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AI For Bridging Socio-Economic Inequities in Indian Education Space

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ABSTRACT

Over the past few years, Artificial Intelligence (AI), data analytics over edge and computer vision have ushered in a plethora of use cases that promise to transform the education landscape, particularly in the developing economies. The significant headways that AI has made in improving the quality of educational pedagogies and in enhancing the accessibility and inclusivity of the education models are now compelling the multiple stakeholders in the education space to reimagine the way learning is done and facilitated.

Vast socio-economic inequities exist in the Indian education landscape, with poor infrastructural facilities, disparities in the technological competence of teachers and the gender & caste related divides plaguing the education space since decades. With a one-size-fits-all approach implemented for learning across the nation and with superficial insights into individual student's cognitive capabilities, the education methodology in India faces serious limitations as students don't receive personalized attention which leads to many students staying bereft of the value of education programs in the country. Artificial Intelligence enabled solutions can help identify the key areas of improvements in the education space, while analyzing the needs of each student in a personalized manner, to help every student derive the benefits of education, which can help bridge the socioeconomic inequities in the country.

The report builds its arguments, analysis and future directions based on the data collected through secondary research. Industry benchmark reports by the leading consultancy firms and market research organizations will be leveraged, while also utilizing the data from open datasets on Unified District Information System for Education (UDISE), World Bank, NITI Aayog India and United Nations International Children's Emergency Fund (UNICEF). Moreover, the authors have reached out to their respective common and divergent networks of educators, technologists and policymakers to understand the systematic approach that AI can take to transform the education landscape. The data-driven value case derivations quantify the benefits and opportunities for AI in education, which form the foundation of actionable and viable recommendations.

Keywords: Artificial intelligence, education, personalized education, digital education, EdTech

INTRODUCTION

Artificial Intelligence (AI) and Machine Learning (ML) models are rapidly impacting all sectors that touch human lives in a myriad of ways. Education being integral to one's self-development is witnessing a transformation with application of AI across multiple facets. 2018 Horizon report states that AI's impact in

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the education sector is anticipated to grow by 43% in the period of 2018 – 2022. A 2019 report by Research and Markets, states global AI Education market reached $1.1 billion in 2019 and is estimated to reach over $25.7 billion by 2030. The four areas of AI's impact on Education Technology (Ed-Tech) are academic support services, and institutional and administrative services such as Profiling and Prediction, Assessment and Evaluation, Adaptive systems, Personalization, and Intelligent Tutoring Systems. The field of AI is both innovative and derivative.

In a post-COVID scenario, developed and developing economies alike are realizing the need for digitizing the education space, which requires reliance of robust digital tools, applications and platforms that can enable the reach and impact of the personalized pedagogy. The continuity of education in the net pandemic or another global disruption will be largely dependent of the resilience of the AI, data analytics and communication infrastructure that can bridge the inequalities between the privileged and the underprivileged sections of students.

The current education models narrowly advocate a one-size-fits-all approach, that prescribes a uniform method of imparting education. This approach encourages compliance to the preset uniform standards of education delivery, instead of a personalized education suited to the individual needs of the students that vary in terms of geography, linguistic skills, cognitive capabilities, income disparities and gender-related concerns. Students who lag in absorption of concepts taught inside traditional classrooms struggle to comprehend the follow-up lessons due to lack of clarity on the previously taught fundamentals. As a result, inconsistencies arise in the volume of lessons absorbed and retained by the students and gaps in their cognitive development grow wider with each passing day. Such gaps may arise between students having different levels of comprehension capabilities inside the same classroom, or students belonging to different regions and income groups altogether. When such inconsistencies in the quality of education get compounded over large sections of population within and beyond domestic borders, they widen the income, gender and regional inequalities over the course of time.

Such global issues that make education less inclusive, less meaningful and less enabling for people stand a chance to be addressed by the transformative use cases of AI. With its advanced capabilities in driving real-time large volume data analytics and in automating majority of crucial cognitive tasks performed by human teachers, AI provides an opportunity not only to mimic teachers' current roles, but also enhance their efficacy manifold. The convergence of embedded data collection techniques in pedagogical tools and computational technologies has enabled the education sector to move beyond proof-of-concept demonstrations and adopt the technologies in multiple facets of education. AI is fast making individualized learning, automated assessments and precision education a reality, not only in the developed world, but in developing economies as well. Moreover, as new use cases are deployed in the developing economies, increasing amount of training data will be generated, which will guide the development, interpretation and verification of the AI algorithms based on model-driven data analytics. With the incorporation of AI in education, teachers and policymakers will be able to customize the learning journey of the students as per their individual needs, which will ensure that the formal and informal education programs around the developing and underdeveloped economies meet their target goals.

