HOW CHEMICAL ENGINEERING STUDENTS HAVE CHANGED OVER TWO DECADES: A PERSPECTIVE FROM GEORGIA TECH

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INTRODUCTION

Since the birth of Chemical Engineering (CHE) as an academic discipline more than a century ago,[1] its curriculum and teaching methods have continuously evolved to adapt to developments in the industry and changes of students.[2–5] The past two decades have witnessed many transformations of society in general, and the scope of chemical engineering in particular. Portable electronic devices have seen a boom, and electric vehicles are increasingly common on the road; many components of these new products rely on the chemical industry. Renewable energy and decarbonization are becoming a global consensus, even with traditional energy companies starting to establish programs to keep up and seek opportunity in the transformation of energy. The fields of biotechnology and nanotechnology have matured from lab concepts to products in widespread use (e.g. personalized medicine, genetically modified crops, "5 nanometer" semiconductor chips). Since the outbreak of COVID-19, vaccine development and scalable production brought chemical engineers to center stage again. It is important for departments to modernize the chemical engineering curriculum and equip students for the new professional opportunities in our field.

The interests, experiences, and demographics of the student body have also changed over the past two decades. Part of the change can be attributed to changes in the chemical industry and public perception of chemical engineering. These aspects can potentially influence the choice of major for freshmen and sophomores and the career planning of junior and senior students in chemical engineering. Another source of change of the student body is less associated with the chemical industry itself and has more to do with general societal changes. For example, the current generation of college students is mostly Generation Z (born 1997-2012). Their parents are often Generation X (born 1965-1980), many of whom were college students themselves 20-30 years ago. Across the two generations, the values, habits, and beliefs of students will be different as a result of the development of society. It is therefore important for educators to know their students and learn about changes over the years so that teaching can be tailored to the new generation to be most effective.

A few studies in the past have surveyed chemical engineering undergraduate students to understand factors leading to their CHE career intention,[6] their specific career preferences,[7] and their perception of curriculum and program.[8] While these studies provide valuable information about a particular generation of students, they lack a precise side-by-side comparison across generations of students, which reveals the evolution over decades. Moreover, these surveys focus

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on a particular topic, rather than collecting comprehensive information that potentially allows better understanding of students from multiple perspectives. In this paper we report the result of the same set of survey questions answered by CHE undergraduate students at Georgia Institute of Technology across two decades. The survey is composed of 36 questions covering the following six topics: 1) influences on decision to major in CHE; 2) preference of future career; 3) perceived level of difficulty and interest of CHE major; 4) general topics of interest; 5) student demographics; and 6) experiences outside of classroom. The results show what has changed in our students and potentially provide a basis for how to improve the curriculum and program to serve today's students.

BACKGROUND

Georgia Institute of Technology (GT) is an R1 public university within the University System of Georgia. The main campus is located in the metropolis of Atlanta, where the School of Chemical and Biomolecular Engineering (ChBE) is housed. The School was established in 1901 and currently has 41 Full-Time Equivalent faculty positions, which includes tenured and tenure-track professors, lecturers, academic professionals and professors of practice, and 3 full-time undergraduate academic advisors. Twenty-five years ago (i.e. in 1996), the School had 29 academic faculty and 2 affiliated faculty, but no professors of the practice or undergraduate academic advisors. Among the 46 faculty in ChBE today, only six were on the faculty 25 years ago.

Currently, ChBE has an enrollment of 730 undergraduate students (including first years, sophomores, juniors, and seniors)[9] among a total of about 16,000 undergraduates at GT drawn from the state of Georgia, across the United States, and around the world. Twenty-five years ago, the undergraduate population was similar with 764 students in CHE (School of Chemical Engineering, the former name of ChBE),[9] but the total undergraduate study body had only about 9,500 undergraduate students. It is noted that in the past two decades, the ChBE graduate enrollment (PhD and MS) has nearly doubled, going from 110 in 1996 and 109 in 1997 to 218 in 2017 and 209 in 2018. Undergraduate students earn a Bachelor of Science degree with ABET accreditation via the Standard Option or the Biotech Option (which was introduced between the first and second survey times), where the latter includes all of the core chemical engineering courses plus a biomolecular emphasis in electives courses, the unit operations laboratory, and the capstone senior design course.[9] The School also offers a five-year BS/MS option, as well as a Pulp and Paper Certificate Program (which already existed before the first survey was conducted). Georgia Tech offered classes using a quarter system in 1996-1997, but shortly after that switched to a semester system.

In terms of experiential opportunities, GT provides students a variety of options to participate in the Cooperative Education (Co-op) and Internship Plan through which students take part in the largest voluntary Co-op program in the country[9] and receive practical experience through industry internships interspersed with their on-campus education. While most students engage in research during their time at GT, interested students can sign up for the Research Option, through which students engage in an in-depth, long-term research experience that culminates in a written thesis. Those with global interests can participate in the International Plan that enables students to take globally focused coursework, earn foreign language proficiency, and spend at least a half year overseas within the context of their chemical engineering training.

Tuition and fees for an academic year at GT is currently $12,852 (for Georgia residents) and $33,964 (for out-of-state). In 1996, tuition and fees were $2,685 (in-state) and $8,496 (out-of-state), which is 2.9 and 2.3 fold lower than today, respectively, in inflation-adjusted dollars.

STUDY OBJECTIVE

As we have transitioned from Gen X students in the 1990s to Gen Z students in our classes today, we wondered what has changed and what has stayed the same in our ChBE undergraduate student population. The objective of this paper is therefore to compare the CHE students who studied at GT in 1996-1997 with recent students in ChBE during the period 2018-2019 in terms of:

(a) influences on student decision to study CHE

(b) student vision of professional future after graduation

(c) perceived level of difficulty and interest in CHE major

(d) student interests outside of CHE

(e) student demographics

(f) student experiences outside of GT

METHODOLOGY

Surveys were administered to sophomores and seniors during the 1996-1997 and 2018-2019 academic years. During the 1996-1997 academic year, data from sophomores were collected from 167 students taking the Chemical Process Principles I course (CHE 2207) during Fall 1996, Winter 1997, Spring 1997 and Summer 1997 quarters, and data from seniors were collected from 106 students taking Chemical Engineering Economics (CHE 4431) during Fall 1996 and Winter 1997 quarters (this course was not offered during spring or summer quarters). During the 2018-2019 academic year, data from sophomores were collected from 187 students taking Chemical Process Principles (CHBE 2100) during

Summer 2018, Fall 2018, and Spring 2019 semesters, and from 129 seniors taking Capstone ChBE Design (or Bio-Design) Project (CHBE 4520/4530) during Summer 2018 and Spring 2019 semesters (these courses were not offered in the Fall semester).

