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The AI & Data Science Workforce

The State of Higher Education in India and an Overview of the U.S. Landscape

August 2022

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Indo-US Science and Technology Forum

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FOREWORD

Artificial Intelligence (AI) and Data Science (DS) tools and technologies are fundamentally transforming society and impacting how we live and work. These new technologies are driving the Fourth Industrial Revolution or Industry 4.0 just like the steam engine and electricity powered the Industrial Revolution in the 18th century. The current and future workforce will need to acquire AI and data science knowledge, skills, and competencies to be ready for Industry 4.0 careers.

The Center for Security and Emerging Technology report published in October 2021 estimates the AI workforce in the U.S. to be 14 million, approximately 9 percent of total U.S. employed, and predicts that number will grow exponentially in the coming years. In India, NASSCOM forecasted in 2020 that the demand for digital skills, that includes AI and data science, was likely to grow over 20 times by 2024-25, and more than 4 million professionals were expected to be trained by that time.

Educational institutions and industry have an important responsibility to make this workforce transformation happen. The Indo-U.S. Science and Technology Forum's (IUSSTF) U.S. India Artificial Intelligence (USIAI) initiative provides a platform for Indian and U.S. stakeholders from academia, industry and the government, to identify opportunities for bilateral AI R&D collaboration, share ideas for developing an AI Workforce, and recommend modes and mechanisms for catalyzing partnerships.

Under the USIAI "AI Workforce" track, itihaasa Research and Digital is partnering with IUSSTF to identify emerging research areas in AI and data science, define knowledge and skills needed for different AI careers, address program and curriculum development at different levels of higher education, and identify infrastructure and resources required by higher education institutions to offer programs in AI and data science.

We carried out a first-of-its-kind survey on the Indian higher education landscape in AI and data science in partnership with the National Programme on Technology Enhanced Learning (NPTEL) and the Association for Computing Machinery (ACM) India. A total of 113 institutions, representing a diverse mix of public and private educational institutions in India, responded, and the survey results and analyses are available in this report.

We have also provided an overview of curriculum development initiatives in the U.S. and Europe to provide a benchmark for the AI Workforce track. As next steps, we have identified several action items to engage the broader stakeholder community in these efforts. We are putting the first of these plans into action in the form of an Indo-U.S. Visioning Workshop on "Developing a Diverse, Robust AI Workforce" in collaboration with the Indian Institute of Science, to be held in Bengaluru, India on 10-11, Aug 2022.

We hope this report will lead to more substantive conversations, catalyze the community, and lead to successful Indo-U.S. collaborations in AI and data science workforce development.

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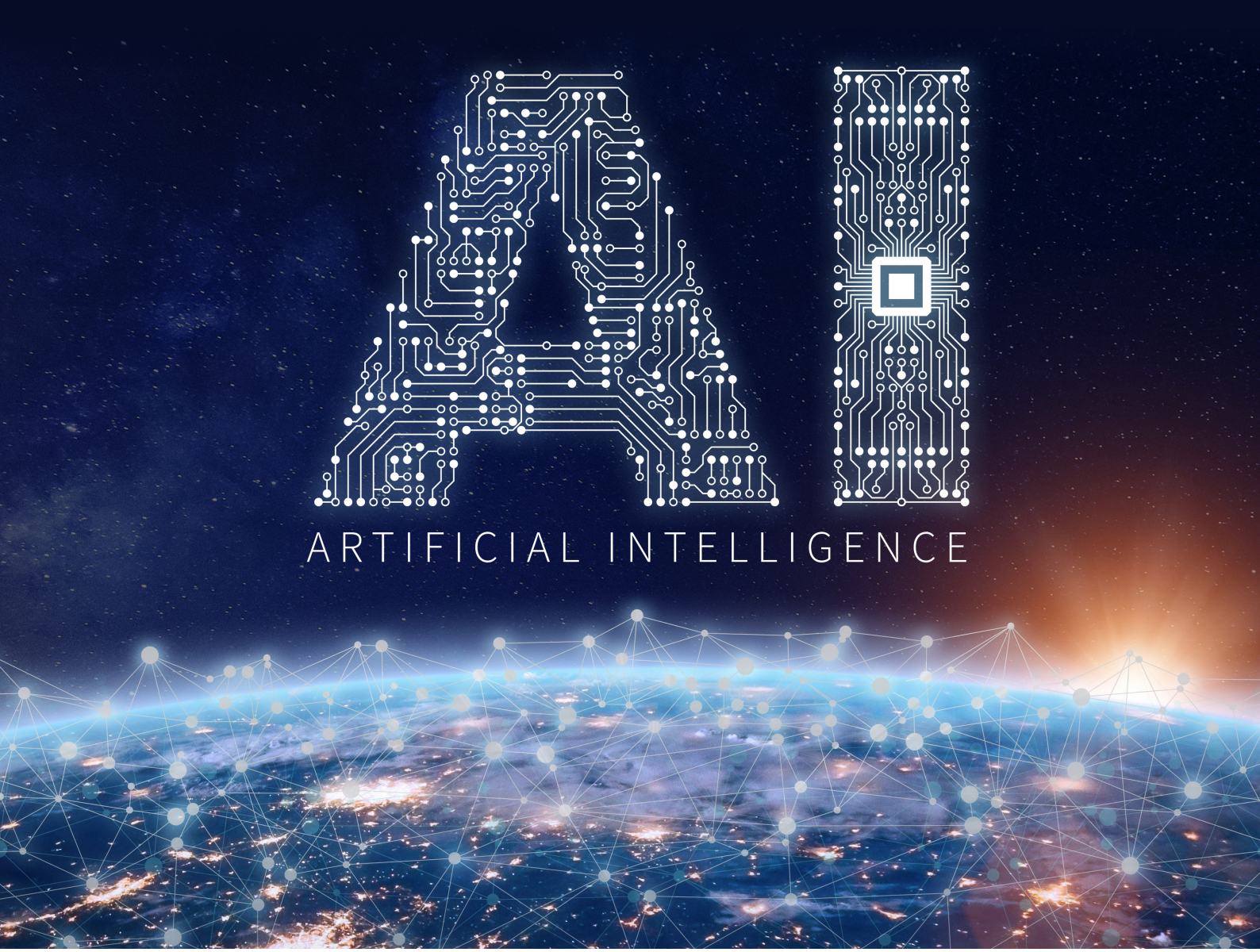


01 INTRODUCTION

The information age that began in the middle of the 20th century led to rapid advances in computing capabilities, capacity, and communications infrastructure, including innovations in hardware, algorithms, systems, and tools, and to the development of new technologies and products including instruments, communication devices, and sensors. Access to computing power and these new technologies combined with the decreasing costs of data acquisition and storage have resulted in the generation and collection of vast amounts of data from different sources across science, industry, and government. The need to leverage and draw insights from these massive data have led to fundamental breakthroughs in deep learning and natural language processing that are driving the AI revolution in the 21st century.

The availability of big data, including public health, demographic, and economic data from governments and agencies, geospatial data from satellites, financial and transactional data from companies, clinical and biomedical

data from hospitals, social media data, and streaming data from the Internet-of-Things, is driving AI innovation, adoption, and implementation in many sectors of the economy. From leveraging deep learning to facilitate the development of new vaccines and repurposing of drugs, automated diagnoses of diseases using images, discovery of new materials through machine learning, real-time weather forecasting and prediction of extreme events, precision agriculture and personalized learning, and autonomous vehicles, Data Science and AI tools and technologies are enabling breakthroughs in many fields of science and engineering, leveraging these scientific breakthroughs to accelerate progress on pressing societal challenges such as public health and climate change, and fundamentally transforming the global economy.

The 2022 AI Index Report published by the Stanford Institute for Human-Centered Artificial Intelligence shows that global corporate investment in AI increased from USD 119.5 billion in 2020 to USD 176.5 billion in 2021 [1]. Private investment in 2021 was USD 93.5 billion, more than double the total in the previous year, with the top five sectors being (i) data management, processing, and cloud, (ii) medical and healthcare, (iii) fintech, (iv) AV, and (v) semiconductors.

As AI tools and technologies become ubiquitous across different sectors, the demand for individuals with a wide range of technical and data skills will continue to increase. The AI workforce will include careers across different application domains requiring a range of skills from coding, visualization, modelling and data analysis, software engineering, to cutting-edge research and development of

the next generation of tools and technologies. Gelhaus et al. define the AI Workforce as "the set of occupations that include people who are qualified to work in AI or on an AI development team, or have the requisite knowledge, skills, and abilities (KSAs) such that they could work on an AI product or application with minor training" [2].

While AI is often viewed as a field within Computer Science, there is an advantage to viewing AI through an interdisciplinary lens, recognizing the role that linguistics, biology, cognitive sciences, psychology, mathematics, and statistics play in the development of new tools and technologies [3]. This holistic view can spur the development of innovative, interdisciplinary programs that train the next generation of researchers enabling breakthroughs in many fields of science and engineering.

Developing a diverse, globally-engaged AI workforce will require significant investments in infrastructure through public-private partnerships. Academic institutions, industry, government agencies, and private foundations must come together to support the development of innovative education pathways for students, new interdisciplinary programs that emphasize applications, and training initiatives to upskill the existing workforce.

1.1 The AI Workforce in India

India is young and ambitious. With approximately 63 % of the population in the 15-59 age group, India has one of the youngest populations in the world. This demographic dividend will require major investments in skill development and the creation of an enabling ecosystem to ensure India's young citizens are ready to enter the highly-skilled, technology driven workforce.

According to NASSCOM, the Indian IT industry including e-commerce has a relative share of about 9% of India's GDP, and was estimated at USD 306 billion in FY 2022 [4]. Out of this, exports contributed to about USD 178 billion. Indian IT, which is probably India's largest employer of undergraduates and graduates, provides employment to about 5 million professionals. The Indian IT sector added about 2,25,000 employees during FY 2022.

In 2020, NASSCOM forecasted that the demand for digital skills that includes AI/DS is likely to grow 20X times by 2024 [5]. Global spending on AI is expected to cross USD 500 billion in 2023 [6]. With AI and DS among the largest drivers of IT spending globally, this translates into a huge opportunity for the IT industry in India. The Indian IT industry is already on a war footing to skill its workforce. It is estimated that about 200,000 IT professionals were skilled on digital technologies in 2019-20, and more than 4 million professionals are expected to be trained in digital skills between 2020 and 2025. There is also an increasing demand for AI/DS educated workforce in startups and all other domains of Indian industry.

As the demand for technical and data skills increase, the Data Science Education market in India is estimated to grow from USD 103 million in 2020 to USD 626 million by 2025 [7]. Indian policy makers and industry groups are certainly cognizant of these trends, with AI and Data Science representing critical focus domains for India's workforce development. India's New Education Policy (2020) acknowledges the importance of these emerging fields right at the beginning [8],

"The world is undergoing rapid changes in the knowledge landscape. With various dramatic scientific and technological advances, such as the rise of big data, machine learning, and artificial intelligence, many unskilled jobs worldwide may be taken over by machines, while the need for a skilled workforce, particularly involving mathematics, computer science, and data science, in conjunction with multidisciplinary abilities across the sciences, social sciences, and humanities, will be increasingly in greater demand."

NITI Aayog in its National Strategy for Artificial Intelligence discussion paper estimates that AI has the potential to add about USD 1 trillion to the Indian economy by 2035 [9]. Prominent among this paper's recommendations is a focus on workforce education and training. Indian higher education institutions are responding to the call to action, launching new programs at all levels. Some examples include:

- IIT Madras launched the world's first online B.Sc. in programming and data science in 2020, and announced a 4-year BS in 2022.
- IISc announced a foundational B.Tech. program in Mathematics and Computing in 2022. The interdisciplinary program leverages expertise across the institute to encourage cross-domain research and offers different specializations.
- IIM Bangalore has started an MBA programme in business analytics that is based on a "DS + X" paradigm [10]. The objective is the innovative application of analytics to solve management problems from different industries such as aerospace, banking and finance, healthcare, insurance, manufacturing, pharmaceutical, retail, services, software, sports, etc.

Private philanthropy is also focusing on AI and data science education. One example is the Bhupat & Jyoti Mehta Family Foundation investments in the Mehta Family School of Data Science and Artificial Intelligence at the Indian Institute of Technology Guwahati and the Indian Institute of Technology Roorkee. In addition to the institutions listed above, a number of public and private institutions have recently launched, or are planning to launch programmes in AI, Data Science, or related areas.

itihaasa's study on the landscape of AI and Machine learning (ML) research in India highlights the need to ramp up graduate and undergraduate level education and provides some recommendations on potential pathways to train students [11]. These include:

1. Summer schools on AI/DS for research-oriented students.
2. Real world driven competitions / hackathons on AI/DS. Provide India-specific problems that include need for data acquisition as well.
3. Undergraduate final year project - students should be encouraged to participate in a national level AI/DS solution development challenge. India should create a platform that offers problems and data and the winners should be promoted on social media so that there is a pull created to participate in such projects.

Government Agencies have also launched new initiatives to support R&D and training. The Indian

Government launched the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS) to "create a strong foundation and a seamless ecosystem for CPS technologies by coordinating and integrating nationwide efforts encompassing knowledge generation, human resource development, research, technology and product development, innovation and commercialization." Under the NM-ICPS, the Department of Science and Technology has funded over 25 Technology Innovation Hubs (TIH) with a total five-year investment of INR 3200 crore (USD 430 million). The National Skill Development Mission is collaborating with NASSCOM on AI skilling and with IBM on a Train-the-Trainer program in Artificial Intelligence.

1.2 The AI Workforce in the United States

The United States is recognized as the global leader in AI with a long history of public and private investments in academic and industrial scientific research. The innovation ecosystem includes technology hubs in Silicon Valley, Research Triangle, Boston, and New York, top public and private research institutions including Stanford, Massachusetts Institute of Technology, Carnegie Mellon, and the University of California Berkeley just to name a few. According to the 2022 AI Index Report, overall U.S. AI private investment totalled approximately USD 52.9 billion, over three times that of second ranked China [1]. The United States also led in several key metrics including the number of newly funded AI companies. The Center for Security and Emerging Technology report published in October 2021 estimates the AI workforce in the U.S. to be 14 million, approximately 9% of total U.S. employed. The report also states that the U.S. AI workforce grew at a rate of 21% over the period 2015-2019 compared to an overall 6% rate and predicts demand for AI-related professions "will likely be strong over the next decade, projected to grow twice as fast as for all U.S. occupations [2]."

The U.S. Congress established the National Artificial Intelligence Initiative (NAII) "to ensure continued U.S. leadership in AI R&D; lead the world in the development and use of trustworthy AI systems in public and private sectors; prepare the present and future U.S. workforce for the integration of artificial intelligence systems across all sectors of the economy and society; and coordinate ongoing AI activities across all Federal agencies, to ensure that each informs the work of others." The National Artificial Intelligence Research And Development Strategic Plan released by the White House Office of Science and Technology Policy (OSTP) notes that "It is critical to maintain a robust academic research ecosystem in AI that, in collaboration with industry R&D, can continue to deliver tremendous dividends by advancing national health, prosperity, and welfare, and securing the national defense." The document further adds that "Federal agencies must therefore continue to strategically foster expertise in the AI R&D workforce that spans multiple disciplines and skill categories to ensure sustained national leadership [12]."

U.S. Academic Institutions have been leading the way in the development of new programs in AI and Data Science. Some examples are listed below:

» Carnegie Mellon University offers a number of different degree programs to prepare students to "Create the AI of the Future". Some of the unique offerings include graduate

degrees in Human-Computer Interaction, Robotics, Language Technologies, Artificial Intelligence and Innovation, and an undergraduate degree in Computational Biology.

- The University of California, Berkeley offers an undergraduate degree in Data Science with curricula that cuts across Computer Science, Statistics, Humanities, and the Social Sciences. Data 8: The Foundations of Data Science course was one of the early attempts to integrate computational and inferential thinking. The course has been replicated in other institutions.
- The Institute for Advanced Analytics at North Carolina State University was the first institution in the U.S. to offer a Master of Science in Analytics. The program offers a unique, innovative curriculum that requires students to work on problems provided by industry and government agencies.

U.S. Institutions are launching programs at all levels, including AI associate degree programs at community colleges.

The report "A 20-Year Community Roadmap for Artificial Intelligence Research in the U.S." notes that "Comprehensive changes need to be undertaken in order to restructure and train a diverse AI workforce to prepare highly skilled researchers and innovators [3]." Some of the recommendations for training a diverse workforce include

- Development of guidelines for professional programs/ certifications
- Interdisciplinary AI Training: programs to train students for careers at the interface of AI and other disciplines.
- The need to incorporate ethics training

The National Science Foundation launched the National AI Research Institutes program in 2019, supporting the establishment of "national nexus points for collaborative efforts spanning institutions of higher education, federal agencies, industry, and nonprofits/foundations" that would "accelerate the transition of AI innovations into many economic sectors, and nurture and grow the next generation of talent." The program is a partnership with several Federal Agencies and private companies including Google, Amazon, Intel, and Accenture.