In such cases, AI-driven data analytics can enable policymakers with the insights and visibility over the reach, engagement and impact of online education. This will further contribute to the cause of quality education (Sustainable Development Goal# 4) and will bridge the inequalities of access to digital technologies across diverse regional and income groups.

While the global concerns get addressed, the pertinent deficiencies in the operationalization of education in current times also stand a chance to undergo digital transformation. A huge opportunity lies in improving the efficiency of teachers inside classrooms, by automating their activities of grading assignments, resolving students' queries, and conducting assessments. AI algorithms can record and track the academic and non-

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academic progress of students in a school and identify those who need additional attention in specific areas. AI-based digital solutions can autonomously formulate revision curriculums and learning frameworks, personalized for such students. Such applications can also assist the teachers with a customized data-driven lesson plan that can help the teacher connect with the student on a personal note and provide pedagogical interventions in the correct areas. For example, there exist several software solutions that offer mathematics packages to assist teachers in assessing the current level of their students' comprehension of concepts, cluster the students according to learning needs, and recommend lesson plans, resources and problem sets for each group. Alongside automatically grading the subjective answers of students using Natural Language Processing, the AI algorithms can also help students visualize information in an immersive fashion, by leveraging the capabilities of Augmented Reality. Use cases for AI in attention monitoring, face recognition-based attendance tracking and resolution of doubts via chatbot are also possibilities that the education space is rapidly exploring. Finally, AI algorithms can also play a major role in mapping students to colleges that align with areas of interests, academic qualifications and income levels, while recommending subjects that align with their cognitive capabilities and areas of interest.

However, challenges do exist in the implementation of the AI solutions in the education landscape. While moderated pilot studies have demonstrated improvements in student learning from technology-rich, personalized blended learning, the improvements have not been realized on a large scale yet. The latest Program for International Student Assessment scores show that, worldwide, students who use AI-enabled digital devices in the classroom are performing worse than those who do not. The disconnect between technology and students' performance has arisen because of the lack of teachers' training on how to leverage AI in the classrooms. The stakeholders and policymakers have to understand that AI is not a substitute, but a supplement to the classroom teaching programmes. This is where basic AI understanding and development of familiarity with AI algorithms is crucial, while trainers need to be upskilled on data analysis in schools. This has to be facilitated by AI research in higher education institutions and upskilling initiatives for workforce development for acquiring new AI skills for career progression. Similarly, policymakers will have to identify ways in which AI can be utilized for supporting life-long learning through continuous learning and assessments for adult literacy. The value of investments made by the public and private sector will have to be evaluated and quantified to critically analyze the feasibility, efficiency, cost-effectiveness and social impact of deploying AI in the Indian context.[i]

- **Focus on AI in National Education Plan**

The New Education Policy 2020 (NEP) offers a far-sighted vision and plans to transform the way Indians learn and acquire skills. NEP places emphasis on India's core strengths, such as multidisciplinary learning and multilingualism, to lay the foundations for setting up an intelligent society and a globally competitive workforce. These are the two crucial factors for the growth of responsible and flourishing AI industry.

NEP 2020 has its focus on making India a knowledge superpower and on offering education to one-and-all. This focus includes instituting night schools, which use school complexes after school hours, to offer learning programmes to adults. These schools help people who work during the day and educate them with vocational subjects such as high-quality modules to teach sign language and others. The New Education Policy (NEP) has acknowledged, in clear terms, the significance of artificial intelligence in education in present times. NEP will transform the education system and that the introduction of Machine Learning (ML), Big Data Analytics and AI will help build computational thinking at an early stage and set groundwork for digital literacy.

Artificial Intelligence, Design Thinking and coding are necessary 21st Century skills that will promote creativity, problem solving abilities and communication in our students. The CBSE curriculum is now focusing on Skill based learning while other schools are aligning to NEP by moving form Rote learning to

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Experiential learning. Mandatory technical training for students for all ages to prepare them for an AI economy. Critical skills including Digital literacy, coding and computing are to be imparted at the school level. Government aims to make the future generations employment-focused by teaching skills required at a modern workplace; this includes introducing and using technologies such as AI and analytics, which are built on the principles of logical thinking, critical thinking, and problem-solving skills.

The policy also aims to use education to sensitize students to the issues and ethics surrounding AI. It recognizes that holistic education of AI-based technologies cannot be complete without raising awareness of issues such as data protection and privacy, and ethical concerns such as data bias.