Identical anonymous surveys were given to the sophomores and seniors each year, and almost identical surveys were given each of the years, with minor changes made in the 2018-2019 survey to reflect, for example, changes in course names. There were 36 questions on each survey, listed in the Appendix. Almost all of the students who took the survey answered all of the questions on the survey. In 1996-1997 the surveys were administered in the classroom using Scantron optical mark recognition forms, and in 2018-2019 the surveys were administered outside the classroom using an online interface. Data analysis was carried out by summing up the responses to each question and expressing them on a percentage basis. When making a comparison between groups, we did not employ formal statistical analysis for this study that emphasizes qualitative trends in the field. The survey was reviewed and approved by the Georgia Tech Institutional Review Board (IRB).

RESULTS

Student Decision to Study CHE

Using the data collected from the surveys in 1996-1997 and 2018-2019, we first addressed which factors influenced the choice of students to study CHE in the 1990s and today (Figure 1). Close to 70% of the surveyed students in both cohorts were satisfied with their major choice, whereas around 30% of students, either in their sophomore or senior year, were still unsure about this decision (Figure 1a). Students' knowledge of what chemical engineers do increased from sophomore year (around 45% indicated an excellent or good knowledge of the profession) to the senior year (around 80% -90%) (Figure 1b). This level of satisfaction and knowledge of the major should have informed students' decision to study CHE.

Considering the factors that strongly or moderately swayed students' decision to pursue CHE as a major, the most influential factors were those related to student abilities, interests, and values. Virtually all students responded that their aptitude for chemistry, science and math was one of the influential factors (Figure 1c). This was followed by a desire for job security and financial reward (around 85%-90%) (Figure 1d), and their general interest in the field of CHE, which was influential among 90% of sophomores and 80% of seniors (Figure 1e). We note that there were again no major changes in the importance of these factors between the two decades. Another factor that students considered a strong or moderate driving force was the opportunity to work on socially important technical problems, which mattered to about 50%-80% of students (Figure 1f). This factor was more important today versus the 1990s and was also more important to sophomores than seniors. These results are in partial agreement with an old survey taken in early 2000's about similar factors that motivated students to pursue Chemical Engineering as a major.[10]

Interactions with other people also had a strong or moderate influence on student decisions, such as with a role model or having a positive experience (about 45%-50%, Figure 1g) or a family member or friend (30%-50%, Figure 1h). High school and faculty advisors had less impact (around 20%, Figure 1i). This trend showed no major changes over the two decades.

Activities for students played some role in student decisions. About 50%-60% of students participated in an open house or career day; among those who attended, around 20% found the event strongly or moderately influential in the 1990s survey and about 30% were influenced in the recent survey (Figure 1j). Only around 30% of students participated in engineering summer programs; among the attendees around 40-50% in the older or the newer survey were strongly or moderately influenced (Figure 1k). Because of limited participation rates and limited impact, these outreach events overall only impacted 10%-20% of students to a strong or moderate degree. The role of internet resources, which are widely available today but were much more limited in the 1990s, was not addressed in the survey and could be an important source of additional information for students.

Finally, GT has offered introductory CHE courses in 1996-1997 (CHE 1110) and today (GT 1000 as a first-year student seminar and GT 2000 as a transfer student seminar). The survey showed that very few students took CHE 1110 (about 10%-20%), but those sophomores who took it responded favorably by reporting relatively strong influence on their choice of CHE as a major; however, the year it was offered to the seniors, the course made little impact (Figure 1l). More recently, GT 1000/2000 has attracted around 50%-60% of students, but only about 25%-30% of the students who took it (i.e. around 10%-15% of students overall) were strongly or moderately influenced. These observations suggest a limited impact of these introductory courses on informing students about CHE when choosing their major, possibly because many students already had their minds made up before taking the course.

Student Vision of Professional Future After Graduation

Our survey next addressed students' plans after graduation (Figure 2). Around 80% of CHE students taking their first chemical engineering course were fairly sure or very sure that they would graduate with a CHE degree (Figure 2a). By senior year, the vast majority of students (> 95%) responded that they will graduate with a CHE degree.