1.3 The India-United States Partnership

Across the world, countries are developing frameworks and policies to leverage the power and potential of AI to serve the needs of their citizens while at the same time grappling with issues of ethics, privacy, access, and the impact of new technologies and automation on the workforce.

The Indian and U.S. Governments have developed comprehensive strategic plans on AI that (a)

identify priority areas for investment in research and infrastructure, (b) highlight the need for workforce development, (c) address the role of partnerships to accelerate progress, and (d) highlight the need for policies and guidelines that address data sharing, benchmarking, ethics and values, and privacy.

India's "National Strategy for Artificial Intelligence" prepared by Niti Aayog identified key sectors where AI tools and technologies could yield significant societal impact and developed a series of recommendations to address critical R&D and workforce issues [9]. The National Artificial Intelligence Research And Development Strategic Plan: 2019 Update released by the White House Office of Science and Technology Policy (OSTP) identified strategic priorities and challenges [12].

A summary of the key takeaways from the two reports is provided below:

Table 1: NITI Aayog Report – Focus Areas and Recommendations

Focus Areas :	
1.	**Healthcare:** increased access and affordability of quality healthcare;
2.	**Agriculture:** enhanced farmers' income, increased farm productivity and reduction of wastage;
3.	**Education:** improved access and quality of education;
4.	**Smart Cities and Infrastructure:** efficient and connectivity for the burgeoning urban population;
5.	**Smart Mobility and Transportation:** smarter and safer modes of transportation and better traffic and congestion problems
Recommendations :	
»	**Research:** Incentivising Core and Applied research in AI
»	**Skilling for the AI age:** Getting India ready for the AI wave
»	**Accelerating Adoption:** AI across the value chain
»	**Ethics, Privacy, Security and Artificial Intelligence:** Towards a "Responsible AI"

Table 2: National AI R&D Strategic Plan: 2019 Update - Priorities

1.	Make long-term investments in **AI research.**
2.	Develop effective methods for human-AI collaboration.
3.	Understand and address the **ethical, legal, and societal** implications of AI.
4.	Ensure the **safety and security** of AI systems.
5.	Develop shared **public datasets** and **environments** for AI training and testing.
6.	Measure and evaluate AI technologies through **standards** and **benchmarks.**
7.	Better understand the national **AI R&D workforce needs**.
8.	Expand **public-private partnerships** to accelerate advances in AI.

The need for investments in AI R&D, workforce development, research data infrastructure, and public-private and international collaborations are priorities for both governments.

Science and Technology form the cornerstone of the strategic partnership between India and the

The genesis of Indo-U.S. collaboration in AI workforce development

The first course on AI in an Indian educational institution is believed to have been introduced in IIT Kanpur in the late 1960s, when H.N. Mahabala returned from his sojourn at MIT, U.S., where he had interacted with Marvin Minsky, one of the early pioneers of AI (but a very different kind of AI from what we have today).

Source: itihaasa, Research and Digital, 'Landscape of Artificial Intelligence / Machine Learning Research in India', 2018.

United States. From the creation of the Indian Institute of Technology, Kanpur with the assistance of a consortium of nine U.S. research universities in 1960, to joint collaborations in areas such as Space, Energy, Agriculture, and Healthcare, to the large numbers of Indian students who pursue advanced degrees in Science and Engineering at U.S. Institutions, these partnerships have strengthened over the years. The Indian diaspora in the U.S. includes leaders within the tech industry, faculty at the top U.S. academic institutions, and leading researchers in the health and biomedical fields. Top U.S. companies have large operations in India, including R&D facilities, leveraging the incredibly talented pool of engineers and quantitatively trained graduates from Indian universities.

The Indo-U.S. Science and Technology Forum (IUSSTF), a binational foundation, was established by the two Governments in 2000 to promote, catalyze and seed S&T cooperation between India and the United States. IUSSTF is uniquely positioned to proactively engage the S&T communities by identifying "leading edge areas" that are high-priority for both nations, bringing together key stakeholders to help create synergies, and supporting workshops/ networking opportunities to initiate new collaborations.

Recognizing the promise and potential of AI, IUSSTF launched the U.S. - India Artificial Intelligence (USIAI) Initiative, a unique opportunity for the world's two largest democracies to strengthen their strategic partnership by focusing on AI cooperation in critical areas that are priorities for both countries. USIAI will serve as a platform to discuss opportunities for bilateral AI R&D collaboration, identify key challenges and barriers to adoption of AI, share ideas for developing an AI workforce, and recommend modes and mechanisms for catalyzing partnerships.

IUSSTF is partnering with itihaasa Research and Digital (https://itihaasa.com/), a not-for-profit, organization that studies the evolution of technology and business domains in India, on a series of activities in the area of Education, Training, and Workforce Development under the USIAI umbrella. With AI workforce development a priority for both countries, the USIAI platform will allow Indian and U.S. academic institutions to come together to share best practices for education and program development, identify synergies for collaborative research and training including faculty and student exchange, and address the challenges associated with developing a diverse, robust AI workforce.

In May 2022, Prime Minister Modi and President Biden welcomed the launch of the United States–India Initiative on Critical and Emerging Technologies (iCET) to expand partnership in these strategic areas. With AI being a priority for both the United States and India, a partnership between our

two democracies can lead to a strategic framework for AI that conforms to the shared values of openness, transparency, and reciprocity and encourages responsible innovation that will benefit both countries.

This report focuses on AI and Data Science higher education initiatives. The second chapter provides an overview of the AI/DS initiatives and their outcomes in the U.S. and Europe. The third chapter presents the key results of a first of a kind survey on the landscape of AI/DS higher education in India. The final chapter of the report presents key action plans in the form of key next steps to be undertaken.

02 Summary of the Global AI and Data Science Education Landscape

There have been a number of efforts led by professional societies, industry groups, and foundations to address AI and Data Science training and curriculum development at different levels. Section 2.1 provides a summary of Data Science knowledge and skills and curriculum guidelines for undergraduate programs. In Section 2.2, we describe some recent efforts at defining an AI curriculum.

2.1 Data Science

While there is no unique definition, there is consensus that Data Science is a new discipline, an interdisciplinary field that leverages principles and tools from computer science, mathematics, and statistics to draw insights from data. The Royal Society in its report, *Dynamics of Data Science Skills*, notes that "there is a wide variety of skills under the label 'data science' and people with relevant skills may associate with other disciplines [13]." In recent years, we have seen the emergence of new programs at the interface of the computational sciences and specific application domains, including Biomedical Data Science and Social Data Science.

2.1.1 Association for Computing Machinery (ACM): Computing Competencies for Undergraduate Data Science Curricula, ACM Data Science Task Force (2021)

The ACM Report recognizes Data Science as an "inherently interdisciplinary field" that brings together "domain data, computer science, and the statistical tools for interrogating the data and extracting useful information [14]." The report defines the following computing-focused Knowledge Areas (KAs) for Data Science:

1. Analysis and Presentation (AP)
2. Artificial Intelligence (AI)
3. Big Data Systems (BDS)
4. Computing and Computer Fundamentals (CCF)
5. Data Acquisition, Management, and Governance (DG)
6. Data Mining (DM)
7. Data Privacy, Security, Integrity, and Analysis for Security (DP)
8. Machine Learning (ML)

9. Professionalism (PR)

10. Programming, Data Structures, and Algorithms (PDA)

11. Software Development and Maintenance (SDM)

The report goes on to add that "the above KAs need to be augmented with competencies in calculus, discrete structures, probability theory, elementary statistics, advanced topics in statistics, and linear algebra, among others. A complete curriculum would also include at least one domain context for application of data science concepts and methods." The table below, excerpted from the report, provides a breakdown of the KAs in terms of sub-domains.

Table 1 : Computing Data Science Knowledge Areas (with sub-domains)

Analysis and Presentation
- Foundational considerations
- Visualization
- User-centered design
- Interaction design
- Interface design and development

Artificial Intelligence
- General
- Knowledge representation and reasoning - logic based.
- Knowledge representation and reasoning - probability based
- Planning and search strategics

Big Data Systems
- Problems of scale
- Big data computing architectures
- Parallel computing frameworks
- Distributed data storage
- Parallel programming
- Techniques for Big Data applications
- Cloud computing
- Complexity theory
- Software support for Big Data applications

Computing and Computer Fundamentals
- Basic computer architecture
- Storage systems fundamentals
- Operating system basics
- File systems
- Networks
- The web and web programming
- Compilers and interpreters

Data Acquisition, Management, and Governance
- Data acquisition
- Information extraction
- Working with various types of data
- Data integration
- Data reduction and compression
- Data transformation
- Data cleaning
- Data privacy and security

Data Mining
- Proximity measurement
- Data preparation
- Information extraction
- Cluster analysis
- Classification and regression
- Pattern mining
- Outlier detection
- Time series data
- Mining web data
- Information retrieval

Data Privacy, Security, Integrity, and Analysis is for Security
- Data privacy
- Data security
- Data integrity
- Analysis for security

Machine learning
- General
- Supervised learning
- Unsupervised learning
- Mixed methods
- Deep learning

Professionalism
- Continuing professional development
- Communication
- Team Work
- Economic considerations
- Privacy and confidentialily
- Ethical considerations
- Legal considerations
- Intellectual property
- On automation

Programming, data structures and algorithms
- Algorithmic thinking and problem solving
- Programming
- Data structures
- Algorithms
- Basic complexity analysis
- Numerical computing

Software development and maintenance
- Software design and development
- Software testing

The ACM report is comprehensive, providing a detailed description of topics within each of the sub-domains and highlighting the associated skills that students will acquire through well-defined learning outcomes. The report also addresses some of the challenges for institutions developing new programs, including recruitment of faculty and access to resources.

2.1.2 Park City Report, U.S. (2017)

The Park City Math Institute (PCMI) convened a group of computer science, mathematics, and statistics faculty to develop curriculum guidelines for undergraduate Data Science programs [15]. The report emphasizes the critical role of data, noting that the "recursive data cycle of obtaining, wrangling, curating, managing and processing data, exploring data, defining questions, performing analyses, and communicating the results lies at the core of the data science experience."

The report identifies the following key competencies for an undergraduate Data Science major:

- Computational and statistical thinking
- Mathematical foundations
- Model building and assessment
- Algorithms and software foundation
- Data curation
- Knowledge transference – communication and responsibility

The document also provides the following curricular content designed to help students acquire the skills and competencies listed above:

- **Introduction to Data Science I and II:** Introduction to high-level language; Exploring and manipulating data; Functions and basic coding; Introduction to modelling, both deterministic and stochastic; Concepts of projects and code management; Databases; Introduction to data collection and statistical inference
- **Mathematical Foundations I and II:** Mathematical structures; Linear modeling and matrix computation; Optimization; Multivariate thinking; Probabilistic thinking and modeling

- **Computational thinking**
  - **Algorithms and Software Foundations:** Algorithm design; Programming concepts and data structures; Tools and environments; Scaling for big data
  - **Data Curation—Databases and Data Management:** Apply Data query languages to relational databases; Data management including cleaning and initial structuring; Transforming data into structured forms required for exploration, visualization, and analysis
- **Statistical thinking:**
  - **Introduction to Statistical Models:** Exploratory data analysis approaches and graphical data analysis methods; Estimation and testing; Simulation and resampling; Introduction to models; Introduction to model selection and performance
  - **Statistical and Machine Learning:** Further exploration of alternatives to classical regression and classification; Algorithmic analysis of models, addressing issues of scalability and implementation; Performance metrics and prediction, and cross validation; Data transformations; Supervised learning versus unsupervised learning; Ensemble methods (e.g., boosting, bagging, and model averaging)
- **Course in an outside discipline**
- **Capstone Course:** A capstone experience in which students consider scientific questions, collect and analyze data and communicate the results

While the content described above may be found in traditional mathematics, computer science, and statistics courses, the PCMI report recognizes the potential synergies that may result from "interweaving and integration of traditionally siloed topics and tools into a cohesive presentation."

2.1.3 National Academies Report on Data Science for Undergraduates, U.S. (2018)

The National Academies conducted a study, sponsored by the National Science Foundation, to "set forth a vision for the emerging discipline of data science at the undergraduate level" [16]. While the study did not specifically focus on curricular guidelines, it explored the types of data science skills essential for current undergraduates as well as the future data science workforce, identified some of the challenges of starting a new data science program, and highlighted the need for multiple pathways.

The report underscores the need to instil data acumen as part of the education of all data scientists, and identifies the following concepts as key to developing data acumen:

- Mathematical foundations
- Computational foundations

- Statistical foundations
- Data management and curation
- Data description and visualization
- Data modelling and assessment
- Workflow and reproducibility
- Communication and teamwork
- Domain-specific considerations
- Ethical problem solving.

Some of the key recommendations from the study include:

- Academic institutions should embrace data science as a vital new field that requires specifically tailored instruction delivered through majors and minors in data science as well as the development of a cadre of faculty equipped to teach in this new field.
- Academic institutions should provide and evolve a range of educational pathways to prepare students for an array of data science roles in the workplace.
- To prepare their graduates for this new data-driven era, academic institutions should encourage the development of a basic understanding of data science in all undergraduates.
- Ethics is a topic that, given the nature of data science, students should learn and practice throughout their education. Academic institutions should ensure that ethics is woven into the data science curriculum from the beginning and throughout.
- As data science programs develop, they should focus on attracting students with varied backgrounds and degrees of preparation and preparing them for success in a variety of careers.
- Academic institutions should ensure that programs are continuously evaluated and should work together to develop professional approaches to evaluation. This should include developing and sharing measurement and evaluation frameworks, data sets, and a culture of evolution guided by high-quality evaluation. Efforts should be made to establish relationships with sector-specific professional societies to help align education evaluation with market impacts.
- Existing professional societies should coordinate to enable regular convening sessions on data science among their members. Peer review and discussion are essential to share ideas, best practices, and data.

2.1.4 EDISON Data Science Framework project, Europe (2017)

EDISON, a EU-funded project comprising seven partners from six different countries across Europe, was tasked with "accelerating the creation of the Data Science profession" by "aligning industry needs with available career paths, and supporting academies in reviewing their curricula with respect to expected profiles, required expertise and professional certification [17]." The resulting EDISON Data Science Framework includes a series of four documents addressing Data Science Competences Framework, Data Science Body of Knowledge, Data Science Model Curriculum, and Data Science Professional Framework.

The Data Science Body of Knowledge builds on guidelines from other disciplines including Computer Science, Business Analytics, Software Engineering, Data Management and Project Management, and identifies Knowledge Area groups (KAG) and corresponding Knowledge Areas that may be used to develop both undergraduate and graduate programs in Data Science.

Table 2: EDISON Knowledge Area groups and Knowledge Areas

KA Groups	Suggested DS Knowledge Areas (KA)
KAG1-DSDA Data Science Analytics	Statistical methods for data analysis Machine Learning Data Mining Text Data Mining Predictive Analytics Computational modelling, simulation and optimisation
KAG2-DSENG Data Science Engineering	Big Data Infrastructure and Technologies Infrastructure and platforms for Data Science applications Cloud Computing technologies for Big Data and Data Analytics Data and Applications security Big Data systems organisation and engineering Data Science (Big Data) applications design Information systems (to support data driven decision making)
KAG3-DSDM Data Management	General principles and concepts in Data Management and organisation Data management systems Data Management and Enterprise data infrastructure Data Governance Big Data storage (large scale) Digital libraries and archives

KAG4-DSRM: Research Methods and Project Management	Research Methods Project Management
KAG5-DSBPM: Business Analytics	Business Analytics Foundation Business Analytics organisation and enterprise management

The documents provide a detailed roadmap for stakeholders from academia and industry "to construct their own structured solutions for educating, training, certifying, recruiting, managing, and otherwise supporting data scientists and other data-dependent professionals."

2.1.5 Computing Curricula 2020 (CC2020)

The CC2020 initiative, led by the Association for Computing Machinery (ACM) and the IEEE Computer Society (IEEE-CS), was launched "to summarize and synthesize the current state of curricular guidelines for academic programs that grant baccalaureate-level degrees in computing as well as propose a vision for future curricular guidelines [18]." The report 'Computing Curricula 2020 (CC2020): Paradigms for Global Computing Education' provides a framework to compare and contrast existing curricular guidelines for the following computing disciplines: computer engineering, computer science, information systems, information technology, software engineering, cybersecurity and data science (under progress).

The report identifies cloud computing, smart cities, sustainability, parallel computing, internet of things, and edge computing as "current curricular areas", and the following top-ten emerging computing trends (I) Deep learning (DL) and Machine Learning (ML); (II) Digital Currencies; (III) Blockchain; (IV) Industrial IoT; (V) Robotics; (VI) Assisted Transportation; (VII) Assisted/augmented reality and virtual reality (AR/VR); (VIII) Ethics, laws, and policies for privacy, security, and liability; (IX) Accelerators and 3D; (X) Cybersecurity and AI.

