When Everyone Knows CS is the Best Major

Decisions about CS in an Indian context

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ABSTRACT

Much of the existing work on student experiences in the CS major focuses on CS in American and European contexts. This paper explores the experience of CS students who – due to India's unusual educational system, joined CS with very little knowledge about CS outside of its reputation. The study was a grounded–theory based interview study based on 20 students at 2 tiers of schools in India. Results suggest that although students generally enjoyed the CS content of their courses, they had a great deal of concern about the lack of freedom in professional programming. This is surprising considering the highly positive view of CS jobs is what initially seems to attract students to the major. We contrast this with educational findings in other contexts and discuss the educational implications of the result.

Categories and Subject Descriptors

K.3.2 [**Computers and Education**]: Computer and Information Science Education — Curriculum

Keywords

Curriculum, India, International

1. INTRODUCTION

> "Parents force their children to take [Computer Science]. In India, every parent wants to made their children either doctor or engineer — not any other thing. Every parent tries this. So I chose engineering and my [admission exam rank] was good enough so I can pick CS in IIT . . . if you are doing good, you have to choose CS."
>
> —Indian student explaining how they choose CS

CS enrollments have massively increased at many schools in the US [26] and elsewhere. Although some research suggests that students currently entering into the major are not academically weaker than in years with poorer enrollment [19] there is no doubt that CS is pulling from a wider pool of applicants. Although many students select CS based on some experience in the discipline or some intrinsic interest, others choose CS for other more mysterious reasons.

One place that is familiar with high CS enrollments is India. In India, CS at the top engineering schools is so popular that in 2014, 85 of the top 100 ranked engineering students in India chose CS as their major [18]. As each major has a cap for student admission, for most having the opportunity to enroll in CS is an unlikely dream. Previous research on affect in CS has focused mostly on places like the US: areas where students can easily choose their major and select it based on personal interest. In India, intrinsic interest is not a major aspect of student major selection. As this paper will explore, social and curricular factors conspire to have give CS a (probably undeserved) reputation as the "best major". This paper presents the results of a qualitative grounded theory based study of CS students at two colleges in India, exploring the affective results of CS's overwhelming popularity with students.

What initially attracts students to the major is a mix of reputation and the promise of certain (and lucrative) employment. This attracts students even if they have no experience with CS and are uncertain they will like it. In India, it is not usually possible to change majors so the choice of major is a four year commitment. Luckily, based on our interviews, students do come to enjoy Computer Science. Unfortunately, they also retain serious misgivings about a lack of freedom in industry jobs and relatively little clarity about what alternatives exist.

This paper proposes to analyze how students with low exposure to CS and pre–college interest experience the major. We focus on two questions:

1. What makes Indian students with little CS experience select CS?

2. After exposure to CS, what do Indian students think about pursuing CS after graduation?

Although the results presented here are specifically about students in an Indian context, the issues raised should be of interest anywhere with a similar educational context: high stakes exams, little pre–college CS exposure, and a strong social focus on finding high paying stable employment. This paper first presents method and results, then discusses similarities and differences with related work, and concludes with a discussion and educational implications.

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2. METHOD

The study was an open–ended qualitative study designed to understand what students views on CS, how they selected the major, and their plans for the future. This work was a replication of Hewner's study [9, 10] of CS students in the US context. The primary data for this study came from interviews with undergraduate CS majors at 2 tiers of schools: (i) Indian Institute of Technology Bombay (IIT) is a prestigious engineering institute, (ii) Mumbai University (MU) are two mid–tier general colleges. We interviewed 14 IIT students and 6 MU students. The interviews were between 35 and 60 minutes.

Recruitment was done through presentations in CS classes. Students were asked to volunteer and not offered compensation. Participation was generally greater than 33% so self–section bias should be limited. When selecting students to interview, we used the grounded theory practice of theoretical sampling [4]. In theoretical sampling, a researcher begins with an initial population to interview and then selects future candidates based on what would further help elaborate the developing theory. This allows the researcher to discover factors that seem to have an effect on interview responses and pursue them. However, this method does not have validity as a statistically representative sample to ascribe characteristics to particular sub–populations.

We selected students to interview in order to get a range of academic success, gender, and (as the study developed) career plans. Students were interviewed at all stages of their undergraduate careers (and one graduate student), with particular focus on 2nd and 3rd year students.