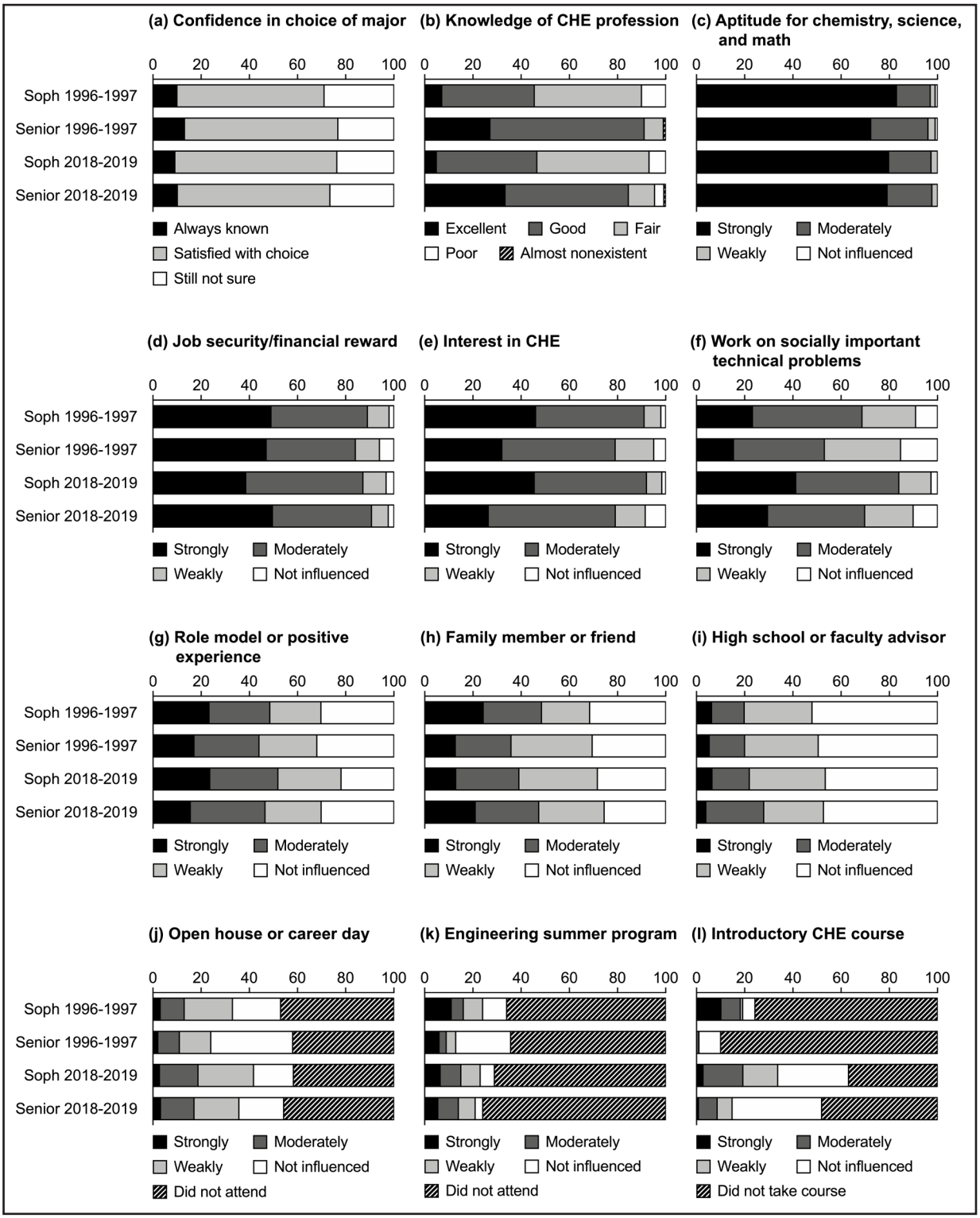

Figure 1. *Influences on student decision to study CHE: (a) confidence in choice of major, (b) knowledge of CHE profession, (c) aptitude for chemistry, science and math, (d) job security/financial reward, (e) interest in CHE, (f) work on socially important technical problems, (g) role model or positive experience, (h) family member or friend, (i) high school or faculty advisor, (j) open house or career day, (k) engineering summer program, and (l) introductory CHE course.*

In terms of job perspective, approximately 60% of sophomore students envision working as chemical engineers, with about a third of those seeking management positions 10 years after graduation (Figure 2b). Roughly 20% expect to seek jobs outside CHE, and another 20% do not know what type of job they expect to have. Students who have progressed through their classes to senior year report somewhat diminished interest in traditional chemical engineering jobs, with 30% or more interested in work outside CHE and about 15% still not knowing what type of job they will have in 10 years. These general perceptions are roughly consistent between now and from 20 years prior.

Concerning their immediate further education and/or work, Figure 2c suggests that CHE students have a variety of plans after graduation. Twenty years ago, a large majority of students (~70%) envisioned pursuing graduate school either after graduation or at a later time, roughly evenly pursuing graduate studies in CHE and other graduate programs, including ~15% interested in professional degrees, such as an MD or MBA. This high level of interest in graduate school has decreased more recently (especially for professional degrees and working before graduate school), where around 50% of students are thinking of pursuing graduate studies. There was a small trend away from graduate school from sophomore to senior year.

In terms of preferred employer, 50%-60% of students seek to work in a large company, whereas 20%-30% of students are interested in working in a small company (Figure 2d). In both time frames, sophomores have higher interest in large companies and academia than seniors. There is somewhat increased interest in small companies among today's students compared to 20 years ago. A small fraction (15%-20%) would like to pursue a career in academia, government, or public service-oriented organizations. Noticeably, interest in public service rose from almost zero to ~5% over the 20 years.

Perceived Difficulty and Interest in CHE Major

We were interested to know what CHE students had heard about the difficulty of their major as well as how interesting the students found their major (Figure 3). From Figure 3a, there is a consistent perception among most CHE students that the major is difficult. Roughly 70% of students heard that CHE was the hardest major on campus, and most of the rest reported it to be difficult. The perception of difficulty was similar among sophomores and seniors and at the two survey time points. In addition, the major was described as interesting among ~50% of students across the board (Figure 3b). Among sophomores, CHE was perceived to be boring or "deadly dull" by about 20% of students, while this low level of interest increased to approximately 40% among seniors over the two timeframes studied. This trend appears to correlate with the increased preference of senior students to seek jobs outside the field of CHE (Figure 2b). Between 20%-30% of sophomores did not yet have an opinion about how interesting they found their new major.

General Topics of Interest

We next considered the students' interest in topics outside the fields of science and engineering (Figure 4). Across the board, students have generally been most interested in health and the environment, with at least 80% of students being moderately or very interested (Figure 4a). Students showed the least interest in writing and speech, with only ~40% express-