CHALLENGES IN INDIAN EDUCATION SECTOR

The education sector in India has its fair share of challenges with regards to its quality, effectiveness, and reach. The Indian education system is among the largest in the world. With above 15 lakh schools, nearly 97 lakh teachers and over 26.5 crore students from the pre-primary to the higher secondary level, the Indian school education system is one of the largest in the world. There are over 3.8 crore students enrolled at the secondary level, of whom 44.3% are in government schools, a little over 20% are with government-aided schools and nearly 35% are with private-unaided schools.[ii] However, the public education infrastructure is particularly ill-resourced and poor in quality, especially because of poorly qualified demotivated teaching force, gender & class inequities students, and lack of personalization in learning. Education infrastructure in India is inequitable and does not effectively support socio-economic mobility necessary for social transformation.

- **Lack of personalized adaptive learning**

A generalized curriculum encourages a one-size-fits-all approach, which further makes the curriculum rigid and adds monotony in the teaching methods. The common grading system across all school in the entire nation ignores and discourages the unique skills of students, thereby hindering the higher education opportunities for academically poor students. The absence of an adaptive curriculum that suits the needs of each individual differently results in educational institutes acting like factories where clones are manufactured, instead of creating free-thinking creative individuals. A standard curriculum also stifles the flexibility and agility of education infrastructure required to stay abreast with changing times and needs. With a common approach to imparting education, the teaching fraternity develops resistance to change and timely improvement in the education system. An industrial model of education denies opportunity to students to enhance their unique skills and prevents them from realizing their full potential.[iii]

Russian Psychologist, Lev Vygotsky, who founded Social Constructivist Theory of Learning, states that ‘content is the best motivator’ for education. If a lesson is designed to actively engage children through a variety of exploratory and investigative tasks, learners would thoroughly enjoy the process of learning and would not require extrinsic motivation like rewards or appreciation. Each student is different, with dissimilar cognitive capabilities and distinctive learning needs & pace. This necessitates educational institutes to diversify the learning scenario and help students identify their areas of inquisitiveness in respective fields of interest.

The limitations in quality of education are evident from the Education Quality Index that was released by NITI Aayog in 2017, based on assessment of learning outcomes, access outcomes, infrastructure outcomes, equity outcomes and governance outcomes.[iv] In the report, some states have witnessed a fall in quality index in base year (2016-17), over the reference year (2015-16). As visible in Figure 1, States Uttarakhand and Jharkhand displayed reduction in education quality index, which demonstrates the necessity for a better education curriculum for students in the states.

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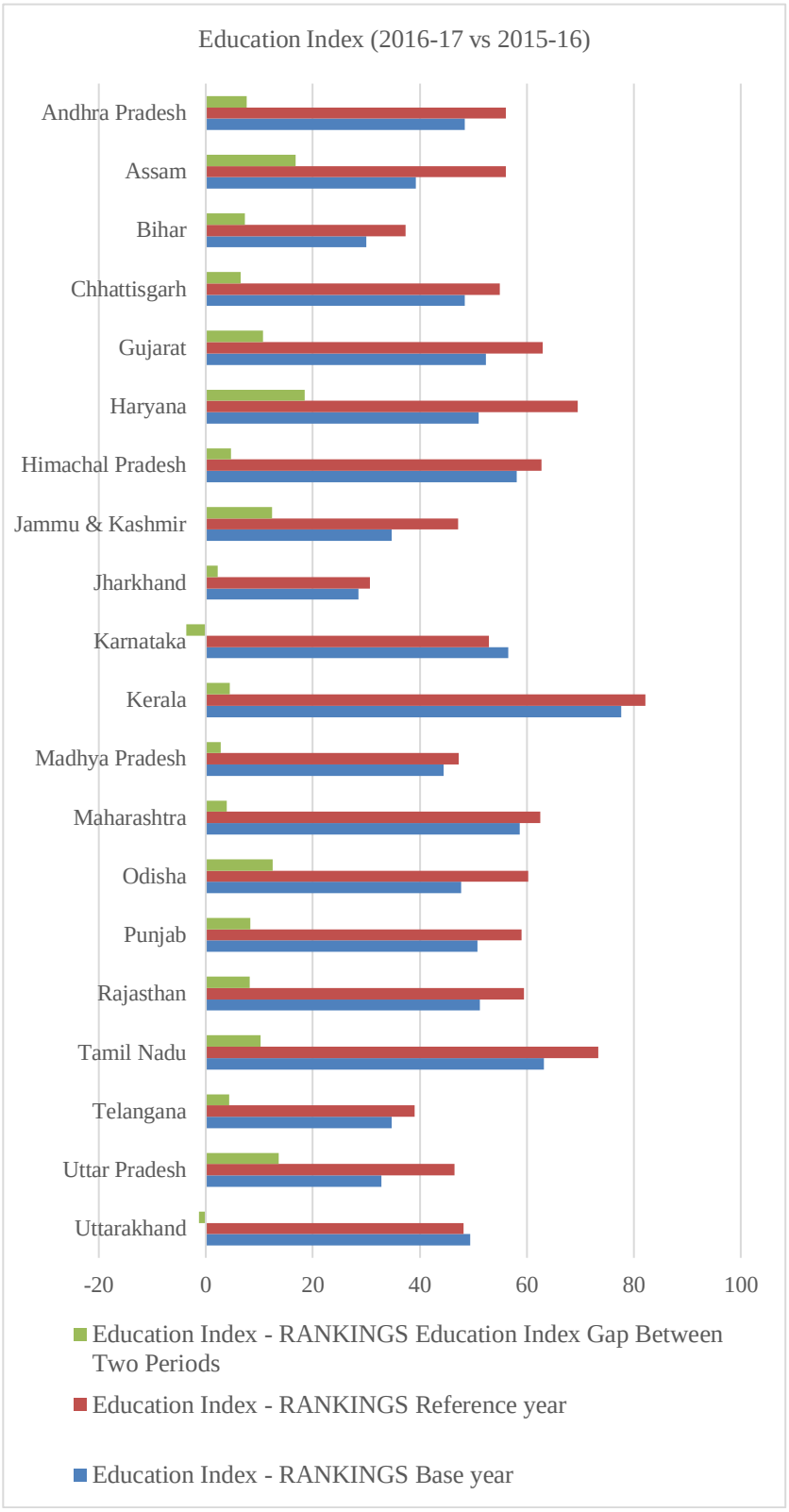