The report recommends a transition from a knowledge-based to a competency-based learning framework and highlights the "need for industry engagement to formulate workplace competencies".

2.1.6 Other Related Initiatives

The Institute for Operations Research and the Management Sciences (INFORMS) provides guidelines for Analytics program focusing primarily on the needs of Business. These programs typically do not require higher level Mathematics courses. Wilder and Ozgur define knowledge and skills for an undergraduate program in analytics and develop a curriculum for a proposed Business Analytics Program [19]. Courses include

- Data Management
- Descriptive Analytics
- Data Visualization
- Predictive Analytics

- Prescriptive Analytics
- Data Mining
- Analytics Practicum

The INFORMS Certified Analytics Professional (CAP) is a global professional certification that provides "an independent verification of the critical technical expertise and soft skills sought by employers across all organizations and industry sectors." Applicants must have a bachelor's degree (or master's degree) in an Analytics related field with 5 (3) years of experience. The exam covers knowledge, skills, and abilities (KSAs) in the following seven domains:

- Business Problem Framing
- Analytics Problem Framing
- Data
- Methodology Selection
- Model Building
- Deployment
- Lifecycle Management

Summary:

Each of the reports/ studies discussed above views Data Science through its unique disciplinary lens. ACM not surprisingly focuses on Computer Science while the Park City report focuses on Mathematics and Statistics. The CC2020 report highlights computing knowledge and skills and the EDISON report focuses on training data science professionals, emphasizing areas such as Data Science Engineering and Business Analytics. The National Academies Study takes a holistic, high-level view of the emerging discipline of Data Science, emphasizing the need to "prepare diverse students for various careers."

Despite the different perspectives, there are a number of common threads:

- While the technical requirements may vary for different data science pathways, it is important for students to have some knowledge of the core disciplines of Computer Science, Mathematics, and Statistics that form the foundations of Data Science
- Students must understand the entire data life cycle from data generation and collection all the way through analysis and interpretation. Access to real-world data and applications is also a critical component of the training.
- Ethics training must be included as part of any Data Science curriculum.

- Communication and Teamwork must be emphasized.
- Given the landscape is constantly evolving, Data Science programs must adapt their curriculum to remain current and address the needs of the future workforce.

2.2 AI

The report, *A 20-Year Community Roadmap for Artificial Intelligence Research in the US*, views AI "as a branch of computer science that studies the properties of intelligence by synthesizing intelligence." However, the report acknowledges that the term AI "has become a colloquial term that is used very loosely" and often "equated with machine learning, and specifically with learning from large amounts of data in order to make predictions [3]." The European Commission's High-Level Expert Group on AI provided the following operational definition of AI [20]:

Artificial intelligence (AI) systems are software (and possibly also hardware) systems designed by humans that, given a complex goal, act in the physical or digital dimension by perceiving their environment through data acquisition, interpreting the collected structured or unstructured data, reasoning on the knowledge, or processing the information, derived from this data and deciding the best action(s) to take to achieve the given goal. AI systems can either use symbolic rules or learn a numeric model, and they can also adapt their behaviour by analysing how the environment is affected by their previous actions

2.2.1 AI Undergraduate Programs

Since no formal "professionally-endorsed" curriculum guidelines exist for undergraduate programs in AI, we compared the curriculum for three programs, one each from China, the United States, and India:

- Nanjing University of Information Science and Technology (NUIST), one of the 35 institutions approved by China's Ministry of Education in 2019 to offer a four-year AI major.
- Carnegie Mellon University, the first U.S. institution to introduce a Bachelor's degree in AI in 2018.
- Indian Institute of Technology, Hyderabad, possibly the first Indian institution to introduce the B. Tech degree in AI.

The curriculum for the three programs is summarized below. We have not included general education requirements, specialized courses, or electives from other disciplines.

	China	United States	India
CORE	» Advanced Mathematics » Probability and Statistics » Python Programming » Data Structure and Algorithms » Machine Learning » Optimization » Computer Vision and Pattern Recognition » Neural Networks and Deep Learning » Introduction to Artificial Intelligence » Natural Language Processing » Digital Image Processing » Information Retrieval and Data Mining	» Mathematics » Statistics » Principles of Imperative Computation » Principles of Functional Programming » Parallel and Sequential Data Structures and Algorithms » Introduction to Computer Systems » Concepts in Artificial Intelligence » Introduction to AI: Representation and Problem Solving » Introduction to Machine Learning » Introduction to Natural Language Processing / Computer Vision » Ethics Elective » Cognitive Science / Cognitive Psychology	» Mathematics » Statistics » Introduction to Artificial Intelligence » Programming for AI » Data Structures » Foundations of Machine Learning » AI and Humanity » Convex Optimization » Algorithms » Deep Learning » Ethics and Values » Robotics » Reinforcement Learning » Advanced Topics in ML
ELECTIVES	Information Theory, Analysis of Social Networks, Multi-agent System, Software Engineering, Knowledge Engineering, and Database Theory.	One course from each of the four clusters: Decision Making and Robotics; Machine Learning; Perception and Language; Human-AI Interaction Cluster	Courses from five different clusters: Core AI and ML; Language Technologies; Speech and Vision; Data Analytics; AI, Neuroscience and Natural Intelligence

The three degrees are very similar, requiring foundational training in Mathematics, Statistics, and Computer Science, and courses in Machine Learning, Data Structures, Deep Learning, Algorithms, and NLP. CMU and IIT Hyderabad both require ethics courses as part of the curriculum.

2.3 AI Graduate Programs

The PREDICT (Prospective Insights on R&D in ICT) project, supported by the European Commission, "focuses on analysing the supply of Information and Communications Technologies (ICT) and Research and Development (R&D) in ICT in Europe [21]." As part of its mandate to assess the availability of advanced digital skills, an analysis of the AI or AI-related curriculum offered by post-graduate academic programs in 13 European countries (Belgium, Denmark, Finland, France, Germany, Italy, Ireland, Netherlands, Portugal, Spain, and Sweden in the EU; plus Switzerland and the United Kingdom) was conducted. The study leverages existing curricular efforts in other Informatics or Computing domains, including Computer Science, Data Science, Information Technology, and Cybersecurity, and "fills a gap that these do not completely fill in relation with knowledge and competences required by strong AI."

The report identifies the key building blocks of Master's programs in terms of the following knowledge areas:

Table 2: Knowledge Areas for a competency- based EU AI curriculum

Group	Knowledge Area		Scope within AI
AI Essentials	FIC	Fundamentals of Informatics/ Computing	Concepts, theories, methods and techniques of Informatics or Computing, Computer Science and Software Engineering that are at the foundations of building an intelligent system
	FMS	Fundamentals of Maths & Statistics	Concepts, theories. methods and techniques of Mathematics. Probability and Statistics that form the foundations of intelligent systems
AI General	AIG	AI General	Systems designed by humans that, given a complex goal, act in the physical or digital dimension by perceiving their environment through data acquisition, interpreting the collected structured or unstructured data, reasoning on the knowledge, or processing the information, derived from this data and deciding the best action(s) to take to achieve the given goal

The report identifies the key building blocks of Master's programs in following knowledge areas:

Group	Knowledge Area		Scope within AI
AI Core areas	KRR	Knowledge Representation and Reasoning	Representation of information and knowledge in logic and probabilistic formalisms. Application of automated reasoning methods to the represented information and knowledge
	PSO	Planning, Search & Optimisation	Methods for planning and executing solutions by intelligent systems
	ML	Machine Learning	Algorithms that improve through experience to identify patterns in data to build models in order to gain valuable information. It includes the processing, analysis and presentation of data
	NLP	Natural Language Processing	Collection and parsing of text data to generate and understand human languages
	CP	Computational Perception	Interpretation of data in a manner that is similar to the way humans uses their senses to relate to the world around them, mainly through vision and audio processing
	RAI	Robotics, Agents & Integration	Distribution, coordination, cooperation, and autonomy of intelligent systems with the environment, as well as the combination of other abilities
	HMI	Human-Machine Interaction	Interaction of humans with computers and intelligent machines and technologies that let humans interact with computers in effective ways
AI Applied areas	AIS	AI Services	Infrastructure, software and platforms provided as digital services or applications to run Al, which are available off-the-shelf and run on demand
	PEA	Philosophy & Ethics of Al	Philosophical and ethical issues associated with AI and related with the compliance of ethical principles and values, including applicable regulation

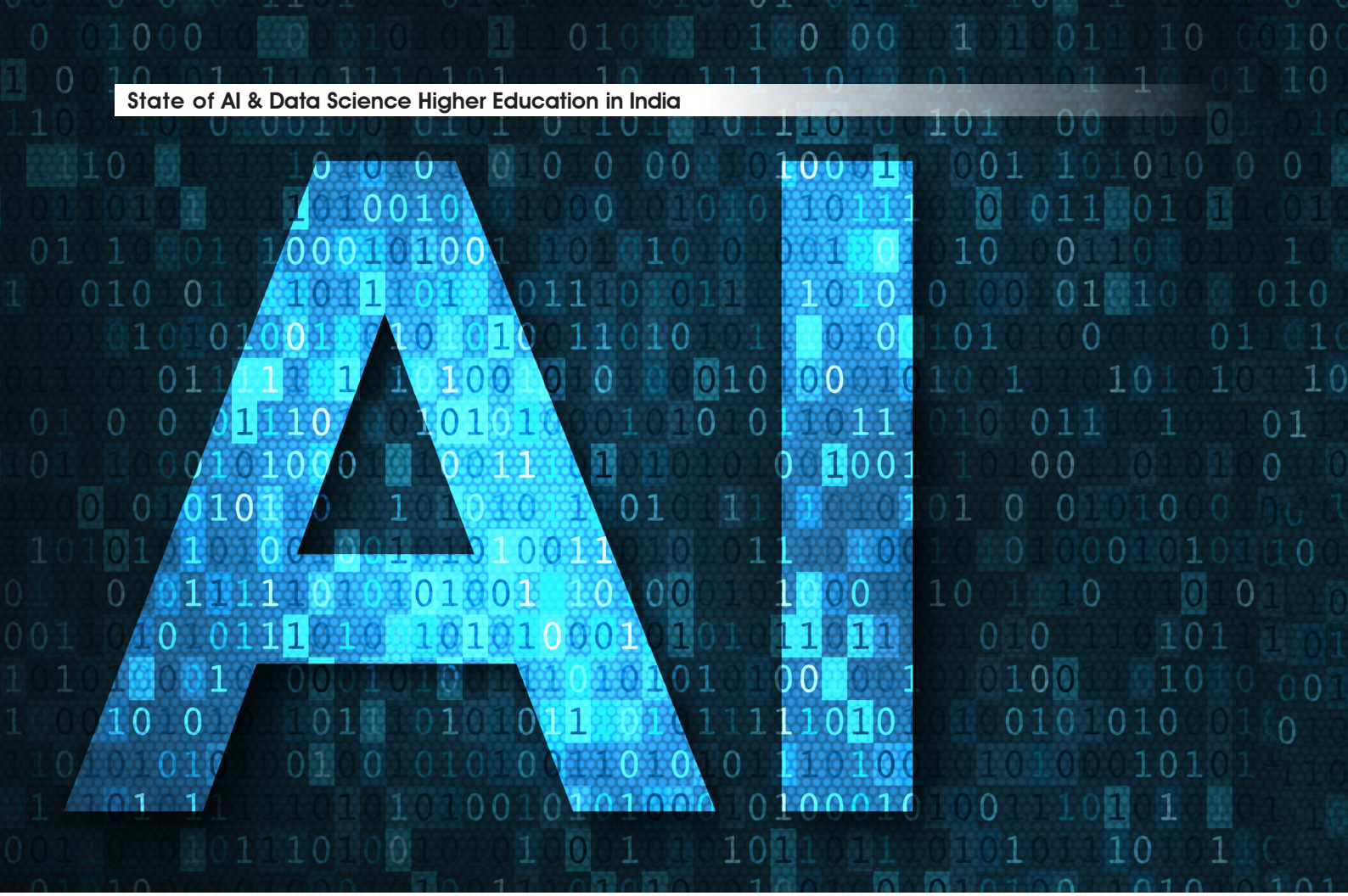
The results of the analysis of knowledge topics on core AI subdomains and AI fundamentals on informatics and statistics from all the programs show the following coverage:

- Machine learning (21.4%),
- Fundamental Informatics/Computing (10.9%),
- Computer vision (10.0%),
- Fundamental maths & statistics (8.1%),
- Human-computer interaction (7.1%),
- Knowledge representation and reasoning (7%),
- Natural language processing (6.4%),
- Planning, search and optimisation (5.4%)
- Robotics and intelligent automation (5.4%)

The report notes that many of the programs focus on topics that are not in their specific domains, and very few offer courses in ethics. Machine learning is reported as "the domain most covered by topics of most programs, independently of the initial master program's aim." The report highlights the need for a more extensive analysis of curricular requirements in consultation with stakeholders from academia and industry.

While there are a number of comprehensive reports addressing curriculum guidelines and recommendations for Data Science programs, there are very few resources available for AI. With the increasing demand for AI professionals, societies like IEEE, AAAI, and ACM, academia, and industry groups need to come together to identify knowledge and skills needed for different AI careers and develop curricular recommendations.

03 AI / Data Science Education in India



In a first-of-its-kind study in India, IUSSTF partnered with itihaasa Research and Digital, Association for Computing Machinery (ACM) India, and National Programme on Technology Enhanced Learning (NPTEL) to conduct a survey of Indian academic institutions to (a) assess the current state of AI, Data Science, and AI-related curriculum, (2) understand the underlying challenges, and (3) identify infrastructure and resource needs, including faculty recruitment. The survey was sent to ACM Chapter members, NPTEL Local Chapters, and IUSSTF grantee institutions. If an institution had multiple academic units offering degrees/ programs, each academic unit was asked to only provide information related to their specific unit.

Many institutions offer multiple programs and therefore, the number of programs will not equal the number of respondents. Response rates may also vary because some institutions provided only partial responses.

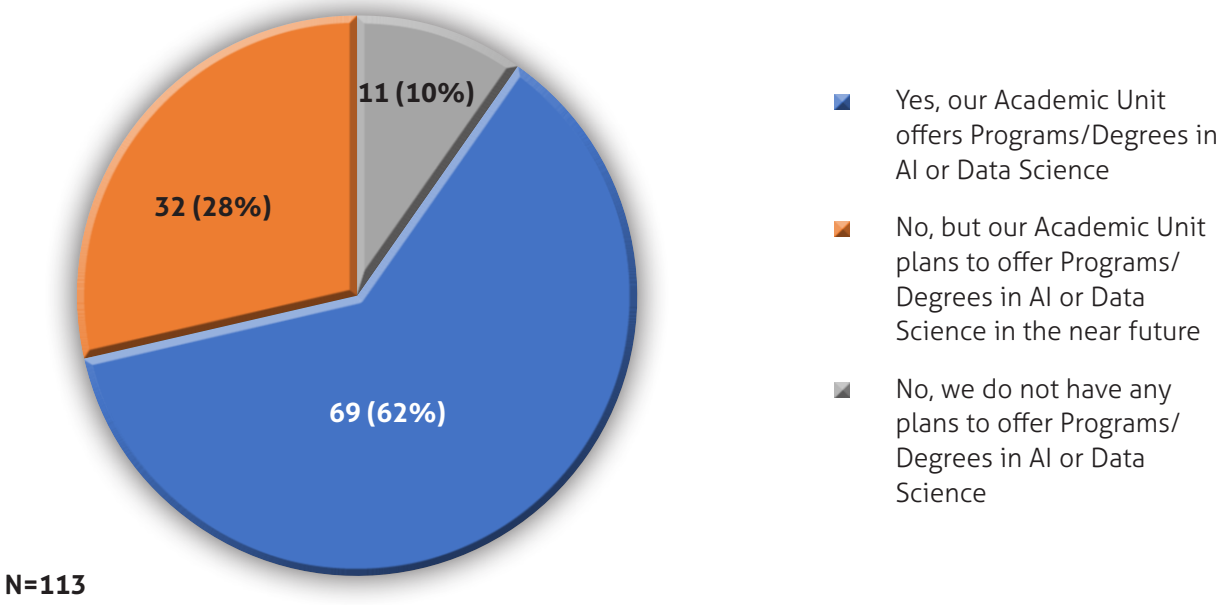
While we provided a definition of 'Artificial Intelligence' and 'Data Science', (Annexure I), respondents were asked to use the definition that was most appropriate for their specific program/ degree. The survey (Annexure I) was divided into three sections: Section A addressed Program Offerings, Section B focused on Curriculum and Instruction, and Section C addressed Faculty, Infrastructure, Resources, and Collaborations.

