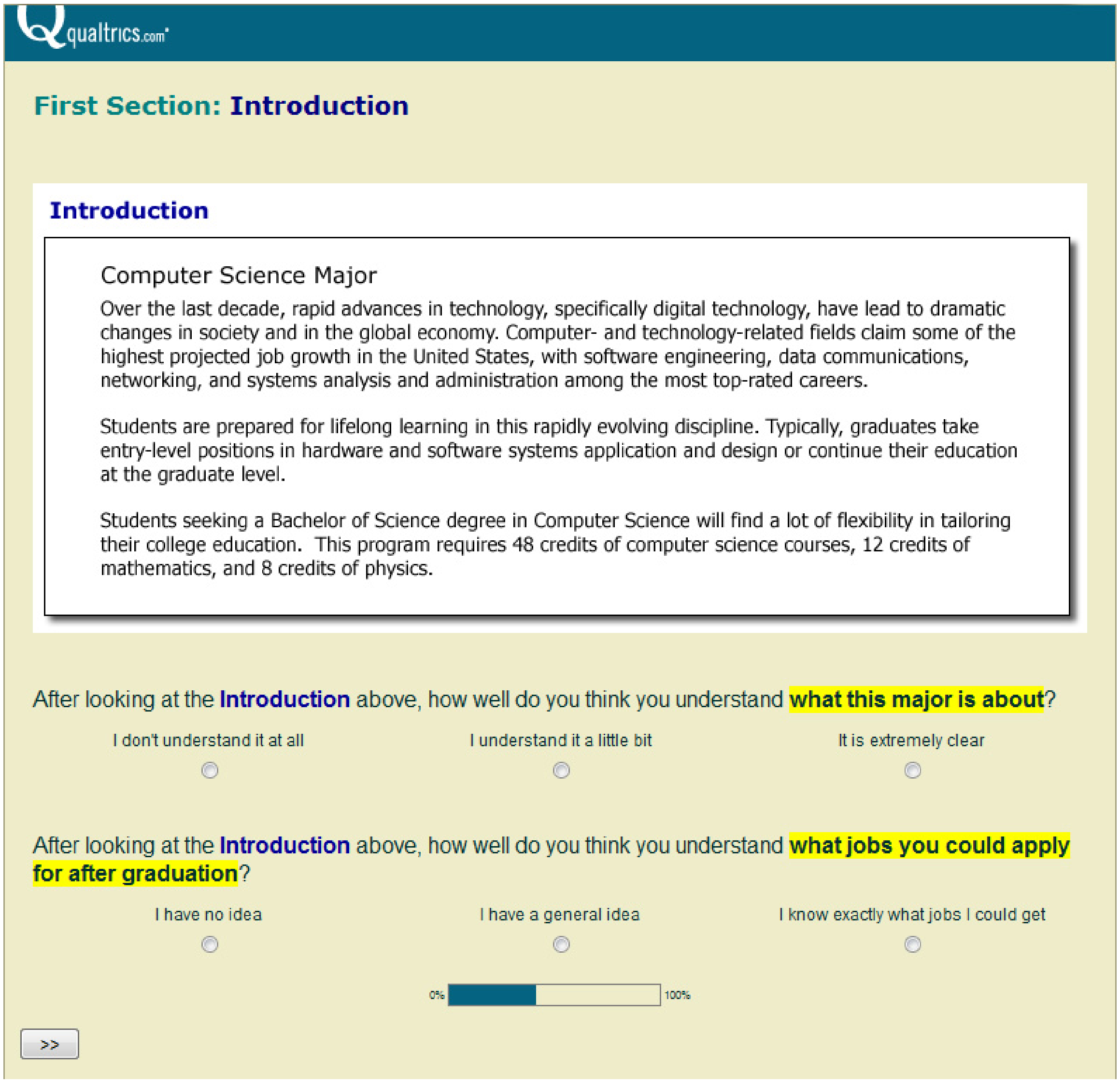
**Sincerely,**
**D. Scott Weaver**
**Principal Investigator**

Before we start the survey, please rate your interest in studying Computer Science.

| It has never crossed my mind | I am not interested | I might consider it | I am a little interested | I am extremely interested |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

### *I.1.2 Typical Curriculum*

#### Introduction



**First Section: Introduction**

**Introduction**

Computer Science Major

Over the last decade, rapid advances in technology, specifically digital technology, have lead to dramatic changes in society and in the global economy. Computer- and technology-related fields claim some of the highest projected job growth in the United States, with software engineering, data communications, networking, and systems analysis and administration among the most top-rated careers.

Students are prepared for lifelong learning in this rapidly evolving discipline. Typically, graduates take entry-level positions in hardware and software systems application and design or continue their education at the graduate level.

Students seeking a Bachelor of Science degree in Computer Science will find a lot of flexibility in tailoring their college education. This program requires 48 credits of computer science courses, 12 credits of mathematics, and 8 credits of physics.

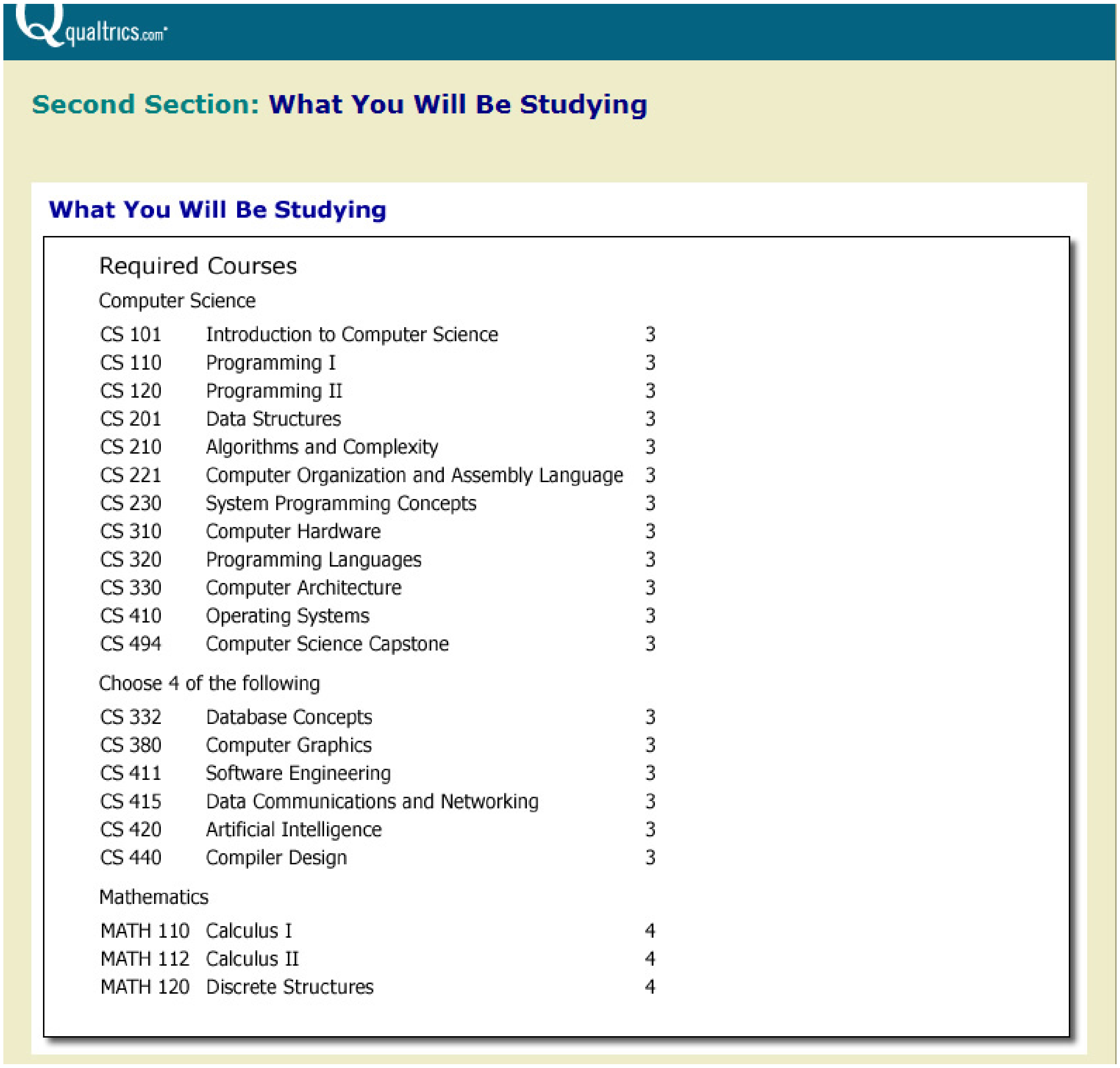
After looking at the **Introduction** above, how well do you think you understand **what this major is about**?

| I don't understand it at all | I understand it a little bit | It is extremely clear |
|---|---|---|
| ○ | ○ | ○ |

After looking at the **Introduction** above, how well do you think you understand **what jobs you could apply for after graduation**?

| I have no idea | I have a general idea | I know exactly what jobs I could get |
|---|---|---|
| ○ | ○ | ○ |

## What You Will Be Studying



**Second Section: What You Will Be Studying**

**What You Will Be Studying**

Required Courses

Computer Science

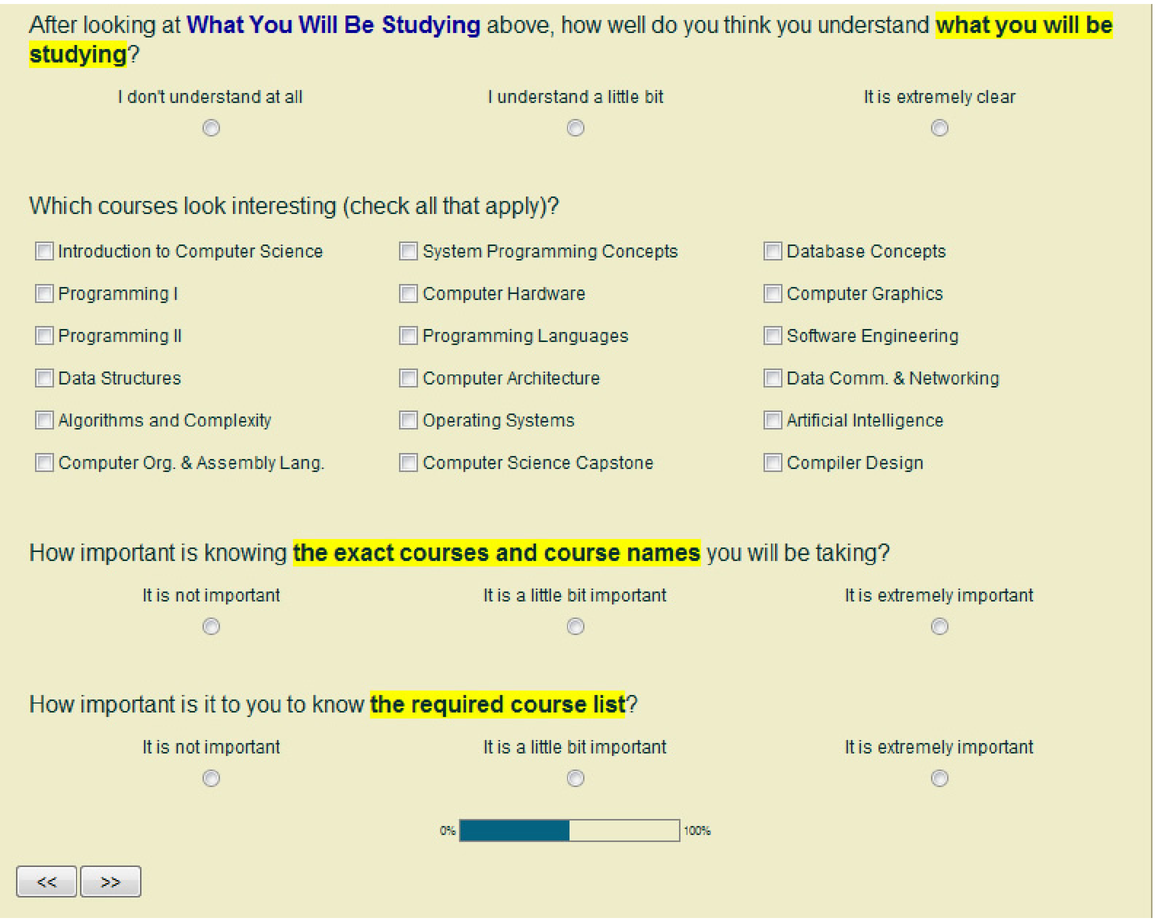
| | | |
|---|---|---|
| CS 101 | Introduction to Computer Science | 3 |
| CS 110 | Programming I | 3 |
| CS 120 | Programming II | 3 |
| CS 201 | Data Structures | 3 |
| CS 210 | Algorithms and Complexity | 3 |
| CS 221 | Computer Organization and Assembly Language | 3 |
| CS 230 | System Programming Concepts | 3 |
| CS 310 | Computer Hardware | 3 |
| CS 320 | Programming Languages | 3 |
| CS 330 | Computer Architecture | 3 |
| CS 410 | Operating Systems | 3 |
| CS 494 | Computer Science Capstone | 3 |

Choose 4 of the following

| | | |
|---|---|---|
| CS 332 | Database Concepts | 3 |
| CS 380 | Computer Graphics | 3 |
| CS 411 | Software Engineering | 3 |
| CS 415 | Data Communications and Networking | 3 |
| CS 420 | Artificial Intelligence | 3 |
| CS 440 | Compiler Design | 3 |

Mathematics

| | | |
|---|---|---|
| MATH 110 | Calculus I | 4 |
| MATH 112 | Calculus II | 4 |
| MATH 120 | Discrete Structures | 4 |



After looking at **What You Will Be Studying** above, how well do you think you understand **what you will be studying**?

| | | |
|---|---|---|
| I don't understand at all | I understand a little bit | It is extremely clear |
| ○ | ○ | ○ |

Which courses look interesting (check all that apply)?

- ☐ Introduction to Computer Science
- ☐ Programming I
- ☐ Programming II
- ☐ Data Structures
- ☐ Algorithms and Complexity
- ☐ Computer Org. & Assembly Lang.
- ☐ System Programming Concepts
- ☐ Computer Hardware
- ☐ Programming Languages
- ☐ Computer Architecture
- ☐ Operating Systems
- ☐ Computer Science Capstone
- ☐ Database Concepts
- ☐ Computer Graphics
- ☐ Software Engineering
- ☐ Data Comm. & Networking
- ☐ Artificial Intelligence
- ☐ Compiler Design

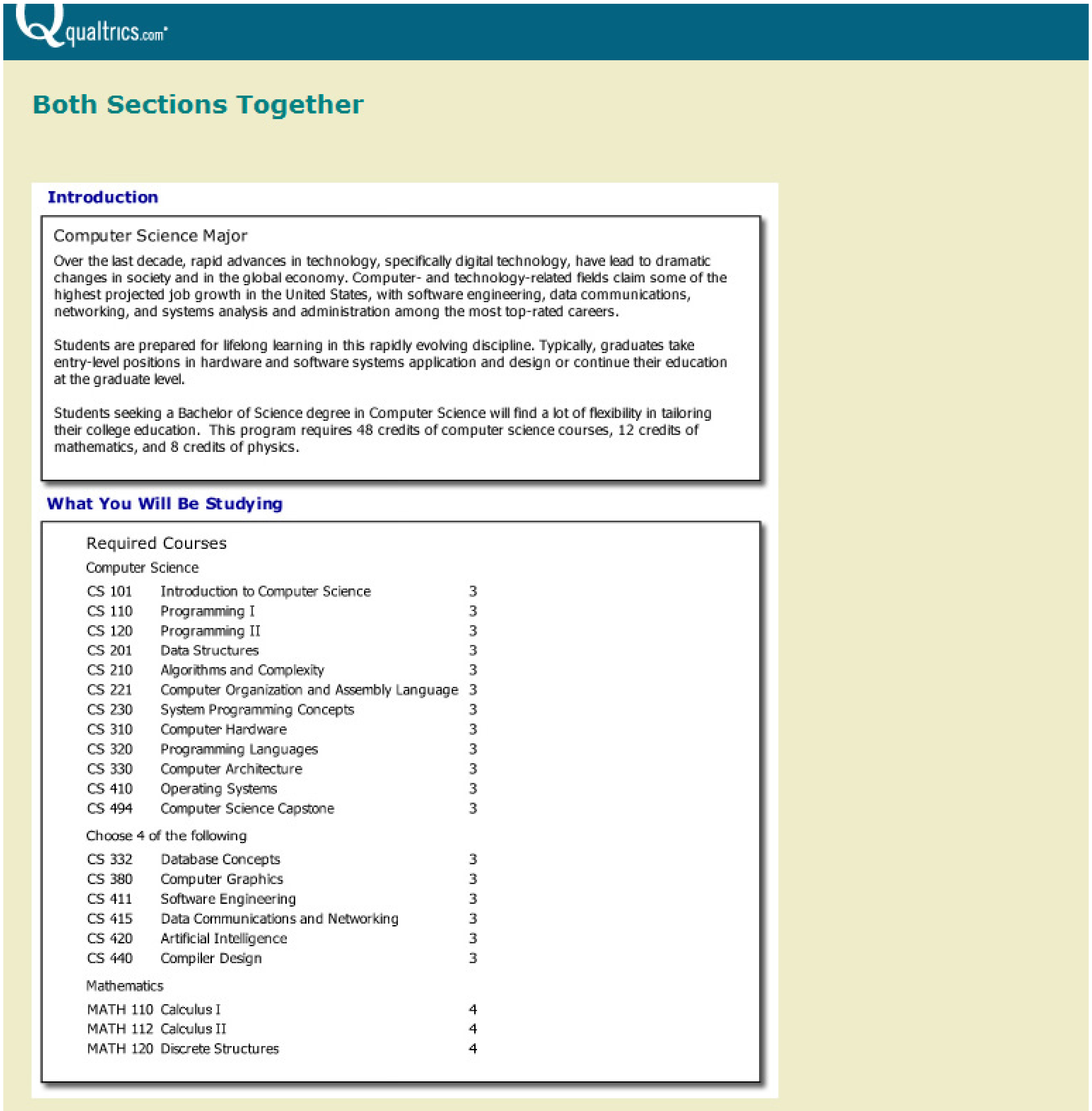
How important is knowing **the exact courses and course names** you will be taking?

| | | |
|---|---|---|
| It is not important | It is a little bit important | It is extremely important |
| ○ | ○ | ○ |

How important is it to you to know **the required course list**?

| | | |
|---|---|---|
| It is not important | It is a little bit important | It is extremely important |
| ○ | ○ | ○ |

## Both Sections Together



### Both Sections Together

**Introduction**

Computer Science Major

Over the last decade, rapid advances in technology, specifically digital technology, have lead to dramatic changes in society and in the global economy. Computer- and technology-related fields claim some of the highest projected job growth in the United States, with software engineering, data communications, networking, and systems analysis and administration among the most top-rated careers.

Students are prepared for lifelong learning in this rapidly evolving discipline. Typically, graduates take entry-level positions in hardware and software systems application and design or continue their education at the graduate level.

Students seeking a Bachelor of Science degree in Computer Science will find a lot of flexibility in tailoring their college education. This program requires 48 credits of computer science courses, 12 credits of mathematics, and 8 credits of physics.

