Landscape Analysis

Responsible Computing in India

Report produced by **Digital Futures Lab**
For **Mozilla Foundation**

August 2022

digital futures lab

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LIST of ABBREVIATIONS

ACM	The Association for Computing Machinery
AICTE	The All-India Council for Technical Education
BCA	Bachelor's in Computer Application
BE	Bachelor of Engineering
BS/BSc	Bachelor of Science
BTech	Bachelor of Technology
CIIE	Centre for Innovation, Incubation and Entrepreneurship
CS	Computer science
FOSS	Free and open-source software
IIT	Indian Institute of Technology
IIIT	Indian Institute of Information Technology
ML	Machine learning
MOOCs	Massive Open Online Courses
NIT	National Institute of Technology
UGC	University Grants Commission
US	United States of America

1. PROJECT OVERVIEW

This report maps the current landscape of responsible computing for undergraduate computer science education in India and develops recommendations for Mozilla and USAID's rollout of the Responsible Computing Challenge in India. For our study, we understand a responsible computing education as that which includes programmes, courses and other interventions that help computer science students understand and critically evaluate the social impacts of software and emerging technologies.

Approach

This study, conducted over 12 weeks, from April – July 2022, examines the following questions:

- What is the variety of academic and vocational training opportunities that exists for computing majors?
- How are ethics and responsible use taught, if at all, in existing computing initiatives at colleges and universities in India?
- What are the characteristics of the job market for computing graduates – does the job market recognise or reward responsible computing?
- What are the key considerations and recommendations for Mozilla to initiate its Responsible Computing Challenge in India?

This report is based on a combination of desk research and semi-structured interviews with professors, students, and placement offices at various institutes offering an undergraduate degree in computer science.

During the first phase of desk research, we created a database of 100 campuses offering undergraduate degrees for computer science. In this dataset we noted the type and duration or program, the compulsory and elective courses, the entry criteria, and any extant data on student demographics. This revealed that only a few premier institutes in India offer courses that support responsible computing. Non-premier institutes tend not to have the faculty or institutional structure to support the introduction of new courses in responsible computing. This point is elaborated upon further in the report.

Based on this finding, the second phase of data collection focussed on these premier institutes as they are in the best position to support the Responsible Computing Challenge. We elaborate on this point further in chapters 3 and 4 of this report. We conducted 15 semi-structured interviews with professors from both non-premier and premier institutes, but most of our interviews about the strategies for introducing the Challenge were with people from premier institutes. Of these professors, 3 were either the current or former head of the CS department at the respective campus. We also conducted 5 interviews with placement officers - 3 from premier institutes and 2 from non-premium, state level universities.

A limitation for this project is that its duration coincided with the summer break at most universities. This made it harder to access administrators, faculty and students for interviews.

2. SETTING THE SCENE

Institutions and Governance

The landscape for undergraduate computer science (CS) education in India is extremely varied. This ecosystem is dominated by university/college/institute level campuses or formal educational establishments. These can be distinguished from distant learning institutions, vocational learning institutions, private companies providing Massive Open Online Courses (MOOCs), and institutions run by employers themselves to train new employees. [i]

Within the formal education system, CS undergraduate degrees are offered at either stand-alone technology institutes or specialised engineering colleges that are a part of a larger university system. A university will typically be comprised of multiple colleges, each specialising in a specific faculty or discipline; the university acts like a central hub and critical decisions regarding courses and curricula are made at the university level.
Even though India produces the highest number of computer science graduates annually, many of these programmes are of poor quality and students graduate with only a basic understanding of concepts and their application.[ii]

A handful of these institutes can be considered ‘premier’ or ‘elite’ institutions. Most of these are stand-alone technology institutes, rather than university colleges, and they tend to be the best resourced, attract the best students and faculty, and offer students the most lucrative employment opportunities.[iii] Admission to these institutes is very competitive and considered a means to upward socio-economic mobility. But, as a 2019 study comparing CS skills across US, India, China, and Russia shows, seniors even from these premier campuses exhibit far lower skills compared to their counterparts in US campuses. While students from premier campuses in India perform far better than those from non-premier campuses, their performance is at par with an average student in the US.[iv]

The best reputed of these are the Indian Institutes of Technology (IITs). The IITs are a group of 23 institutes that are owned and governed by the Central Government and were created by an Act of Parliament under the Ministry of Education. They are the best funded campuses in the country, and the most coveted by students.[v] Two other groups of campuses can be considered premier - the National Institutes of Technology (NITs) and the Indian Institutes of Information Technology (IIITs). NITs are a group of 31 campuses under the Central Government's Ministry of Education. Five of the IIITs are under the Ministry of Education and the other 20 are funded by a combination of Central Government, state governments, and private funders.