A total of 113 responses (105 unique institutions) were received from a wide range of public and private institutions across India. The list of participating institutions who consented to have their names published is provided in Annexure II. We acknowledge that this was an exploratory study and some of the inferences/ conclusions may not be generalizable. As a follow-up, a more extensive study involving a larger number of Indian institutions should be conducted.

3.1 Program Offerings

Among all respondents, 62% (69) of institutions indicated they are offering programs in AI, Data Science, or related areas, with only 10% reporting no plans to offer such programs in the future (Figure 1).

Figure 1: Program Offerings



Figures 2 and 3 summarize the degree programs offered at the Bachelor's, Master's, and Ph.D. levels. Of the 69 respondents, 80% (55) offered Bachelor's programs, 57 % (39) offered Master's programs, and 58% (40) offered Ph.D. programs.

Figure 2 : Program Offered at Different Levels

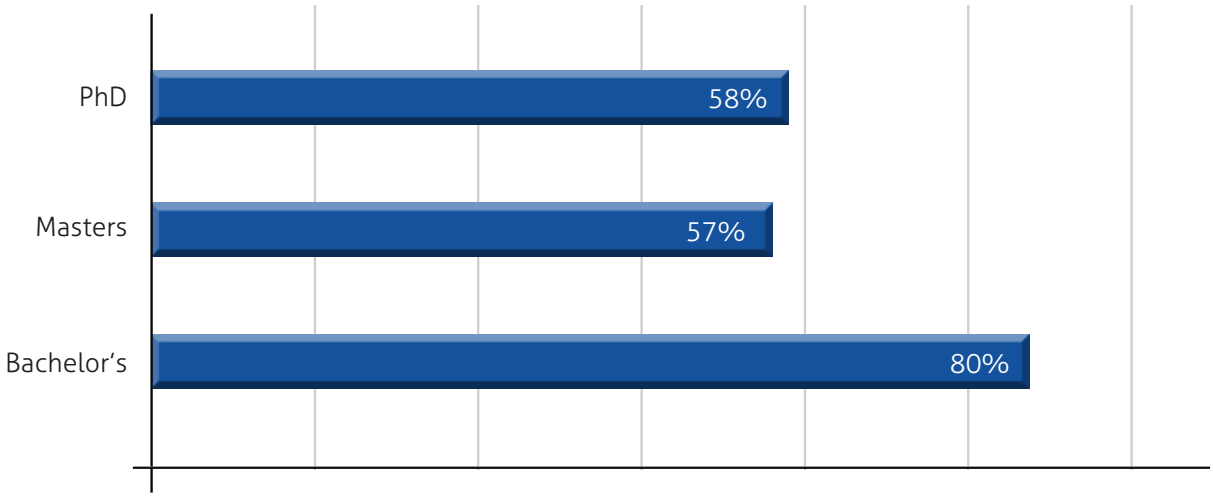
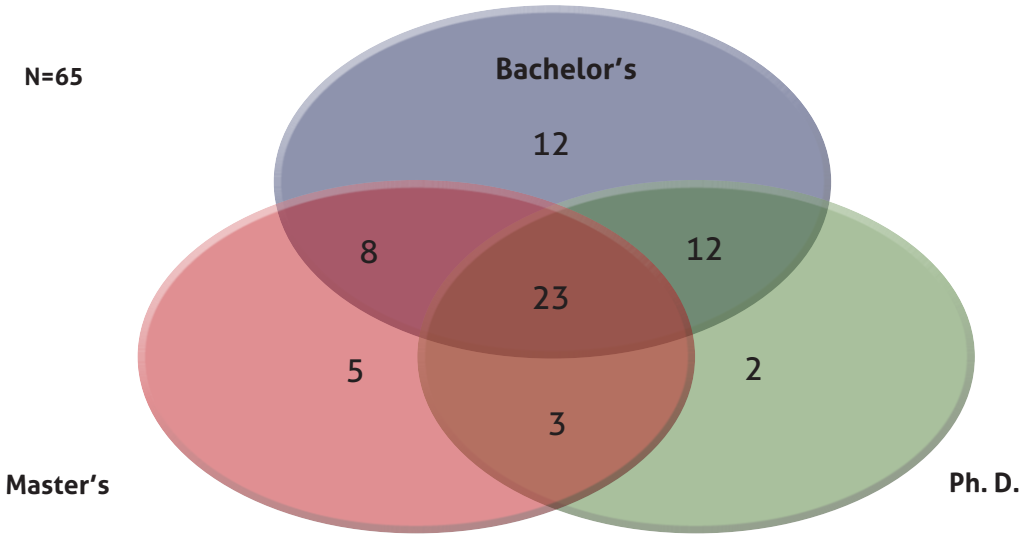


Figure 3 : Institutions and Programs Offered



Respondents were asked to describe the types of AI or Data Science Programs/ Degrees offered by their Academic Unit (Department, School, Center, College). There were four possible options at the Bachelor's, Master's, and Ph.D. levels:

- Stand-alone AI Program
- Stand-alone Data Science or Analytics Program
- Computer Science program with a specialisation in AI or Data Science
- Programs in other disciplines with a specialisation in AI or Data Science

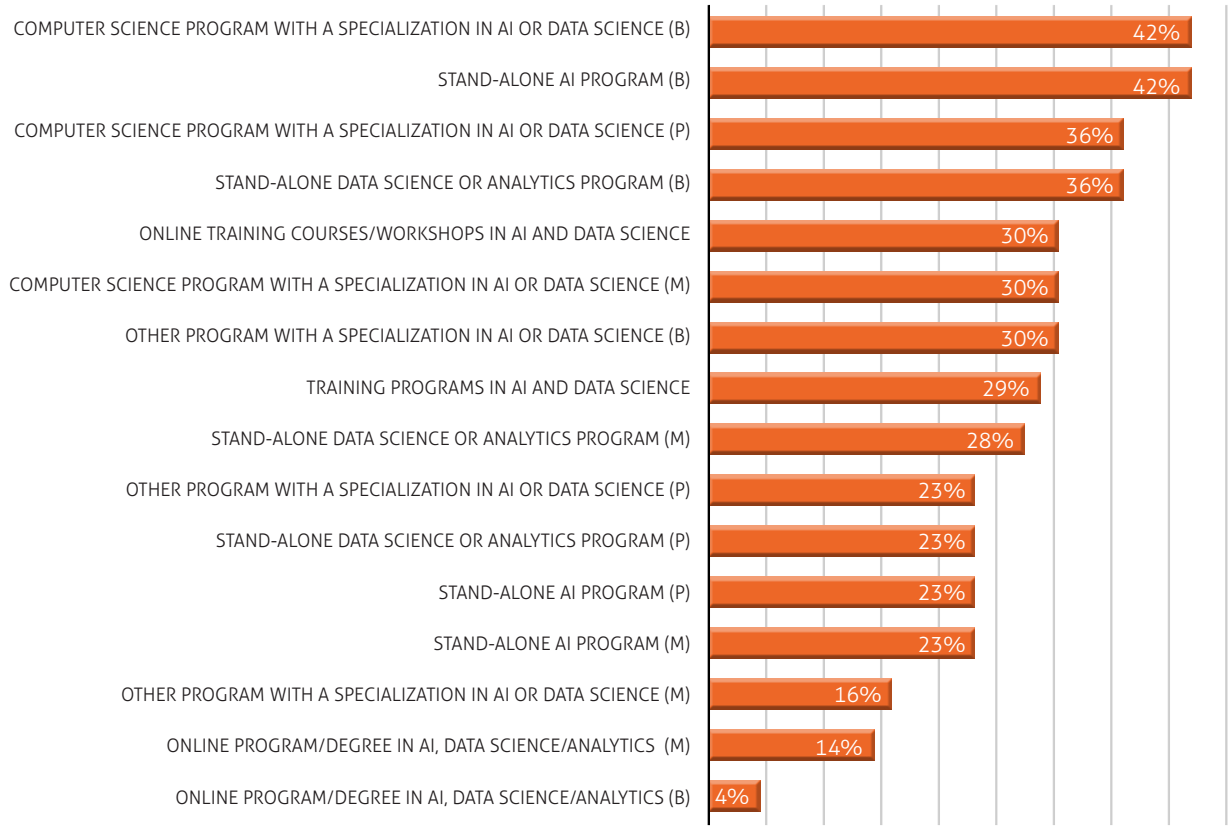
In addition to formal degrees, respondents were also asked if they offered any one or more of the following programs:

- Online program/degree in AI, Data Science/Analytics at the Master's level
- Online program/degree in AI, Data Science/Analytics at the Bachelor's level
- Online Training Courses/Workshops in AI and Data Science
- Training Programs in AI and Data Science

Figure 4 provides the percentage of institutions offering each of the different programs. One surprising finding is that 42% of respondents offered Bachelor's stand-alone AI programs or Bachelor's programs in Computer Science with a specialisation in AI or Data Science. Conventional wisdom would suggest that a larger number of institutions would offer programs in AI and Data Science at the Master's level. The fact that such a specialisation is seen at the undergraduate level may be a reflection of the demand from students as well as market demand from industry.

Another reflection of the market demand for AI and Data Science skills is the fact that nearly a third of the respondents offer training courses / workshops and certifications – both in person (29%) and online (30%). The high prevalence of online training courses could also be a consequence of the Covid pandemic.

Figure 4 : Types of Programs



N=69 **B=**Bachelor's **M=**Master's **P=**Ph.D.

We are also beginning to see the emergence of online degree programs in AI and Data Science at both the Bachelor's (4% of respondents) and Master's level (14% of respondents). While the numbers are small, we see this as an encouraging trend given India's push toward enhancing the Gross Enrolment Ratio (GER) in quality higher education.

Institutions also provided information about programs in AI, Data Science, or related fields not covered by the categories listed in the survey. These include:

- BTech (Data Science)
- BTech in Information Technology, BTech in Information Technology with Specialization in Business Informatics
- BTech in AI and Data Science. Minor in AI and ML for engineering students

- BTech In Math and Computing
- BTech Honors and Minors in AI &ML, AI&DS
- MTech in Information Technology with Specialization in (1) Data Engineering, (2) Human Computer Interaction, (3) Machine Learning and Intelligent Systems, (4) Robotics and Machine Intelligence
- MTech Data Analytics and Decision Sciences
- Interdisciplinary Dual Degree Program in AI ML and Applications
- Executive MTech in AI
- Quantitative Economics (MSQE) and Quality, Reliability & Operations Research (M. Tech. in QROR), MS in Quality Management Science
- PhD in Machine Learning

3.1.1 Academic Units Housing AI and Data Science Programs

Figures 5-7 provide information about the academic units housing different programs.Conventional wisdom would suggest that AI and Data Science programs are housed in a Computer Science department, and the data for Bachelor's, Master's and PhD programs certainly indicate this to be the case. But a surprising finding of the study is the existence of a unit dedicated to AI in many institutions. Given the small number of respondents to some of these questions, the trend, rather than the actual percentages, is certainly interesting.

Figure 5: Bachelor's Program

(Counts indicate number of institutions in each category -
Number of respondents for each category are indicated in parentheses)

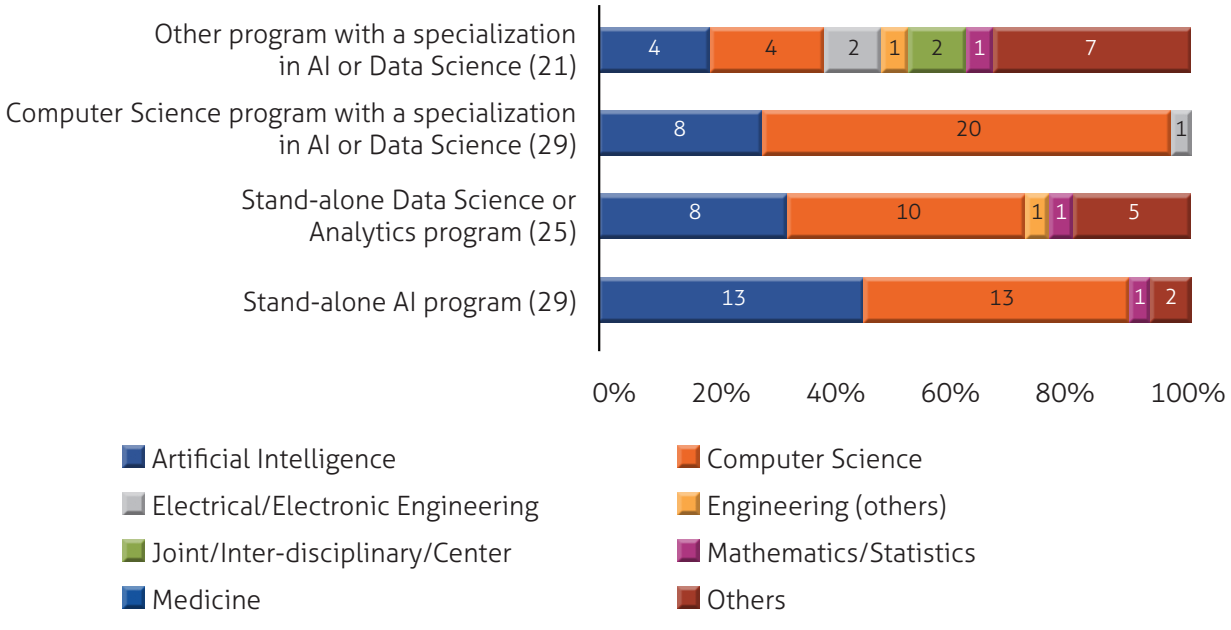


Figure 6 : Master's Program

(Counts indicate number of institutions in each category -
Number of respondents for each category are indicated in parentheses)

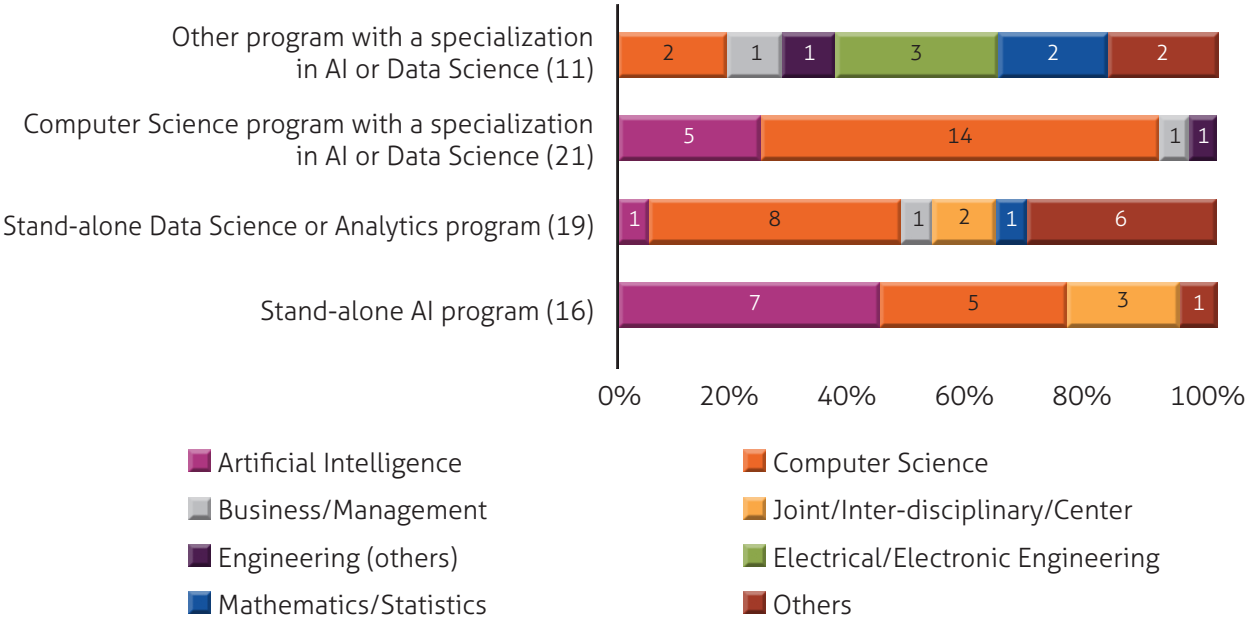
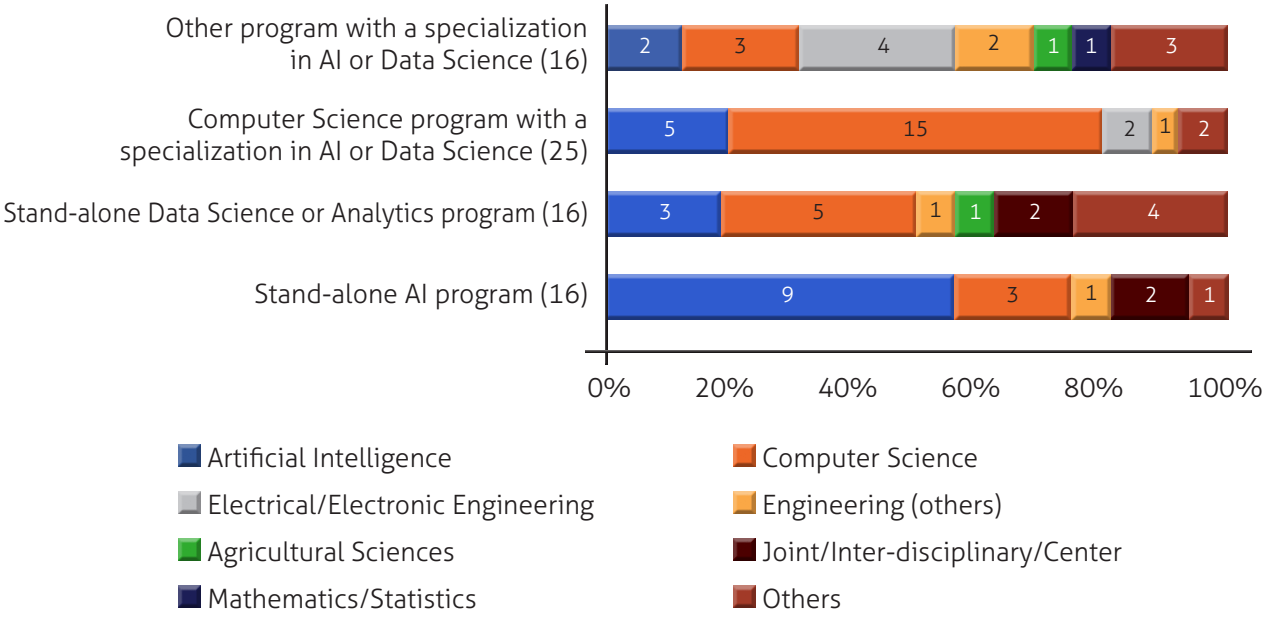


Figure 7 : Ph. D. Program

(Counts indicate number of institutions in each category -
Number of respondents for each category are indicated in parentheses)



The creation of a separate AI department may be a recognition of the fact that AI has permeated every discipline of knowledge, be it engineering, medicine or humanities, and the increasing demand for such programs. The study captures some of this diversity with institutions reporting programs in disciplines such as agricultural sciences, biological sciences, and medicine that include a specialisation in AI or Data Science.