**What You Will Be Studying**

Required Courses

Computer Science

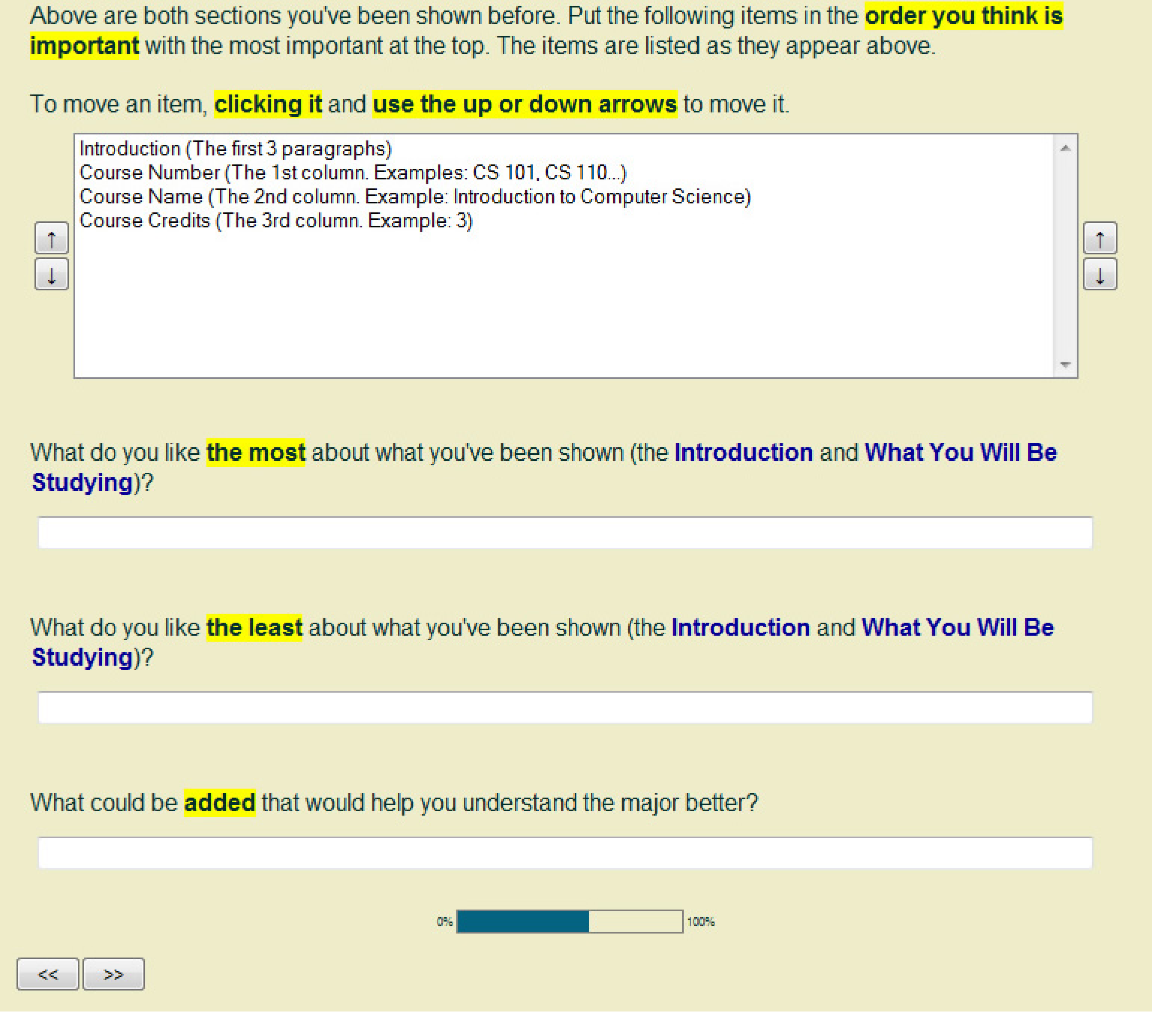
| | | |
|---|---|---|
| CS 101 | Introduction to Computer Science | 3 |
| CS 110 | Programming I | 3 |
| CS 120 | Programming II | 3 |
| CS 201 | Data Structures | 3 |
| CS 210 | Algorithms and Complexity | 3 |
| CS 221 | Computer Organization and Assembly Language | 3 |
| CS 230 | System Programming Concepts | 3 |
| CS 310 | Computer Hardware | 3 |
| CS 320 | Programming Languages | 3 |
| CS 330 | Computer Architecture | 3 |
| CS 410 | Operating Systems | 3 |
| CS 494 | Computer Science Capstone | 3 |

Choose 4 of the following

| | | |
|---|---|---|
| CS 332 | Database Concepts | 3 |
| CS 380 | Computer Graphics | 3 |
| CS 411 | Software Engineering | 3 |
| CS 415 | Data Communications and Networking | 3 |
| CS 420 | Artificial Intelligence | 3 |
| CS 440 | Compiler Design | 3 |

Mathematics

| | | |
|---|---|---|
| MATH 110 | Calculus I | 4 |
| MATH 112 | Calculus II | 4 |
| MATH 120 | Discrete Structures | 4 |



Above are both sections you've been shown before. Put the following items in the **order you think is important** with the most important at the top. The items are listed as they appear above.

To move an item, **clicking it** and **use the up or down arrows** to move it.

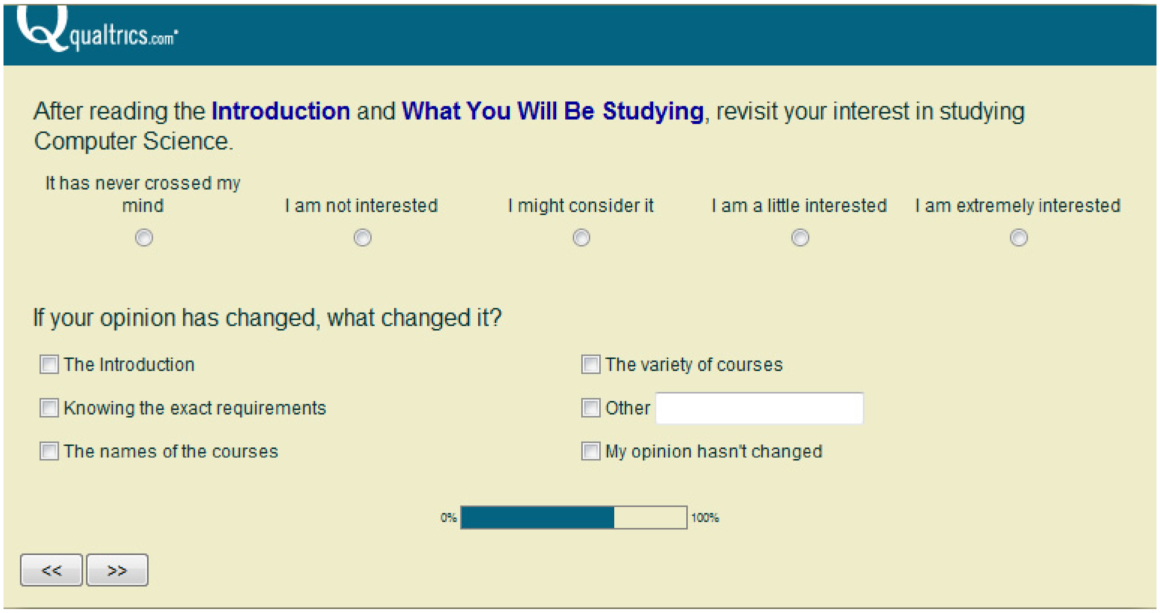
Introduction (The first 3 paragraphs)
Course Number (The 1st column. Examples: CS 101, CS 110...)
Course Name (The 2nd column. Example: Introduction to Computer Science)
Course Credits (The 3rd column. Example: 3)

What do you like **the most** about what you've been shown (the **Introduction** and **What You Will Be Studying**)?

What do you like **the least** about what you've been shown (the **Introduction** and **What You Will Be Studying**)?

What could be **added** that would help you understand the major better?

## Interest Level Revisited



After reading the **Introduction** and **What You Will Be Studying**, revisit your interest in studying Computer Science.

| It has never crossed my mind | I am not interested | I might consider it | I am a little interested | I am extremely interested |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

If your opinion has changed, what changed it?

☐ The Introduction

☐ Knowing the exact requirements

☐ The names of the courses

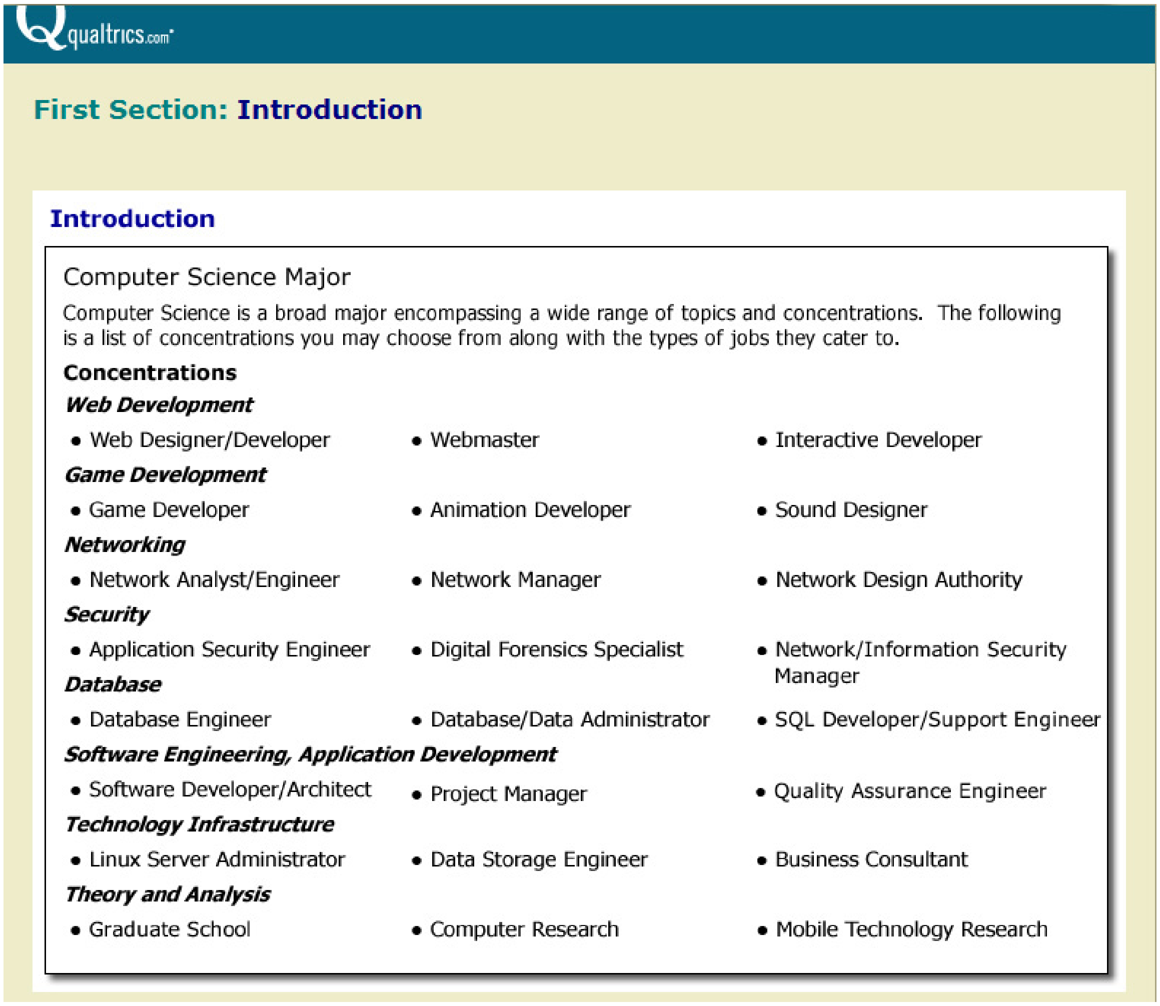
☐ The variety of courses

☐ Other

☐ My opinion hasn't changed

### *I.1.3 Job-Focused Curriculum*

#### Introduction



**First Section: Introduction**

**Introduction**

Computer Science Major

Computer Science is a broad major encompassing a wide range of topics and concentrations. The following is a list of concentrations you may choose from along with the types of jobs they cater to.

**Concentrations**

***Web Development***

- Web Designer/Developer
- Webmaster
- Interactive Developer

***Game Development***

- Game Developer
- Animation Developer
- Sound Designer

***Networking***

- Network Analyst/Engineer
- Network Manager
- Network Design Authority

***Security***

- Application Security Engineer
- Digital Forensics Specialist
- Network/Information Security Manager

***Database***

- Database Engineer
- Database/Data Administrator
- SQL Developer/Support Engineer

***Software Engineering, Application Development***

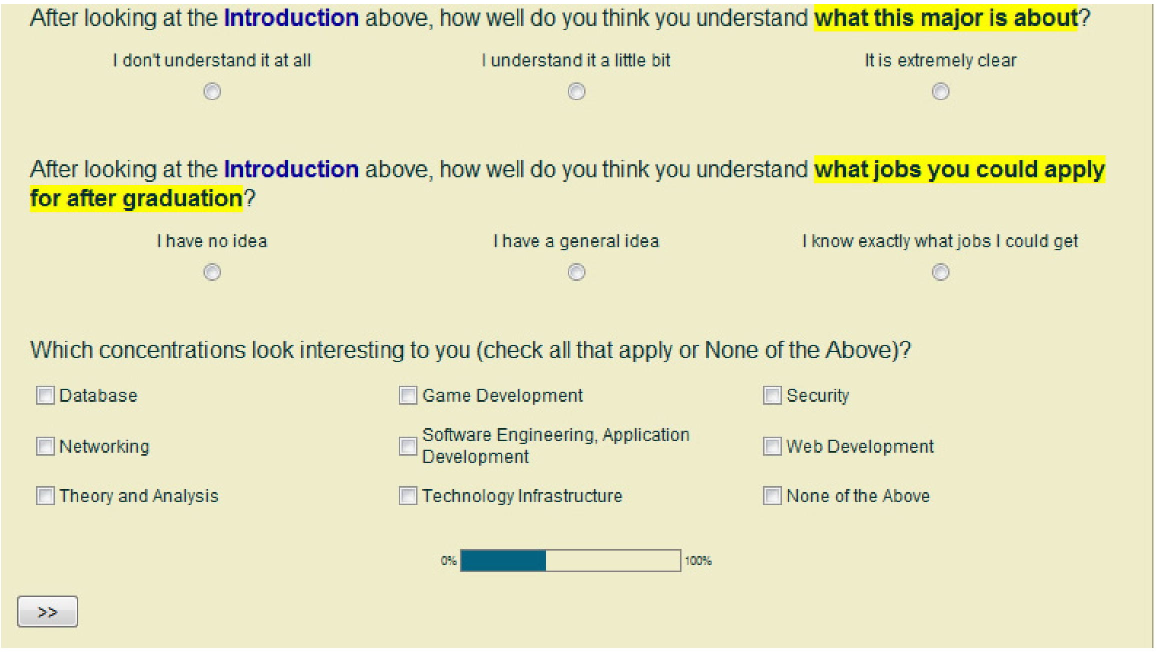
- Software Developer/Architect
- Project Manager
- Quality Assurance Engineer

***Technology Infrastructure***

- Linux Server Administrator
- Data Storage Engineer
- Business Consultant

***Theory and Analysis***

- Graduate School
- Computer Research
- Mobile Technology Research



After looking at the **Introduction** above, how well do you think you understand **what this major is about**?

○ I don't understand it at all
○ I understand it a little bit
○ It is extremely clear

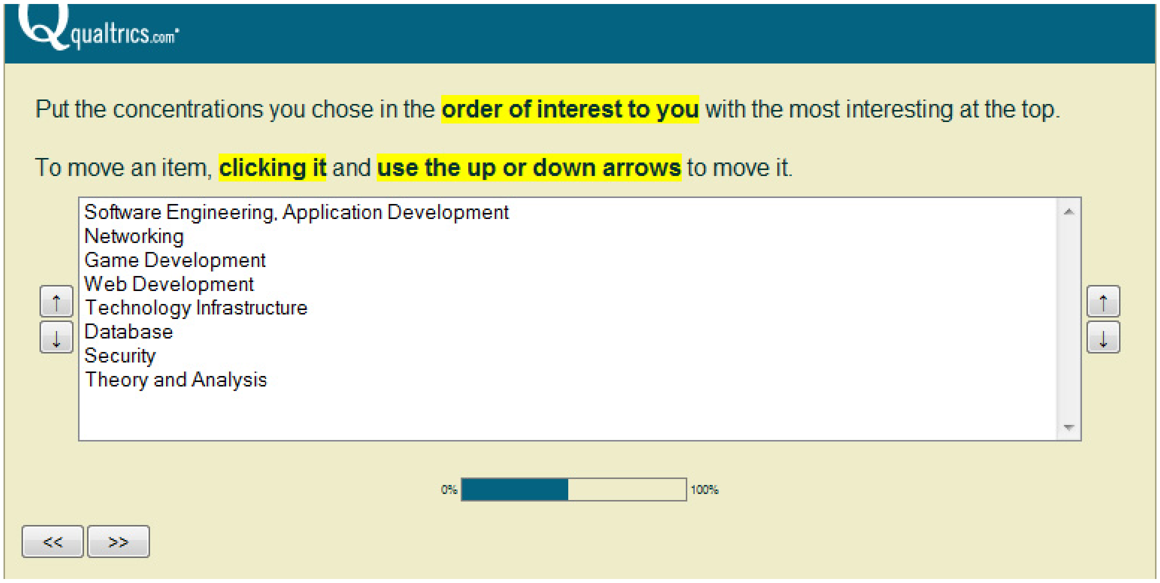
After looking at the **Introduction** above, how well do you think you understand **what jobs you could apply for after graduation**?

○ I have no idea
○ I have a general idea
○ I know exactly what jobs I could get

Which concentrations look interesting to you (check all that apply or None of the Above)?

☐ Database
☐ Networking
☐ Theory and Analysis
☐ Game Development
☐ Software Engineering, Application Development
☐ Technology Infrastructure
☐ Security
☐ Web Development
☐ None of the Above

## Ordering of Concentrations

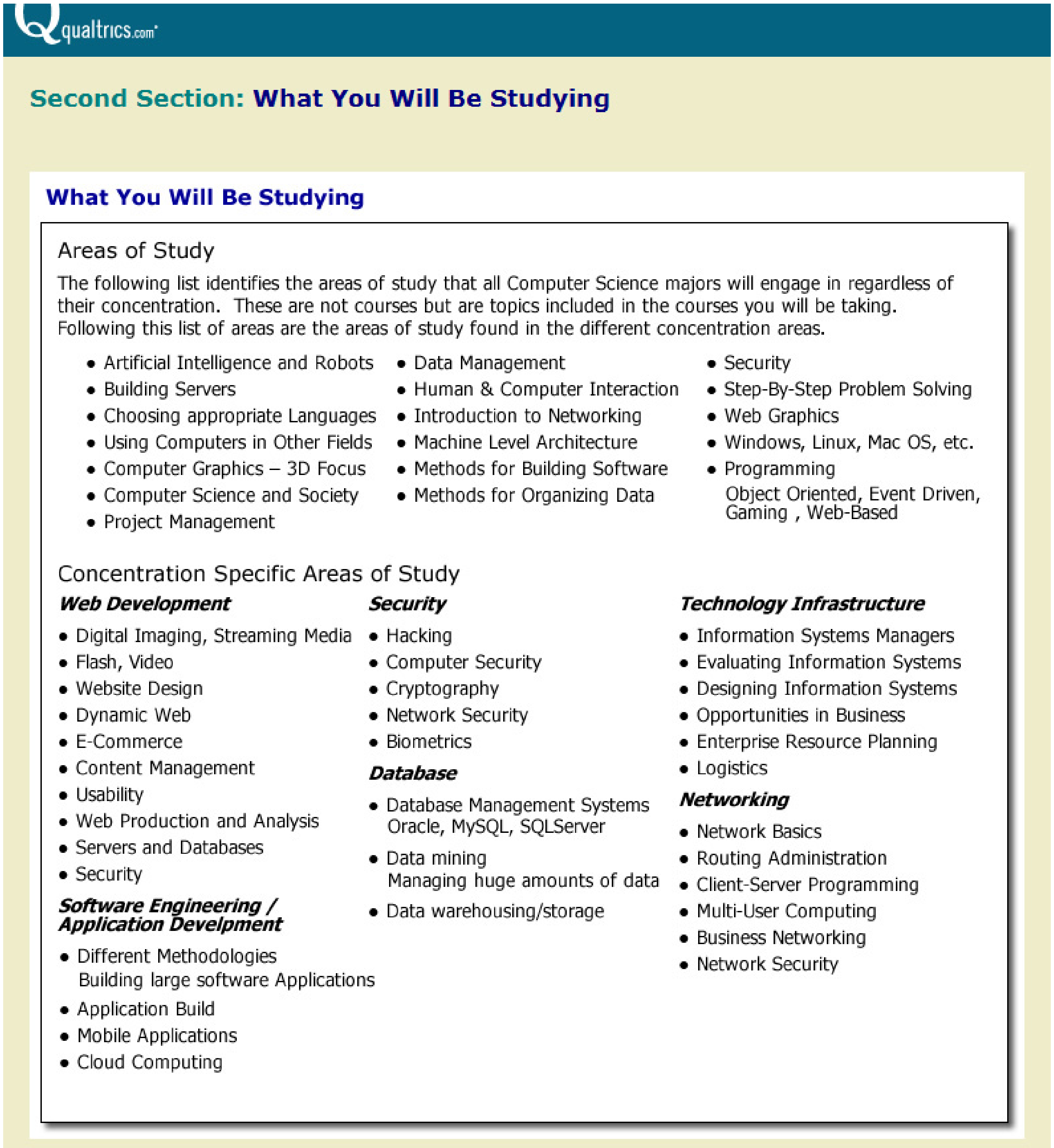


Put the concentrations you chose in the **order of interest to you** with the most interesting at the top.