Fig 1: Education Index Rankings of major states in India (2016-17 vs 2015-16) (Source: NITI Aayog)

A personalized adaptive learning methodology will help increase the Education Quality Index, especially on the front of Learning Outcomes, which has been a matter of concern for few states, as evident in Figure 2. Multiple states have demonstrated a decline in the learning outcomes experienced by the students, which is where a revamp of education system looks necessitated.

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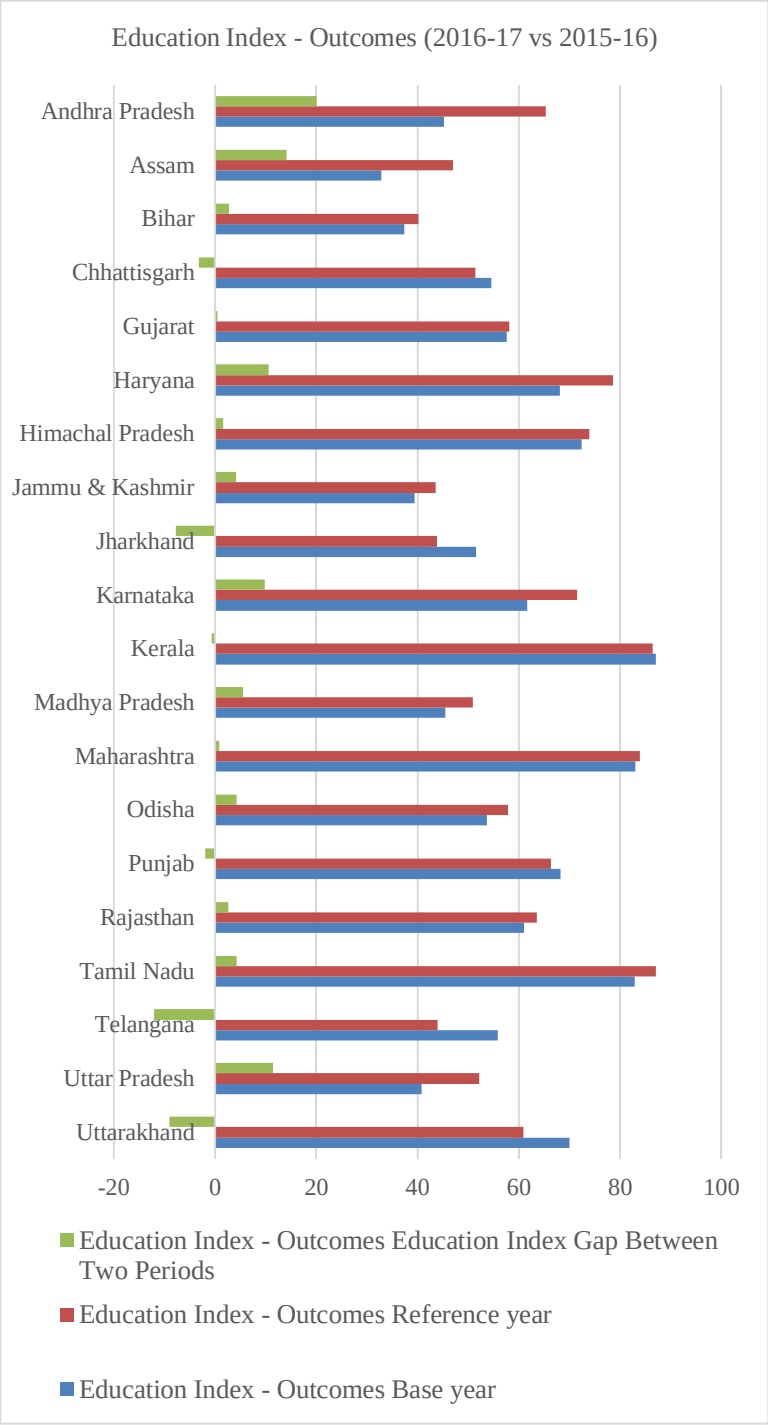