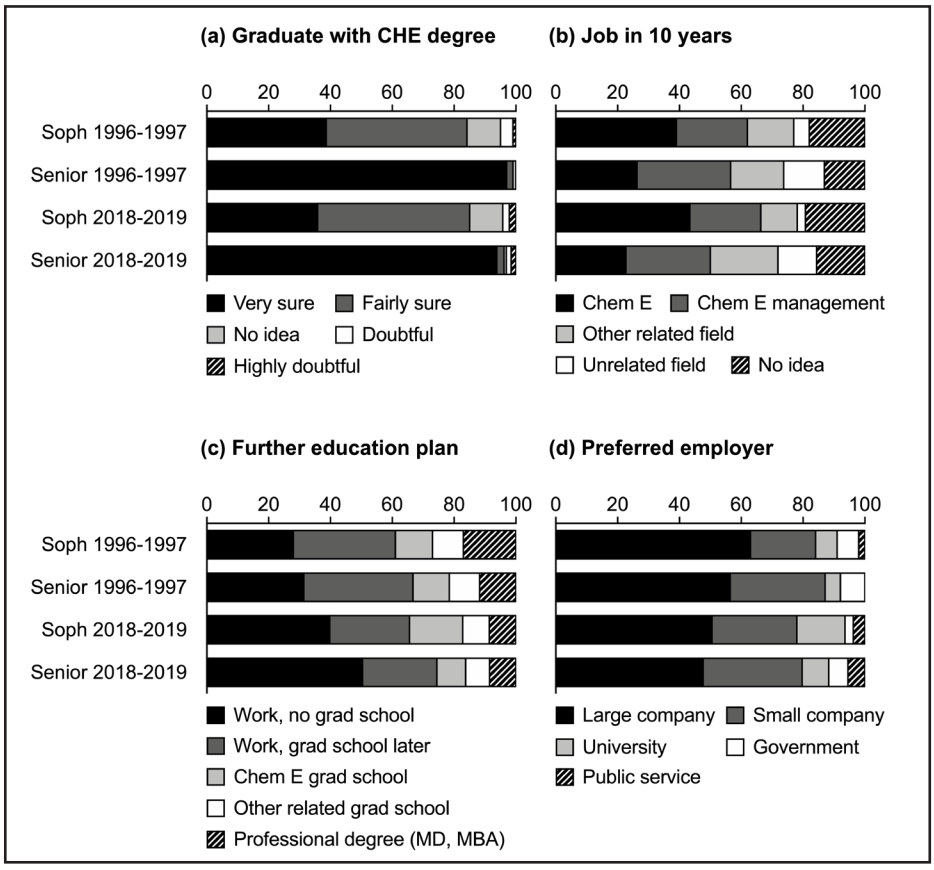

Figure 2. *CHE student preference for the future: (a) graduate with CHE degree, (b) job in 10 years, (c) further education plan, and (d) preferred employer.*

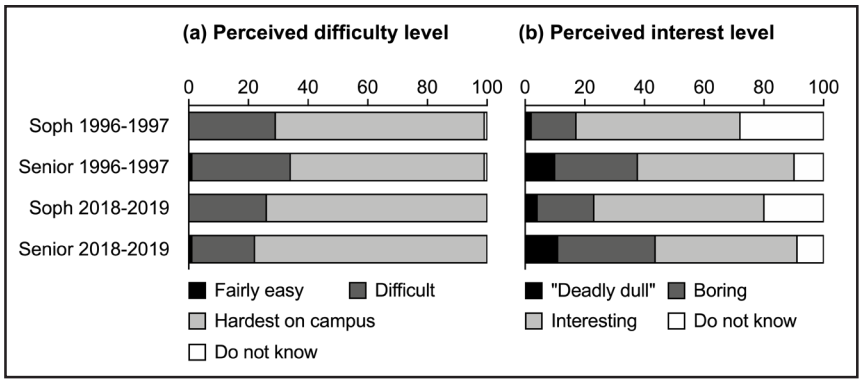

Figure 3. *Perceived level of difficulty and interest of CHE major at Georgia Tech: (a) perceived difficulty and (b) level of interest.*

ing moderate or high interest (Figure 4e). There was similar level of interest in the remaining three topic areas, with about 60% being moderately or very interested in anthropology, ethnicity and international culture (Figure 4b), politics, law and history (Figure 4c), and economics and business (Figure 4d).

It should be noted that the differences between grade groups and year of the survey were generally small. Especially among recent students, senior students were generally more interested in politics, law and history (Figure 4c), economics and business (Figure 4d), and writing and speech (Figure 4e) compared to sophomores. For example, 26% of sophomore in 1996-1997 were "very interested" in economics and business, while the number for seniors was 37%. These two percentages decreased to 18% and 22% in 2018-2019, respectively, yet the interest level of seniors was still higher than the number of sophomores.

Student Demographics

In the 1990s and today, the survey reported that the sophomore population is roughly half women and half men (Figure 5a). By senior year, the ratio shifted to approximately 40% women and 60% men. This is also consistent with national trends showing that attrition of women from engineering majors occurs at a greater rate than for men.[11–13]

The age distribution of our students is not surprising, with most sophomores in the 18-20 year-old range and most seniors in the 21-23 year-old range (Figure 5b). Our students are mostly unmarried (≥ 96%) and have no children (100%) (Figure 5c and 5d). However, it is notable that in the older survey, the sophomore respondents included 27% who were older than 20 years and that this number shrunk to just 5% of students in 2018-2019. This trend is similar to other reports regarding the age distribution of first-year students in college.[14] This indicates that today most of our students enter college immediately after high school. On the other hand, by senior year among our recent students, some (10%) were ≥ 24 years old, indicating that they required significant additional time to get through the ChBE curriculum possibly due to taking multiple semesters away from school for professional or personal reasons (e.g. internships, personal/family needs) and/or needing to take additional classes (e.g. due to failing classes or switching majors).

There have been changes in ethnic diversity over the last 25 years. White/European students accounted for two-thirds of CHE students in the 1990s, and that proportion decreased to about half of students in recent years (Figure 5e). That indicates a proportional increase in the representation of other racial/ethnic groups. Notably, Asian students' population has nearly doubled, constituting 14% of sophomores in 1996-1997 and 27% of sophomores in 2018-2019. A similar trend was also observed in Hispanic students' representation, with a large relative increase from 2% to 5% of sophomores. Similar trends were seen for the seniors. In contrast, the representation of Black/African students declined over time. In the 1990s, 16% of sophomores and 10% of seniors were Black. More recently, Black students comprised 8% and 7% of the sophomore and senior classes, respectively.

We can compare these findings to demographic trends in Georgia and in the United States overall. It is worth noting that the undergraduate population at Georgia Tech is approximately 60% in-state and 40% out-of-state. The large increases in Asian and Hispanic students in CHE at Georgia Tech are consistent with trends in Georgia, where Asians increased from 1% to 4% in Georgia and from 4% to 5% in the United States between the 1990s and the late 2010s.[15–17] However, the decrease in Black students is not consistent with societal trends, since African Americans increased in Georgia (27% to 31%) and held roughly constant across the country (at 13%) over the roughly 20-year period. This is also in agreement with a previous study where the total degrees awarded towards Hispanic students does increase over time, compared with Black/African students.[18]

In the 1990s most students came from either a small-town (> 37%) or a suburban area (> 41%), with only about 10% each coming from rural or urban areas (Figure 5f). However, the 2018-2019 survey revealed a shift to mostly suburban (~65%), with urban students somewhat increasing and students from small towns (16%) and rural locations (≤ 4%) in decline.