To move an item, **clicking it** and **use the up or down arrows** to move it.

- Software Engineering, Application Development
- Networking
- Game Development
- Web Development
- Technology Infrastructure
- Database
- Security
- Theory and Analysis

## What You Will Be Studying



### Second Section: What You Will Be Studying

### What You Will Be Studying

#### Areas of Study

The following list identifies the areas of study that all Computer Science majors will engage in regardless of their concentration. These are not courses but are topics included in the courses you will be taking. Following this list of areas are the areas of study found in the different concentration areas.

- Artificial Intelligence and Robots
- Building Servers
- Choosing appropriate Languages
- Using Computers in Other Fields
- Computer Graphics – 3D Focus
- Computer Science and Society
- Project Management
- Data Management
- Human & Computer Interaction
- Introduction to Networking
- Machine Level Architecture
- Methods for Building Software
- Methods for Organizing Data
- Security
- Step-By-Step Problem Solving
- Web Graphics
- Windows, Linux, Mac OS, etc.
- Programming
  Object Oriented, Event Driven, Gaming , Web-Based

#### Concentration Specific Areas of Study

***Web Development***

- Digital Imaging, Streaming Media
- Flash, Video
- Website Design
- Dynamic Web
- E-Commerce
- Content Management
- Usability
- Web Production and Analysis
- Servers and Databases
- Security

***Software Engineering / Application Develpment***

- Different Methodologies
  Building large software Applications
- Application Build
- Mobile Applications
- Cloud Computing

***Security***

- Hacking
- Computer Security
- Cryptography
- Network Security
- Biometrics

***Database***

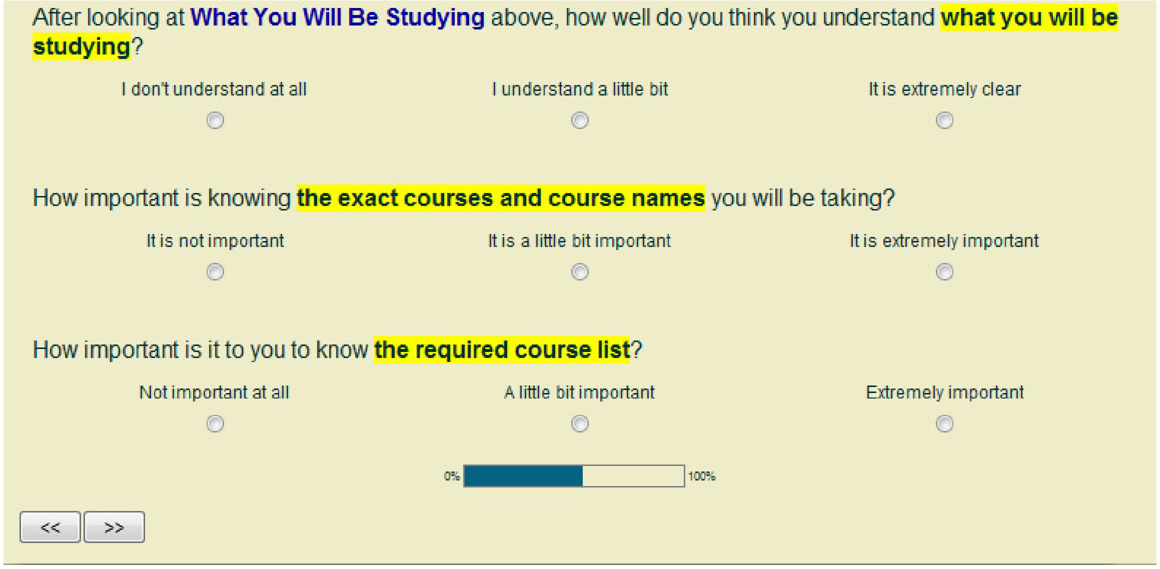
- Database Management Systems
  Oracle, MySQL, SQLServer
- Data mining
  Managing huge amounts of data
- Data warehousing/storage

***Technology Infrastructure***

- Information Systems Managers
- Evaluating Information Systems
- Designing Information Systems
- Opportunities in Business
- Enterprise Resource Planning
- Logistics

***Networking***

- Network Basics
- Routing Administration
- Client-Server Programming
- Multi-User Computing
- Business Networking
- Network Security



After looking at **What You Will Be Studying** above, how well do you think you understand **what you will be studying**?

| I don't understand at all | I understand a little bit | It is extremely clear |
|---|---|---|
| ○ | ○ | ○ |

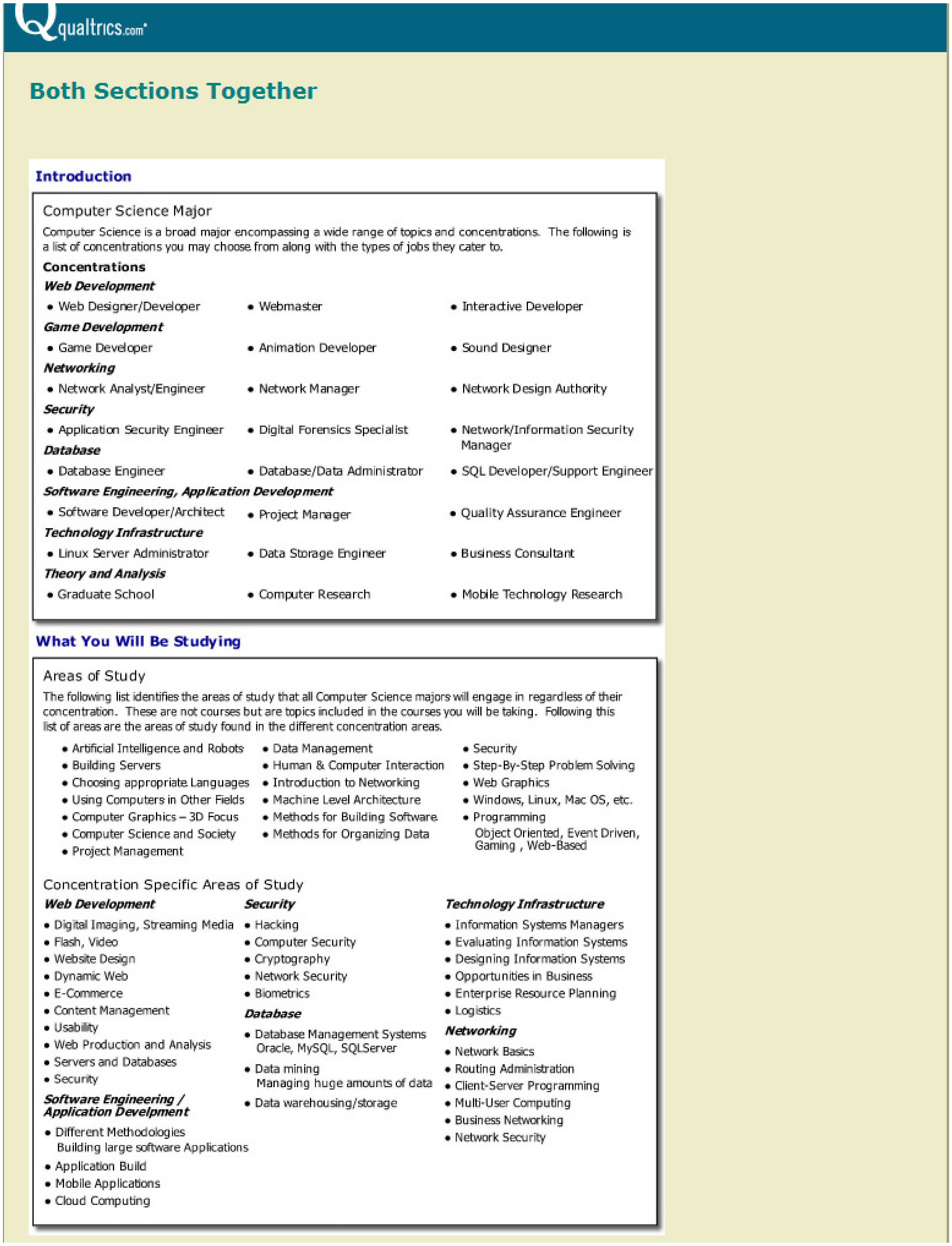
How important is knowing **the exact courses and course names** you will be taking?

| It is not important | It is a little bit important | It is extremely important |
|---|---|---|
| ○ | ○ | ○ |

How important is it to you to know **the required course list**?

| Not important at all | A little bit important | Extremely important |
|---|---|---|
| ○ | ○ | ○ |

# Both Sections Together



qualtrics.com

## Both Sections Together

### Introduction

Computer Science Major

Computer Science is a broad major encompassing a wide range of topics and concentrations. The following is a list of concentrations you may choose from along with the types of jobs they cater to.

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- Sound Designer

***Networking***

- Network Analyst/Engineer
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- Database/Data Administrator
- SQL Developer/Support Engineer

***Software Engineering, Application Development***

- Software Developer/Architect
- Project Manager
- Quality Assurance Engineer

***Technology Infrastructure***

- Linux Server Administrator
- Data Storage Engineer
- Business Consultant

***Theory and Analysis***

- Graduate School
- Computer Research
- Mobile Technology Research

### What You Will Be Studying

Areas of Study

The following list identifies the areas of study that all Computer Science majors will engage in regardless of their concentration. These are not courses but are topics included in the courses you will be taking. Following this list of areas are the areas of study found in the different concentration areas.

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- Human & Computer Interaction
- Introduction to Networking
- Machine Level Architecture
- Methods for Building Software
- Methods for Organizing Data
- Security
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Concentration Specific Areas of Study

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- Application Build
- Mobile Applications
- Cloud Computing

***Security***

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- Biometrics

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- Data warehousing/storage

***Technology Infrastructure***

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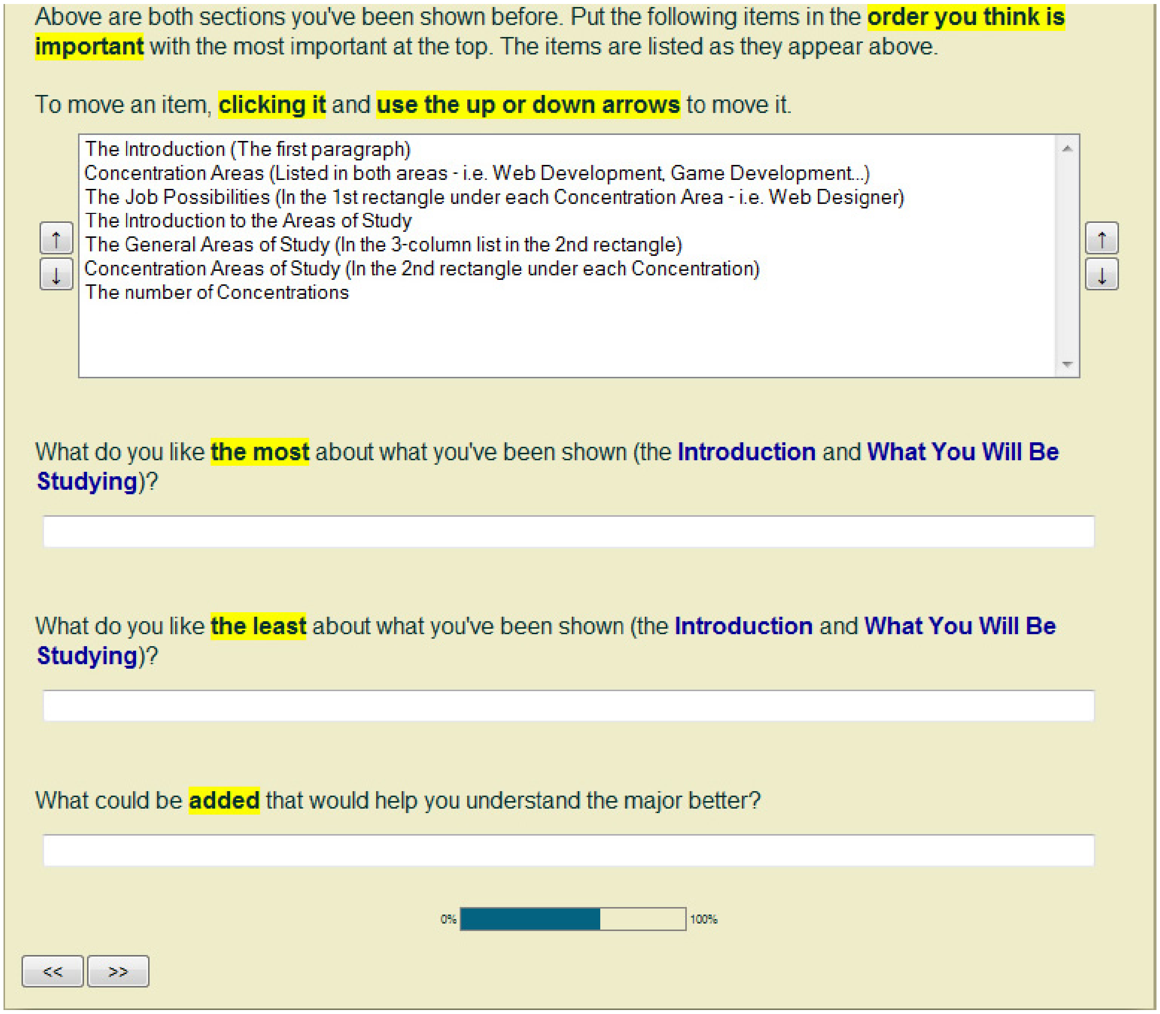
- Evaluating Information Systems
- Designing Information Systems
- Opportunities in Business
- Enterprise Resource Planning
- Logistics

***Networking***

- Network Basics
- Routing Administration
- Client-Server Programming
- Multi-User Computing
- Business Networking
- Network Security



Above are both sections you've been shown before. Put the following items in the **order you think is important** with the most important at the top. The items are listed as they appear above.

To move an item, **clicking it** and **use the up or down arrows** to move it.

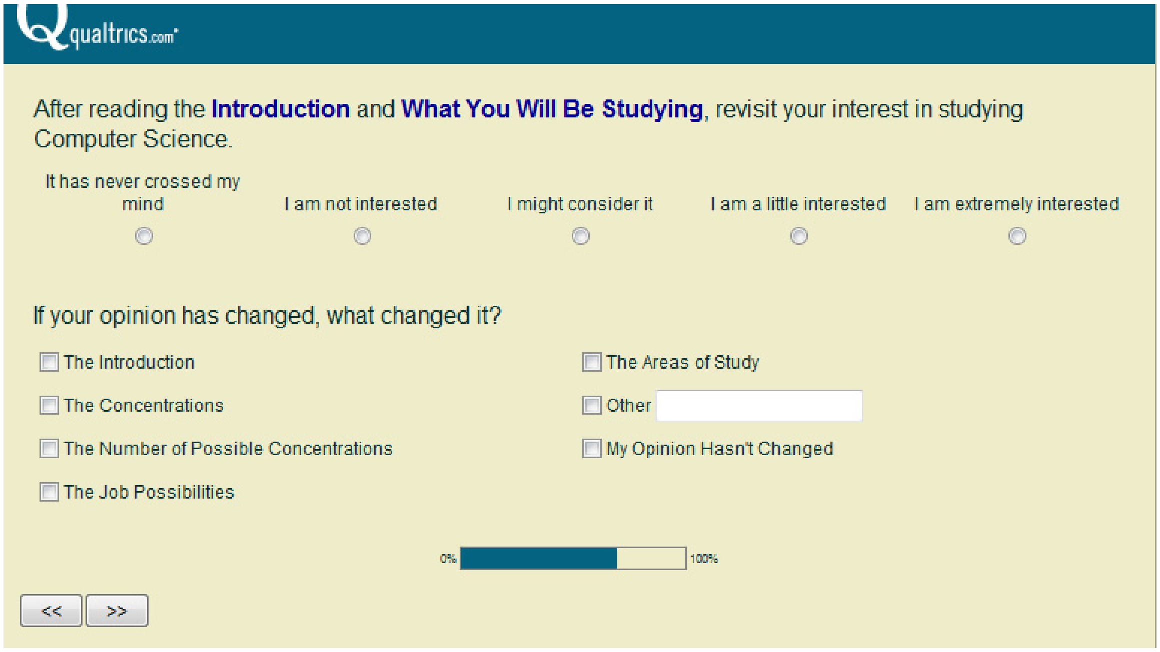
The Introduction (The first paragraph)
Concentration Areas (Listed in both areas - i.e. Web Development, Game Development...)
The Job Possibilities (In the 1st rectangle under each Concentration Area - i.e. Web Designer)
The Introduction to the Areas of Study
The General Areas of Study (In the 3-column list in the 2nd rectangle)
Concentration Areas of Study (In the 2nd rectangle under each Concentration)
The number of Concentrations

What do you like **the most** about what you've been shown (the **Introduction** and **What You Will Be Studying**)?

What do you like **the least** about what you've been shown (the **Introduction** and **What You Will Be Studying**)?

What could be **added** that would help you understand the major better?

## Interest Level Revisited



After reading the **Introduction** and **What You Will Be Studying**, revisit your interest in studying Computer Science.

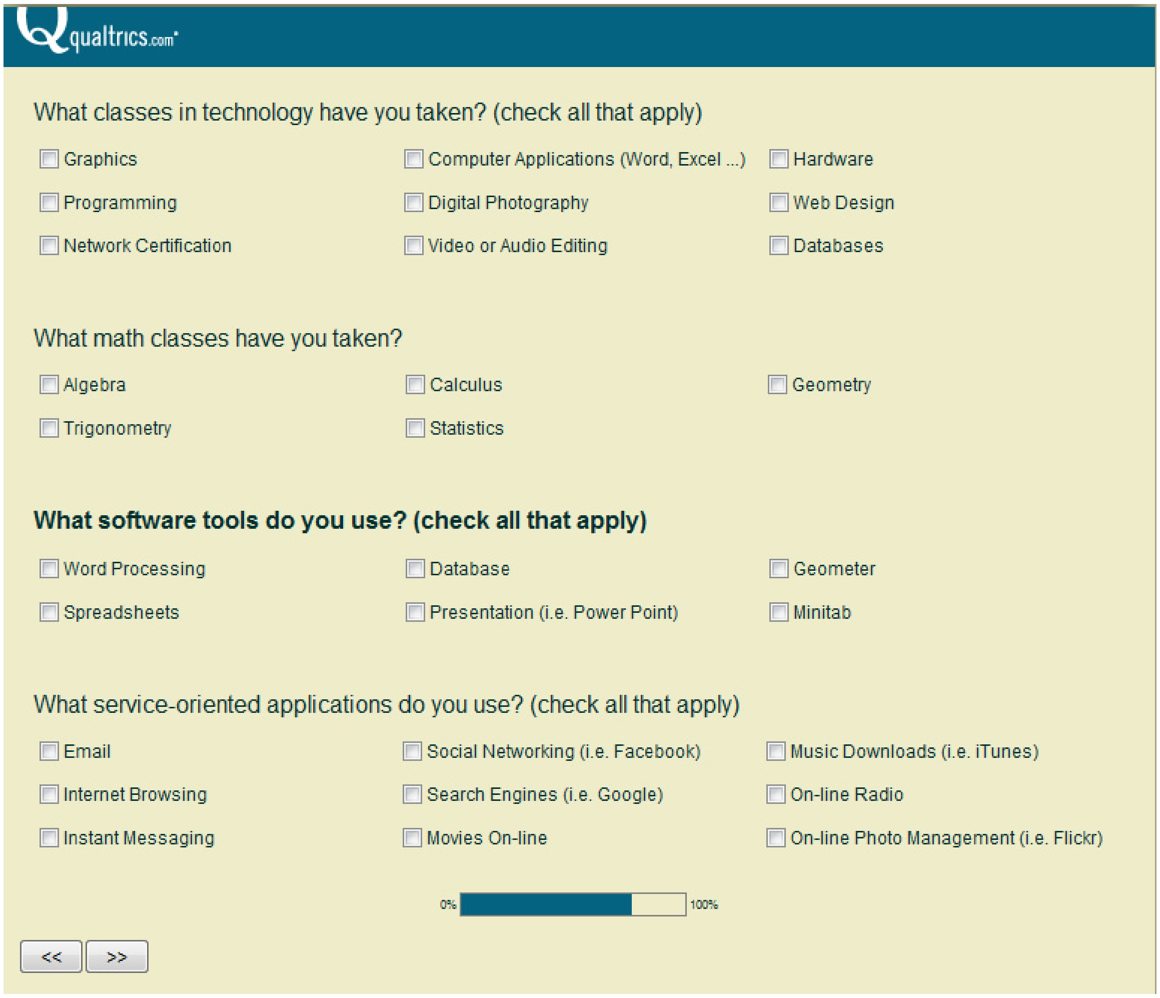
| It has never crossed my mind | I am not interested | I might consider it | I am a little interested | I am extremely interested |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

If your opinion has changed, what changed it?