Fig 2: Education Index – Outcomes (2016-17 vs 2015-16) (Source: NITI Aayog)

- **Socio-economic inequities**

There exist massive socioeconomic and gender-based inequities in education sector. The National Statistical Office (NSO) survey on education in 2017-18, highlights that students from the richest 20% of the society are seventeen times more likely to be studying law than those from the poorest 20%.[v] Students belonging to backward castes are 6 times less likely to study management related courses in India, while the gap is also significantly wide in other fields of study. The report also states that women are less likely to receive English medium education compared to men in the country, while men take higher enrollment in Science, Technology, Engineering and Mathematics (STEM) compared to women. The education landscape shows

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inequalities in terms of income class as well.

The top 20% population in terms of income, shows much higher affinity (39.1%) to pursue Engineering and Technology related courses, as compared to a disproportionately smaller segment (17.6%) for bottom 20%. A student from the top 20% of society is 10 times more likely to be studying in an English medium school than someone who belongs to the bottom 20%.[vi] Region-based disparities exist with just 6% students receiving English medium education in Bihar, compared 63% in Telangana and 95% in Jammu and Kashmir. Hindi belt states fare badly on inter-caste inequality in English medium education.

The poor state of infrastructure facilities in schools is evident from the UDISE+ data for 2019-20 in Figure 3, which shows abysmally low number of schools with internet facilities in all regions of India.