The initial interviews focused on questions about students' experiences in the classroom, their views about computer science and reasons for selecting it as major, and their plans for the future. The initial question–set was similar to those used by Hewner [9] but as the theory developed focus changed over time. The interviews also added greater focus on students' pre–college decision making; especially near 10th year (when they choose a specialization) and after college placement exams (when they choose a specific school and major). The interviews attempted to be as non–leading as possible: with questions like "tell me about how you decided to go into engineering". However, encouraging the students to be as detailed as possible ("Would you say you had decided on engineering before 10th year, or did you decide at that time?") tended to open up more information about conflicts or concerns in those times.

2.1 Checks to Ensure Validity

When attempting to understand student conceptions, there is a risk of misinterpretation and bias. This is a common problem in qualitative research; even when participants and researchers act in good faith, it is difficult to understand when backgrounds and assumptions are different. There are a variety of techniques to mitigate this risk [16]. The main technique used was reviewing coding and analysis between researchers to consider other possible interpretations. We generally would both review the transcripts of interviews, one researcher would code it and present summaries/notes of their view the most relevant sections to the other. Oftentimes this discussion would go back to the source and cause re–coding. This is not the same as formal inter-rater reliability, but that level of exactness is not possible given that the codes themselves are in flux in the qualitative process.

2.2 Grounded Theory Analysis

The theory of student conceptions presented here was developed based on line–by–line analysis of interview transcripts. Our process was based on the approach outlined by Charmaz [4]:

1. First, the researcher develops initial codes that describe what is being expressed in each line of the data.
2. Second, the researcher goes back through the body of research accumulated and selects 'focused' codes that explain larger segments of the data.
3. Third, the focused codes are abstracted into categories in a tentative theory that is then checked against other parts of the data to test its explanatory power. There are several techniques to help the researcher attempt to develop the categories in this larger theory: axial coding [6], theoretical coding [4], and situational maps [5].
4. Steps 1–3 continue until saturation: where new interviews do not significantly elaborate the existing theory.

A subset of codes are shown as an example in fig. 1. These codes give insight of the theory about "reasons for choosing CS". The upper table in the figure shows the 'focused' codes. The lower table shows the 'initial' codes which were grouped as "CS is the best major".

Choosing Engineering			CS is the Best Major	Parents and Relatives
Interest in Maths	Limited choice	Not serious about non-CS		
5	3	3	11	5

Good jobs	The brand	Flexible major	If you do well in exams
7	5	3	4

Figure 1: Example of a codes. Numbers are the frequencies of interviews in which any code appeared

Below is a demonstration of the analysis process explained using an excerpt from one of the interview.

> "[Tech companies] are looking for a person who can work in their scenario . . . they have the assignments with some organizations. They need people who are [intelligent] and people who can work for them without any — I won't say ideas — endeavor of their own . . . They won't explore they won't create something of their own and they won't try to think in a different way . . . Yeah, I definitely wouldn't like to work [in a place like that]."

So in the initial pass this was coded as "wanting input into the creative/design process". This code was shared with a few other quotes that had a similar concern about just being given specifications and not having input. As analysis continued this was incorporated into a larger focused code of "autonomy", which was part of a larger section on student future goals.

However, about half way through the process, a second pass was done and codes were reorganized. We recognized commonalities between this quote and other concerns that

jobs would be algorithmically uninteresting, or that managers would make excessive demands. These issues were motivating most students to seriously consider alternatives to work in industry. All these ideas became part of the larger "Wanting Freedom" category that forms a key part of our theory of student future desires.

3. REASONS FOR CHOOSING CS

3.1 Choosing Engineering

> "Well it's basically after 10th you need to decide [which general area to go into] ... practice for the competitive exams. After [my 10th year] I wanted to go engineering. Basically that was building up in my mind a long time since [year] 9 maybe. Cause I was interested in mathematics my parents and my sister and my entire family they're all doctors but I preferred mathematics no matter what. The most – what can you say – prominent branch in mathematics is engineering."

To understand major selection at Indian colleges, it's first necessary to understand India's exam system. College (and major) admission are entirely based on performance on one of several exams students take in their 12th year of schooling. Students prepare for these exams by enrolling in exam–prep schools in their 11th and 12th year: the entirely of those two years is devoted to exam preparation.

There are four different categories of exams: engineering, science, commerce, and arts. As a result, the first decision students need to make is which exam track they wish to prepare for in 10th year.