☐ The Introduction
☐ The Concentrations
☐ The Number of Possible Concentrations
☐ The Job Possibilities
☐ The Areas of Study
☐ Other
☐ My Opinion Hasn't Changed

### *I.1.4 Technology Block*

#### Introduction



What classes in technology have you taken? (check all that apply)

☐ Graphics
☐ Programming
☐ Network Certification
☐ Computer Applications (Word, Excel ...)
☐ Digital Photography
☐ Video or Audio Editing
☐ Hardware
☐ Web Design
☐ Databases

What math classes have you taken?

☐ Algebra
☐ Trigonometry
☐ Calculus
☐ Statistics
☐ Geometry

**What software tools do you use? (check all that apply)**

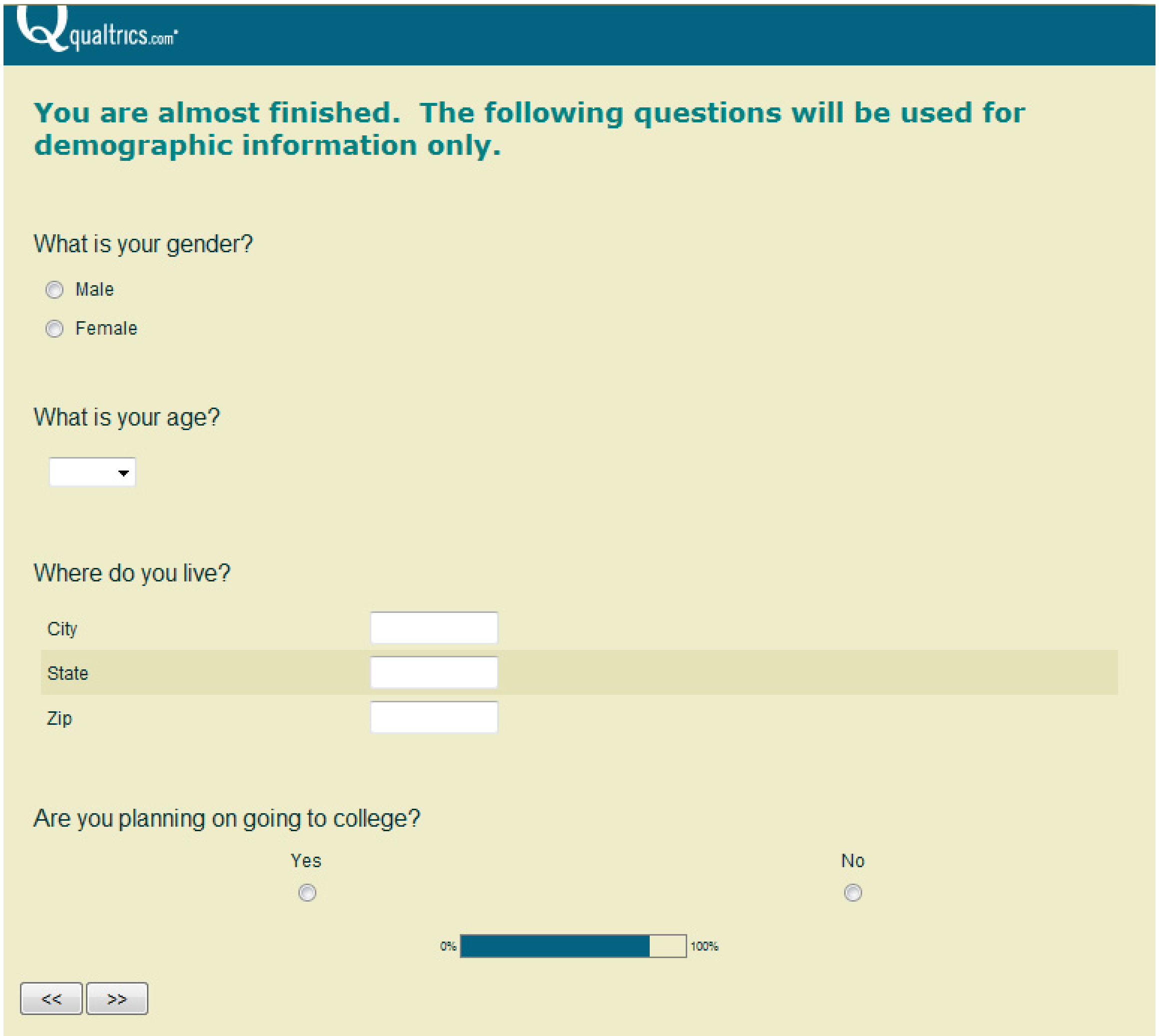
☐ Word Processing
☐ Spreadsheets
☐ Database
☐ Presentation (i.e. Power Point)
☐ Geometer
☐ Minitab

What service-oriented applications do you use? (check all that apply)

☐ Email
☐ Internet Browsing
☐ Instant Messaging
☐ Social Networking (i.e. Facebook)
☐ Search Engines (i.e. Google)
☐ Movies On-line
☐ Music Downloads (i.e. iTunes)
☐ On-line Radio
☐ On-line Photo Management (i.e. Flickr)

### *I.1.5 Demographics Block*

#### Introduction



**You are almost finished. The following questions will be used for demographic information only.**

What is your gender?

○ Male

○ Female

What is your age?

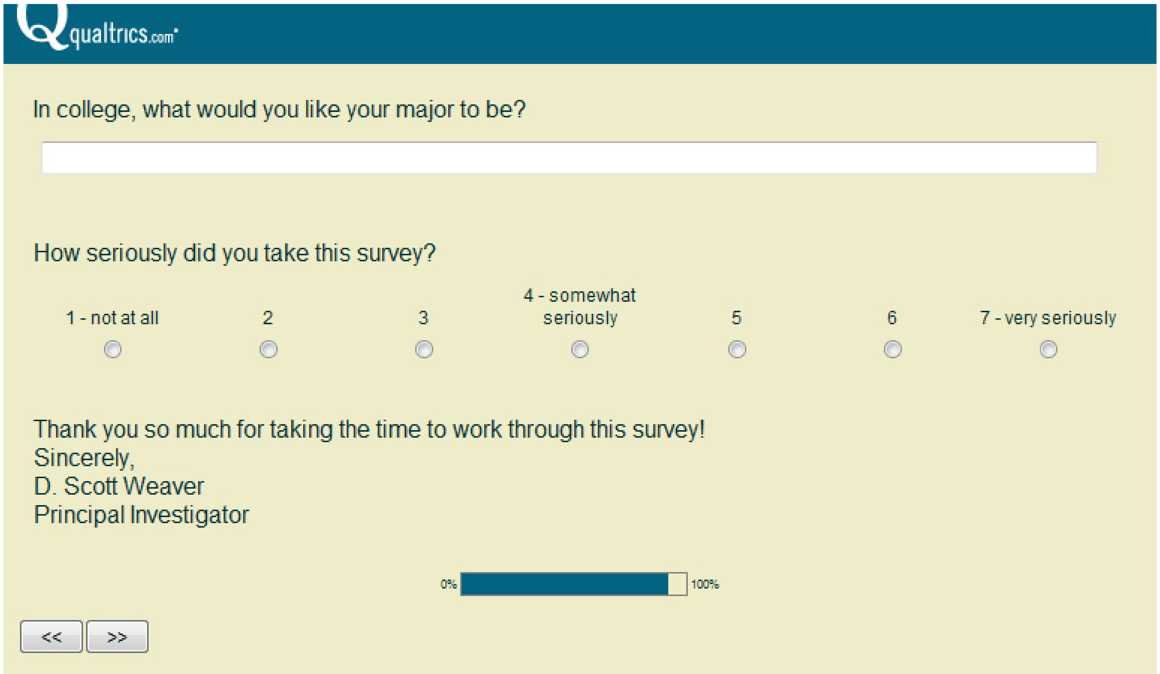
Where do you live?

| | |
|---|---|
| City | |
| State | |
| Zip | |

Are you planning on going to college?

| Yes | No |
|---|---|
| ○ | ○ |

### I.1.6 Conclusion



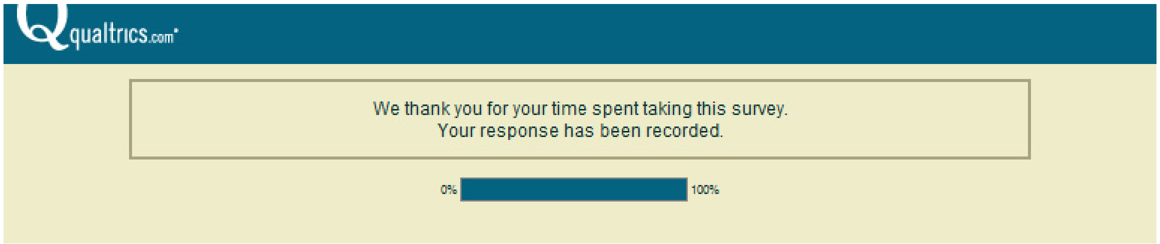
In college, what would you like your major to be?

How seriously did you take this survey?

| 1 - not at all | 2 | 3 | 4 - somewhat seriously | 5 | 6 | 7 - very seriously |
|---|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Thank you so much for taking the time to work through this survey!
Sincerely,
D. Scott Weaver
Principal Investigator

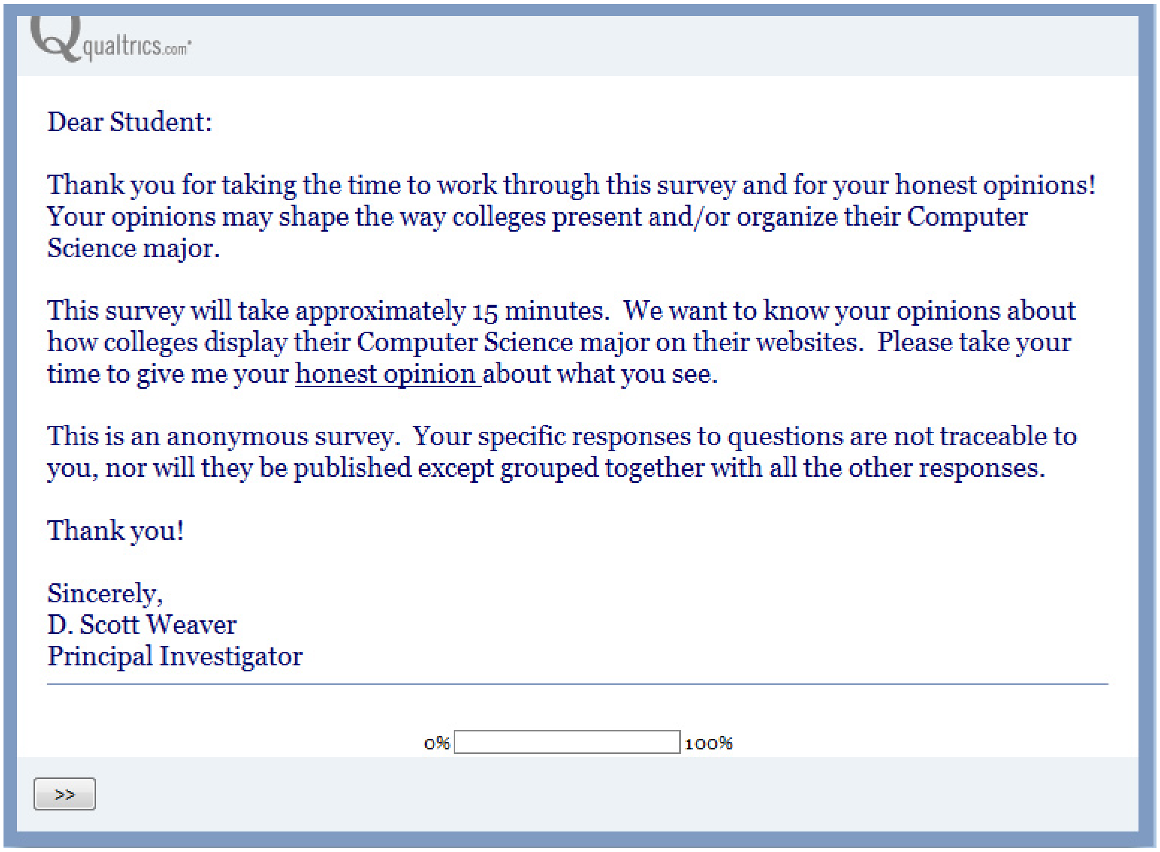
### I.1.7 Completion



We thank you for your time spent taking this survey.
Your response has been recorded.

## I.2 Second Survey Instrument

### *I.2.1 Introduction Block*



Dear Student:

Thank you for taking the time to work through this survey and for your honest opinions! Your opinions may shape the way colleges present and/or organize their Computer Science major.

This survey will take approximately 15 minutes. We want to know your opinions about how colleges display their Computer Science major on their websites. Please take your time to give me your honest opinion about what you see.

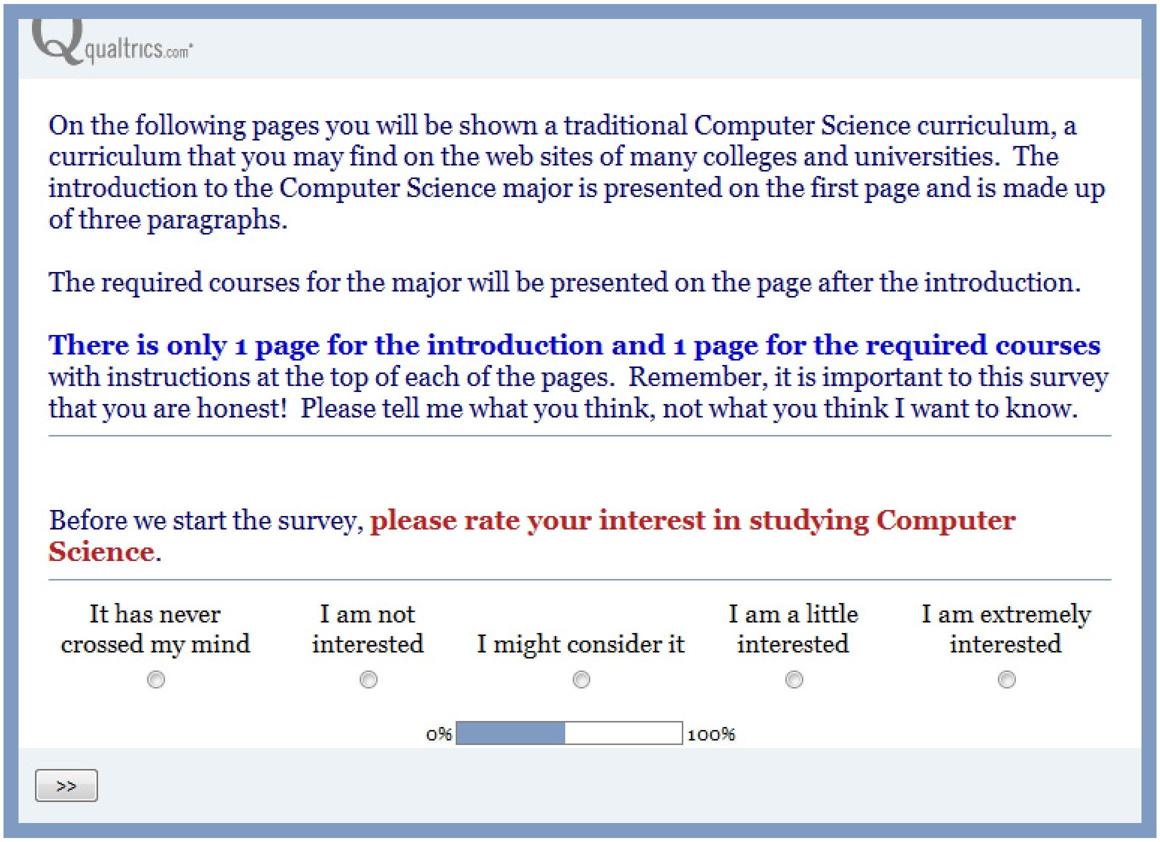
This is an anonymous survey. Your specific responses to questions are not traceable to you, nor will they be published except grouped together with all the other responses.

Thank you!

Sincerely,
D. Scott Weaver
Principal Investigator

### *I.2.2 Typical Curriculum*

#### Introduction and Interest Level



On the following pages you will be shown a traditional Computer Science curriculum, a curriculum that you may find on the web sites of many colleges and universities. The introduction to the Computer Science major is presented on the first page and is made up of three paragraphs.

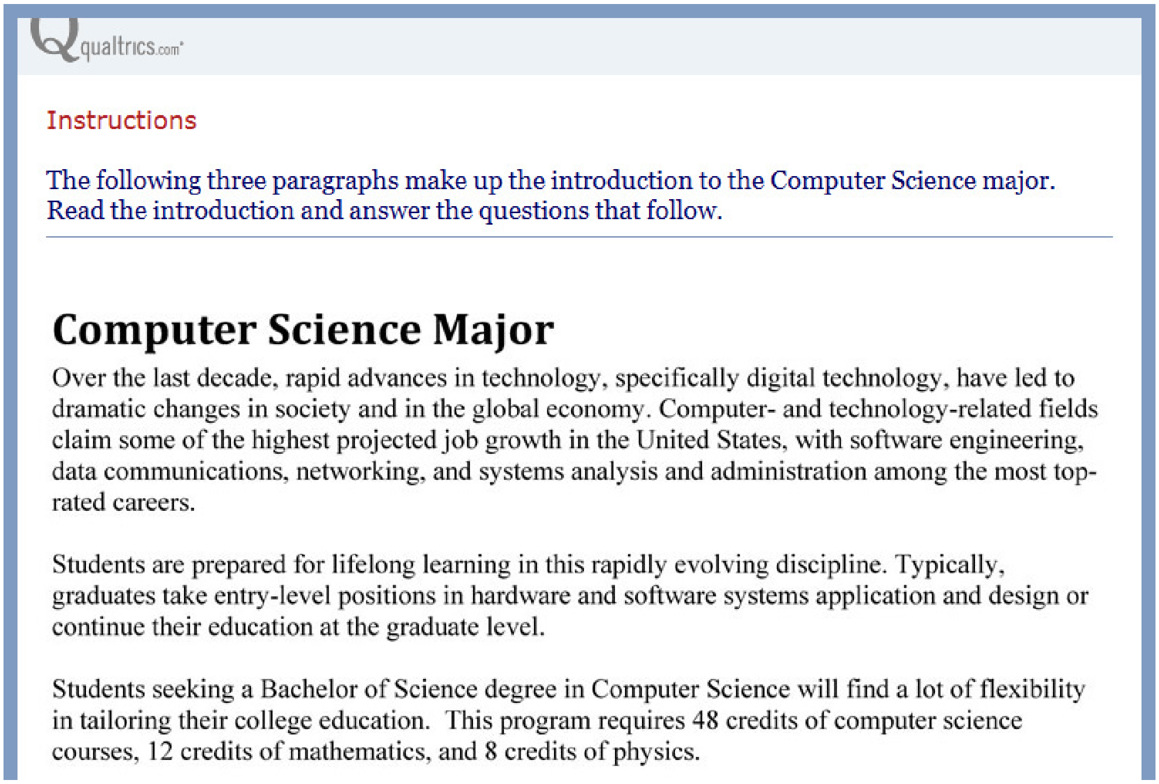
The required courses for the major will be presented on the page after the introduction.