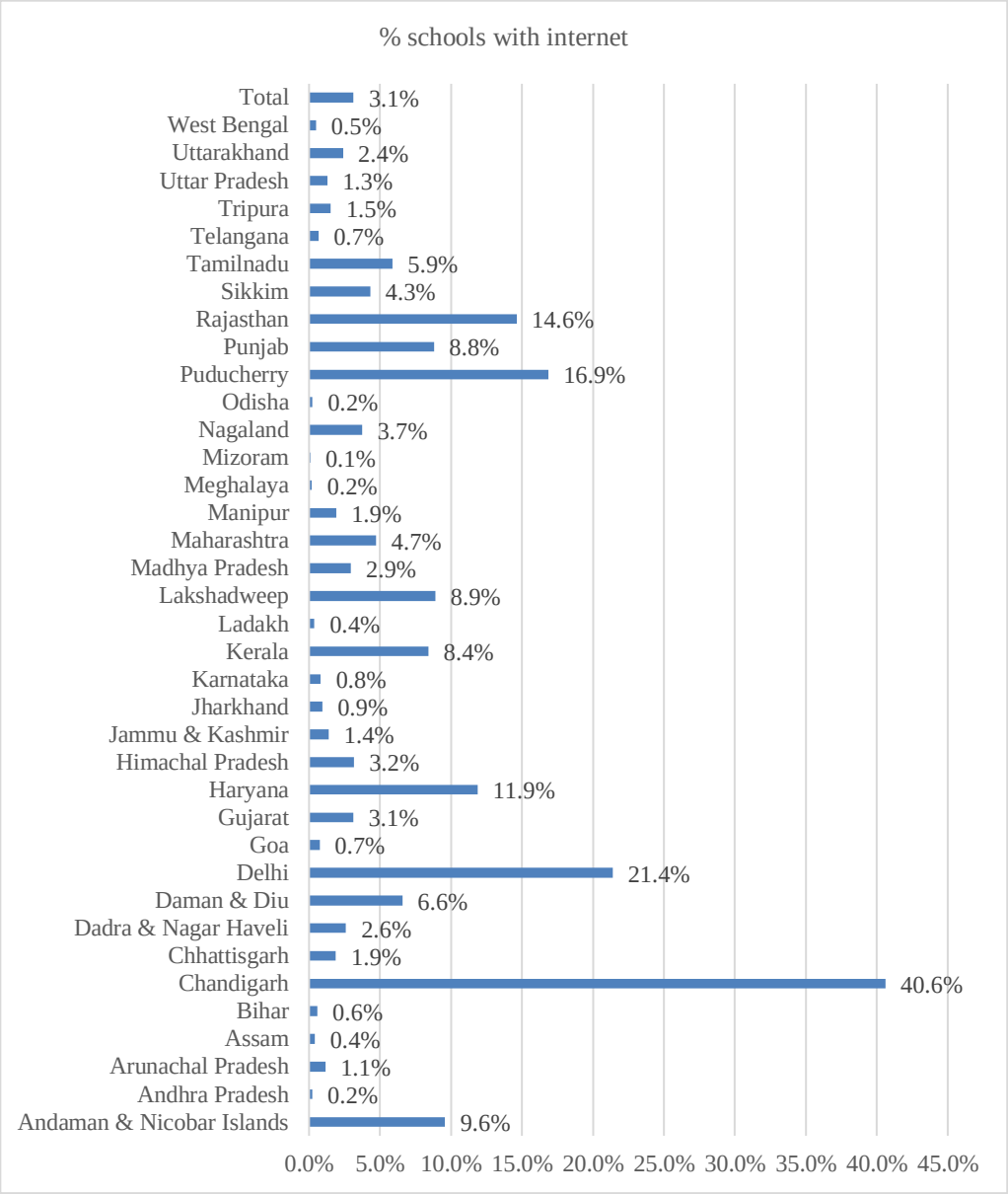

Fig 3: Disparities in internet facilities in schools across major states of India (Source: UDISE+ 2019-20)

Moreover, the Gender Parity Index in Gross Enrolment Ratio (GER), as shown in Figure 4, highlights that most states in India have GER in favor of girls, whereas few states like Rajasthan, Madhya Pradesh and Odisha have GER consistently in favor of males. However, the gap between males and females in terms of enrolment is not wide, which portrays a positive picture for India.

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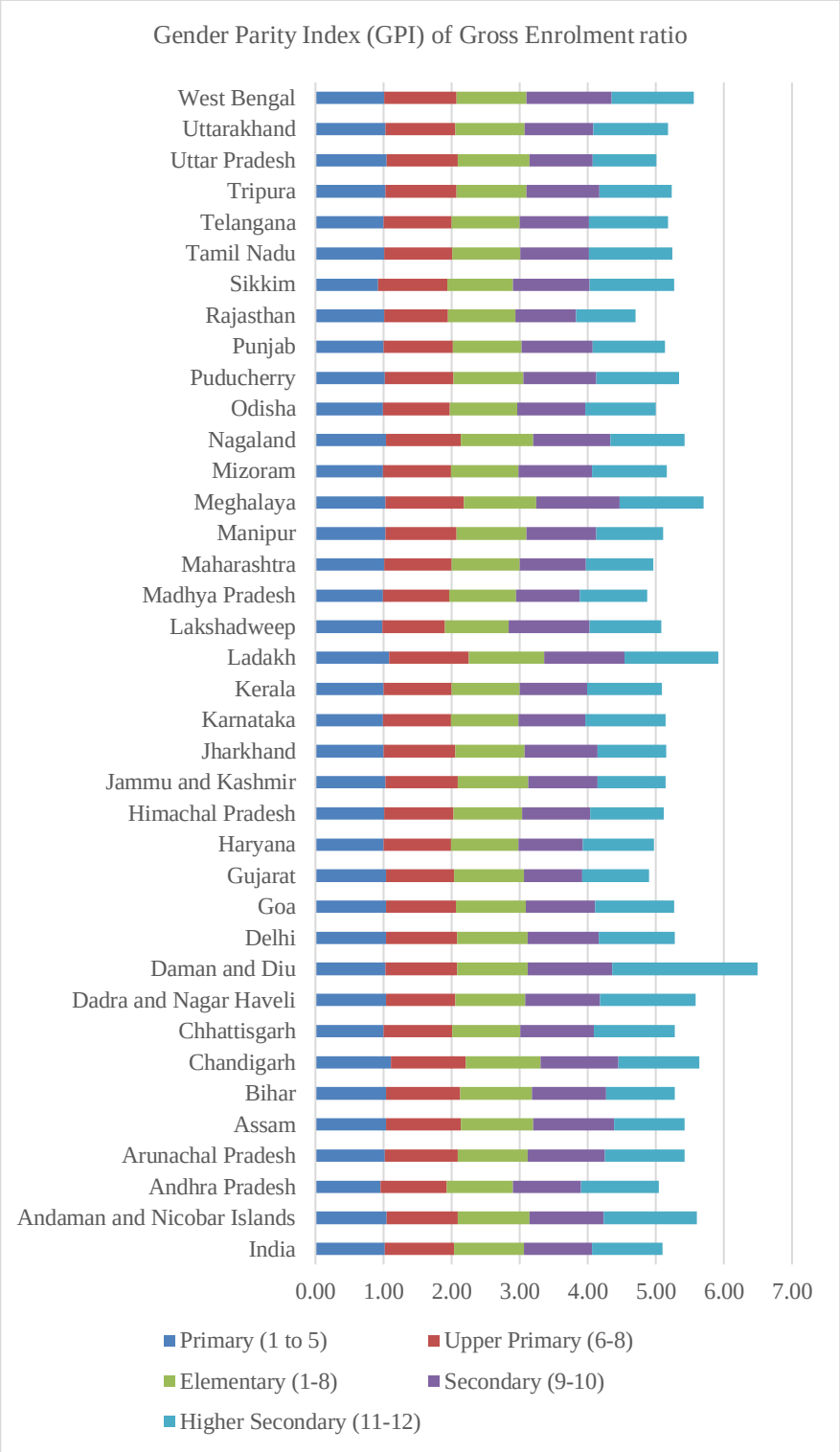