All the students we interviewed selected an engineering exam track (otherwise they would not have entered the CS major). Generally, the decision seemed very straightforward from them. Commonly they framed the decision as a choice between engineering and medicine (science) – the two most prestigious choices – occasionally they also entertained pure mathematics (science exam) as an option.

Parents and relatives were frequently involved in the decision. This ranged from students who felt they could choose freely but parents made some suggestion to students who felt that they were forced to choose between engineering and medicine and had no other option. Regardless of the level of involvement, students generally did not consider this a tough decision and made it pretty casually. As noted by Hewner in his CS study [10] and replicated with Indian students, just because an educational decision is important does not mean students will spend a lot of time (or research) making it. Students did not have a specific branch of engineering selected at this time. Skill with math was often cited as a factor in their decision, but rarely experience with or interest in technology.

3.2 Choosing a College and Major

When 12th year exam results are in, students apply to a particular major within a particular college. Priority is determined by exam grade. The type of college largely determines its reputation, so for example students would definitely prefer IIT to MU simply based on the kind of college it is. Once a school's pre–determined number of major slots are filled, no more students can enter that major in that school. Students know it is almost impossible to change majors after entering a school, so this major choice is binding.

The result of this system is that students generally have very little knowledge about what colleges or majors will be available to them until exam results are in. Students may well have to choose either a more prestigious college or a preferred major. As a result, most students did not consider what area of engineering they were most interested in until they received their exam results. The engineering exam itself consists of mathematics, physics, and chemistry questions; exam-prep schools therefore did not attempt to educate students about the various branches of engineering.

3.3 No Strong Vision

> "Actually I was really interested for computers. When I was in 11th 10th grade I knew the basics of computers but I did not have the knowledge that what happens in if I take engineering in Computer Science. I did not have that knowledge. But I was interested towards it somehow — intuition you can say. So I took that computer science engineering in my bachelors ... I used to play a lot of games."

Similar to previous studies of US students [10], students did not have a concrete career goal when they selected their major (or even when I interviewed them). Given that it is almost impossible to transfer between majors after admission, one might expect that students would devote energy to researching the possible majors in detail, but this does not seem to be the case.

Some of the students we interviewed has some previous interest in technology. The majority of the involvement was very limited though – playing games, using webpages etc. None had done any serious programming (i.e. a full year long course) or significant hobbyist projects. This contrasts with Hewner's work [10] in which many students had at least some exposure pre–college. Furthermore, because they did not know what degrees would be available to them until they saw the exam results, none had planned on CS in particular until that time.

A few students did research into the topics and course content of the various degree programs before selecting the major. For them, the discrete math and algorithm side of CS was most attractive. But this was definitely the exception: most students did not do research before choosing their major. Even the students who did research still did not generally have a specific post graduation goal at the time of entering their degree.

3.4 CS is the Best Major

> "It's more like a tradition. If you are among the top rankers in IIT it's like you generally prefer Computer Science. So you can say that unless you're very much interested in some other field which I wasn't — and Computer Science it looks like you can get a deal out of it. ... I think it's the placements mostly like we do have rankings in every department from IIT so CS is mostly tops in it in terms of placement ... So it's a kind

> of tradition building up and that's because of the placements we get. CS people get maximum placements, the highest packages. Plus I think CS is also the most intriguing branch as per me at least. It is a branch that really fancies me. Like algorithms, programming . . . "

The idea that "everyone knew" CS was the best major was by far the most commonly cited reason for students deciding to enter the CS major. Although initially it seemed like students might be simply interested in getting high salary jobs (i.e. "placements" or "packages") post graduation, this idea turned out to be more complicated. We think there are several aspects that combine to make CS so strongly appealing.

When students were asked to reflect on why CS was considered "the best major", high salaries was always the first explanation. This was a bit strange because students in general did seem to consider money a major consideration elsewhere in their decision making process. When considering jobs near graduation, for example, salary generally seemed to be important but secondary to ensuring that the job itself was enjoyable.

Part of the appeal of good packages seems to be job security; high packages signal high demand and therefore the certainty of finding a reasonable job. Several students mentioned that, if they chose some other field they might have difficulty getting a job. This was mentioned even at the prestigious IIT , which likely has good placement in all fields. There is a sense in which, if they chose another degree path for capricious reasons, they might someday regret having given up the opportunity for a "sure thing" in a CS degree.