This is certainly encouraging and a sign that Indian academic institutions are responding to the global trends. The timelines involved in the creation of India's first CS department in the 1960s provide an interesting contrast. At IIT Kanpur, computer science courses were initially offered by electrical engineering faculty as there was no separate CS department. It took a couple of years before MTech students in the electrical engineering department were allowed to choose "computer science" as their specialisation. It took another decade before CS was available as an area of specialisation for the under-graduate program.

A high-level analysis of the institutions that participated in our survey reveals that several private engineering institutions and the newer IITs / NITs / IIITs have embraced the idea of offering stand-alone AI programs at the Bachelor's level and have also established separate departments dedicated to AI. This may be an effective strategy to attract students and recruit top faculty members to their institutions. We also find that the older and more established institutions like IISc and the five original IITs have developed stand-alone AI programs at the Master's level.

3.2 Curriculum and Instruction

In this section of the survey, we provided a list of courses and asked respondents to indicate whether the course was (a) Required or (b) Elective or (c) Not Offered. Figures 8 and 9 indicate the percentages in each of the three categories for Bachelor's level and Master's/Ph.D. level courses respectively. Respondents could choose to skip over an item so the number of institutions may be different for different responses.

From the graph, we see that the following courses are not offered by 25% or more of the departments as part of their bachelor's program: (i) Philosophy of AI, (ii) AI & Brain sciences, (iii) Multi-Agent Systems, (iv) Human-Computer Interaction, (v) Speech Processing , (vi) Robotics & Automation, (vii) Ethics (privacy, fairness, explainability), and (ix) Text Mining. The same patterns persist at the Master's level. Except for Text Mining, 25% (or more) of the departments do not offer the remaining eight courses listed above. While some of these topics are quite specialized, any undergraduate program must include coursework in Ethics addressing critical issues related to privacy, fairness, explainability, and trust.

One of the major challenges in offering these specialized courses is the lack of faculty with expertise in these areas. One solution to address this gap is to leverage online courses available on platforms such as NPTEL or other third-party education platforms such as Coursera / EdX / Upgrad.

Institutions were asked to list other courses offered as part of their AI and Data Science programs. The list includes:

- Bayesian data analysis, financial data analysis, risk management, survival analysis
- Introduction to smart sensing, information retrieval, fundamentals of sensors and transducers, pattern recognition, introduction to R and Python, data curation, data warehousing, image processing, business analytics
- Soft computing, visual recognition, convex optimization, advanced data analytics, computational astrophysics
- Robotic perception, data driven control
- Database management, advanced computer vision, machine learning in bioinformatics
- Computational finance, Computational psychology, algorithms for big data, information retrieval, computational biology and bioinformatics
- Fundamentals of data science
- Computational data science, time series and survival analysis, tools for big data computing
- Cloud architecture, reinforcement learning, game theory in AI, GPU computing, evolutionary algorithms, data visualization
- Information systems, distributed computing, computer integrated manufacturing
- AI for cyber security
- Reinforcement learning, signals and systems, image processing

Figure 8: Course Offerings at the Bachelor's Level

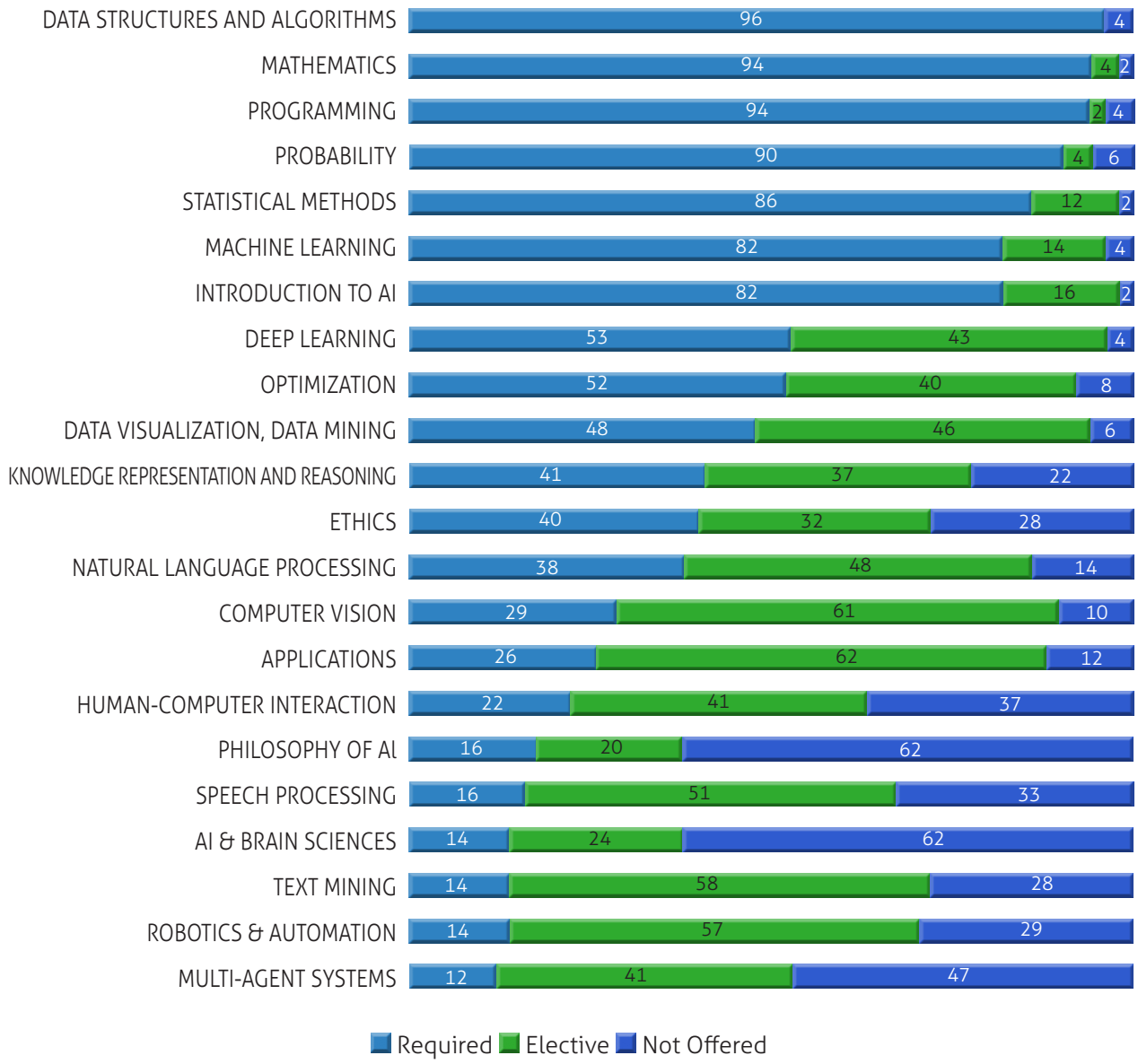
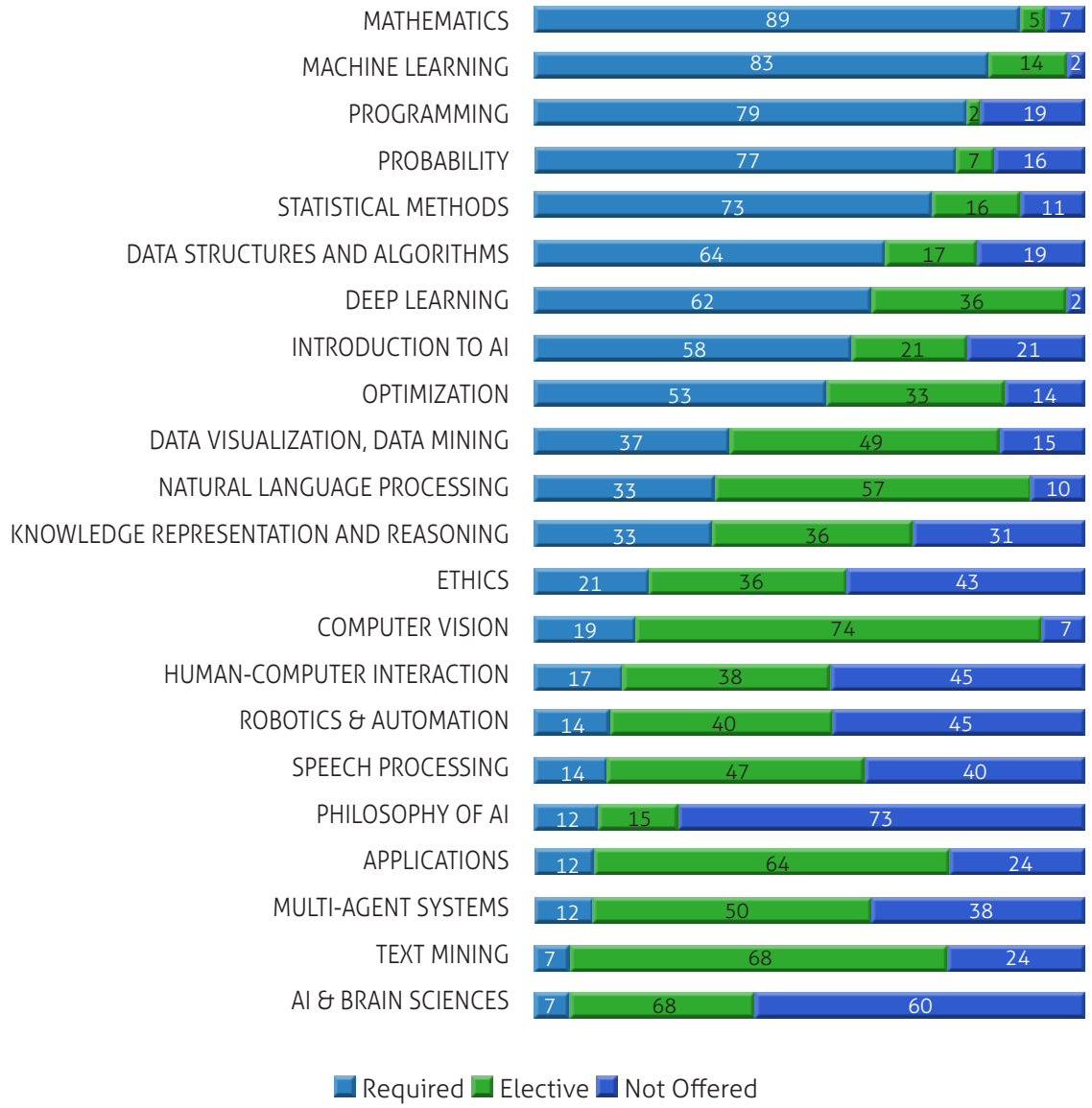


Figure 9 : Course Offerings at the Master's Level

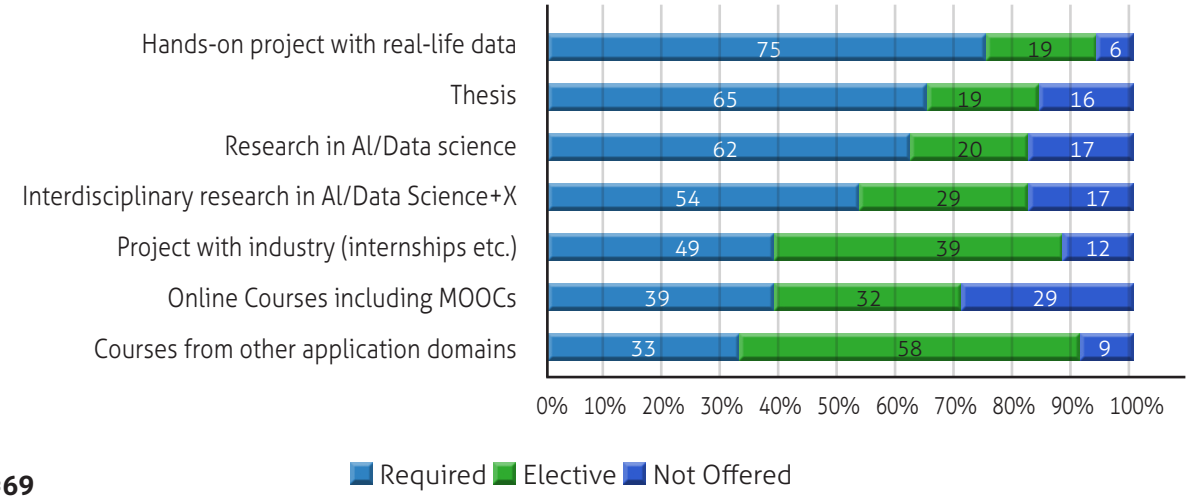


In addition to coursework, we also wanted to understand what additional learning and training opportunities are available to students to prepare them for careers in AI and Data Science. Figure 10 shows the percentage of responses in each of the three categories: Required, Optional, Not Offered.

While the data reveal that a majority of departments require some form of research as part of the training, this is not surprising given that 58% of institutions (see Figure 2) that responded to the survey offer a Ph. D. program. If we consider only the 25 institutions that do not offer a Ph.D. program, the figure drops to 44%. What was also surprising and counter intuitive was the drop (64%) in the requirement for hands-on projects in this category. While the sample size is not sufficient to draw inferences, this may explain some of the findings related to the lack of access to quality datasets. The data indicate that 71% of institutions offer online courses including MOOCs. While this may be

a consequence of the pandemic or a dearth of faculty, it would be interesting to see if educational institutions continue to embrace online instruction and flipped classrooms. Two areas that need to be addressed include increasing interactions with industry and a more interdisciplinary curriculum.

Figure 10: Modes of Training and Learning



N=69

3.3. Faculty, Infrastructure, Resources, and Collaborations

This section of the survey addressed the state of resources (human capital and technology infrastructure) available in institutes for teaching AI and Data Science, and factors that impact the institution's ability to offer these types of programs.