**There is only 1 page for the introduction and 1 page for the required courses** with instructions at the top of each of the pages. Remember, it is important to this survey that you are honest! Please tell me what you think, not what you think I want to know.

Before we start the survey, **please rate your interest in studying Computer Science**.

| It has never crossed my mind | I am not interested | I might consider it | I am a little interested | I am extremely interested |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

**Curriculum Introduction**



Instructions

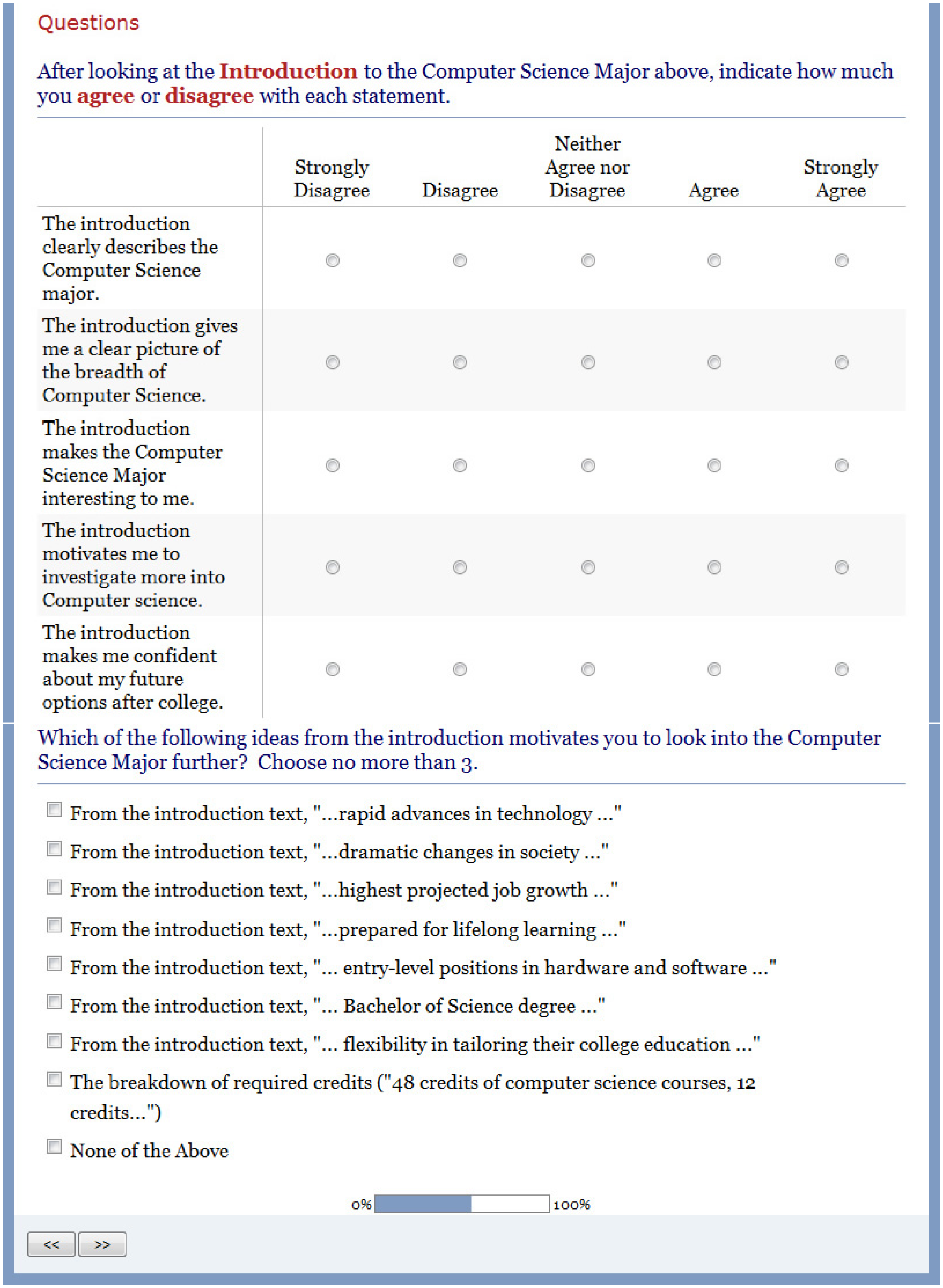
The following three paragraphs make up the introduction to the Computer Science major. Read the introduction and answer the questions that follow.

## Computer Science Major

Over the last decade, rapid advances in technology, specifically digital technology, have led to dramatic changes in society and in the global economy. Computer- and technology-related fields claim some of the highest projected job growth in the United States, with software engineering, data communications, networking, and systems analysis and administration among the most top-rated careers.

Students are prepared for lifelong learning in this rapidly evolving discipline. Typically, graduates take entry-level positions in hardware and software systems application and design or continue their education at the graduate level.

Students seeking a Bachelor of Science degree in Computer Science will find a lot of flexibility in tailoring their college education. This program requires 48 credits of computer science courses, 12 credits of mathematics, and 8 credits of physics.



Questions

After looking at the **Introduction** to the Computer Science Major above, indicate how much you **agree** or **disagree** with each statement.

| | Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |
|---|---|---|---|---|---|
| The introduction clearly describes the Computer Science major. | ○ | ○ | ○ | ○ | ○ |
| The introduction gives me a clear picture of the breadth of Computer Science. | ○ | ○ | ○ | ○ | ○ |
| The introduction makes the Computer Science Major interesting to me. | ○ | ○ | ○ | ○ | ○ |
| The introduction motivates me to investigate more into Computer science. | ○ | ○ | ○ | ○ | ○ |
| The introduction makes me confident about my future options after college. | ○ | ○ | ○ | ○ | ○ |

Which of the following ideas from the introduction motivates you to look into the Computer Science Major further? Choose no more than 3.

☐ From the introduction text, "...rapid advances in technology ..."

☐ From the introduction text, "...dramatic changes in society ..."

☐ From the introduction text, "...highest projected job growth ..."

☐ From the introduction text, "...prepared for lifelong learning ..."

☐ From the introduction text, "... entry-level positions in hardware and software ..."

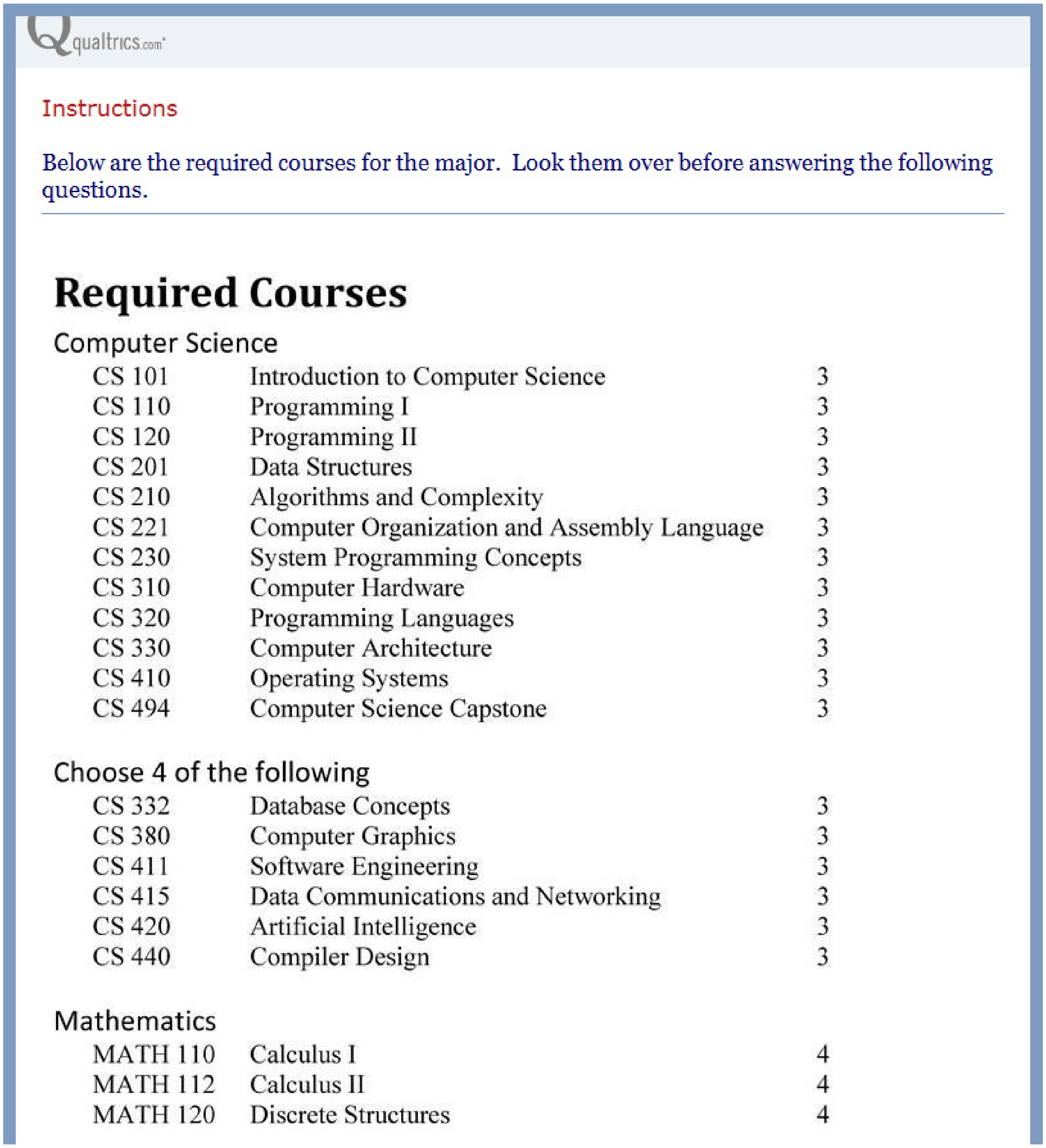
☐ From the introduction text, "... Bachelor of Science degree ..."

☐ From the introduction text, "... flexibility in tailoring their college education ..."

☐ The breakdown of required credits ("48 credits of computer science courses, 12 credits...")

☐ None of the Above

## Required Courses



Instructions

Below are the required courses for the major. Look them over before answering the following questions.

### Required Courses

Computer Science

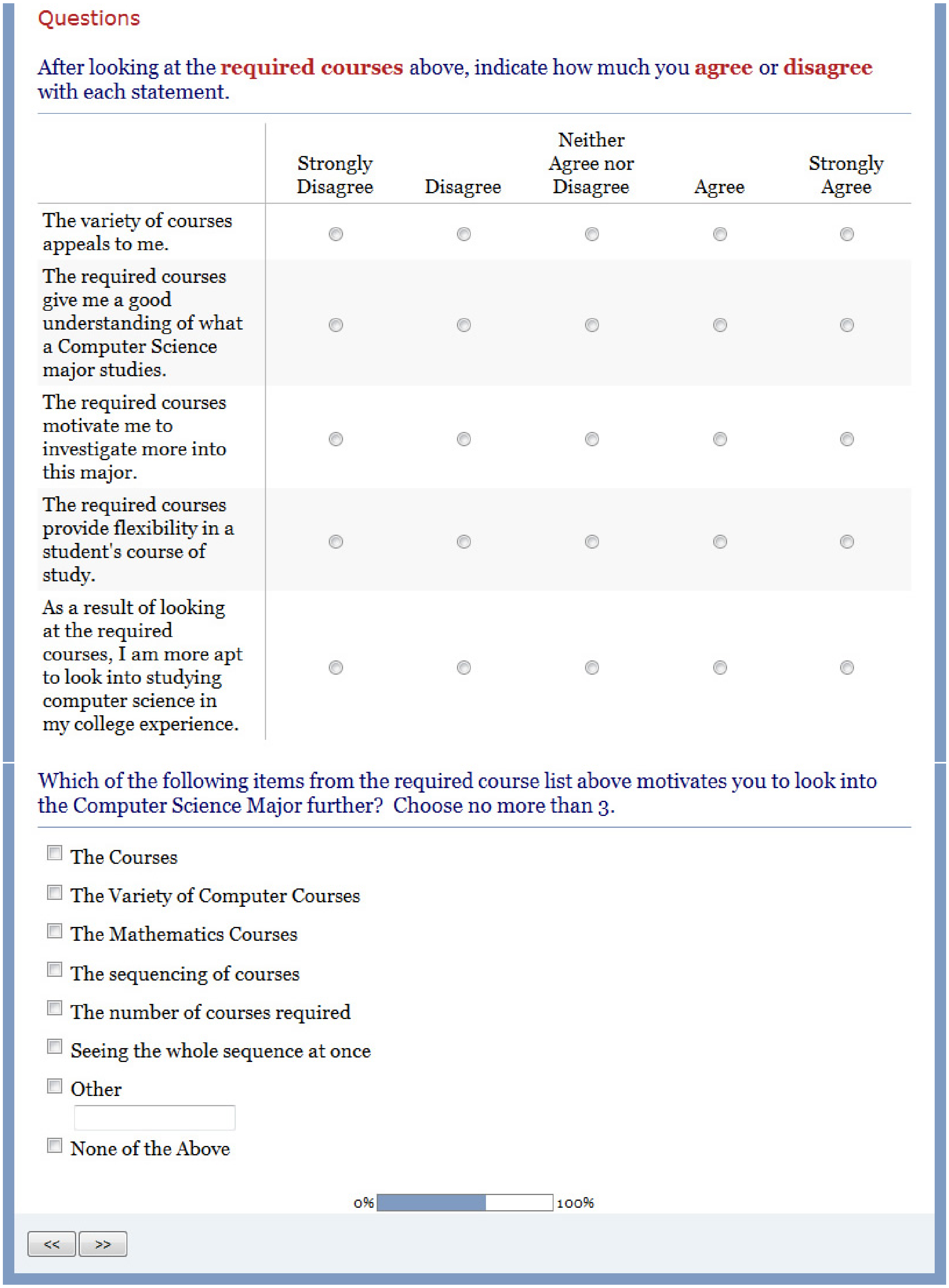
| | | |
|---|---|---|
| CS 101 | Introduction to Computer Science | 3 |
| CS 110 | Programming I | 3 |
| CS 120 | Programming II | 3 |
| CS 201 | Data Structures | 3 |
| CS 210 | Algorithms and Complexity | 3 |
| CS 221 | Computer Organization and Assembly Language | 3 |
| CS 230 | System Programming Concepts | 3 |
| CS 310 | Computer Hardware | 3 |
| CS 320 | Programming Languages | 3 |
| CS 330 | Computer Architecture | 3 |
| CS 410 | Operating Systems | 3 |
| CS 494 | Computer Science Capstone | 3 |

Choose 4 of the following

| | | |
|---|---|---|
| CS 332 | Database Concepts | 3 |
| CS 380 | Computer Graphics | 3 |
| CS 411 | Software Engineering | 3 |
| CS 415 | Data Communications and Networking | 3 |
| CS 420 | Artificial Intelligence | 3 |
| CS 440 | Compiler Design | 3 |

Mathematics

| | | |
|---|---|---|
| MATH 110 | Calculus I | 4 |
| MATH 112 | Calculus II | 4 |
| MATH 120 | Discrete Structures | 4 |



Questions

After looking at the **required courses** above, indicate how much you **agree** or **disagree** with each statement.

| | Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |
|---|---|---|---|---|---|
| The variety of courses appeals to me. | ○ | ○ | ○ | ○ | ○ |
| The required courses give me a good understanding of what a Computer Science major studies. | ○ | ○ | ○ | ○ | ○ |
| The required courses motivate me to investigate more into this major. | ○ | ○ | ○ | ○ | ○ |
| The required courses provide flexibility in a student's course of study. | ○ | ○ | ○ | ○ | ○ |
| As a result of looking at the required courses, I am more apt to look into studying computer science in my college experience. | ○ | ○ | ○ | ○ | ○ |

Which of the following items from the required course list above motivates you to look into the Computer Science Major further? Choose no more than 3.

☐ The Courses

☐ The Variety of Computer Courses

☐ The Mathematics Courses

☐ The sequencing of courses

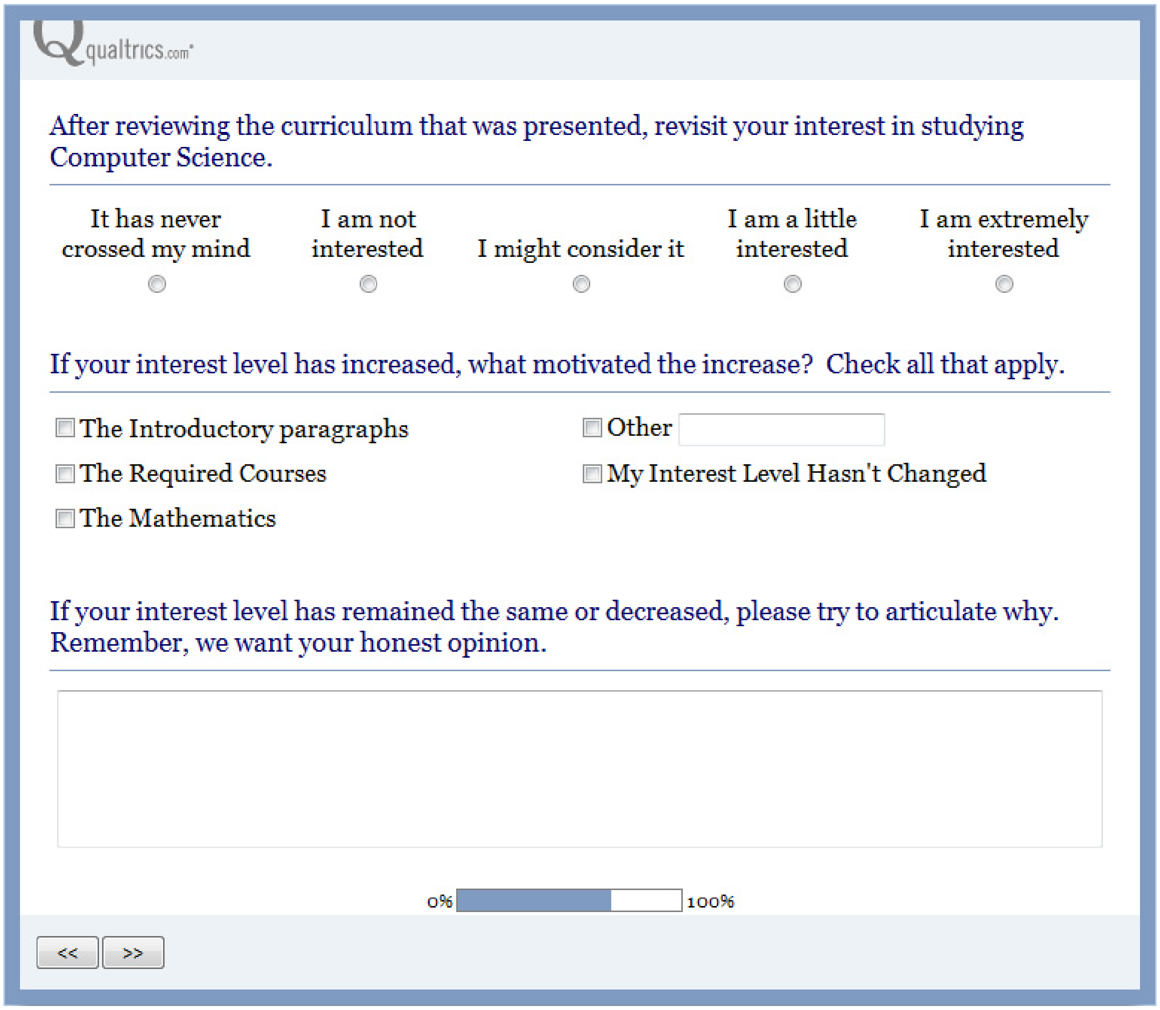
☐ The number of courses required

☐ Seeing the whole sequence at once

☐ Other

☐ None of the Above

### Interest Level Revisited



After reviewing the curriculum that was presented, revisit your interest in studying Computer Science.