These campuses cover a very small fraction of the yearly intake of computer science students across India. They admit approximately 45000 students among them, of which roughly 5000 are computer science students.[vi]

These campuses have a high degree of autonomy in how they are run, including the design of programmes and courses. In the IITs for example, formal governing bodies such as the IIT Council and Senate tend to defer to faculty on issues related to programme and course design; job placement processes are also run almost entirely by student bodies. This contrasts with even high-ranked state university-colleges, where decisions about programme design are taken at a university level, with far less input from individual colleges or faculty.

Programmes and Courses

Computer Science is taught through different degree programmes, such as a Bachelor of Technology (BTech), Bachelor of Engineering (BE), Bachelor's in Computer Application (BCA), and Bachelor of Science (BS or BSc). The BCA is a three-year degree course focussing on the more instrumental aspects of CS education, and BTech and BE are four-year degree courses which explore foundational concepts and have a range of core and elective courses. The distinctions between BTech and BE are not clearly defined, as they are practically identical. For the purpose of our study the BTech degree is the focus as it is the most widespread.

The average BTech or BE course lasts four years. The academic year usually begins between July and September, but there are variations across courses and campuses. Students are required to take several compulsory courses called core courses, alongside a number of 'elective' courses. Students typically take electives from the second or third year onwards, depending on the campus.

Core courses are broadly similar across campuses, primarily science and engineering courses. Students also take a range of core courses specific to computer science. These include introductory coding and programming courses, communication theory, organisation theory, signals, and processing, among others. Courses on data science and machine learning have also recently become part of the core curricula in some institutions.

Electives are far more varied across institutions. The range and type of electives are influenced by the institute's resources and structures rather than the degree type. Premier institutes like the IITs and IIITs offer a far wider range of electives than non-premier colleges as they are better resourced and structured to support multi-disciplinary programmes. In the IITs and the IIITs the same subject-area could also have a variety of electives because multiple professors want to teach the same subject with slight variances and thus multiple electives of a popular area, say machine learning, can exist. Alongside the CS department or stream, IITs also have social science 'stream' and faculty. This allows them to offer a wider range of electives from the humanities, social sciences and management studies, among others. The IITs and IIITs also offer graduate degrees in

interdisciplinary fields such as information and society as well as social science subjects. Since campuses at the NIT level do not have non-STEM departments they cannot offer a comparable number of electives, but still have a significant amount of variation and a strong list of technology electives from which a student can choose.

Many of the university-affiliated colleges are far more limited in their elective offerings. A number of them have limited resources and faculty expertise to teach even niche courses in computer science. Many of these universities do not have colleges specialising in multiple disciplines; thus, they have a smaller variety of disciplinary competencies from which to draw faculties for electives. Also, while students at premier institutes can cross-register for courses across departments, students in state universities generally cannot cross-register across colleges, even if a university has colleges offering various fields of study.

Placement and Employment

As these premier campuses are relatively expensive when compared to Indian median household incomes, students and parents are keen to secure the best possible employment prospects. Pressure and competition are known to have led to anxiety and suicide among students.[vii] Employment prospects are believed to be the main factor influencing the selection of certain courses by students.
Because of the competitive nature of the job market, students place a lot of importance on advice coming from the campus placement cells.

The placement processes differ widely from campus to campus, although in most campuses there is a faculty member at the campus level and one at the department level who oversees this process. In some premier campuses, like IIT Bombay, the placement process is completely controlled by students, with little faculty involvement. In contrast, in state-level university colleges, the process is typically top down and led by the faculty.

Placement cells regularly organise workshops to help students match industry needs. Much of this information is obtained through alumni networks. For example, there is a high demand for AI-related courses among the student body, based on the perception that this is important in the job market. Placement offices may arrange external tutorials and courses for students to polish their machine learning skills.

CS undergraduate students land a variety of jobs, differing in both their nature and their salaries. Companies are looking for either a ‘service-based profile’, i.e., an employee to work in a role such as a software developer or a tester etc., for a client company, or a ‘product-based profile’ where an employee is to work on a particular technological artefact or project directly being developed by the company that hired them. Many leading consulting firms and management organisations also recruit from CS departments, particularly from the premium institutions.

In the more premier campuses like IITs, there has been a decline in the number of students opting for masters and PhD studies. In contrast, in university-colleges this

number seems to have increased. The reason is twofold. Students take up research either because they are genuinely interested in further exploring that area, or because they want a higher degree so they can navigate the job market with a better salary. But since the premier campuses are now offering research-based job profiles - albeit still rarely – as well as extremely high salaries, the students take these jobs and opt for a PhD after a few years of job experience, instead of applying directly for a higher degree. This trend was apparent in all the IITs we observed.