Faculty Strength and Expertise

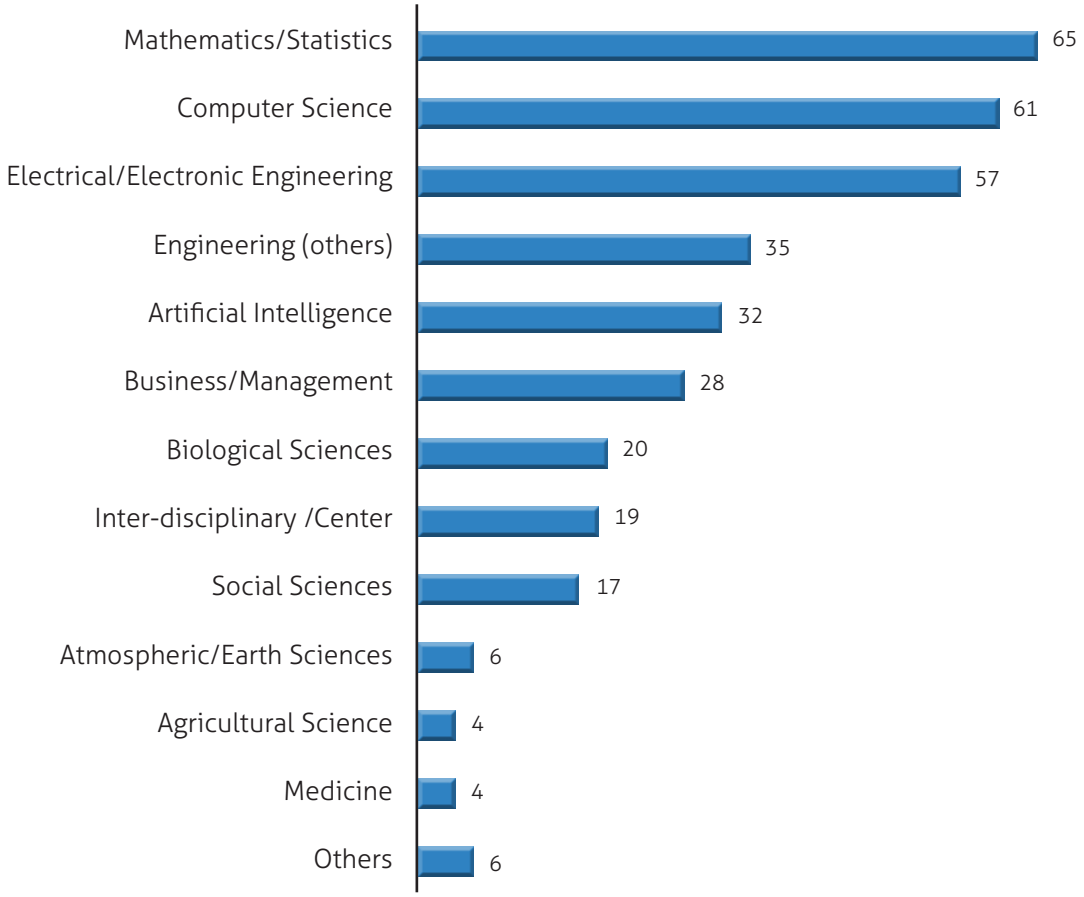
Respondents were asked to indicate the faculty strength of their respective academic units. Form the table we see that a third of the departments have fewer than 10 faculty members.

Department Size	Percentage
01 - 10	33
11 - 20	20
21 - 30	12
31 and above	35

We also asked respondents to estimate the total number of faculty members in their academic unit with core experience / expertise and training in AI and Data Science. Only 29% estimated that their academic unit had a high proportion (> 50%) of faculty members with expertise in these areas. This dearth of trained faculty with expertise in these areas is certainly a major concern. We need to significantly increase the numbers of AI / DS faculty members in India to address the demands of the AI Workforce.

To assess the extent to which the programs are inter-disciplinary, we asked respondents to indicate whether or not faculty members from other Academic Units were involved with their specific AI or Data Science degree/ program (Figure 11).

Figure 11 : Participation by Other Academic Units (%age)



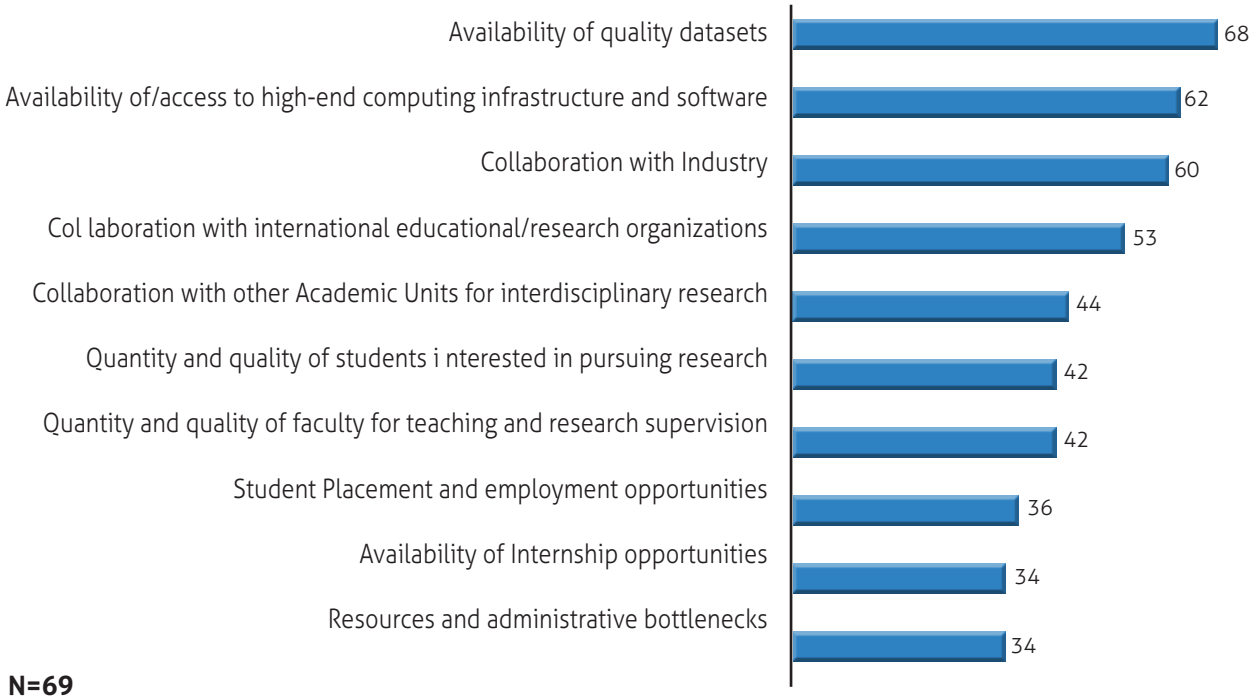
As is to be expected, Faculty from the Departments of Mathematics/ Statistics, Computer Science, Electrical / Electronic Engineering, and Artificial Intelligence are heavily involved with the AI and Data Science programs offered at their institutions. It is heartening to note the involvement of other engineering (35%) departments as well as departments of business/ management (28%), biological sciences (20%), and social sciences (17%).

While the participation from departments like medicine (4%) and agricultural science (4%) is low, this is not surprising as many of the institutions that participated in the survey focus on engineering/ technical education.

3.3.1 Factors affecting AI / DS programs

We asked respondents to assess the extent to which (greatly, to some extent, not at all) each of the following factors affected/ impacted their AI / DS programs. Figure 12 displays the net score (greatly + to some extent – not at all) for each factor.

Figure 12 : Challenges Ranked by Net Score



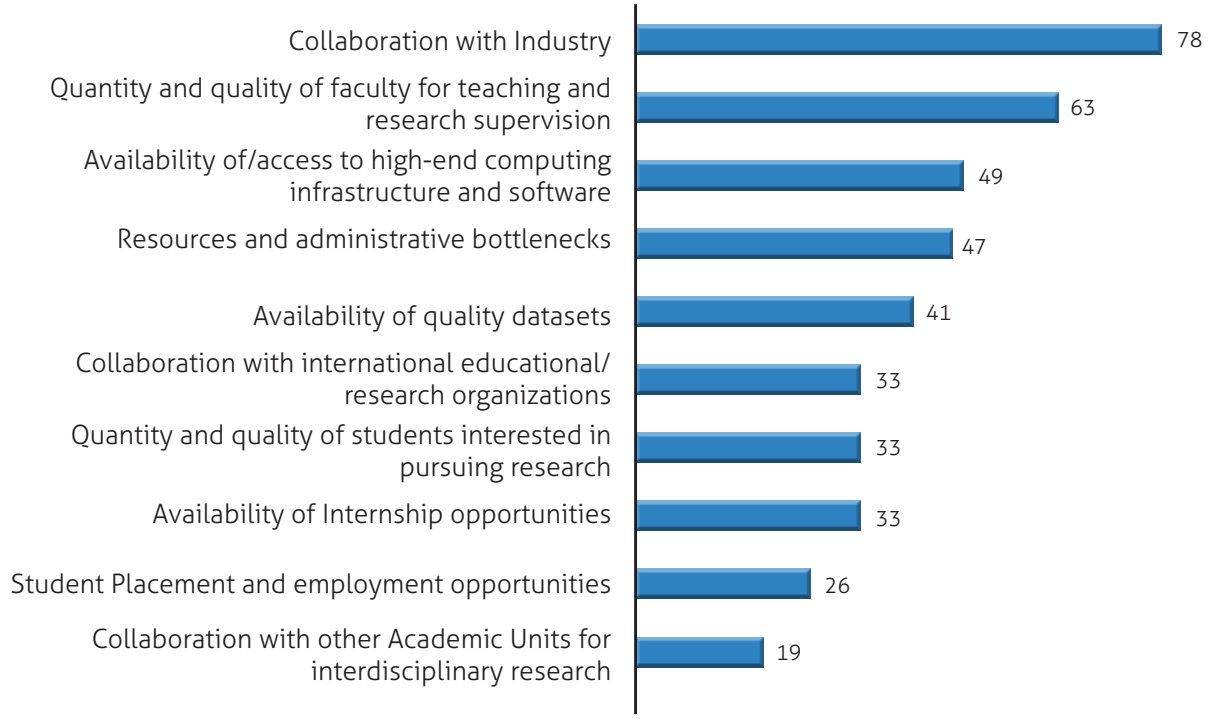
The lack of availability of quality datasets and access to computing infrastructure are clearly major challenges. High quality, annotated, benchmarked, domain-specific datasets are required to train AI models and systems. While there are a number of Government Agencies in India that collect data, issues of interoperability and provenance will need to be addressed to ensure the availability of large datasets for research and training. Industry can help in this regard by providing real-world data for student projects. When it comes to high-end computing infrastructure, institutions need access to Graphics Processing Units (GPUs) and specialized hardware such as Tensor Processing Units (TPUs), Field Programmable Gate Arrays (FPGAs), Application Specific Integrated Circuits (ASICs). Access to cloud infrastructure may address some of these issues.

External collaborations, both with industry and global universities and research organizations, is another challenge faced by many institutions. The need for deep collaboration with industry is clear - ensuring the availability of quality datasets, access to internships, and input on curriculum and training to ensure students have the knowledge and skills to enter the AI workforce. International and Public-Private partnerships are critical to the development of a diverse, globally-engaged, technology-abled workforce. The USIAI can serve as a platform to facilitate collaboration between

Indian and U.S. academic institutions to address the challenges associated with developing a diverse, robust AI workforce.

The same question was posed to Institutions that are planning to offer Programs in AI or Data Science in the near future. While there are many similarities, Collaboration with industry and Lack of Faculty with expertise in AI and Data Science are the biggest challenges (Figure 13).

Figure 13: Challenges Ranked by Net Score for Programs that are in the planning stages

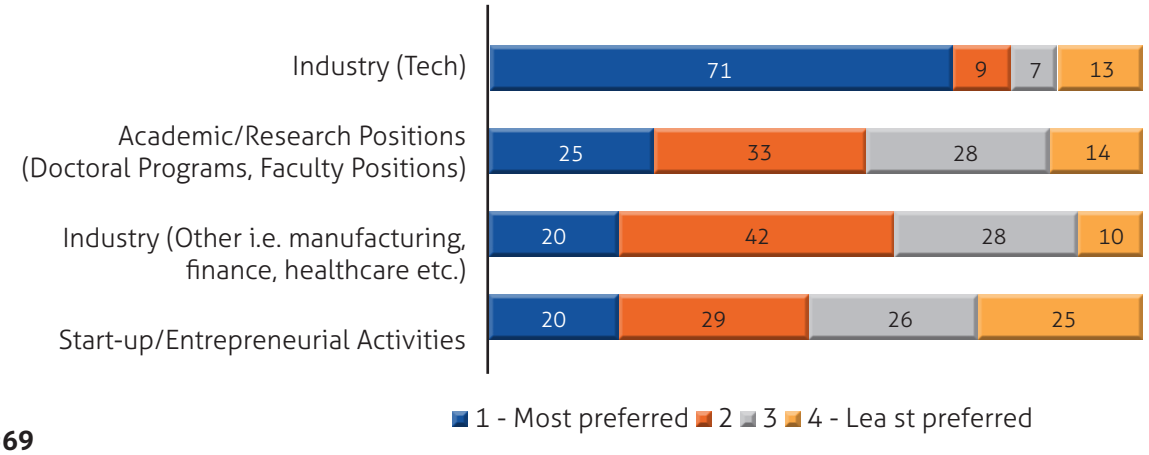


N=27

3.4 Career Paths/ Aspirations of Students in AI and Data Science Programs

Respondents were asked to describe the career paths/ aspirations of students in their AI and Data Science Programs by ranking the four categories on a scale of 1 (Most preferred) to 4 (Least preferred) (Figure 14)

Figure 14 : Career Path Preferences



N=69

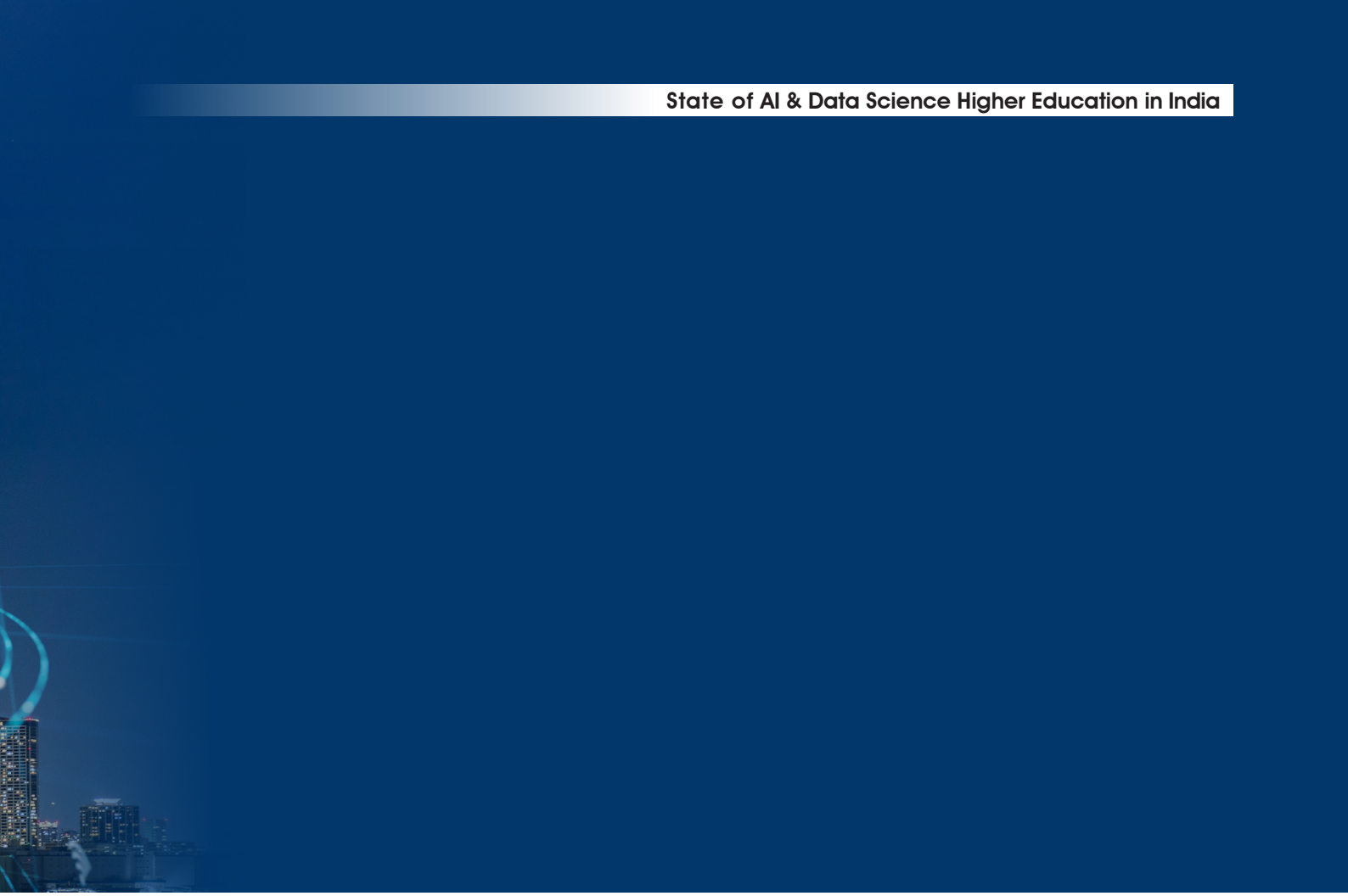
It appears that the overwhelming preference for students (across undergraduate and graduate AI/DS programs) is to join the Tech industry. Careers in academic / research streams seem to be lower in priority. Funding agencies and academic institutions can make research positions more attractive through fellowship and mentoring programs. The extremely low preference for startup / entrepreneurial careers may be an indication of the inherent risks, lack of exposure to incubators, and most importantly capital. Students may prefer to join an existing startup (which may be counted under Industry (Tech) careers).