| It has never crossed my mind | I am not interested | I might consider it | I am a little interested | I am extremely interested |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

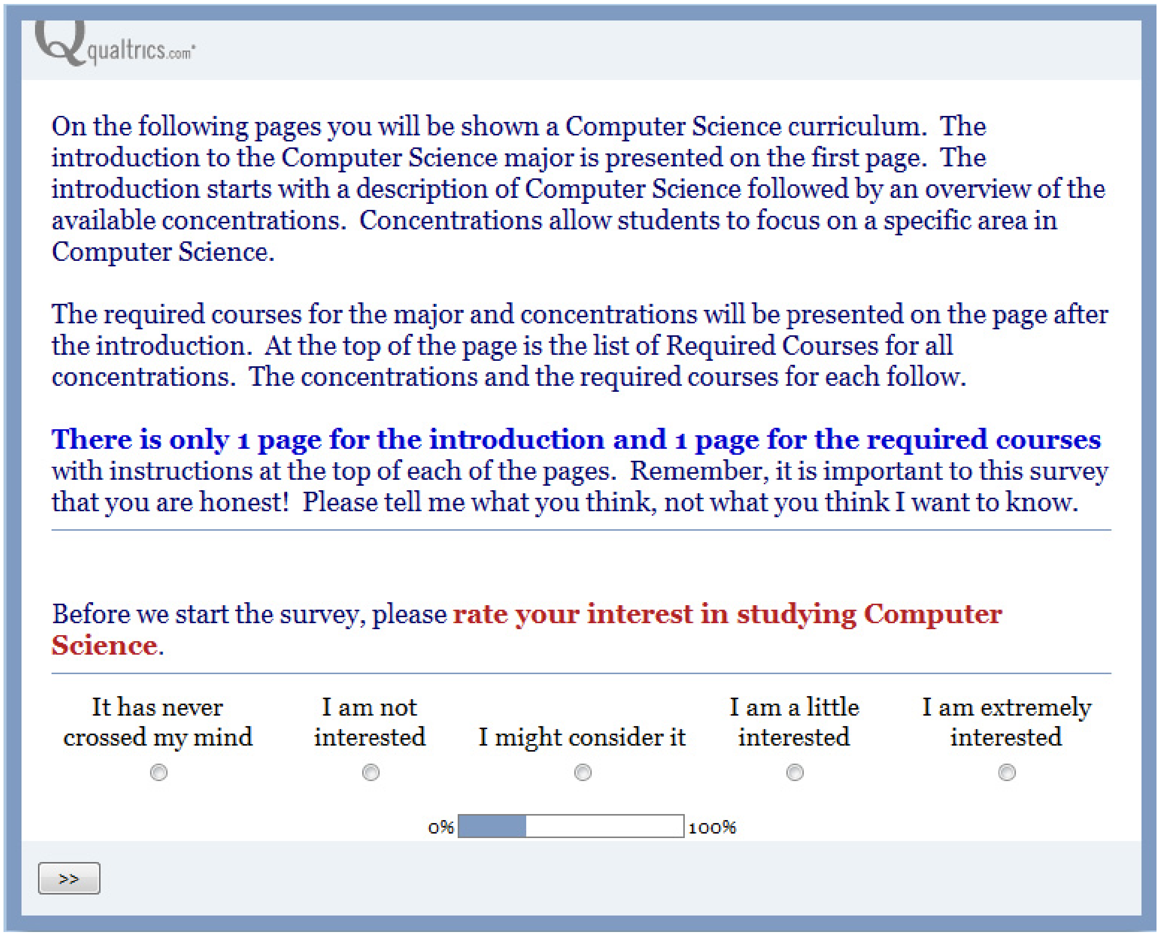
If your interest level has increased, what motivated the increase? Check all that apply.

☐ The Introductory paragraphs
☐ The Required Courses
☐ The Mathematics
☐ Other
☐ My Interest Level Hasn't Changed

If your interest level has remained the same or decreased, please try to articulate why. Remember, we want your honest opinion.

### *I.2.3 Student-Focused Curriculum*

### Introduction and Interest Level



On the following pages you will be shown a Computer Science curriculum. The introduction to the Computer Science major is presented on the first page. The introduction starts with a description of Computer Science followed by an overview of the available concentrations. Concentrations allow students to focus on a specific area in Computer Science.

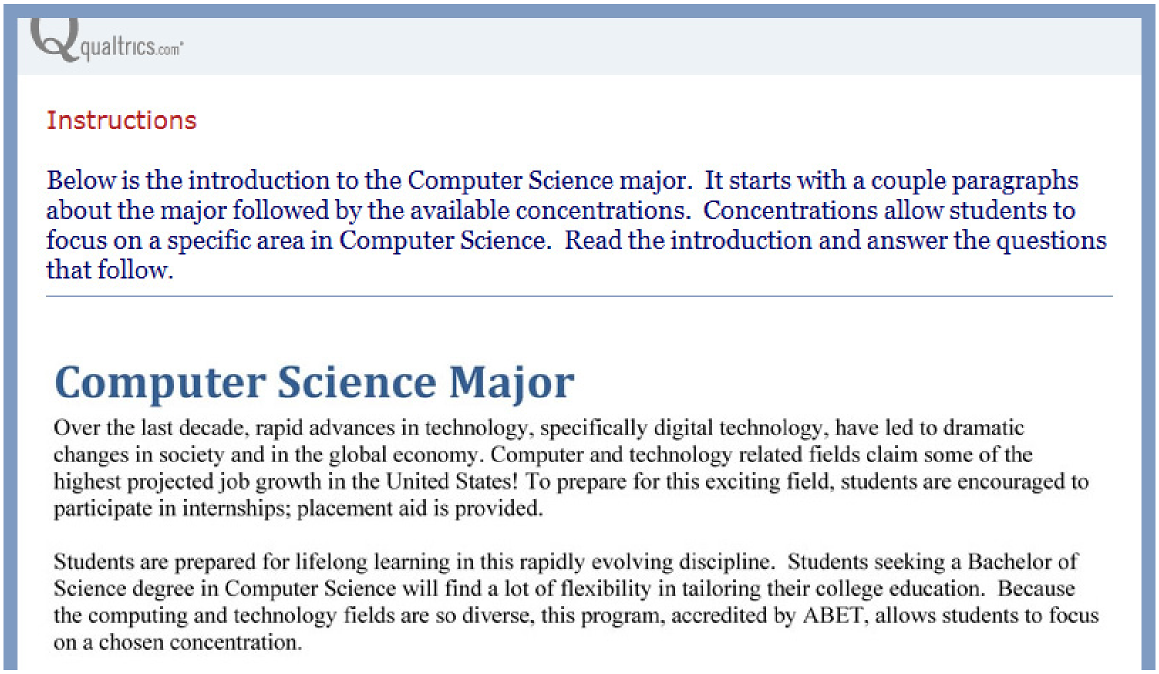
The required courses for the major and concentrations will be presented on the page after the introduction. At the top of the page is the list of Required Courses for all concentrations. The concentrations and the required courses for each follow.

**There is only 1 page for the introduction and 1 page for the required courses** with instructions at the top of each of the pages. Remember, it is important to this survey that you are honest! Please tell me what you think, not what you think I want to know.

Before we start the survey, please **rate your interest in studying Computer Science**.

| It has never crossed my mind | I am not interested | I might consider it | I am a little interested | I am extremely interested |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

## Curriculum Introduction



Instructions

Below is the introduction to the Computer Science major. It starts with a couple paragraphs about the major followed by the available concentrations. Concentrations allow students to focus on a specific area in Computer Science. Read the introduction and answer the questions that follow.

Computer Science Major

Over the last decade, rapid advances in technology, specifically digital technology, have led to dramatic changes in society and in the global economy. Computer and technology related fields claim some of the highest projected job growth in the United States! To prepare for this exciting field, students are encouraged to participate in internships; placement aid is provided.

Students are prepared for lifelong learning in this rapidly evolving discipline. Students seeking a Bachelor of Science degree in Computer Science will find a lot of flexibility in tailoring their college education. Because the computing and technology fields are so diverse, this program, accredited by ABET, allows students to focus on a chosen concentration.

## Concentrations

### Security and Forensic Computing

Technologically competent criminals exploit new technologies to commit crime. Specialists are needed to thwart criminals by developing secure environments as well as examining digital evidence when a crime has occurred. Recent graduates are currently working as:

- Quality Assurance Project Manager at a large Online News Firm
- Systems Administrator for a large Health Insurance Firm

### Artificial Intelligence

Artificial intelligence is used in everything from the Spirit robot sent to mars to collect data to GPS units and cell phones. Specialists are needed to develop products that behave intelligently. The student-run robotics club provides opportunities to apply learning. Recent graduates are currently working as:

- System Engineer developing satellite intelligence for a contracting firm near Washington, DC
- Artificial Intelligence Specialist for a nonprofit scientific society based in California.

### Networking

Networking and the Internet have increased the abilities of different technologies such as cars, cell phones and computers to communicate directly with each other. Specialists are needed to design, install, configure and maintain networks to allow devices to do so. Recent graduates are currently working as:

- IT Project Manager for a large networking firm in Kenya, Africa
- Systems and Network Engineer for a financial organization

### Game Development

With the ever increasing power of computers and their graphics capabilities, game development has become a global industry. Specialists are needed to focus on all aspects of interactive video game design, developing games like those available for the PS3 and Xbox gaming consoles. The student-run gaming club provides opportunities to test game ideas. Recent graduates are currently working as:

- Flash Game Developer for an online media company
- Project Creative Director for a large gaming company.

### Software Engineering

Software Engineers work in all aspects of society designing, implementing and modifying high quality software for many different types of applications. Specialists are needed to provide software solutions to real-world challenges in many settings from airliners to iPhones. Recent graduates are currently working as:

- Solutions Architect for a worldwide contracting firm.
- Director of Software Engineering for a global firm based in Minnesota

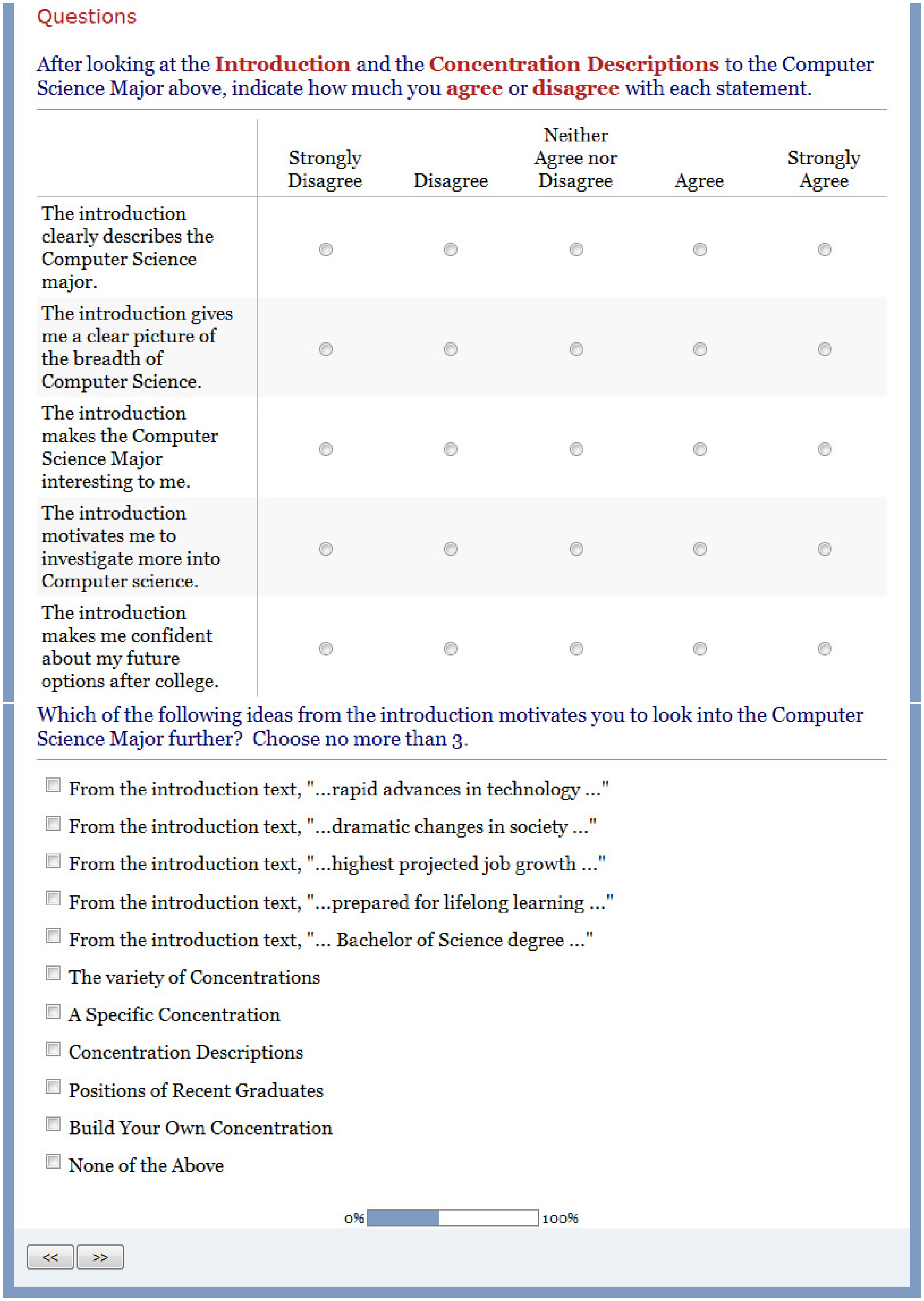
### Web and Media Development

The Internet is used more and more as a vehicle for commerce and information. As the saying goes, "Knowledge is Power." Specialists are needed to develop dynamic, interactive web applications for a world dependent on the World Wide Web. The student-run Web Development organization provides web solutions to many non-profit organizations. Recent graduates are currently working as:

- Mobile Application Development Research for a large, global non-profit organization
- Web Designer and Developer for a local web development business

### Build-Your Own

Sometimes students are not sure which direction to take. This program allows students to develop a concentration uniquely their own. With the help of their advisor, any student can tailor the Computer Science major to their needs and dreams.



Questions

After looking at the **Introduction** and the **Concentration Descriptions** to the Computer Science Major above, indicate how much you **agree** or **disagree** with each statement.

| | Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |
|---|---|---|---|---|---|
| The introduction clearly describes the Computer Science major. | ○ | ○ | ○ | ○ | ○ |
| The introduction gives me a clear picture of the breadth of Computer Science. | ○ | ○ | ○ | ○ | ○ |
| The introduction makes the Computer Science Major interesting to me. | ○ | ○ | ○ | ○ | ○ |
| The introduction motivates me to investigate more into Computer science. | ○ | ○ | ○ | ○ | ○ |
| The introduction makes me confident about my future options after college. | ○ | ○ | ○ | ○ | ○ |

Which of the following ideas from the introduction motivates you to look into the Computer Science Major further? Choose no more than 3.

- ☐ From the introduction text, "...rapid advances in technology ..."
- ☐ From the introduction text, "...dramatic changes in society ..."
- ☐ From the introduction text, "...highest projected job growth ..."
- ☐ From the introduction text, "...prepared for lifelong learning ..."
- ☐ From the introduction text, "... Bachelor of Science degree ..."
- ☐ The variety of Concentrations
- ☐ A Specific Concentration
- ☐ Concentration Descriptions
- ☐ Positions of Recent Graduates
- ☐ Build Your Own Concentration
- ☐ None of the Above

## Core Requirements and Concentration Details

Instructions

Below are the required courses. The Core Required Courses are presented first followed by the required courses for each concentration. Study each before answering the following questions.

### Core Required Courses

The following are the courses that all Computer Science majors engage in regardless of their chosen concentration.

**Calculus I**

Calculus I takes the processes of finding the slope of a line and the area in a closed region and considers them as infinite processes. Students study of how things change and how to model systems in which there is change.

**Discrete Mathematics**

Computers deal with discrete objects, those things which can be separated from each other. Students learn the fundamentals of discrete mathematics which can be applied to real-world problems from the placement of cell-phone towers so they won't interfere with each other to the orbits of satellites.

**Introduction to Computer Science**

Students are introduced to the various aspects of Computer Science through a general survey course of technology "meccas", the history of various aspects of development in Computer Science, ethical practices in the field and emerging technologies.

**Programming I**

Students become familiar with basic programming structures such as loops, conditional statements, variables and methods through weekly lab assignments in the Java programming language.

**Database Concepts**

Students explore the fundamental concepts involved in building and maintaining a database using the MySQL and Oracle database management systems, CSS and PHP programming languages. In cooperation with the Intermediate Web Design course, students create a dynamic, database-driven web site.

**Database Applications**

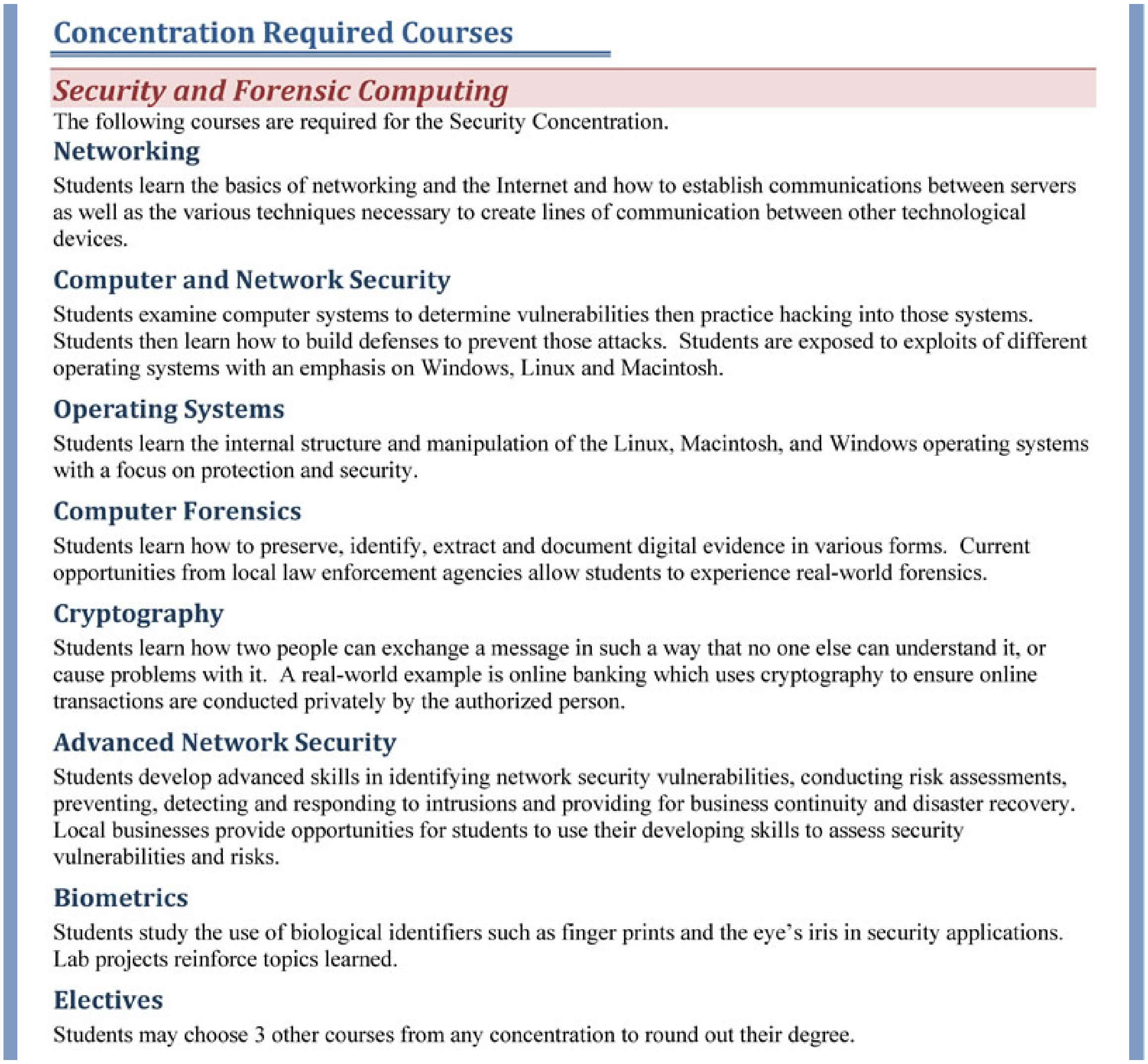
Students apply what they have learned in Database Concepts to develop a solution to a real-world need expressed by a non-profit organization. Emphasis is placed on communication and cooperation between multiple teams to design, create, implement and maintain a large-scale application.