The origin of ChBE students has not notably changed compared to the 1990s. Our survey revealed that roughly 10% of students come from countries other than the US or Canada, of which Asian students accounted for the largest portion (Figure 5g). Additionally, most students (> 93%) were at a fluent level in English during both time periods (Figure 5h).

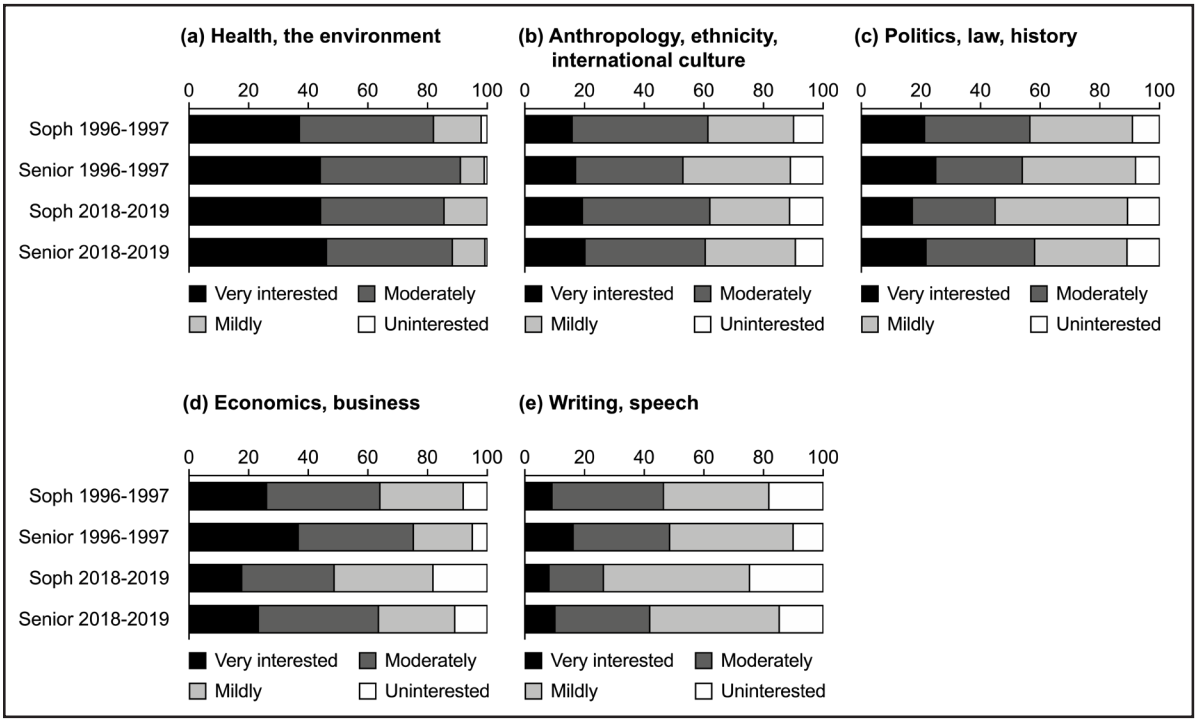

Figure 4. *Level of interested in the following topics: (a) health and environment, (b) anthropology, ethnicity, and international culture, (c) politics, law, and history, (d) economics and business, and (e) writing and speech.*

Student Experiences Outside of the Classroom

The survey also addressed the students' experiences outside of classes at Georgia Tech (Figure 6). In both years that students were surveyed, about 40% of students attended other colleges before joining Georgia Tech (Figure 6a), which likely reflects the significant population of transfer students from other colleges in Georgia. A contrast we notice is that among sophomore students in the recent survey who attended other colleges before Georgia Tech, only ~10% of them spent 3-5 years in other colleges; this number was ~40% for the other three groups of students. It is unclear why that class was different. Another contrast we see associated with the sophomores in the recent survey is that ~30% of them had worked full time jobs (other than summer or Co-op jobs), whereas only ~10% of the other students had non-internship job experience (Figure 6b). Overall, around 90-100% of students had some type of full-time employment, other than the sophomores in the older survey, among whom only about 75% had worked full time.

In both cohorts, a higher percentage of seniors were working during the term when they took the survey (Figure 6c); approximately 50% of seniors had a job, whereas only about 30% of sophomores were working. Among the students working, up to around 50% worked more than 10 hours per week. Approximately 80% of students participated in extracurricular activities for at least 2 hours per week, and about 30% participated for 9 hours or more per week (Figure 6d). The sophomore class in the recent survey was again anomalous, engaging in more hours of extracurriculars than the others, which may be explained by the lower number of hours they devoted to jobs. The Co-op program at Georgia Tech alternates a school term with a work term in a structured manner, giving students both classroom-based education and practical work experience. We found that 30%-40% of students participated in the Co-op program, with the exception of the recent sophomore class that had very little participation, but significant interest in participating (Figure 6e). We believe that this reflects a change in the timing of enrollment in the Co-op program over the last 20 years due to greater program flexibility today than in the 1990s.

DISCUSSION

Instructors often know their students in only a limited context, such as in the classroom or during office hours, or in some cases as undergraduate research advisors or academic mentors. However, faculty would benefit from a broader understanding of the needs, interests, and circumstances of their students. In this study we took advantage of a survey of CHE sophomores and seniors at Georgia Tech conducted in 1996-1997 and conducted an essentially identical survey among ChBE students in 2018-2019 to enable comparisons between students at the beginning and the end of the CHE curriculum, and between students almost a generation apart.