The career prospects of students graduating with a CS degree depend more on the reputation of the institute where they have studied, than on the degree. Our landscape survey via interviews and desk research indicates that these premier campuses attract the highest paying job offers from companies, especially in computer science and students who graduate from them often move on to decision-making roles in those companies.

Very few companies have research-oriented roles, those being for students with higher (graduate) degrees, but some students - especially those with research interests and undergraduate research experience - may get these very rare offers.

3. FACTORS TO CONSIDER WHEN DESIGNING THE CHALLENGE

Very few courses directly support the promotion of responsible computing; the few courses on offer are almost entirely for graduate students, and at premier institutions.

Within the undergraduate curriculum, there are very few courses related to responsible computing. A few courses were identified at premier institutes like the IITs and IIITs, but most of these are offered as electives for graduate students and select senior undergraduate students. A few ethics courses specific to AI were also identified, though most of these take a technical approach to issues such as fairness, accountability, and transparency. A few of the premier technology institutes are also in the process of setting up graduate centres or courses on technology policy.

IIT Delhi has a course on technology ethics which senior undergrads can also attend, though interviews indicate it attracts a very small number of final year undergrads. The IIT Bombay CS department is planning to introduce a course on CS history. It also has an AI Policy course at its Centre for Policy Studies which looks at the ethical, regulatory, legal, and economic issues around data, algorithms and AI, which is popular among CS graduate students. However, this is a graduate level elective, not available to undergrads. IIT Kharagpur also has a technology ethics course for graduate students and senior undergraduates. NIT Durgapur has a course on technology ethics, but due to the pandemic it has not yet attracted many students into this elective.

Ethics courses at most non-premier institutes, mostly state level university colleges, are primarily about professional ethics. For example, a new BA in AI is slated to be launched at state universities next year and the new syllabus has one course on ‘Universal Human Values - Understanding Ethical Conduct’.

The conversation around responsible community is more vibrant outside traditional engineering departments. A few leading private, social science and humanity universities, such as Ashoka University, are planning to set up an interdisciplinary Centre on Data Science and Ethics. Technology policy think tanks, civic tech and civil society organisations and media publications regularly engage in public debate on the social impacts of technology, though there is far less discussion on upstream approaches to promote responsible innovation, computing, such as redesigning CS programmes and curricula.

Premier institutions are better equipped and structured to support the introduction of responsible computing curricula.

Curricula change in premier technology institutes like IITs, NITs and IIITs is decided at the level of the institutes’ internal governing bodies. It typically involves a consultative process with faculty and can be driven by faculty initiative. In contrast, in state universities, courses and curricula are determined through a centralised system at the

university level - it is not easy for changes to be initiated at the level of individual colleges or faculty. Universities have a much tighter level of control on course design and changes to programme and curricula are made only every few years.
Well-funded premier institutions like the IITs and IIITs have departments and faculty offering non-CS and engineering courses in social science, management, and other disciplines. Students are offered a wide range of electives in other disciplines and a multi-disciplinary faculty is available. IIIT Delhi for example has an elective on AI ethics which was possible to put together because it has professors from diverse humanities and social science backgrounds. A somewhat simplistic but useful pattern indicated by our research is that the more 'premier' the campus, the more electives it will have and the students will be able to experiment with those electives earlier in their four-year time.
There is also a lack of resources and trained academics outside premier institutes to develop and deliver these courses. Many smaller, less-funded technology institutes struggle to deliver high-quality programmes and attract faculty for even specialised or niche CS programmes. These universities generally do not have colleges specialising in multiple disciplines, especially the sort which lead to mature interdisciplinary work. Many CS colleges and technology institutes are primarily teaching campuses, and faculty are not engaged in research or pedagogy development.

Students are not incentivised to pursue courses on Responsible Computing.

Interviews with faculty suggest that uptake for humanities and social sciences courses is not very high among students at premier institutes. They believe that students select courses based on how they would impact their employment prospects, and courses about responsible computing are not perceived to be important for getting a job.

The job market does not seem to prioritise competencies in responsible computing. Most jobs are for 'service-based profiles' where students are batch-trained to perform specific backend tasks and are often interchangeable between projects. These jobs do not require competencies in responsible computing. A lot of the placement faculty we interviewed were of the opinion that companies care a lot for core competencies and analytical skills and not necessarily the perception of flashier technology like ML. Quantitative skills, verbal skills, and logical skills are in demand, along with good articulation.