**Information Systems**

Students explore how information technology is used to support the decision-making process in businesses.

**Senior Capstone**

This two-semester course provides a finale to each student's academic career. While preparing for life after college through various professional preparatory activities, students utilize their cumulative knowledge to develop a final project in their chosen concentration. Students are encouraged to seek current needs in the business and non-profit communities for real-world opportunities.



## Concentration Required Courses

### *Security and Forensic Computing*

The following courses are required for the Security Concentration.

#### Networking

Students learn the basics of networking and the Internet and how to establish communications between servers as well as the various techniques necessary to create lines of communication between other technological devices.

#### Computer and Network Security

Students examine computer systems to determine vulnerabilities then practice hacking into those systems. Students then learn how to build defenses to prevent those attacks. Students are exposed to exploits of different operating systems with an emphasis on Windows, Linux and Macintosh.

#### Operating Systems

Students learn the internal structure and manipulation of the Linux, Macintosh, and Windows operating systems with a focus on protection and security.

#### Computer Forensics

Students learn how to preserve, identify, extract and document digital evidence in various forms. Current opportunities from local law enforcement agencies allow students to experience real-world forensics.

#### Cryptography

Students learn how two people can exchange a message in such a way that no one else can understand it, or cause problems with it. A real-world example is online banking which uses cryptography to ensure online transactions are conducted privately by the authorized person.

#### Advanced Network Security

Students develop advanced skills in identifying network security vulnerabilities, conducting risk assessments, preventing, detecting and responding to intrusions and providing for business continuity and disaster recovery. Local businesses provide opportunities for students to use their developing skills to assess security vulnerabilities and risks.

#### Biometrics

Students study the use of biological identifiers such as finger prints and the eye's iris in security applications. Lab projects reinforce topics learned.

#### Electives

Students may choose 3 other courses from any concentration to round out their degree.

## *Artificial Intelligence*

The following courses are required for the Artificial Intelligence Concentration.

### Image Processing and Computer Vision

Students learn how to use models of digital image formation, image representation, image enhancement and image understanding to enable machines to make decisions based on the acquired image.

### Introduction to Artificial Intelligence

Students learn how to develop intelligent devices including machine problem solving, game playing, pattern recognition and perception problems, machine learning, expert systems and robotics. Graduate students involved in Artificial Intelligence in industry present their current challenges and real-world projects.

### Pattern Recognition

Students expand their understanding of the structures and problems of digital pattern recognition; helping machines classify data (patterns) based on the machine's prior knowledge or on statistical information extracted from the data (pattern).

### Natural Language Processing

Students examine how computers process and understand natural language with an emphasis on English.

### Expert Systems

Students learn the fundamentals of intelligent data processing through an in depth understanding of various concepts and popular techniques used in the field of data mining.

### Knowledge-Based Software Engineering

Students expand their understanding of expert systems and natural language processing, developing applications to process and understand large amounts of data and provide solutions to human questions. Companies utilizing current methods discussed in class describe their use and development of knowledge-based applications in real-world settings.

### Electives

Students may choose 3 other courses from any concentration to round out their degree.

## Networking

The following courses are required for the Networking Concentration.

### Networking

Students learn the basics of networking and the Internet and how to establish communications between servers as well as the various techniques necessary to create lines of communication between other technological devices.

### Wireless Networks and Mobile Computing

Students extend their understanding of networking to wireless and mobile devices including smart phones and pda's learning how to provide access to information anywhere, anyplace, and anytime.

### Distributed Systems

Students explore the issues surrounding applications that are distributed in different locations that do not share the same address space but are working together to solve a problem.

### Computer and Network Security

Students examine computer systems to determine vulnerabilities then practice hacking into those systems. Students then learn how to build defenses to prevent those attacks. Students are exposed to exploits of different operating systems with an emphasis on Windows, Linux and Macintosh.

### Converged Networks

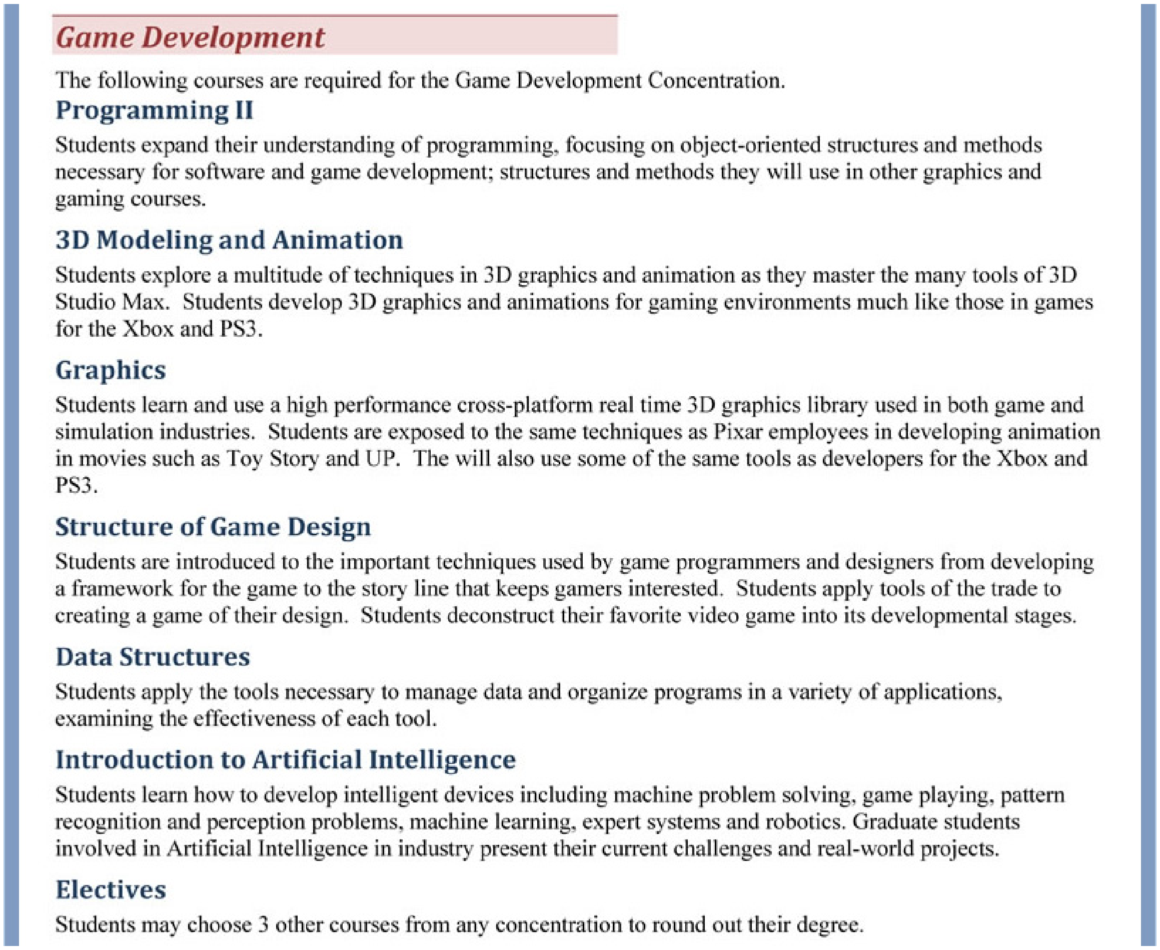
Students examine current and emerging network technologies that have differing architecture to deliver varying information from voice, data, and video/imaging and how to make them work together. Students tour various local Internet Service Provider facilities to observe current, real-world converged networks in operation.

### Advanced Network Security

Students develop advanced skills in identifying network security vulnerabilities, conducting risk assessments, preventing, detecting and responding to intrusions and providing for business continuity and disaster recovery. Local businesses provide opportunities for students to use their developing skills to assess security vulnerabilities and risks.

### Electives

Students may choose 3 other courses from any concentration to round out their degree.



## Game Development

The following courses are required for the Game Development Concentration.

### Programming II

Students expand their understanding of programming, focusing on object-oriented structures and methods necessary for software and game development; structures and methods they will use in other graphics and gaming courses.

### 3D Modeling and Animation

Students explore a multitude of techniques in 3D graphics and animation as they master the many tools of 3D Studio Max. Students develop 3D graphics and animations for gaming environments much like those in games for the Xbox and PS3.

### Graphics

Students learn and use a high performance cross-platform real time 3D graphics library used in both game and simulation industries. Students are exposed to the same techniques as Pixar employees in developing animation in movies such as Toy Story and UP. The will also use some of the same tools as developers for the Xbox and PS3.

### Structure of Game Design

Students are introduced to the important techniques used by game programmers and designers from developing a framework for the game to the story line that keeps gamers interested. Students apply tools of the trade to creating a game of their design. Students deconstruct their favorite video game into its developmental stages.

### Data Structures

Students apply the tools necessary to manage data and organize programs in a variety of applications, examining the effectiveness of each tool.

### Introduction to Artificial Intelligence

Students learn how to develop intelligent devices including machine problem solving, game playing, pattern recognition and perception problems, machine learning, expert systems and robotics. Graduate students involved in Artificial Intelligence in industry present their current challenges and real-world projects.

### Electives

Students may choose 3 other courses from any concentration to round out their degree.

## *Software Engineering*

The following courses are required for the Software Engineering Concentration.

### Programming II

Students expand their understanding of programming, focusing on object-oriented structures and methods necessary for software and game development; structures and methods they will use in other graphics and gaming courses.

### Data Structures

Students apply the tools necessary to manage data and organize programs in a variety of applications, examining the effectiveness of each tool.

### Principles and Practices of Software Engineering

Students examine the principles and methods of software engineering from development methodology, software requirements and specifications, software design, testing software quality assurance, and project management. Students are also exposed to a number of popular tools used extensively in industry to support software engineering activities.

### Object Oriented Modeling

Student are provided with the tools and techniques needed to solve complex, real-world software engineering problems in an object-oriented manner, using the most effective elements of the widely used Unified Process. Students develop an Object-Oriented Model to a current, real-world situation provided by local businesses.

### Computer Systems

Students explore machine-level programming and architecture and learn discernment in when and where to use them.

### Distributed Systems

Students explore the issues surrounding applications that are distributed in different locations that do not share the same address space but are working together to solve a problem.

### Electives

Students may choose 3 other courses from any concentration to round out their degree.

## *Web and Media Development*

The following courses are required for the Web and Media Development Concentration.

### Principles of Web Site Design

Students are introduced to the concepts and principles for designing Web sites. They apply design basics to developing a web site using XHTML and Cascading Style Sheets and publish their web site to a web server.

### Web Graphics

Students are introduced to the basic techniques of digital photography manipulation with an emphasis on techniques for working with images for Web design. Students apply their understanding to preparing graphic images for the web in a variety of ways.

### Basic Typography

Students are introduced to the terminology, technology and design aspects of typography and visual communication, developing an understanding of the foundations of typography and its effective use in graphic design.

### Webmasters and Servers

Students explore existing and emerging Web development technologies including specialized Web markup and scripting languages evaluating their effective use in an enterprise Web development environment. Students are exposed to web developers currently using these technologies in solving their real-world challenges.

### Intermediate Web Design

Students combine their knowledge of web design, graphics and typography to create complex page layouts and navigation. They develop scripting and database skills using current scripting languages to deliver dynamic web sites. In cooperation with the Database Concepts course, students create a dynamic, database-driven web site.

### Digital Imaging and Streaming Video

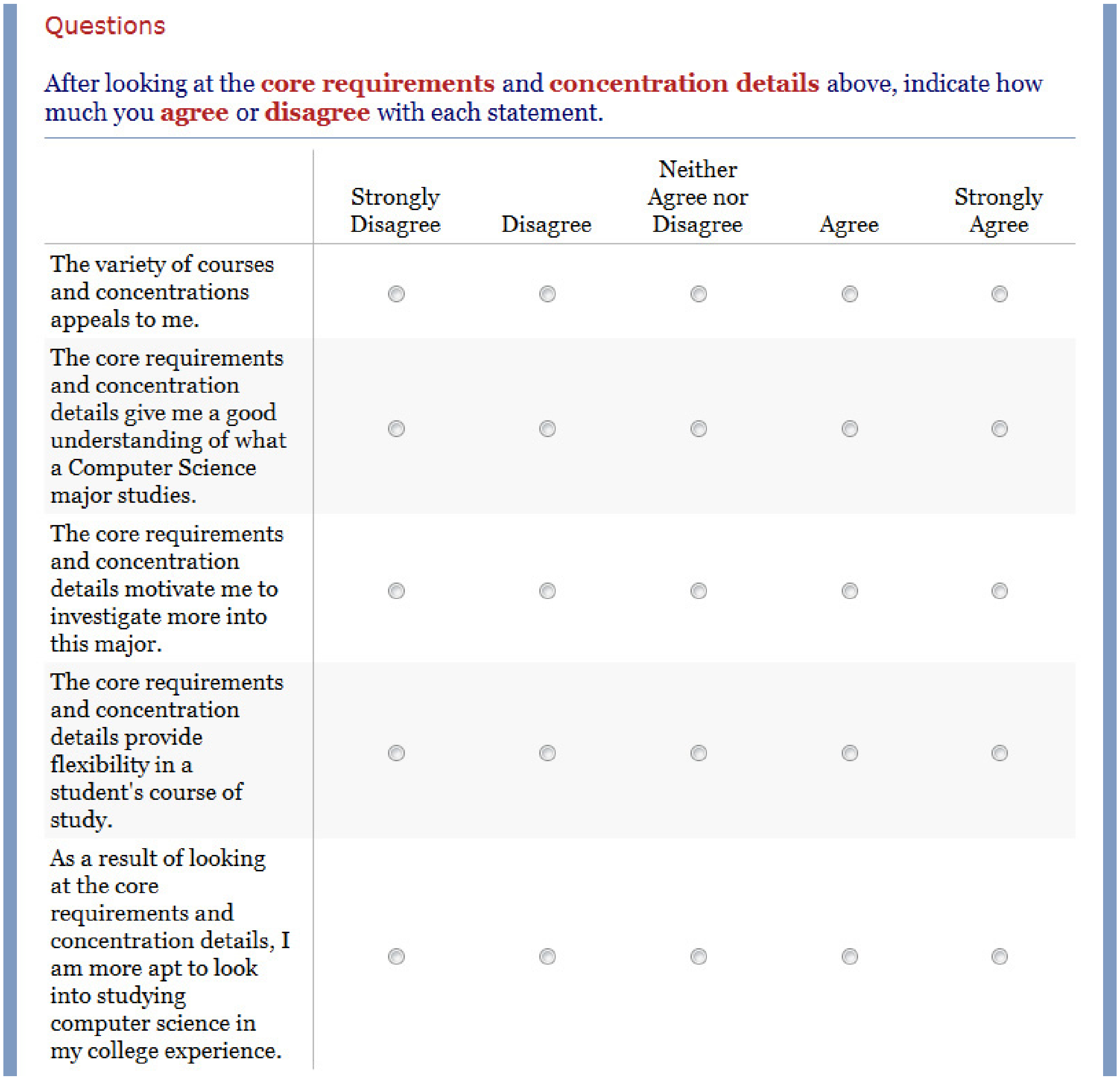
Students are provided hands on projects learning about digital imaging and streaming video.

### E-Commerce

Students explore multi-faceted issues of commerce on the Internet from the customer experience to business expectations with an emphasis on security for both customer and business.

### Electives

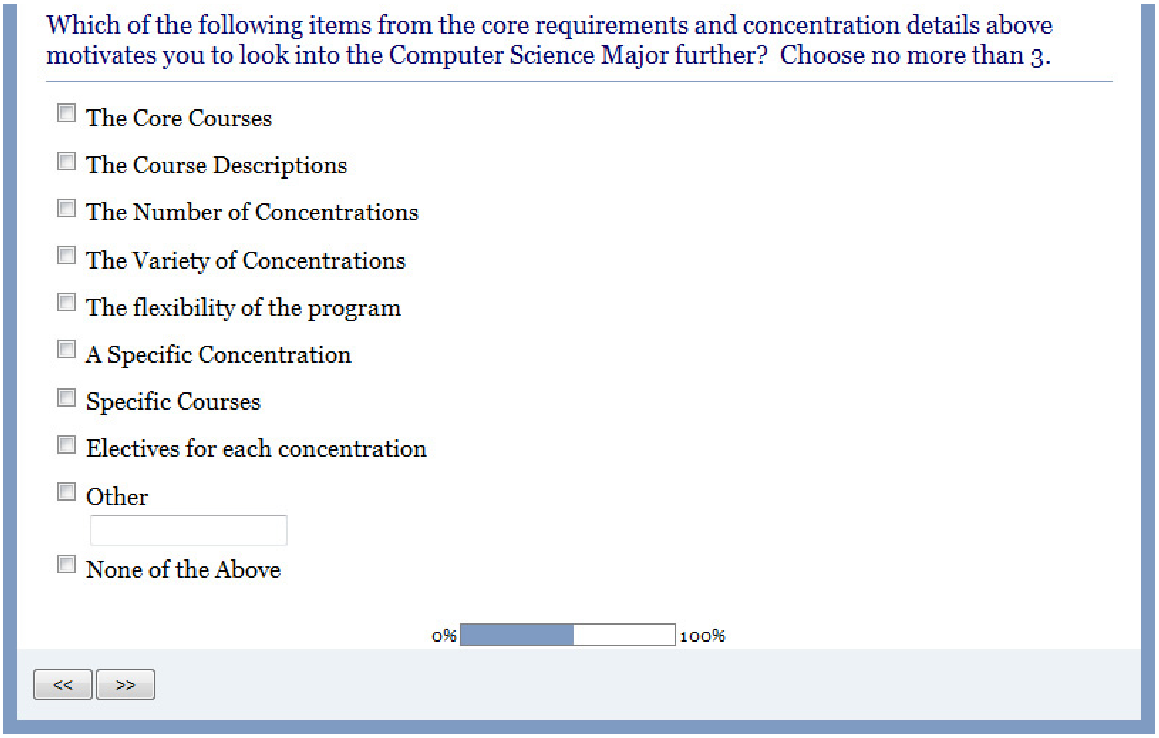
Students may choose 3 other courses from any concentration to round out their degree.



Questions

After looking at the **core requirements** and **concentration details** above, indicate how much you **agree** or **disagree** with each statement.

| | Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |
|---|---|---|---|---|---|
| The variety of courses and concentrations appeals to me. | ○ | ○ | ○ | ○ | ○ |
| The core requirements and concentration details give me a good understanding of what a Computer Science major studies. | ○ | ○ | ○ | ○ | ○ |
| The core requirements and concentration details motivate me to investigate more into this major. | ○ | ○ | ○ | ○ | ○ |
| The core requirements and concentration details provide flexibility in a student's course of study. | ○ | ○ | ○ | ○ | ○ |
| As a result of looking at the core requirements and concentration details, I am more apt to look into studying computer science in my college experience. | ○ | ○ | ○ | ○ | ○ |



Which of the following items from the core requirements and concentration details above motivates you to look into the Computer Science Major further? Choose no more than 3.