Fig 4: Gender Parity Index of Gross Enrolment Ratio across states of India as per levels of education (Source: UDISE+ 2019-20)

- **Poor infrastructure for remote education and assessments**

The COVID-19 pandemic has exposed the poor quality of online education infrastructure in India. A 2021 sample survey by ICRIER and LIRNEAsia, only 20% of school age children in India had access to remote education during the pandemic, of whom only half participated in live online lessons. The survey stated that 38% of households said at least one child had dropped out of school completely due to COVID-19. Despite

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digital connectivity surging by 40% during the pandemic, low access to devices, high costs and poor signal quality prevented most students in India from reaping its benefits. Among the 20% who enjoyed continuity in education, only 55% had access to live online classes, while 68% had access to recorded audio or video lessons. 75% of the students had work sent to them over a smartphone, usually via WhatsApp, and 61% via text messages.[vii]

This indicates that the benefits of increased digitalization have been unevenly spread across the geography and population. Additional policy support is necessary for the benefits to trickle down to lower income groups and laggard regions. This becomes crucial because below 50% of Indian households own a digital device and approximately 75% don't have access to the internet. This leaves many parents, students and educators extremely skeptical of online learning, which they consider to be less effective than offline learning.[viii]

- **High incidence of school dropout**

The 2018 report by Ministry of Statistics and Programme Implementation defines a dropout an "ever-enrolled person" who does not complete the last level of education for which he/she has enrolled and is currently not attending any educational institution. A report by National Statistical Office (NSO) has revealed that around 12.6% of students drop out of school in India, 19.8% discontinued education at the secondary level, while 17.5% dropped out at the upper primary level.[ix] According to a Government of India report, the dropout rate at the secondary school level in India is above 17%, while the dropout rate at upper-primary and primary level is 1.8% and 1.5% respectively. A 2019-20 report by Unified District Information System for Education Plus (UDISE+) states that approximately 30% of students in India do not make the transition from secondary to senior secondary level.[x] The dropout numbers have also surged due to the long-term effect of the pandemic. Girls are at a higher risk as, according to the National Right to Education forum's policy brief, 10 million girls are at risk of dropping out. A study by ChildFund India highlights that 64% of the children surveyed have expressed preference for drop out if not provided additional educational support.[xi] The dropout rate for boys in primary classes was 1.7% as against the girls' 1.2%. Similarly, the dropout rate for boys was higher in secondary classes (18.3%) than girls (16.3%). [xii]

The report also revealed that only 22% of schools in India had internet facilities in the academic year 2019-20, highlighting that the vast majority of schools would have fallen short in ensuring learning continuity for students through digital media necessitated by the COVID-19 pandemic. The survey also revealed that less than 12% of government schools had internet facilities and less than 30% had functional computers. These factors have further contributed to high dropout rates in Indian schools. UNICEF suggests that a 'dropout early warning system' can enable schools to identify students facing risk of dropping out of school, and to focus on individuals who struggle with academic performance. Schools need to practice innovative teaching methods to draw students towards education and spark interest in them. Digital learning strategies can be instrumental to provide education in the confines of their homes, students can access free educational content through smart-phone applications or YouTube provided by different institutions.[xiii]

Figure 5 highlights the dropout rates in schools across all states and Union Territories (UTs) of India (data for Union Territories of Jammu & Kashmir and Ladakh has been consolidated under 'Jammu & Kashmir'). A general analysis shows that regions like Arunachal Pradesh, Assam, Bihar and Madhya Pradesh have high dropout rates, which can be a result of lack of sufficient functional toilets for boys and girls, electricity provision and provision of computers. However, regions like Daman & Diu suffer from high school dropout rates, despite high availability of all infrastructural facilities across schools. Moreover, regions like Nagaland and Odisha have lower dropout rates, despite lower availability of infrastructural facilities across schools.

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Fig 5: School dropout rates across all states of India (2014-15) (Source: Open Government Data (OGD) Platform)

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This highlights that school dropout rate is a function of a number of other factors that are beyond the parameters captured by the Government of India, and therefore, active data acquisition and analysis is required to identify the key factors contributing to school dropout cases, and to identify strategies to mitigate the same.