Another aspect of it is the competitiveness of the degree programs themselves act as a signifier of intelligence/prestige. No student we interviewed directly attributed their choice of CS to interest in prestige, but a few confided that they suspected their classmates of having such motives. Some mentioned that they appreciated the flexibility of an engineering degree: it allows graduate study abroad or can allow entrance into competitive MBA programs. Some students definitely choose CS because of this flexibility and even admitted they planned on future careers in business that did not use their CS knowledge directly, but this was uncommon in the students we interviewed.

Of course, students don't evaluate each of these aspects of "CS is the best major" intellectually. For most students, no particular relative or friend told them about CS: this idea has been casually absorbed from newspapers, conversations, etc. All this amounts to is a feeling that they have an unusual opportunity to be able to choose CS (because most students can't) and that they would need a particularly good reason not to take advantage of it. Because students don't often have particular experience with any engineering discipline when they apply, this feeling becomes a major factor in their decision.

3.5 Parents and Relatives

> "Actually my Dad had a dream, to see somebody who can actually go to IIT . . . I planned to clear [the entrance exam], and then I thought I'll do some Math [and not go to IIT] . . . After [the exam], when I got rank, my cousin, he told me that there is a lot of scope of math in Computer Science, and in Electrical Engineering as well. [He] told me that [CS and EE would be more useful in life]."

In talking with Indian instructors and school administrators, it seems to be a common refrain that Indian students enter CS because their conservative parents think it is a good idea. Based on our interviews, that does not seem to be borne out. In fact, parents and relatives' involvement in the major decision making process was extremely diverse: everything from no input whatsoever to heavy involvement even with post–graduation plans. Moreover, students don't need their parents involvement to act conservatively: the factors outlined in "CS is the best major" affect the students strongly even without the parents.

Most of the students we interviewed said that their families made suggestions but that in the end they were free to choose for themselves. Some students, when probed further, admitted that certain options (e.g. commerce or arts) would cause arguments or were implicitly disallowed. Other students insisted that they had almost complete control over their educational decisions, however, and that their parents would be supportive regardless.

Even when parents were heavily involved, students also were willing to stand up to their parents if necessary. One student's parents favored a civil engineering degree as opposed to CS, and actually used the student's credentials to log on to the college website and pick the degree they favored. Later, the student secretly changed the degree section back. This kind of fighting was definitely the exception, however: most times students and parents were on the same page in terms of goals.

3.6 Summary

There is no single factor motivating students to study CS. Students did not have a particular long–term careers in view. Students did not usually have experience with CS. Students did also not choose CS for cynical reasons: although good career prospects were a positive aspect of CS (and students were aware of it), no students seemed to be strictly looking for the best paying job. Family input was involved, but no students felt strictly forced by their families into CS. Instead, the choice of CS was motivated by the fact that the students did not have a particular concrete goal, and CS has a good reputation. Despite the fact that choice of a particular major was a 4 year commitment, students made the decision fairly casually.

4. ENJOYING CS

> "Mainly in the 3rd semester... like when I was working on a project in the lab, data structure lab, so we have to complete a project basically. There we created new games.. also created [a] search engine... for Ubuntu... We got the feel that, what is in CS, and how can we use the CS. Like in the 1st semester I [didn't] know what CS was.."

Most of the students did not have exposure to Computer Science before starting college. Further, students did not seem to primarily use the potential for enjoyment as their reason for choosing the major. Despite this, almost all of the

students said they had come to enjoy the field of Computer Science and the content of their classes. Of course, many students had a few CS courses they did not enjoy, but their overall view of the field was interested and positive.

The process of enjoying CS took time for many (but not all students) students: many students cited 2-3 semesters. Students felt that in their intro classes they did not fully understand what they were learning. But even though students did not generally have much freedom to choose courses, later courses in the curriculum generally persuaded them of CS's potential.

We observed a marked difference between IIT and MU students in reasons for liking CS. For IIT students, CS's mathematical nature was a great draw. Students often talked about discovering importance of algorithms and the enjoyment of coming up with a novel approach. They mentioned they liked the activity of coding as well but it was usually secondary. This may be partly a result of the exam system: students entrance exams focused on mathematics, physics, and chemistry. All three have a strong mathematical component so it's not too surprising that top scorers would enjoy mathematics.