☐ The Core Courses

☐ The Course Descriptions

☐ The Number of Concentrations

☐ The Variety of Concentrations

☐ The flexibility of the program

☐ A Specific Concentration

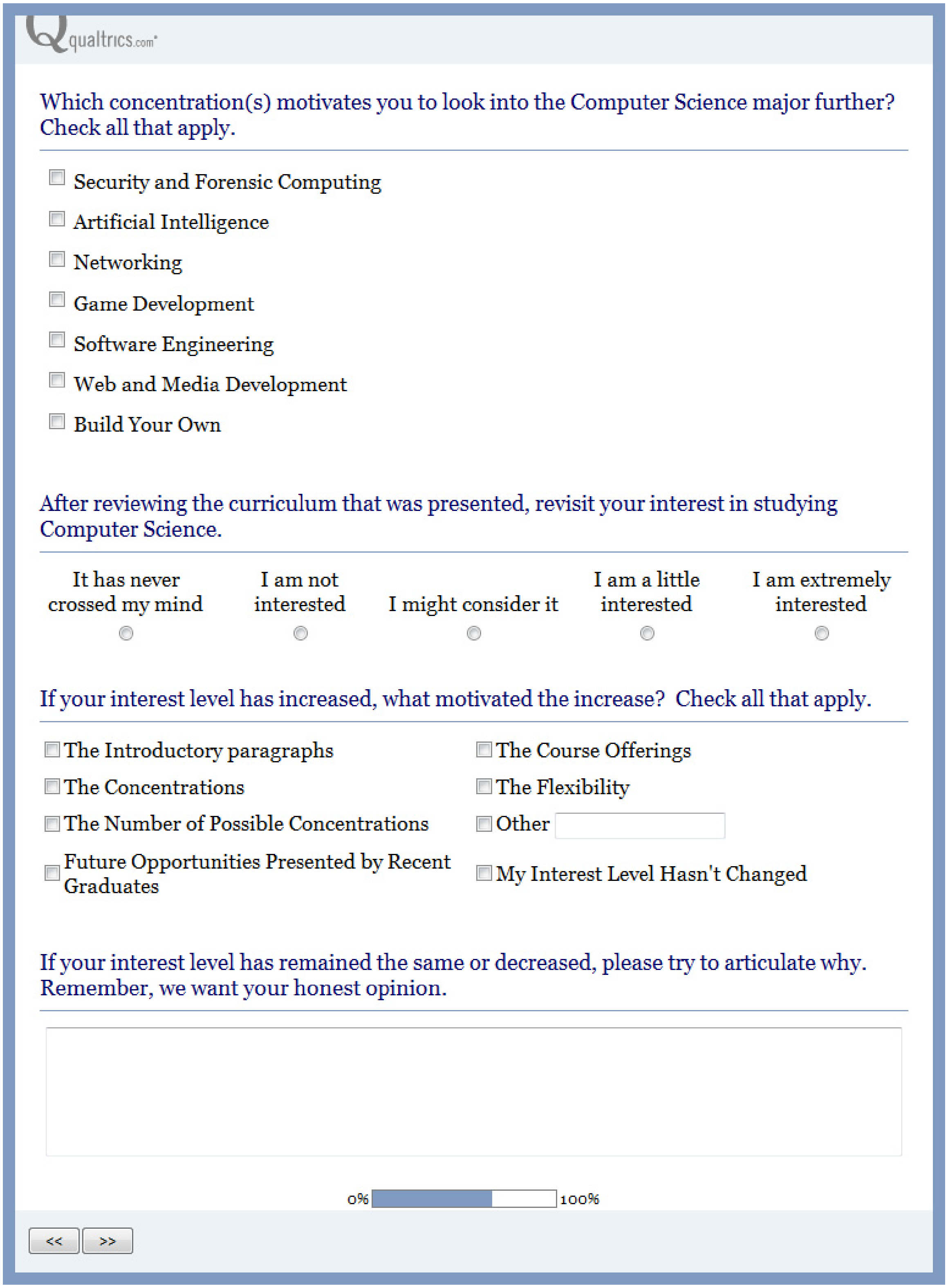
☐ Specific Courses

☐ Electives for each concentration

☐ Other

☐ None of the Above

## Interest Level Revisited



Which concentration(s) motivates you to look into the Computer Science major further? Check all that apply.

- ☐ Security and Forensic Computing
- ☐ Artificial Intelligence
- ☐ Networking
- ☐ Game Development
- ☐ Software Engineering
- ☐ Web and Media Development
- ☐ Build Your Own

After reviewing the curriculum that was presented, revisit your interest in studying Computer Science.

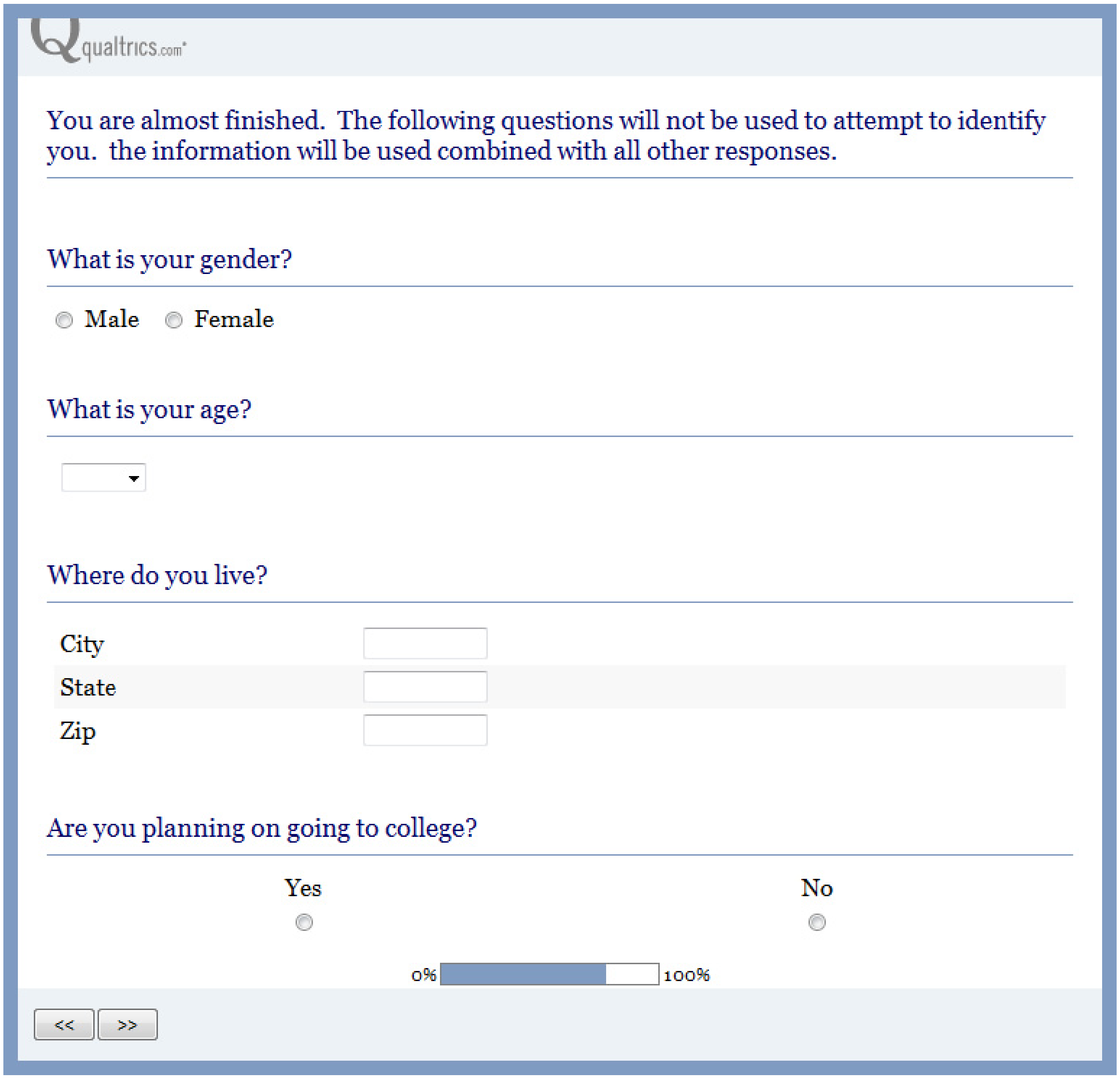
| It has never crossed my mind | I am not interested | I might consider it | I am a little interested | I am extremely interested |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

If your interest level has increased, what motivated the increase? Check all that apply.

- ☐ The Introductory paragraphs
- ☐ The Concentrations
- ☐ The Number of Possible Concentrations
- ☐ Future Opportunities Presented by Recent Graduates
- ☐ The Course Offerings
- ☐ The Flexibility
- ☐ Other ______
- ☐ My Interest Level Hasn't Changed

If your interest level has remained the same or decreased, please try to articulate why. Remember, we want your honest opinion.

### I.2.4 Demographics and Closure Block



You are almost finished. The following questions will not be used to attempt to identify you. the information will be used combined with all other responses.

What is your gender?

○ Male ○ Female

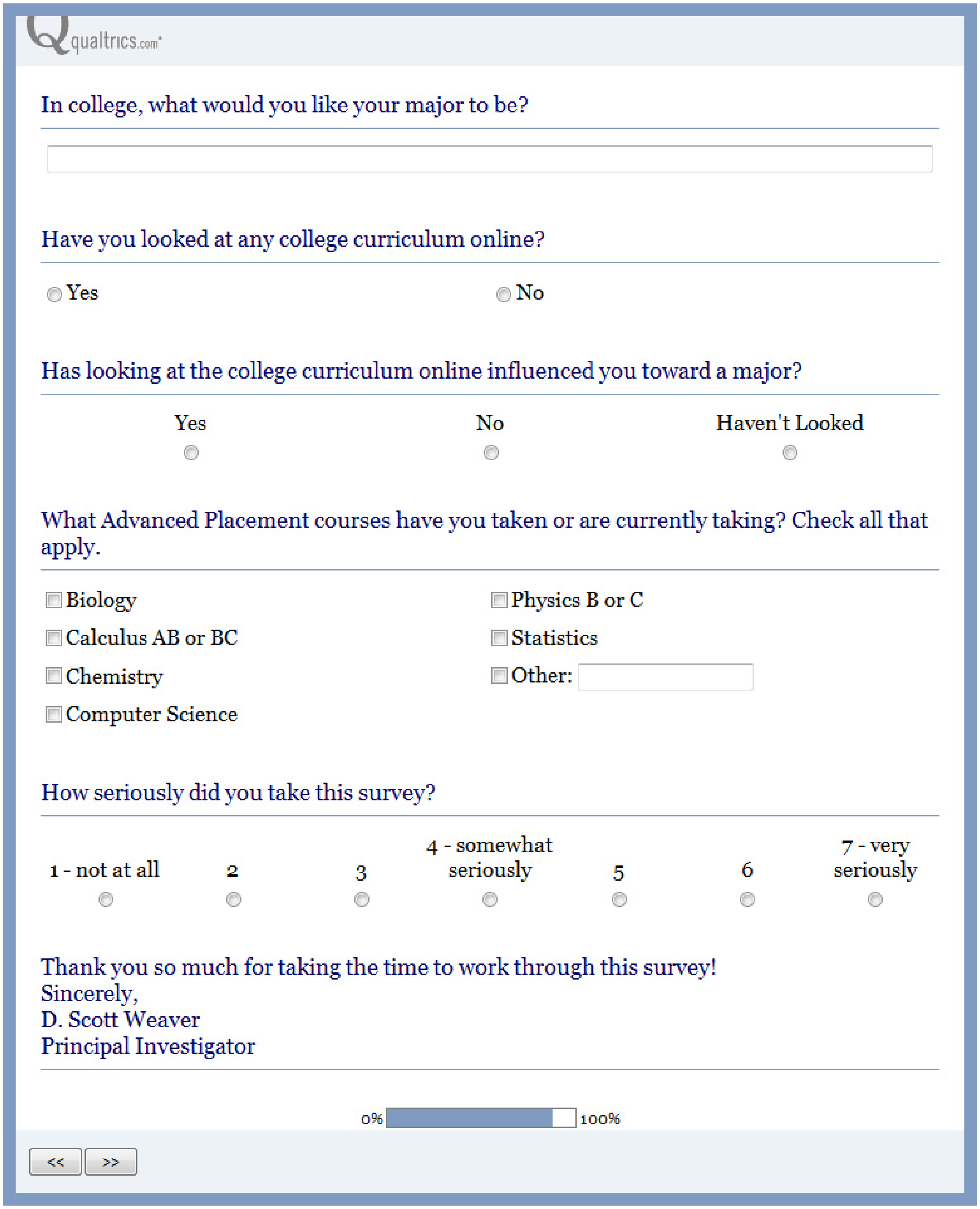
What is your age?

Where do you live?

| | |
|---|---|
| City | |
| State | |
| Zip | |

Are you planning on going to college?

| Yes | No |
|---|---|
| ○ | ○ |



In college, what would you like your major to be?

Have you looked at any college curriculum online?

○ Yes ○ No

Has looking at the college curriculum online influenced you toward a major?

| | | |
|---|---|---|
| Yes | No | Haven't Looked |
| ○ | ○ | ○ |

What Advanced Placement courses have you taken or are currently taking? Check all that apply.

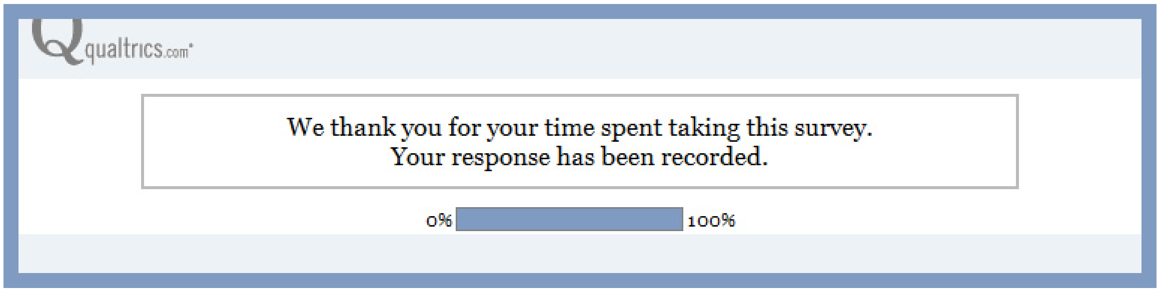
☐ Biology
☐ Calculus AB or BC
☐ Chemistry
☐ Computer Science
☐ Physics B or C
☐ Statistics
☐ Other:

How seriously did you take this survey?

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 - not at all | 2 | 3 | 4 - somewhat seriously | 5 | 6 | 7 - very seriously |
| ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Thank you so much for taking the time to work through this survey!
Sincerely,
D. Scott Weaver
Principal Investigator

### I.2.5 Completion



We thank you for your time spent taking this survey.
Your response has been recorded.

# Appendix J

# Institutional Review Board for Human Investigation

MESSIAH COLLEGE

## Institutional Review Board for Human Investigation

The Messiah College Institutional Review Board has reviewed the proposal and informed consent with respect to:

1. The rights and welfare of the individuals
2. The appropriateness of the methods to be used to secure informed consent
3. The risks and potential benefits of the investigation

**Submitted by:** D. Scott Weaver
**Entitled:** Using Attitudes and Perceptions of the Next Generation to Refocus Computing

**The Board considers this project, IRB protocol # 2008-027 :**

☒ **FULLY ACCEPTABLE, without reservation; approved through 12/01/09.**
☐ **APPROVED CONTINGENT ON REVISIONS (*See attached*); approved through _____.**
☐ **NOT ACCEPTABLE for reasons noted. (*See attached.*)**
☒ **A WAIVER OR ALTERATION OF CONSENT PROCEDURE OR DOCUMENTATION IS GRANTED.**

**Type of Review:** ☐ **FULL (approved by IRB Meeting on _____).**
☒ **EXPEDITED (see reasons checked below).**

**This approval requires the use of the IRB-approved informed consent form unless a waiver has been granted. Include the approval date NA and the expiration date NA on the form.**

**NOTE: The IRB should be notified of any changes to the research protocol using Form 400 (Request to Amend).**

Reasons for **EXPEDITED** review as listed under Expedited Review Categories in OHRP document *34 CFR 97 and 45 CFR 46.110 (check all that apply; must be completed if EXPEDITED is checked above as Type of Review)*:

**Meets Minimal Risk (required) AND**

☐ # 2 Collection of blood samples by finger stick, heel stick, ear stick, or venipuncture as follows: (a) from healthy, non-pregnant adults who weigh at least 110 pounds. For these subjects, the amounts drawn may not exceed 550 ml in an 8 week period and collection may not occur more frequently than 2 times per week; or (b) from other adults and children[2], considering the age, weight, and health of the subjects, the collection procedure, the amount of blood to be collected, and the frequency with which it will be collected. For these subjects, the amount drawn may not exceed the lesser of 50 ml or 3 ml per kg in an 8 week period and collection may not occur more frequently than 2 times per week.

☐ #4 Collection of data through noninvasive procedures . . . (e) moderate exercise, muscular strength testing, body composition assessment, and flexibility testing where appropriate given the age, weight, and health of the individual.

☒ #7 Research on individual or group characteristics or behavior or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

☒ OTHER: #6 Collection of data from voice, video, digital, or image recordings made for research purposes.

**SOURCE OF SUPPORT:** ☐ None ☒ Departmental ☐ Outside Funding *(specify)*
Agency: _____ Agency Number: _____

**ARE ANY OF THE FOLLOWING INVOLVED?** ☐ No ☒ Yes, those checked
☒ Minors ☐ Prisoners ☐ Pregnant Women ☐ Mentally Disabled ☐ Mentally Retarded
Protocols involving children approved under ☒ 45 CFR 46.404 ☐ 45CFR 46.405 ☐ 45 CFR 46.406

12/2/08
*Date of Approval*

*Signature of Reviewer*

**The Messiah College IRB operates under the HHS Multiple Project Assurance of Compliance Number FWA 0000 1871.**

Revised 9/08

## Explanation of Decision

**Revisions contingent for approval:**

**NOT ACCEPTABLE for the following reasons:**

**Additional Comments:**

Any significant change in the questionnaire or focus group outline will need an update to the IRB. Once you develop the final survey after the focus group stage, that should also be submitted to the IRB. We would also like a copy of any approval you receive from Mechanicsburg High School for our files.

# Appendix K

## The Blind Men and the Elephant

The Blind Men and the Elephant A Hindoo Fable

I

It was six men of Indostan
To learning much inclined,
Who went to see the Elephant
(Though all of them were blind),
That each by observation
Might satisfy his mind.

II

The *First* approached the Elephant,
And happening to fall
Against his broad and study side, At once began to bawl: “God bless
me! but the Elephant Is very like a wall!”

III

The *Second*, feeling of the tusk, Cried, “Ho! what have we here So very
round and smooth and sharp? To me ’t is mighty clear this wonder of an
Elephant Is very like a spear!”

IV

The *Third* approached the animal, And happening to take The
squirming trunk within his hands, Thus boldly up and spake: “I see,”
quoth he, “the Elephant Is very like a snake!”

V

The *Fourth* reached out his eager hand, And felt about the knee. “What
most this wondrous beast is like Is mighty plain,” quoth he; “‘T is clear
enough the Elephant Is very like a tree!”

VI

The *Fifth*, who chanced to touch the ear, Said: “E‘en the blindest man Can tell what this resembles most; Deny the fact who can, This marvel of an Elephant is very like a fan!”

VII

The *Sixth* no sooner had begun About the beat to grope, Than, seizing on the swinging tail That fell within his scope, “I see,” quoth he, “the Elephant Is very like a rope!”

VIII

And so these men of Indostan Disputed loud and long, Each in his own opinion Exceeding stiff and strong, Though each was partly in the right, And all were in the wrong!

Moral

So oft in theologic wars, The disputants, I ween, Rail on in utter ignorance Of what each other mean, *And prate about an Elephant Not one of them has seen!* [97]

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