The survey, while exploratory, provides an interesting window into the AI education and training landscape. While the number of programs is growing rapidly, we need to also evaluate the quality of these programs in terms of research productivity, and knowledge and skills. itihaasa's landscape study of AI research in India also found that the quality of the Indian AI/DS programs has to be greatly enhanced in order to meet the requirements of industry and research. Accrediting bodies, professional societies, and industry associations can play a role in setting guidelines and standards for new programs.

04 Action Plan: Building a Diverse AI and Data Science Workforce

The AI and Data Science higher education landscape in India is changing rapidly. While a number of India's higher education institutions are well on their way to developing new AI and DS programmes, other institutions are just beginning the journey [7]. With the gap between supply and demand of individuals with AI and DS knowledge and skills expected to grow significantly, it is imperative that a wider set of stakeholders including higher education institutions, professional societies, industry, start-ups, and government departments come together to define the common contours of AI and DS curricula that can serve as the foundation for innovative programmes across a large number of Indian institutions. Academic institutions in the United States are further along the road on this journey, and Indian institutions can benefit from their experiences, leveraging best practices in education and training.

Programs that prepare professionals in cutting edge disciplines at the interface of big data and machine learning and domains



such as health, environment, and sustainable living are a priority under India's NEP 2020 [8]. This is an important policy statement as it highlights the need for interdisciplinary programs and integrated curricula that focus on the implementation of AI and DS tools in specific application domains. The U.S. has several successful models including the University of California, Berkely's Division of Computing, Data Science, and Society whose "dynamic structure connects computing, statistics, the humanities, and social and natural sciences to create a vibrant and collaborative environment that accelerates breakthrough research across scientific and technological frontiers."

U.S. and European AI and DS models can serve as a framework for adoption and implementation by Indian institutions. However, understanding the unique challenges in the Indian context and identifying the knowledge and skills gap will be critical to developing innovative programs to address India's workforce priorities.

The IUSSTF/ itihaasa exploratory survey provides an overview of the AI and Data Science higher education landscape in India and identifies some of the gaps and challenges. While the geographic diversity of institutions that responded to our survey was encouraging, one cause for concern was the limited number of interdisciplinary programs in the priority areas of health and agriculture.

To address some of the challenges and gaps and identify potential solutions, we propose a series of action items that will engage the broader stakeholder community and lead to more substantive conversations about the AI Workforce.

Action Item 1

Conduct a visioning workshop on "Developing a Diverse, Robust AI Workforce: Innovations in AI Training and Program Development".

One of the goals of IUSSTF's USIAI initiative is to build on key priorities, recommendations, and common challenges articulated in the AI Strategic Plans of the two countries. USIAI provides a platform to engage key stakeholders, including government agencies, academic institutions, industries that are creating/adopting AI tools and technologies, think tanks, professional societies, and foundations.

IUSSTF and itihaasa are planning an Indo-U.S. Visioning Workshop that will bring together faculty from Indian and U.S. academic institutions and representatives from industry to address the challenges associated with developing a diverse, robust workforce. The workshop will focus on specific aspects of training and program development under four broad themes:

- AI, Data Science training for Industry
- Undergraduate Level Programs
- Graduate Level Programs – Computer Science focused
- Graduate Level Programs – Other Engineering / Science / Research focused

The goal of the proposed workshop is to create a roadmap for developing a diverse, globally engaged, AI workforce through the following objectives:

- Identify the knowledge and skills required for different AI and DS careers and recommend different education and training pathways.
- Map domain-specific and sector-specific AI and DS knowledge and skills
- Share best practices between India and the U.S. for teaching and training
- Build a more inclusive and diverse AI/DS discipline
- Recognize the key challenges in AI and DS education and training, and develop strategies to mitigate these challenges
- Identify synergies for collaborative research and training activities

Last, but not the least, we hope the workshop will foster individual and institutional partnerships and create a vibrant community passionate about education and training.

Action Item 2

Study the AI and DS programs in India and the U.S.: Identify exemplars - course curriculum, datasets and tools, resources

Chapter 2 provided a detailed summary of U.S. and European initiatives addressing competencies and curricular guidelines for AI and Data Science. Our survey provides some preliminary insights into

the structure of AI and DS programs in India. We recommend a detailed follow-up study to identify building blocks of Bachelor's and Master's programs in AI and DS on the basis of the course content and learning outcomes from a representative sample of universities in India. This study will also compare and contrast the curriculum at U.S. and Indian universities and identify significant gaps/challenges, if any, in the Indian context. The study will serve as a resource for accrediting bodies and industry groups and help in the development of new India-specific guidelines for curriculum and training.

Action Item 3

Organize follow-up workshops/meetings on AI and DS Workforce Development

Ramping up India's AI and DS workforce will require the sustained efforts of different stakeholders including the Department of Science and Technology, Ministry of Education, All India Council for Technical Education (AICTE), Ministry of Electronics and IT (MeitY), academic institutions, professional societies, and industry.

Industry, the largest employer of AI and DS talent in India, must play a key role in the development of new programs as the knowledge, skills, and competencies vary across different sectors. Collaboration with industry was identified as the third most important factor impacting AI and DS higher education programs in our survey. This is a challenge faced by many U.S. institutions as well. Organizations such as the U.S. India Business Council, U.S. India Strategic Partnership Forum, NASSCOM, and FICCI can identify successful models and mechanisms for industry-academia collaborations.

Bilateral workshops on critical issues such as Explainable AI, Ethics and Trust, Guidelines for data sharing and benchmarking can help in the development of a shared framework for enabling impactful and responsible innovation in AI.

Action Item 4

Accelerate efforts to scale-up computing infrastructure and access to large datasets.

The top two challenges impacting AI and DS programs in India in our survey are (1) access to high end computing infrastructure and software, and (2) availability of quality datasets. This is consistent with the findings from itihaasa's study on the landscape of AI/ML research in India [11].

Setting up world-class computing infrastructure for AI/ML research is expensive. India's MeitY and NITI Aayog have programs to ramp up shared computing infrastructure [22] [23]. In recent years, a total compute capacity of 22-petaflop spread across 15 educational and research institutions, including a National AI facility at CDAC Pune, have been installed. Another 32-petaflop spread will be deployed with indigenously designed systems. The NITI Aayog report recommended a national computing infrastructure, AI Research, Analytics and knowledge Assimilation (AIRAWAT), a 100-petaflop supercomputing system for AI applications [9].

While the Indian computing infrastructure is ramping up, U.S. cloud computing infrastructure companies could fill the gap by offering affordable plans to Indian higher education institutions

under a special agreement between stakeholders on both sides. India is already a large market of many of these companies and an investment in the future AI workforce would certainly be mutually beneficial.

Collaborations between India and the U.S. can accelerate the development of data infrastructure and resources to facilitate AI and DS research and training. While publicly funded AI/DS research in India may focus on India-specific challenges, some of the solutions may be relevant in the U.S. context, especially in areas such as health equity, energy, and climate. India's draft National Data Governance Policy formulated by MeitY proposes the launch of a non-personal data-based India Datasets program and addresses rules to ensure that non-personal data and anonymized data from both government and private entities are safely accessible by research and innovation ecosystems. [24]. India and the U.S. can learn from each other's experience to leverage anonymized data from public sources for R&D and training.

Action Item 5

Identify potential mechanisms to address some of the challenges identified in the report

- **Faculty Development:** Our survey indicates that there is a dearth of faculty with expertise in AI / DS in higher education institutions outside of the IISc, IITs and a few others. Faculty development programs can mitigate this problem to some extent. Many of the NSF funded AI Institutes and Big Data Hubs offer these types of programs.
- **Access to specialized content:** The dearth of faculty with core AI and Data Science expertise limits the ability of institutions to offer specialized courses. Interdisciplinary training was also seen as a major challenge for many small institutions. An immediate solution to address this gap is for Indian and U.S. institutions to co-develop content that could be hosted on platforms such as NPTEL/SWAYAM.
- **The Research pipeline:** Joint Ph.D. programs and opportunities for co-mentoring of postdoctoral fellows can enhance the quality of research, increase impact, and facilitate long-term institutional collaborations. We recommend Indo-U.S. joint doctoral and post-doctoral fellowship programs, and opportunities for faculty exchange.
- **Catalyze collaborations:** Funding agencies, foundations, and industry can support pilot projects that propose innovative solutions to AI and DS Workforce Development, including creation of innovative curricula, faculty training, innovative training programs for upskilling, creation of datasets, curricular materials, and case studies.

Summary

The promise and potential of Artificial Intelligence to disrupt and transform society is driving the new Industrial Revolution. The NEP (2020) is on target when it states ***"AI's disruptive potential in the workplace is clear, and the education system must be poised to respond quickly."*** India's academic institutions must respond to this challenge and become global leaders in AI and DS.

The AI and Data Science ecosystems are constantly evolving with technological breakthroughs and the emergence of new application domains. The future AI Workforce will need a different set of knowledge, skills, and competencies. An Indo-U.S. strategic partnership on AI can accelerate the pace of R&D, lead to the development of global standards for education and training of the future workforce, and create a shared framework for enabling impactful and responsible innovation in AI.

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ANNEXURE I

Survey Questionaire

Background

The Indo-U.S. Science and Technology Forum (IUSSTF) recently launched the U.S. - India Artificial Intelligence (USIAI) Initiative, a platform for key stakeholders to discuss opportunities and barriers for bilateral AI R&D collaboration, share ideas for developing an AI workforce, and recommend modes and mechanisms for catalyzing partnerships between the two countries. (For more details, please visit https://usiai.iusstf.org/)

As part of its AI-Workforce track, USIAI will organize a series of events (Roundtables, Panels, Workshops) that bring together U. S. and Indian representatives from academic institutions, industry, and government to 1) Identify emerging research areas in AI and related areas; 2) Define knowledge and skills needed for different AI careers; 3) Address Program and Curriculum Development at different levels; and 4) Identify Infrastructure and Resource needs.

This Survey is intended to assess the current state of **AI, Data Science, and AI-related curriculum** in Indian institutions, understand the underlying challenges, and identify infrastructure and resource needs including faculty recruitment.

Results from the survey will form part of IUSSTF's recommendations to key stakeholders, including government agencies, academic institutions, industry, and foundations. IUSSTF in collaboration with its Knowledge Partners will prepare white papers that address the technical, research, infrastructure, and workforce opportunities and challenges, highlight best practices for training and program development, and recommend mechanisms/models to facilitate partnerships between Indian and U.S. institutions with the goal of developing a robust AI workforce. The white paper will be shared with both Governments and key stakeholders, including funding agencies.

Your participation in the survey is completely voluntary and all individual responses will be kept confidential: only summaries based on aggregated data will be made public. The responses will be shared only with IUSSTF and itihaasa staff. The list of participating institutions and responses to open-ended questions (unattributed) may be shared in reports.

IUSSTF is partnering with itihaasa Research and Digital (https://itihaasa.com/), ACM India (https://india.acm.org/) and NPTEL (https://nptel.ac.in/) on this initiative.

We hope you will participate in the survey - your feedback is very important to this process.

Thank you very much for your time and effort.

Sincerely,

The IUSSTF-USIAI
itihaasa, ACM India, and
NPTEL Teams

Definitions

In this Survey, **'Artificial Intelligence'** and **'Data Science'** are broadly defined as follows:

[1] **Artificial Intelligence**: A program that focuses on the symbolic inference, representation, and simulation by computers and software of human learning and reasoning processes and capabilities, and the computer modelling of human motor control and motion. Includes instruction in computing theory, cybernetics, human factors, natural language processing, and applicable aspects of engineering, technology, and specific end-use applications.[1]

Artificial intelligence (AI) systems are software (and possibly also hardware) systems designed by humans that, given a complex goal, act in the physical or digital dimension by perceiving their environment through data acquisition, interpreting the collected structured or unstructured data, reasoning on the knowledge, or processing the information, derived from this data, and deciding the best action(s) to take to achieve the given goal. AI systems can either use symbolic rules or learn a numeric model, and they can also adapt their behaviour by analysing how the environment is affected by their previous actions.[2]

[2] **Data science**: A program that focuses on the analysis of large-scale data sources from the interdisciplinary perspectives of applied statistics, computer science, data storage, data representation, data modelling, mathematics, and statistics. Includes instruction in computer algorithms, computer programming, data management, data mining, information policy, information retrieval, mathematical modelling, quantitative analysis, statistics, trend spotting, and visual analytics.1

[3] **Data Analytics**: A program that prepares individuals to apply data science to generate insights from data and identify and predict trends. Includes instruction in computer databases, computer programming, inference, machine learning, optimization, probability and stochastic models, statistics, strategy, uncertainty quantification, and visual analytics.

These definitions are in no way meant to be prescriptive. Please use the definition that is most appropriate for your program/ degree.

1 National Center for Education Statistics (NCES), Classification of Instructional Programs
2 European Commission, AI Watch

Instructions

Please read the following instructions before completing the survey form:

- In the Survey, the term '**Academic Unit**' refers to a Department, Center, College, Division, School or similar entity at your institution.
- The survey focuses only on programs in AI, Data Science/ Analytics or related fields.
- We recommend the Academic Unit Head complete the survey or oversee the completion of the survey. **Please only provide information related to your specific Academic Unit.**
- The survey has been divided into three sections. Section A: Program Offerings, Section B: Curriculum and Instruction, and Section C: Faculty, Infrastructure, Resources, and Collaborations.
- While the Survey includes both compulsory and optional questions, we would very much appreciate if you could provide detailed responses to **all** the questions to help us better understand the current state of AI education in India and the underlying challenges.
- The survey will take approximately 15-20 minutes to complete.
- If there are other Academic Units within your Institution that offer AI and Data Science Programs/ Degrees, we ask that you share the link with the appropriate individual(s).

Information about the Respondent:

Name of the Institution*

<Free Text Field>

Institution website*

<Free Text Field>

Name of the person responding to the survey*

<Free Text Field>

Academic Unit*

<Free Text Field>

Position/Title*

<Free Text Field>

Email address*

<Free Text Field>

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*Does your Academic Unit offer Programs/Degrees in AI or Data Science? **

Option	Response
1	Yes, our Academic Unit offers Programs/Degrees in AI or Data Science
2	No, but our Academic Unit plans to offer Programs/Degrees in AI or Data Science in the near future
3	No, we do not have any plans to offer Programs/Degrees in AI or Data Science

PART A: PROGRAM OFFERINGS

A1. Which of the following types of Bachelor's Level AI or Data Science Programs/ Degrees are offered by your Academic Unit? Please use the drop-down menus to indicate the Academic Unit that houses the program and the number of students enrolled in the program per year. Select all applicable programs.*

If the type of program is not offered, please select the "N/A" option for both columns.

Bachelor's Program	**In which Academic Unit is the Program housed? Select from the dropdown menu**	**Number of students enrolled in the Program per year: Select from the dropdown menu**
Stand-alone AI program	• Artificial Intelligence • Computer Science • Electrical / Electronic Engineering • Engineering (others) • Business / Management • Mathematics/ Statistics • Joint / Inter-disciplinary/ Center • Biological Sciences • Atmospheric/ Earth Sciences • Medicine • Social Sciences • Agricultural Sciences • N/A • Others (please specify)	• 1 - 25 • 26- 50 • 51 – 100 • 100+ • N/A
Stand-alone Data Science or Analytics program		
Computer Science program with a specialization in AI or Data Science		
Other program with a specialization in AI or Data Science		

A2. Which of the following types of Master's Level AI or Data Science Programs/ Degrees are offered by your Academic Unit? Please use the drop-down menus to indicate the Academic Unit that houses the program and the number of students enrolled in the program per year. Select all applicable programs.* If the type of program is not offered, please select the "N/A" option for both columns.