For MU students, the activity of programming was definitely more primary. MU would usually say that they like solving a problem by writing good programs: not distinguishing between the design of the algorithm and coding itself. Even non-programming courses had a strong focus on eventually writing code: "Even in Operating Systems, you need to program and then only you can use any OS concept . . . ".

Both groups perceived CS as broader than they originally expected and involved with many challenging problems. They cited application domains like artificial intelligence, multi-processing, and data analysis. Of course students were aware abstractly that Computer Science was involved in these activities before starting the major, but many commented that understanding the complexity behind these various systems was beyond what they had anticipated when they chose CS.

5. CONCERNS ABOUT CAREERS IN CS

The story thus far seems relatively positive. Students decide to major in Computer Science with relatively little exposure, relying in part on CS's good reputation as "the best major". In their CS classes, students learn the discipline and generally find it enjoyable (which is good, because they can't switch majors). Surely then they are looking forward to a career in industry?

Many students had significant concerns about jobs in industry. They were considering them, but many had negative perceptions about working in CS. Both IIT and MU students viewed many industry jobs as uncreative and demanding, and most hoped to (in various ways) find an alternative that allowed them greater "freedom". Following findings are the parts of larger "Wanting Freedom" focused code.

5.1 Negative View of CS Jobs

> Student: "I want not to do coding in a Google can: 4x4 can only coding. It should have some adventure, something — not just coding. Not only C++. It's related to coding but not only coding. . . . You know?"
>
> Interviewer: "Do you have an idea of what other thing than coding you'd like to be working on?"
>
> Student: "I like to do many stuffs — I don't know. I have no absolute explanation for it."

What are the problems with CS jobs, given CS's reputation for the best packages — many jobs and high salaries? Students still perceived that the jobs paid reasonably and were available (although some MU students did worry at least in part about finding any job at all). Students' reasons were different but they share some common themes:

1. Students were concerned that most CS jobs were just to implement features decided by someone else — that they would have no say in the design or feature set.
2. Students were concerned that they would be solving technically or algorithmically trivial problems.
3. Students were concerned they would be required to work long hours.
4. Students were concerned their environment would be conservative: that they would be forced to work regular business hours or have a dress code.
5. In general, that a industry CS job would be boring or that unreasonable demands would be forced on them by management.

On the whole, students view CS jobs as stifling and monotonous. This perception was not confined to a few "bad jobs/ managers/ companies" out there: instead it was the view that the majority of jobs available had these negative characteristics. This was true for both IIT and MU students: some IIT students felt that industry jobs would be good for lower tier school graduates, but in fact both groups shared similar concerns.

These views were not, in general, based on direct experience with industry jobs: MU students did not usually get internships and most IIT students we interviewed had more research–oriented summer work (if any). Similar to the perception of CS as the "best major", these views were described as things that "everybody knows" or as coming from senior students — but not usually a specific senior with a specific bad experience. Students with actual work experience tended to be more positive about industry jobs.

5.2 Alternatives to Bad CS Jobs

Students concerned about potential bad jobs suggested several alternatives. In each case, the alternative seemed chosen to focus on the perceived main failing of industry jobs (i.e. a student concerned with having a unreasonable boss might want to start a startup or maybe get and MBA and become a boss themselves). Mostly, these alternatives were pretty speculative: e.g. students who wished to start startups did not have an idea yet, students who wished to go to graduate school did not have an area of specialization, etc.

5.2.1 Facebook, Microsoft and Google

> "But then there are these jobs which are not just about coding in which you also have to put your minds — there are various algorithms. . . you

> have this graph search on Facebook that is one of the coolest things I have seen till now on Facebook. There are people designing these algorithms . . . So all that requires some mind . . . there are all kinds of jobs in a company so I would personally prefer using my brain to some extent for these things and not just do some naive coding."

One group was strangely absent from student complaints about bad work environments: large American companies. Especially for students concerned about technologically interesting work, these companies were perceived to be able to guarantee algorithmically interesting technical focus. No Indian company had a similarly high reputation and indeed being Indian seemed to be a detriment to students' perception.

Perhaps unsurprisingly given students' view of the company's technical focus, students perceived the main way to get these desirable jobs was through excelling in algorithm–focused interview questions. This was seen as very difficult: several students acknowledged they would like to work at these companies but probably would not be able to. The process itself seemed surprisingly similar to the college entrance exams: students perceived the jobs as desirable but did not know the details. They felt the main way to get them was by competing in a another high–stakes examination.