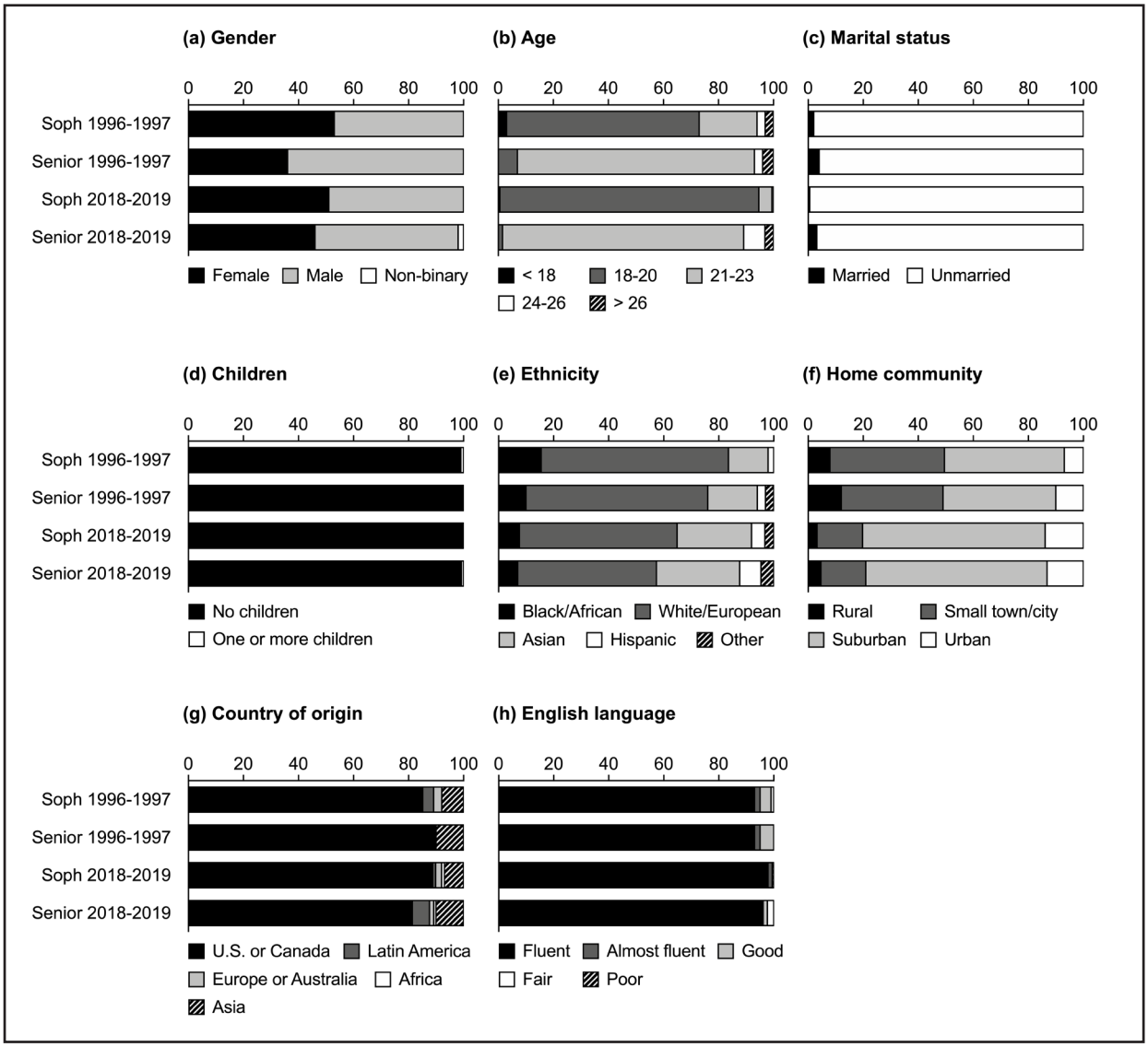

Figure 5. *Distribution of student demographics: (a) gender, (b) age, (c) marital status, (d) children, (e) ethnicity, (f) home community, (g) country of origin, and (h) English language fluency. Soph and Senior refer to students taking either sophomore or senior level courses, respectively, in the years 1996-1997 and 2018-2019. Terminology established in the 1996-1997 survey was used identically in the 2018-2019 survey, other than adding a "non-binary" option to gender.*

While some of the findings of this study may be specific to Georgia Tech, we expect that many learnings will be relevant to students at other universities too.

The decision to choose CHE as a major appears to be based on limited information for many students. Less than half of sophomores reported having at least a good knowledge of what chemical engineers do. While some students participated in outreach events like career days and engineering camps, the impact of these events on decision-making appears to have had limited impact. What strongly motivated students to major in CHE was being good at STEM, having an interest in what they thought chemical engineers do, and prioritizing getting a good job. Role models as well as family and friends were also sometimes influential. Participation in a first-year introductory class had some impact, while the value of high school and college advisors was limited. Shallcross reported that "an enjoyment of chemistry at school and the role of chemistry teachers influences students to study chemical engineering,"[10] and our survey confirms that ability and interest in math and science have the most impact on students' desire to purse chemical engineering.

After graduation, students were interested in jobs mostly in what they consider CHE, which was balanced by significant interest by others to work in other professional fields.