Master's Program	**In which Academic Unit is the Program housed? Select from the dropdown menu**	**Number of students enrolled in the Program per year: Select from the dropdown menu**
Stand-alone AI program	• Artificial Intelligence • Computer Science • Electrical / Electronic Engineering • Engineering (others) • Business / Management • Mathematics/ Statistics • Joint / Inter-disciplinary/ Center • Biological Sciences • Atmospheric/ Earth Sciences • Medicine • Social Sciences • Agricultural Sciences • N/A • Others (please specify)	• 1 - 25 • 26- 50 • 51 – 100 • 100+ • N/A
Stand-alone Data Science or Analytics program		
Computer Science program with a specialization in AI or Data Science		
Other program with a specialization in AI or Data Science		

A3. Which of the following types of Ph.D. AI or Data Science Programs/ Degrees are offered by your Academic Unit? Please use the drop-down menus to indicate the Academic Unit that houses the program and the number of students enrolled in the program per year. Select all applicable programs.*
If the type of program is not offered, please select the "N/A" option for both columns.

Ph.D. Program	**In which Academic Unit is the Program housed? Select from the dropdown menu**	**Number of students enrolled in the Program per year: Select from the dropdown menu**
Stand-alone AI program	• Artificial Intelligence • Computer Science • Electrical / Electronic Engineering • Engineering (others) • Business / Management • Mathematics/ Statistics • Joint / Inter-disciplinary/ Center • Biological Sciences • Atmospheric/ Earth Sciences • Medicine • Social Sciences • Agricultural Sciences • N/A • Others (please specify)	• 1 - 25 • 26- 50 • 51 – 100 • 100+ • N/A
Stand-alone Data Science or Analytics program		
Computer Science program with a specialization in AI or Data Science		
Other program with a specialization in AI or Data Science		

A4. Which of the following types of "Other" AI or Data Science Programs/ Degrees are offered by your Academic Unit? Please use the drop-down menus to indicate the Academic Unit that houses the program and the number of students enrolled in the program per year. Select all applicable programs.**
If the type of program is not offered, please select the "N/A" option for both columns.

Program	In which Academic Unit is the Program housed? Select from the dropdown menu	Number of students enrolled in the Program per year: Select from the dropdown menu
Online program/degree in AI, Data Science/Analytics at the Bachelor's level	• Artificial Intelligence • Computer Science • Electrical / Electronic Engineering • Engineering (others) • Business / Management • Mathematics/ Statistics • Joint / Inter-disciplinary/ Center • Biological Sciences • Atmospheric/ Earth Sciences • Medicine • Social Sciences • Agricultural Sciences • N/A • Others (please specify)	• 1 - 25 • 26- 50 • 51 – 100 • 100+ • N/A
Online program/degree in AI, Data Science/Analytics at the Master's level		
Training Programs in AI and Data Science (Examples: certificate programs, summer / winter school, workshops)		
Online Training Courses/ Workshops in AI and Data Science		
Other – Please Specify		

PART B: CURRICULUM AND INSTRUCTION

B1. For the Bachelor's level AI or Data Science Program / Degree offered by your Academic Unit, please select all that apply and indicate whether the course is (a) Required or (b) Elective or (c) Course not offered.

If your Academic Unit does not offer a Bachelor's level Program / Degree, please move to the next question.

Bachelor's Level Courses	**Required/Elective/ Not offered** (*Radio button, respondent needs to choose any one)*
Programming	
Mathematics	
Probability	
Statistical Methods	
Data Structures and Algorithms	
Introduction to AI	
Knowledge Representation and Reasoning	
Optimization	
Machine Learning	
Natural Language Processing	
Deep Learning, ANN, Reinforcement Learning, Generative Models	
Multi-Agent Systems	
Data visualization, data mining	
Robotics & Automation	
Human-Computer Interaction	
Computer Vision	
Text Mining	
Speech Processing	
Applications (the internet of things, virtual reality, healthcare, social sciences, cybersecurity, etc.)	
Ethics (privacy, fairness, explainability)	
AI & Brain sciences (Neuromorphic Computing)	
Philosophy of AI	

B2. For the Master's / Ph.D. level AI or Data Science Program / Degree offered by your Academic Unit, please select all that apply and indicate whether the course is (a) Required or (b) Elective or (c) Course not offered.

If your Academic Unit does not offer a Master's / Ph.D. level Program / Degree, please move to the next question.

Master's / Ph.D. Level Courses	**Required/Elective/ Not offered** (*Radio button, respondent need to choose any one)*
Programming	
Mathematics	
Probability	
Statistical Methods	
Data Structures and Algorithms	
Introduction to AI	
Knowledge Representation and Reasoning	
Optimization	
Machine Learning	
Natural Language Processing	
Deep Learning, ANN, Reinforcement Learning, Generative Models	
Multi-Agent Systems	
Data visualization, data mining	
Robotics & Automation	
Human-Computer Interaction	
Computer Vision	
Text Mining	
Speech Processing	
Applications (the internet of things, virtual reality, healthcare, social sciences, cybersecurity, etc.)	
Ethics (privacy, fairness, explainability)	

Master's / Ph.D. Level Courses	Required/Elective/ Not offered (*Radio button, respondent need to choose any one)*
AI & Brain sciences (Neuromorphic Computing)	
Philosophy of AI	

B3. Please list any other AI or Data Science-related courses offered by your Academic Unit. (Optional)

<Free Text Field>

B4. Which of the following modes of training and learning are available to students in the AI or Data Science Programs/ Degrees offered by your Academic Unit? **

	Required/ Optional/ Not Offered *(Radio button for each option, select any one)*
Research in AI / Data science	
Interdisciplinary research in AI/ Data Science +X, where X is another research domain)	
Courses from other application domains	
Hands-on project with real-life data (Capstone project, course project, mini project)	
Online Courses including MOOCs	
Project with industry (internships etc.)	
Thesis	
Other (please specify)	

PART C: FACULTY, INFRASTRUCTURE AND RESOURCES, COLLABORATION

C1. Please indicate the total number of faculty members in your Academic Unit.*

Total number of faculty in the Academic Unit	Range
	1-10
	11-20
	21 -30
	31 and above

C2. Please indicate the percentage of faculty members in your Academic Unit with core experience/ expertise and training in AI or Data Science.*

Percentage of faculty with core experience/ training in AI / Data Science	% age Range
	1-10%
	11-20%
	21-30%
	31-40%
	41-50%
	51% and above

C3. Do faculty members from other Academic Units participate in your AI or Data Science Program/ Degree? If Yes, please indicate the Academic Units that participate in your program. If 'No', please check N/A. **

Discipline	Please check all applicable
Artificial Intelligence	
Computer Science	
Electrical / Electronic Engineering	
Engineering (others)	
Business / Management	
Mathematics/ Statistics	
Joint / Inter-disciplinary/ Center	
Biological Sciences	
Atmospheric/ Earth Sciences	

Medicine	
Social Sciences	
Agricultural Science	
Others (please specify)	
N/A	

C4. To what extent do the following factors affect/ pose a challenge to the AI or Data Science programs/ degrees offered by your Academic Unit?*

Please **rate** each of the factors

Factors	
Quantity and quality of students interested in pursuing research	• Not at All • To some extent • Greatly
Quantity and quality of faculty for teaching and research supervision	
Availability of/ access to high-end computing infrastructure and software	
Availability of quality datasets	
Resources and administrative bottlenecks	
Collaboration with Industry	
Collaboration with other Academic Units for interdisciplinary research	
Collaboration with international educational / research organizations	
Availability of Internship opportunities	
Student Placement and employment opportunities	

C5. How would you rate the demand in the past 1-5 years for AI or Data Science courses offered by your Academic Unit from the following groups? **

Please select 'Not Applicable' if it is not applicable for your Academic Unit

	Please select from the dropdown menu • Significantly increased • Increased • Unchanged • Decreased • Significantly Decreased • Not applicable
Bachelor's Students from your own Academic Unit	
Bachelor's Students from other Academic Units	
Master's /Ph.D Students from your own Academic Unit	
Master's/ Ph.D. Students from other Academic Units	

C6. Which of the following best describes the career paths/ aspirations of students in your AI and Data Science Program/ Degree? **

Please rank each of the following career choices from 1 to 4, where 1 is ‹Most preferred› and 4 is ‹Least preferred›

Challenges	1 (Most preferred) to 4 (Least preferred)
Industry (Tech)	
Industry (Other i.e. manufacturing, finance, healthcare etc.)	
Academic/ Research Positions (Doctoral Programs, Faculty Positions)	
Start-up/Entrepreneurial Activities	

C7. Please describe any existing partnerships your Academic Unit has with (a) global institutions/ research laboratories; (b) Industry in support of the AI and Data Science Program/ Degree. Please specify the country, institution/ organization, and type of collaboration (student/ faculty exchange, joint research collaborations, internships). (Optional)

<Free Text Field>

C8. Please provide a detailed description of one of the undergraduate or post-graduate programs in AI and Data Science offered by your Academic Unit, including the list of courses, modes of training, and other degree requirements. You may send this information via email to usindia.ai@gmail.com. (Optional)

C9. If you are willing to participate in a follow-up discussion with the IUSSTF-USIAI team to answer questions about your program, please provide a phone number where we may reach you. (Optional)

<Free Text Field>

I give my consent to use the Name of the Institution, Name of the Academic Unit, the Program/ Degree offered by the Academic Unit and the URL of the Institution website to be used for future use/publication.

1) Yes 2) No

Thank you for your participation in the survey.

Please visit the USIAI website to learn more about the initiative.

D. FUTURE PLANS

D1. Please share more details of the program that your Academic Unit plans to offer and a tentative start date. You may also paste the URL of your program web page. (Optional)

<Free Text Field>

D2. To what extent do the following factors limit your ability to offer a program/ degree in the future?*

Factors	
Quantity and quality of students interested in pursuing research	• Not at All • To some extent • Greatly
Quantity and quality of faculty for teaching and research supervision	
Availability of/ access to high-end computing infrastructure and software	
Availability of quality datasets	
Resources and administrative bottlenecks	
Collaboration with Industry	
Collaboration with other Academic Units for interdisciplinary research	
Collaboration with international educational / research organizations	
Availability of Internship opportunities	
Student Placement and employment opportunities	

I give my consent to use the Name of the Institution, Name of the Academic Unit, the Program/ Degree offered by the Academic Unit and the URL of the Institution website to be used for future use/publication.

1) Yes 2) No

Thank you for your participation in the survey.

Please visit the USIAI website to learn more about the initiative.

ANNEXURE II

List of Institutions

Name of the Institution	Institution website	Academic Unit
Aligarh Muslim Univerisity, Aligarh	https://www.amu.ac.in/	Interdisciplinary Centre for Artificial Intelligence
Chameli Devi Group of Institutions	https://cdgi.edu.in/cdgi.php	Computer Science and Engineering
Chandubhai S Patel Institute of Technology	https://www.charusat.ac.in/cspit/	Department of Information Technology
Chennai Mathematical Institute	https://www.cmi.ac.in	Chennai Mathematical Institute
Christ University, Bengaluru	http://christuniversity.in/	Computer Science
Cummins College of Engineering for Women, Pune	https://www.cumminscollege.org	Computer engineering
Elitte College of Engineering, Kolkata	https://petindia.org/ece/	Computer Science and Engineering Department
Heritage Institute of technology	www.heritageit.edu	Computer Science and Engineering
ICCS College of Engineering and Management, Thrissur	www.iccscem.ac.in	
IFET College of Engineering	www.ifet.ac.in	Computer Science and Engineering
IIIT Allahabad	https://iiita.ac.in/	Department of Information Technology
IIIT Design and Manufacturing Kancheepuram	www.iiitdm.ac.in	
IIIT Design and Manufacturing Kurnool	www.iiitk.ac.in	Department of Computer Science and Engineering
IIIT Dharwad	https://iiitdwd.ac.in/	Data Science and Intelligent Systems
IIIT Hyderabad	www.iiit.ac.in	
IIIT Kota	www.iiitkota.ac.in	
IIIT Nagpur	https://iiitn.ac.in	Computer Science & Engineering
IIIT Sri City Chittoor	www.iiits.ac.in	Computer Science and Engineering
IIITDelhi	www.iiitd.ac.in	Computer Science & Engineering
IISc Bengaluru	https://iisc.ac.in	Robert Bosch Center for Cyber Physical Systems

IISc Bengaluru	https://iisc.ac.in	Department of Computer Science and Automation
IISc Bengaluru	https://iisc.ac.in/	Division of Electrical, Electronics, and Computer Sciences
IISER Bhopal	www.iiserb.ac.in	Department of Data Science and Engineering
IISER Kolkata	https://www.iiserkol.ac.in/web/en/#gsc.tab=0	Computational and Data Sciences
IISER Tirupati	http://www.iisertirupati.ac.in	Department of Chemistry
IIT Bhubaneswar	www.iitbbs.ac.in	School of Electrical Sciences
IIT Delhi	www.iitd.ac.in	Yardi School of Artificial Intelligence
IIT Dharwad	www.iitdh.ac.in	Department of Computer Science and Engineering
IIT Gandhinagar	https://iitgn.ac.in	Computer Science and Engineering
IIT Hyderabad	www.iith.ac.in	Department of AI
IIT Jammu	https://www.iitjammu.ac.in	Computer Science and Engineering
IIT Jodhpur	https://iitj.ac.in/	Computer Science and Engineering
IIT Kanpur	http://iitk.ac.in/	Department of Mathematics and Statistics
IIT Kharagpur	www.iitkgp.ac.in	Centre of Excellence in Artificial Intelligence
IIT Mandi	www.iitmandi.ac.in	School of Computing and Electrical Engineering
IIT Patna	www.iitp.ac.in	Department of Computer Science and Engineering
IIT Ropar	www.iitrpr.ac.in	Centre for Applied Research in Data Science
IIT Ropar	www.iitrpr.ac.in	Computer Science and Engineering
IIT Tirupati	www.iittp.ac.in	Department of Computer Science and Engineering
Indian Statistical Institute, Kolkata	www.isical.ac.in	Computer and Communication Sciences Division (CCSD) and Centre for Artificial Intelligence and Machine Learning (CAIML)

Jawaharlal Nehru National College of Engineering	www.jnnce.ac.in	
Jawaharlal Nehru University, Delhi	https://www.jnu.ac.in/main/	School of Computational and Integrative Sciences
Kakatiya Institute of Technology and Science, Warangal	https://www.kitsw.ac.in	Computer Science and Engineering (Artificial Intelligence & Machine Learning)
Kargil Campus University Of Ladakh	https://www.universityofladakh.org.in	Department of Computer Science and IT
Maharaja institute of technology, Mysore	www.mitmysore.in	Computer Science and Engineering
Malaviya National Institute of Technology Jaipur	www.mnit.ac.in	Department of Computer Science & Engineering
Manakula Vinayagar Institute of Technology, Puducherry	https://mvit.edu.in/	Department of Computer Science and Engineering (IoT & Cybersecurity including Blockchain Technology)
Manipal Institute of Technology, Manipal	https://manipal.edu/mu.html	Department of Data Science and Computer Applications
Manipal University Jaipur	https://manipaljaipur.in/?utm_source=Brannia&utm_medium=SEO&utm_campaign=SocialMedia	School of Computing and IT
NIMS Institute Of Engineering and Technology, Jaipur	https://www.nimsuniversity.org/colleges/engineering-and-technology.php	Artificial Intelligence
NIT Arunachal Pradesh	www.nitap.ac.in	Computer Science and Engineering
NIT Calicut	http://www.nitc.ac.in	Computer Science & Engineering Department
NIT Hamirpur	https://nith.ac.in/	Department of Computer Science & Engineering
NIT Kurukshetra	www.nitkkr.ac.in	Computer Engineering Dept.
NIT Patna	www.nitp.ac.in	Computer Science and Engineering
NIT Puducherry	https://www.nitpy.ac.in	Department of Computer Science and Engineering
Punjabi University Patiala	http://www.punjabiuniversity.ac.in	Computer Science

Ramakrishna Mission Vivekananda Educational and Research Institute	www.rkmvu.ac.in	Computer Science
Rathinam College of Arts and Science	https://rathinamcollege.ac.in	Computer Science
RV College of Engineering, Bengaluru	https://rvce.edu.in	Department of Computer Science and Engineering
Sangam University	https://www.sangamuniversity.ac.in	School of Engineering and Technology
Sathyabama Institute of Science And Technology, Chennai	www.sathyabama.ac.in	Department of Information Technology
SNJB'S Late Sau Kantabai Bhavarlalji Jain College of Engineering Chandwad	http://www.snjb.org/engineering/	Computer Science
Sreepathy Institute of Management And Technology, Koottanad	http://simat.ac.in/	Electrical and Electronics Engineering
St. Thomas Arts & Science college, Chennai	www.stcpcz.in	Bachelors in Computer Administration
Theivanai Ammal College for Women, Viluppuram	http://www.tacw.in/default.aspx	Mathematics
Vinayaka Mission's Kirupananda Variyar Engineering College, Salem	http://www.vmkvec.ac.in	
Vinayaka Mission's Virupananda Variyar Arts and Science College, Salem	http://www.vmkvec.ac.in	
Yashavantrao Chavan Institute of Science, Satara (Autonomous), Maharashtra	www.ycis.ac.in	Centre of Excellence in Artificial Intelligence Application

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