5.2.2 Your Own Startup

For students primarily interested in being their own boss, creating a startup was a common plan. Interestingly, no students interviewed expressed interest in joining an existing Indian startup, even though apparently such startups frequently recruited on campuses.

Students who were interested in starting their own business often planned to do so after working in industry for several years (2 years was the generally quoted number). They felt that this would allow them to understand how business worked and save some money beforehand. A few mentioned that this might also please families concerned about their long–term careers.

5.2.3 Social Services and MBAs

One of the unusual characteristics of Indian engineering degrees is that they were perceived as a good way to prepare for entering Social Services: government jobs that were considered highly prestigious and depended on doing well on another national examination. Though a few students mentioned this as a possible alternative, this option generally seemed more popular with students' parents than students themselves, although it was viewed as helping society in a way an ordinary industry job did not.

Another possibility seemed to be continuing in school to get an MBA: this option was particularly popular among MU students. Managers were perceived as not being subject to the same limiting constraints as ordinary employees. Students planning to go for an MBA felt learning a technical field like CS would be beneficial in understanding technology from a business sense, but generally saw themselves as moving into a pure-management role after the MBA.

5.2.4 Graduate School

For both MU and IIT students continuing on to graduate school, especially graduate school abroad, was considered a strong alternative. Students generally had little experience with academic careers, so their expectations of graduate school varied quite a bit between students:

1. Some viewed academic careers as method of focusing on some technically challenging sub–discipline.
2. Some viewed foreign schools as better than Indian schools and hoped to learn more, eventually perhaps securing a desirable foreign job.
3. Some viewed it as an opportunity to work without deliverables and invent something new.

5.3 Summary

Indian students have negative perceptions of industry CS work. In many ways, these perceptions mirror the feelings of non–CS–majors elsewhere [24, 2]: that CS work is uncreative, stuck behind a computer etc. What is surprising is that these negative opinions of CS jobs can coexist with excitement and interest about the academic content of CS. Students like the academic topics of CS, but much of the negative association of CS work remain – even in India, where the promise of excellent (i.e. highly stable and high paying) jobs is one of the main factors attracting students to CS in particular.

As alternatives to the negative aspects of CS jobs, students considered a wide variety of alternatives that gave them more freedom. However, similar to before entering the major, students views of the future were very speculative. Although many students felt strongly they did not want a CS industry job, almost none had a well researched alternative in mind.

As far as the career advising offered by the schools is concerned, these schools have training and placement cells, but no students mentioned ever about using them for advisory purposes.

6. RELATION TO EXISTING WORK

A lot research exists on how students select majors. [23, 15, 13] In a study performed by Serapilgia and Lenox [21], several categories of factors that affect the decision of women to enter into a course of study in Information Science programs were found, viz., influence by male role models; introduction to computers in the home and school; interest in problem solving; early exposure to computers/technology; greater opportunity for higher salaries. Stinebrickner and Stinebrickner [22] found that "over-optimism about completing a degree" affected student choice of the major. Pedro et al. [20] found the indicators such as student knowledge, performance and gaming behaviours which vary among students who choose different college majors. Zimmerman et al.[25] found that the factors influenced the students choice of CS major were "money", "knowing someone in the CS field", and "experience with computers". To the best of our knowledge there is a dearth of such research for India like educational context. Moreover the Indian context differs in two very significant ways from these places: (i) students have much less freedom in choosing a major; and (ii) Indian students have this feeling about CS being particularly great.

In some ways, the Indian students seem similar to what we've seen in the past – in other ways they are different:

Vague vision of the future. Similar to the students in Hewner's study of CS students [10], Indian students did not

choose their major with a vision of a career post graduation. In Hewner's studies, students chose their courses based on personal interest, which did not seem as strong in the Indian students. However, what is consistent is that forcing students to make high–stakes decisions earlier (specialization choice in Hewner's work, 4–year degree in an Indian context) encouraged students to chose in a casual and somewhat arbitrary fashion.

Pre–college perceptions of CS. Pre-college work suggests that before college many US students are interested in computing careers [7] but generally speaking do not have a strong idea of what Computer Science is [3]. This seems very similar to what we observed with Indian students pre–college recollections (although clearly CS is vastly more popular major in India). Despite the importance of decisions about majors in the Indian context, approaches to learning about potential majors seems relatively similar.