Students from premier institutes tend to dominate recruitment for product-based profiles – these jobs could potentially have an interest in responsible computing understanding and skills, but this does not currently seem to be a requirement.

Faculty are sceptical about student uptake of such courses and the broader impact of such interventions.

Students often opt for humanities and social science courses thinking they will be easy to pass, and there is a chance that students will similarly look to 'game' new courses on responsible computing. Faculty also believe that many in the current student populations are not equipped to deal with the language of ethics. The quality of their high school education is variable, and most would not have been exposed to social science or

humanities concepts effectively. Some also felt that the emphasis on responsible computing could be perceived as elitist and not reflect what students want, namely, things to help them get a job.

Some faculty were also concerned that such siloed interventions could amount to ethics washing - with questions of ethics and social responsibility being reduced to how best to optimise algorithms for positive social outcomes rather than a meaningful engagement with the social and structural implications of software and emerging technologies. They also pointed out that such interventions would have limited value without broader training in critical reasoning and exposure to humanities and social science subjects for most students.

It is not common practice among universities and technology institutes for faculty to take time off to build course material. Were faculty to engage in designing a new course it would be during the summer break or alongside their regular teaching load during a term. One faculty member described it as a 'mindset issue.'

4. RECOMMENDATIONS

Team

Specify qualification criteria that prioritise interdisciplinary collaboration.

Elite campuses have the potential for interdisciplinary collaboration, experience with pedagogical research, and extant experiments with responsible computing or tech ethics courses. Professors at premier technology institutes have far greater agency and resources to conceptualise and deliver responsible computing courses. Hence, it would make the most sense to target these campuses.

While students from premier institutes make up only a small proportion of Indian CS graduates, many of these students tend to get prominent industry positions and are perceived as leaders in their field. Admission to these universities is considered aspirational and often associated with upward socio-economic mobility. As a result, these institutes also have broader cultural power and influence.

But, as targeting these institutes directly may be perceived as elitist or exclusionary, the Challenge could specify the below minimum qualification requirements instead:

- Team should comprise a **minimum of 2 faculty members from different disciplines -** one of whom must be from a CS department and the second from a social science discipline or technology policy
- Additional team members **need not be from academia;** the Challenge could encourage collaborating with technology policy and civil society organisations
- Team should be able to demonstrate **experience in interdisciplinary collaboration and research.** If research is not available, this could include events and media engagements around the social and policy issues pertaining to emerging technology

- The Challenge could target **junior CS faculty (**assistant or associate professors) as they are more actively involved in undergraduate education.
- The Challenge should target / invite applications from faculty, rather than institutions. Faculty at premier institutions can introduce new elective courses but at a university-college, the process would have to be initiated at the level of the university administration.

Courses

Design the Challenge in a way that balances student abilities and priorities with broader responsible computing priorities.

As it is much easier to add or modify electives, the challenge should focus on these rather than core courses.

The Challenge can accept proposals for three types of elective courses - each option entails trade-offs. As a general note, courses on AI are very popular among students – framing the Challenge in terms of AI and social good or AI and social impact could be attractive for students.

- **Courses focussed on making tools and techniques to make AI more explainable and robust.** Such courses are more accessible to the average undergraduate student and are perceived to be important for employment. However, such courses run the risk of reducing complex social problems to questions of algorithmic optimisation and are prone to 'ethics-washing'. Proposals must demonstrate a clear commitment to framing these tools as socio-technical instruments, helping students understand not only their benefits, but also their limitations.

- **Courses on data ethics, data science and privacy.** These courses are more accessible and desirable for students. To avoid a technical or instrumental approach to data science or privacy, proposals should include a clear awareness of the social ontology and epistemology of data and seek to help students understand data as a social science.

- **Social science courses on topics such as technology ethics, digital rights and technology policy.** These courses should have a strong interactive element - very theoretical courses are likely to be less popular. Courses linked to technology policy and current affairs may also attract more students. Faculty caution that courses on social impacts and policy and legal issues are likely to be lost on the average undergraduate student.

The Challenge could also be conceived as multiple sub-challenges, some to create more thorough and advanced level electives, some to design small modules which can be taught in workshops etc. It is better if the student is introduced to responsible computing through multiple vectors. The Challenge could require teams to propose a phased or gradational approach, with evaluation based on how many aspects of the students' learning arc the team addresses through these multiple sub-courses.

Scope

Challenge design should take into consideration institutional processes and term calendar, help grantees increase their visibility and networks and leverage the Mozilla brand.