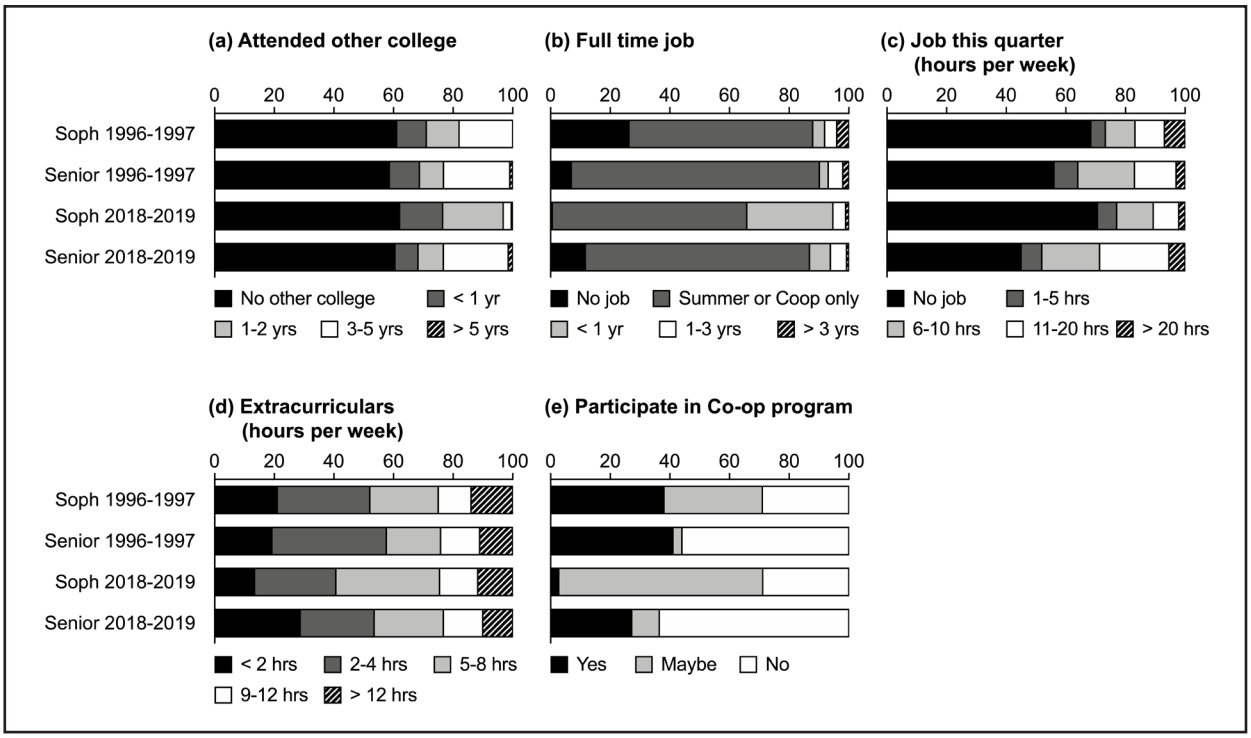

Figure 6. *Student experience in the following: (a) attendance at a college other than GT, (b) full time employment, (c) employment while in school, (d) level of commitment to extracurricular activities, and (e) participation in the Co-op program (i.e. industrial internships).*

The majority of students were interested in graduate school, either right after college or after working first. Most students wanted to work in industry, especially in large companies. This statement is in alignment with a recent AIChE placement survey about students' final actual destination.[19]

Essentially all respondents to the survey characterized the CHE major as hard, and most considered it the hardest major on campus. Only about half of students found CHE to be interesting, with the other half of seniors finding it boring, and the remaining sophomores split between finding it boring or not yet having an opinion. Most students were interested in health and the environment. The majority of students were interested in social science areas like anthropology, ethnicity, and international culture; politics, law, and history; and economics and business. Less than half found writing and speech to be of interest.

Considering demographics, most students were of an age during sophomore and senior years that suggested roughly direct progression from high school and through college. In the initial survey most students were from small towns or suburbia, but more recently, students from suburban communities increased, as did those from urban environments, while much fewer students came from small towns. This may reflect national trends of increasing suburban living, as well as the growth of metro-Atlanta among the in-state students.[20] According to one recent report,[19] since 2000, the US population has been increasingly concentrated in the 52 largest metropolitan areas, particularly their suburban counties. In addition, 27% of suburban students completed at least a bachelor's degree in 2000, whereas in 2018 only 34% of the suburban population had finished college.

A small fraction of students came from outside the United States, mostly Asia. While a small fraction of students reported non-fluency in English in the initial survey, fewer did more recently. The majority of students identified as White, but that number decreased over time as the percentage of Asian students increased. Although small in absolute number, the Hispanic population increased, while the fraction of students who identified as Black decreased somewhat. By comparison, nationally over the 20 years between surveys, the Asian and Hispanic populations both roughly doubled on a percentage basis, while the percent of people in the United States reported as Black/African American held roughly constant and those who were White decreased, but remained in the majority.[21,22] In Georgia, the Asian and Hispanic populations increased manyfold, while the Black population had a modest increase and the White population fell significantly to just above 50%.[23–25] While these local and national trends can partially explain the changing demographics in CHE at Georgia Tech, the lack of correspondence between racial dis-

tributions in college and in the population as a whole is well documented and is caused by a number of different factors that are beyond the scope of this study.[26–29]

Students in ChBE have had a variety of experiences outside the classroom, with many students having attended college elsewhere and transferred to Georgia Tech. In terms of employment, most students had summer jobs, some had long-term employment, and up to half were employed part-time during the term. There was widespread interest in the Co-op program, and a large fraction of the students participated in it. Students broadly participated in extracurricular activities, mostly up to 8 hours per week. As highlighted by Rhinehart,[30] experiential opportunities provided by Co-ops, internships or other extracurricular activities are an important part of their formation as engineers.

Considering trends from sophomore to senior year, most perspectives did not appear to change much, but there were some notable differences. Not surprisingly, seniors were older, were more certain of graduating with a CHE degree, and had better knowledge of what chemical engineers do. In addition, seniors were more likely to have a job during the term and have increased interest in economics and business, but were less motivated by socially important technical problems and were less likely to pursue a career in a traditional CHE field.

Considering trends from the 1996-1997 survey to the 2018-2019 survey, the more recent students were less interested in graduate school and more interested in working at small companies. There were also demographic differences, such as a shift to students from suburban locations and a trend toward a smaller percentage of students who reported as White and a larger percentage of Asian and Hispanic students. Also, retention of female students appears to have improved in recent years.

Reviewing these data raises many questions about why students provided the answers that they did and which factors influenced changes (or consistency) of answers from the original to the recent survey, and from sophomore to senior year. While it would be interesting to dig deeper to address these questions, the current survey does not provide that information. Indeed, the goal of this survey was to characterize the CHE student body so that we can better serve them as educators and administrators. Additional studies are needed to probe student motivations and external influences that drive student responses.

CONCLUSIONS

Students chose CHE based on an aptitude for STEM, interest in CHE, and access to good jobs. Lesser factors included opportunity to work on socially important technical problems and influence by role models, family, and friends. The majority of students were interested in graduate school, although that interest has waned somewhat over time. Almost all students wanted to work in industry, with a preference for large companies and a growing interest in small companies. About half of students wanted to work in the field of CHE, and the other half were interested in other fields or do not yet know.

Most students felt that CHE was the hardest major on campus. Only about half of students found the major interesting, with the rest either being bored or not yet having an opinion (i.e. sophomores). CHE students did express interest in other fields, with widespread interest in health and the environment, modest interest in various social sciences, and weakest interest in writing and speech.

Student were about evenly split among men and women, with a shrinking majority of students being White and significant growth among Asian and Hispanic students over the 20-year period studied. Students also were previously more evenly split between small town and suburban communities, but are now largely from suburban homes.

A large fraction of students transferred from another college, and most have worked at least at a summer job, with many participating in the Co-op program. During the term, up to half of students have jobs, and all have varying levels of commitment to extracurricular activities.