Most commonly cited reason for opting for CS major was the idea that "everyone knew" CS was the best major. This reconfirms and further elaborates on the findings by Holmegaard et al., [12] that the choice of major is not an isolated individual event but its a social process.

One key area that Indian students obviously do differ from counterparts studied in previous work is in their potential to be exposed to CS prior to selecting the CS major. At this point, many countries are either requiring CS to all post–secondary students (e.g. Israel, Russia) or at least increasing its availability as an elective (e.g. New Zealand, Sweden). [1] In a study based on United States students, CS education in school is itself a strong predictor for student STEM major choices. [14] In India, the fact that the last few years of high school occur at exam prep schools make it very unlikely a student would have had formal pre–college CS experience. Even if the student had the opportunity, they would not have been able to be sure they would get into a CS program so they would not be likely to pursue it seriously.

In–college perceptions of CS. One result that definitely exists across cultural contexts is that CS majors are excited about the academic content Computer Science. Even though Indian students did not know much about CS before they selected the field, they enjoyed it. Similarly, previous work asking students to write about CS has prompted them to talk about how broad and enjoyable it is. [11] Biggers et al. study also found that compared to CS majors who left the discipline, majors who stayed were talked significantly more about how broad and exciting it was. [2] Yardi and Bruckman also found CS professionals to be upbeat in their estimation of the CS field. [24]

In contrast Indian students' perceptions of CS industry jobs seemed more similar to impressions attributable to either those who left the CS major in Bigger's survey [2] or pre–college students not planning to major in Yardi and Bruckman's work. [24] But student concern about post graduation careers did not seem motivated by bad experiences in the classroom, which Hewner identified as a primary motivator of long–career decision making. [10]

6.1 Academia and Industry in India

There is some research that suggests that the negative perception of CS industry jobs in Indian students may be related to pedagogy. Introducing industry–oriented topics like software engineering may be more difficult because recruiting professors with industry experience is particularly difficult in the developing world [17]. As a result, the disconnect that always exists between academia and industry is exacerbated and professors avoid talking about software engineering and industrial topics. When the topics are presented, they focus on theory and don't take into account actual local practices. This leads students to view them as inauthentic and boring [17]. Garg and Varma did an analysis of CS curricula and found that software engineering topics were de-emphasized and also tended to be taught in lecture style separated from projects (which were graded on CS content – not technique) [8]. So part of negative views of industrial software development may have been absorbed implicitly from professors.

7. DISCUSSION

7.1 Impact of Educational System

Many structures of the Indian educational system contributes to some of the unusual results seen here:

1. The national exam system forces students to specialize in engineering/science/others well before they have a concrete career plan

2. Being accepted into particular college majors at application time causes students to wait on deciding on a major until exam results are returned, making it impossible for students to explore their major before college begins

3. Policies which limit major change to only a few students restrict students who discover their major is not a good fit

4. The application process to both colleges and jobs encourage students to view career paths as competing for a small number of "guaranteed good" spots, rather than differentiating themselves

As with similar policies in the US [10], it seems clear that requiring students to make high–stakes decisions before they have a clear plan does not encourage them to make the decision more carefully. The Indian system forces decisions on things like engineering vs. science etc. as early at year 10. Similarly, in year 12 they must commit to a major from a limited list of choices after getting their exam results. Both decisions are high–stakes, but because students don't really know enough to make a well–reasoned decision they make them quite casually.

In Indian school administrators and educators often voice dissatisfaction with the way students make major decisions, and they usually blame parents demanding students make conservative choices. Based on these interviews, however, it seems more likely that the college application/exam process forcing students to decide very early is causing students to pick in very similar and conservative ways.

As educators, we often don't have a mechanism to change national education policies. But there are a lot of individual school policies that exacerbate the problem of high–stakes choices early. At the school level, policies which restrict students changing their mind seem to cause unnecessary problems. At IIT for example, despite the fact that all majors have a common introductory sequence, the number of students allowed to enter or leave a major are strictly limited.

Even if a student wishes to leave a popular major like CS, they could be limited even if individuals in the destination major are willing to switch to CS. Little support for double–majors, minors, and other outside–of–discipline classwork further limit student options.

On the individual level, high stakes exams seem to have encouraged a very similar strategic approach among students. Even taking for granted that CS has the best packages on average, surely there is some advantage to being a top–tier chemist as opposed to a below average computer scientist? Although most students we interviewed find the perception of CS to be overblown, they nonetheless tend to follow the conventional wisdom (although, admittedly, this is skewed by our sample).