- The grant size can be between **20000-25000 USD,** [calculated as average daily rate of associate faculty ($375) * number of person days (60)].

- The institute would typically deduct 30 percent from the faculty fee. Contracting and invoicing can also take up to 4-5 months due to slow bureaucratic processes. As faculty tend to be aware of these delays, work on many projects often starts even before the contracting and invoicing is in place.

- The point of entry for the challenge should be **faculty rather than institutions**. There are already examples of faculty collaborating across departments and across institutes. Applications from faculty from multiple institutions however may take longer in terms of contracting.

- At least some of the duration of the grant should include **the summer break** - most faculty spend at least some part of the summer preparing the upcoming course and will not get time off from their regular teaching schedule to work on this project.

- The Challenge should be **rolled out in stages, s**tarting with a pitch for course, its rationale and likely uptake. A smaller grant of 2000 USD could be awarded for this stage. Selected winners could then be provided **direct and ongoing support for pedagogical development** and curriculum design, including opportunities for peer learning and networks.

- Winners should be **supported to participate and present working at leading global and national conferences,** access to leading CS and other research communities.

- The Mozilla brand itself is a draw - the Challenge could also be **packaged as a fellowship**, which would also give the winner access to a broader Mozilla community and events.

- Mozilla could open internship opportunities for students in specific short-term projects on responsible computer science, in collaboration with these campuses and external companies. The Challenge itself could encourage participating teams to design contours of these projects, which can be further developed by Mozilla even after the Challenge has ended.

Incentives

Absence of a broader culture for pedagogical innovation makes it essential to find alternative levers to incentivise faculty.

- **Research publications** are important for junior faculty. Faculty can be incentivised to apply if the Challenge is part of a **broader research grant,** with curriculum development as one of the required outputs. At the minimum, the Challenge should enable faculty to produce a research publication.

- Faculty could also be incentivised by supporting **greater visibility of their work.** This could entail a range of interventions from support to delivering the module as an online course, to tying up with the CS curriculum accreditation board for state universities.

- Mozilla could also link up with leading global and national conferences on CS pedagogy and propose an o**pportunity to lead a workshop or even contribute to a journal edition.** The **prestige of presenting at a global conference** could be a draw for faculty.

The ACM India chapter hosts an annual conference on CS education called COMPUTE, where faculty present innovative ways of teaching and course design. The conference issues an annual call for papers and also hosts workshop sessions where faculty can share challenges and new approaches to teaching specific CS concepts.

Sustainability

For the Challenge to contribute to meaningful and sustained change, a community building approach is required that seeks to seed a broader cultural change.

- Seminars and workshops on responsible computing through campus placement cells can increase student interest. Placement cells can be supported with information about internship and job opportunities with leading technology companies that prioritise elements of responsible computing. Workshops targeted at students at college festivals and campus placement fairs could be important avenues for Mozilla to spread information about the Challenge and its broader objectives. We also recommend that Mozilla reaches out directly to placement officials in these campuses to conduct seminars and workshops on the issue of responsible computing.

- Our research shows that there is a small but eager community of academics interested in responsible computing. But they tend to be working in isolation and would benefit from building an academic community around this issue. These academics are also struggling to establish their credibility among their peers who are sceptical about responsible computing. Mozilla could help these nascent communities by supporting workshops, conferences and other networking events. Mozilla could also support sessions on responsible computing at already established conferences such as ACM India, COMPUTE, and the Annual Data Science Conference (CODS)

- For a larger policy push Mozilla would need to influence accreditation bodies like AICTE and UGC and university leadership bodies. This could be done by identifying faculty who are on the boards of these bodies, or who advise them, and who could also

act as champions for this Challenge. The head of the Bosch Centre for AI at IIT Madras, for example, could be one such champion.

- There is also a larger policy push toward building AI talent in India as well as AI for Social Good and Responsible AI. This could also provide a strategic entry point for Mozilla to introduce a discussion on Responsible Computung – the Ministry of IT for example organises an annual conference on Responsible AI and a new portal (india.ai) to celebrate India's progress on AI. Helping introduce a discourse around responsible computing in such spaces could be important for seeding a broader cultural shift.

- A recent study by CIIE identified 500-600 civic tech start-ups. The FOSS and technology policy communities also play an active role in public discussion and run various flagship conferences. Seeding responsible computing within these spaces could be an important lever. Partnerships or collaboration with organisations such as Has Geek, Civic Data Labs, Tattle, Agami, and E-Gov Foundation could help socialise the idea of responsible computing among a wider audience. Many of these organisations are also directly engaged in building civic tech products for public service delivery and citizen engagement.

ENDNOTES

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