We conclude that ChBE students at Georgia Tech have a diversity of interests, backgrounds, and goals that require attention inside and outside the classroom in order to help our students achieve their educational and professional goals.

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APPENDIX

TABLE A1 Questions (in bold) and possible answers on the survey given to CHE students at GT	
1. **My gender is:** Female; Male; Non-binary/transgender/third gender/other	Fig. 5a
2. **My age is:** Younger than 18 years old; 18-20 years old; 21-23 years old; 24-26 years old; Older than 26 years old	Fig. 5b
3. **My ethnic background is best described as:** Black/African; White/European; Asian; Hispanic; Other	Fig. 5e
4. **My home community (where I attended high school) is best described as:** Rural; Small town/city; Suburban; Urban	Fig. 5f
5. **My country of origin (where I spent the first years of my life) is best described as:** United States or Canada; North or South America (other than United States or Canada); Europe or Australia; Africa; Asia.	Fig. 5g
6. **My ability right now to read, speak, and understand English is best described as:** Fluent; Almost fluent; Good; Fair; Poor	Fig. 5h
7. **My marital status is best described as:** Married; Unmarried (single, divorced or widowed)	Fig. 5c
8. **I am the care-provider to:** No children; One or more children	Fig. 5d
9. **My level of interest in anthropology, ethnicity, and international culture is:** Very interested; Moderately interested; Mildly interested; Uninterested	Fig. 4b
10. **My level of interest in health and the environment is:** Very interested; Moderately interested; Mildly interested; Uninterested	Fig. 4a
11. **My level of interest in politics, law, and history is:** Very interested; Moderately interested; Mildly interested; Uninterested	Fig. 4c
12. **My level of interest in economics and business is:** Very interested; Moderately interested; Mildly interested; Uninterested	Fig. 4d
13. **My level of interest in writing and speech is**: Very interested; Moderately interested; Mildly interested; Uninterested	Fig. 4e
14. **Since graduation from high school, I have attended a college/university other than Georgia Tech for**: Less than 1 year; 1-2 years; 3-5 years; More than 5 years; I did not attend another college/university.	Fig. 6a
15. **Since graduation from high school, I have worked at a full-time job (e.g., more than 30 hours per week):** Only during summers or through the Co-op program; Less than 1 year (excluding summers and Co-op jobs); 1-3 years (excluding summers and Co-op jobs); More than 3 years (excluding summers and Co-op jobs); I did not work full-time.	Fig. 6b
16. **On the average, I expect to work at a job each week this quarter for:** 1-5 hours; 6-10 hours; 11-20 hours; More than 20 hours; I do not have a job this quarter.	Fig. 6c
17. **On the average, I expect to be involved in extracurricular or community activities (e.g., sports, religious involvement, fraternities/sororities) each week this quarter for:** Less than 2 hours; 2-4 hours; 5-8 hours; 9-12 hours; More than 12 hours.	Fig. 6d
18. **Which statement best describes your involvement with the Co-op program?:** I am presently participating in the Coop program; I am not presently participating in the Coop program, But may participate in the future; I do not intend on participating in the Co-op program.	Fig. 6e
19. **Which statement best describes your decision to become a chemical engineer?:** I've almost always known I'd go into chemical engineering; I considered a number of options but felt that chemical engineering best suited me. I'm satisfied with this decision; It was very difficult to reach the decision and I still waver sometimes.	Fig. 1a
20. **I would rate my current knowledge of what chemical engineers do as:** Excellent; Good; Fair; Poor; Almost nonexistent.	Fig. 1b
21. **A role model or positive experience:** Strongly influenced; Moderately influenced; Weakly influenced; Not influenced	Fig. 1g
22. **Opportunity for job security and/or financial reward?:** Strongly influenced; Moderately influenced; Weakly influenced; Not influenced	Fig. 1d
23. **Interest in the field of chemical engineering:** Strongly influenced; Moderately influenced; Weakly influenced; Not influenced	Fig. 1e
24. **Aptitude for and/or interest in chemistry, science and/or math?:** Strongly influenced; Moderately influenced; Weakly influenced; Not influenced	Fig. 1c
25. **Desire to work on socially important technical problems:** Strongly influenced; Moderately influenced; Weakly influenced; Not influenced	Fig. 1f
26. **Information given by a high school or faculty advisor:** Strongly influenced; Moderately influenced; Weakly influenced; Not influenced	Fig. 1i
27. **Family member or friend's influence:** Strongly influenced; Moderately influenced; Weakly influenced; Not influenced	Fig. 1h
28. **Information presented at an open house or career day event:** Strongly influenced; Moderately influenced; Weakly influenced; Not influenced; I did not attend an open house or career day event	Fig. 1j
29. **Participation in an engineering summer program:** Strongly influenced; Moderately influenced; Weakly influenced; Not influenced; I did not participate in an engineering summer program	Fig. 1k
30. **Participation in the course CHE 1110/CHBE 1000:** Strongly influenced; Moderately influenced; Weakly influenced; Not influenced; I did not take the course CHE 1110	Fig. 1l
31. **How sure are you that you will graduate with a degree in chemical engineering?** Very sure; Fairly sure; I have no idea; Somewhat doubtful; Highly doubtful	Fig. 2a
32. **I would guess that in ten years:** I'll be working as a chemical engineer; I'll be working in management in the chemical industry; I'll have moved to a related field outside of the chemical industry; I'll be in a totally unrelated field; I have no idea	Fig. 2b
33. **After graduation, I hope to go to:** Graduate school in chemical engineering; Graduate school for an M.S. or Ph.D. in another field (e.g. chemistry).; Graduate school for a professional degree (e.g. medicine, law, business); Work and build my professional career; Work for a few years and then go to graduate school	Fig. 2c
34. **When I graduate, I would rather work for:** A large and established corporation; A small, innovative company; A university or research institute; The government; A public service oriented organization	Fig. 2d
35. **I have heard that the Chemical Engineering major at Georgia Tech is:** Fairly easy; Difficult; The most difficult major on campus; I haven't heard anything about it	Fig. 3a
36. **I have heard that the Chemical Engineering major at Georgia Tech is:** Deadly dull; Somewhat boring; Interesting; I haven't heard anything about it.	Fig. 3b