7.2 Envisioning a Future in CS

One of the most interesting results of the study was the discovery that students could be excited about CS concepts while at the same time have a great deal of concern about careers in CS. It almost seemed like the negative stereotypes associated with the CS major itself observed in other countries [24] had been transposed to programming jobs in the Indian context. Strangely, no student mentioned concerns about these negative jobs until after entering the major, despite the fact that the availability and compensation of these jobs are part of what make the major so popular.

Given our data, it's impossible to know if student perceptions of industry jobs are inaccurate or if Indian programming jobs are as uncreative and demanding as students imagine. Either way, it seems that the widespread negative perception of industry jobs is causing a recruitment problem for Indian technology companies.

Based on Garg and Varma's work in Indian Software Engineering education [8], it may be that students are inheriting part of their distaste for Indian industry work from their professors/curricula. This is one area where pedagogical changes in the curricula or teaching style might benefit students. Both IIT and MU students had described class experiences designed to give a feel for industry–style development. More emphasis in the curriculum might help reduce the concerns of students about the boring nature of industry jobs.

Furthermore, beyond industry jobs in particular, Indian students seemed to have a strong desire for career opportunities that provide a greater amount of freedom. Freedom and an enjoyable job does not seem to be a concern for students in the initial choice of college and degree, yet it seems a dominant factor as they examine career options near graduation. As students look into alternatives, they don't have much information.

For example, students who are considering applying for graduate school abroad have little idea what they ought to be doing (outside presumably of performing well on standardized tests like the GRE). As a result, student perceptions of graduate work seems to be a mix of the accurate (e.g. you can specialize in a particular subdomain and choose your own projects) and the fantastical (e.g. you have no accountability and are just supposed to produce innovative ideas). In some cases students have desires that can probably be accommodated within the space of possible CS jobs (e.g. the desire to do something good for the community as a whole) but make plans that seem outlandish (e.g. somehow funding and managing a hospital).

The Indian educational system seems to be effectively solving the problem of taking students who don't know much about CS and presenting it a way they enjoy in their classes at both IIT and MU . But students seem to have difficulty taking those enjoyable classroom experiences and finding realistic career opportunities they feel they will also enjoy. If students could find a realistic career goal and understand what sorts of things they ought to be doing in and outside the classroom to pursue it, then it seems like students might be able to pursue CS with even more confidence and success.

8. CONCLUSION

In this paper we have focused on two questions:

1. What makes Indian students with little CS experience select CS?

2. After exposure to CS, what do Indian students think about pursuing CS after graduation?

In answer to the first question, CS college education in India is in an interesting position. The major is extremely popular, but most students are not being forced in the major by their parents or cynically picking to maximize financial returns. Certainly, CS's reputation as the "best major" and a unusual opportunity influences many students. The constraints imposed by the engineering testing system make it difficult for students to foster independent interests in engineering before starting college. Despite this, students mostly seem to have approached CS with great curiosity and in general seemed to enjoy the discipline and their classes.

In answer to the second question, despite CS's reputation for the best salaries and jobs, most students seemed concerned about the transition to industry. Indian CS industry jobs were perceived as uncreative and demanding. Students were considering perceived alternatives like graduate work, American technical firms, startups, and even non–CS career paths. Although freedom did not seem to be a major goal of students as they chose their college/major, it seems significant as they consider post–college careers.

More broadly, this work suggests that policies that force students to make high–stakes decisions early cause strange education effects. In the Indian case, it contributes to students perception of CS as the "best" major and its very high popularity. In general, ensuring that school policies to allow later term decisions about goals may allow for less random student decision making.

This work also suggests that students can be enjoying the academic content of their CS courses while at the same time having great trepidation with regard to CS jobs. In this Indian case, this suggests a greater a better connection between industry and academia and more explicit school support for other options could help. Beyond India specifically, it suggests a greater attention to student post-graduation careers might be worthwhile.

Although this study has focused on the specific details of the Indian context, there are many countries with similar educational structures (e.g. high stakes exams that entirely control college admissions) that may find similar reactions in their own students. Even for educators with a different context, India provides an interesting example of the ways in which a superficially good thing (overwhelming popularity of the CS major) can have unusual effects.

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