Another area of concern is the high dropout rate of students as they progress in their academic journey. Figure 6 shows that Gross Enrolment Ratio decreases with progress in the grade. This shows that fewer students who commenced their education in primary grade reach to the higher grades with time, which highlights that students and parents lac a sense of value in the education system with the passage of time, due to a multitude of factors.

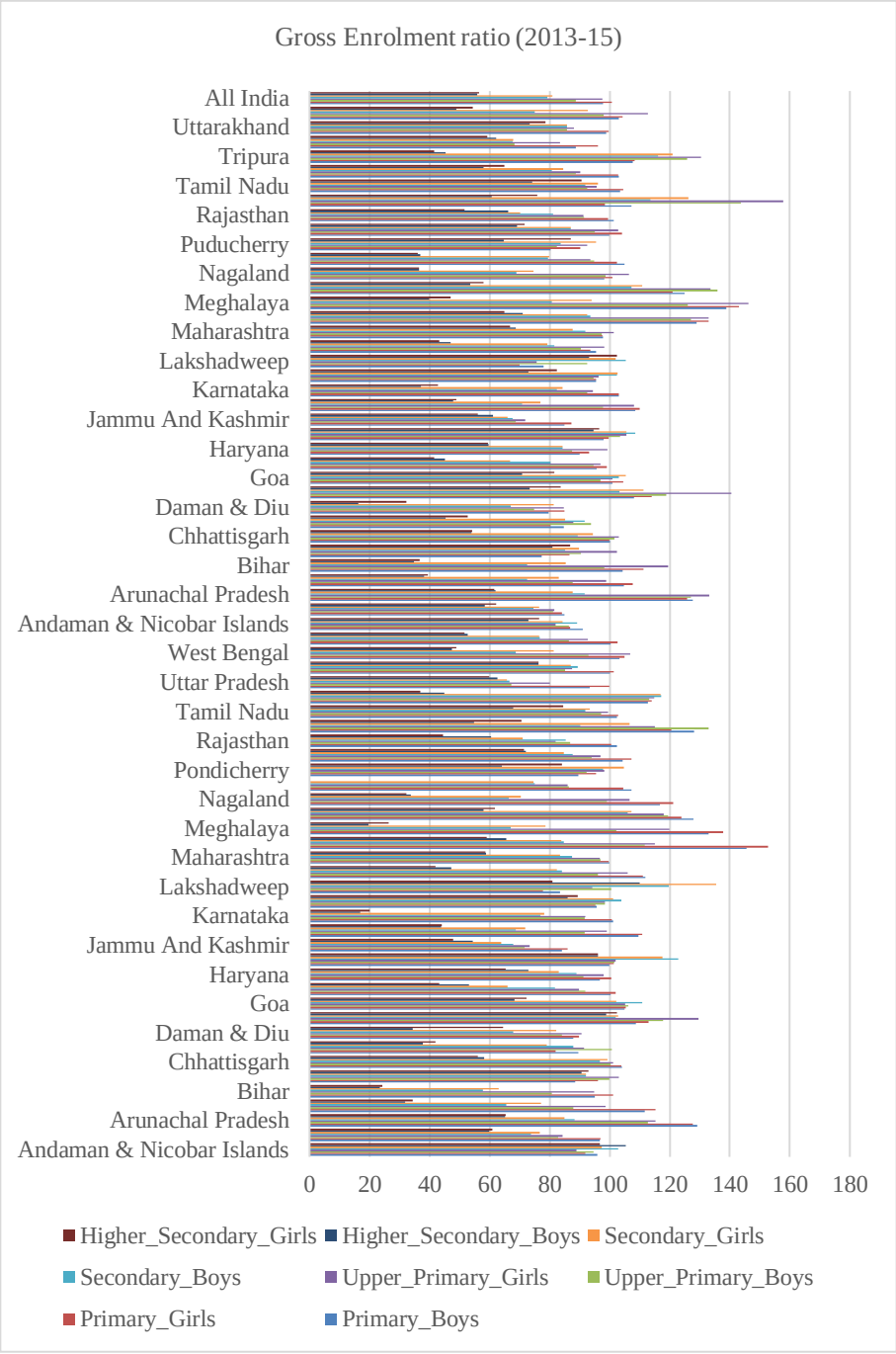

Fig 6: Gross Enrolment ratio of students across different grades (Source: Open Government Data (OGD) Platform)

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In Figure 7, 2019-20 data from Unified District Information System for Education (UDISE) shows that Retention Rate decreases as students progress over the years through their academic grades, while Figure 8 highlights that retention rate of girls is generally higher than boys in most of the Indian states, which looks counterintuitive, given the preference given by Indian families on education of boys over that of girls.

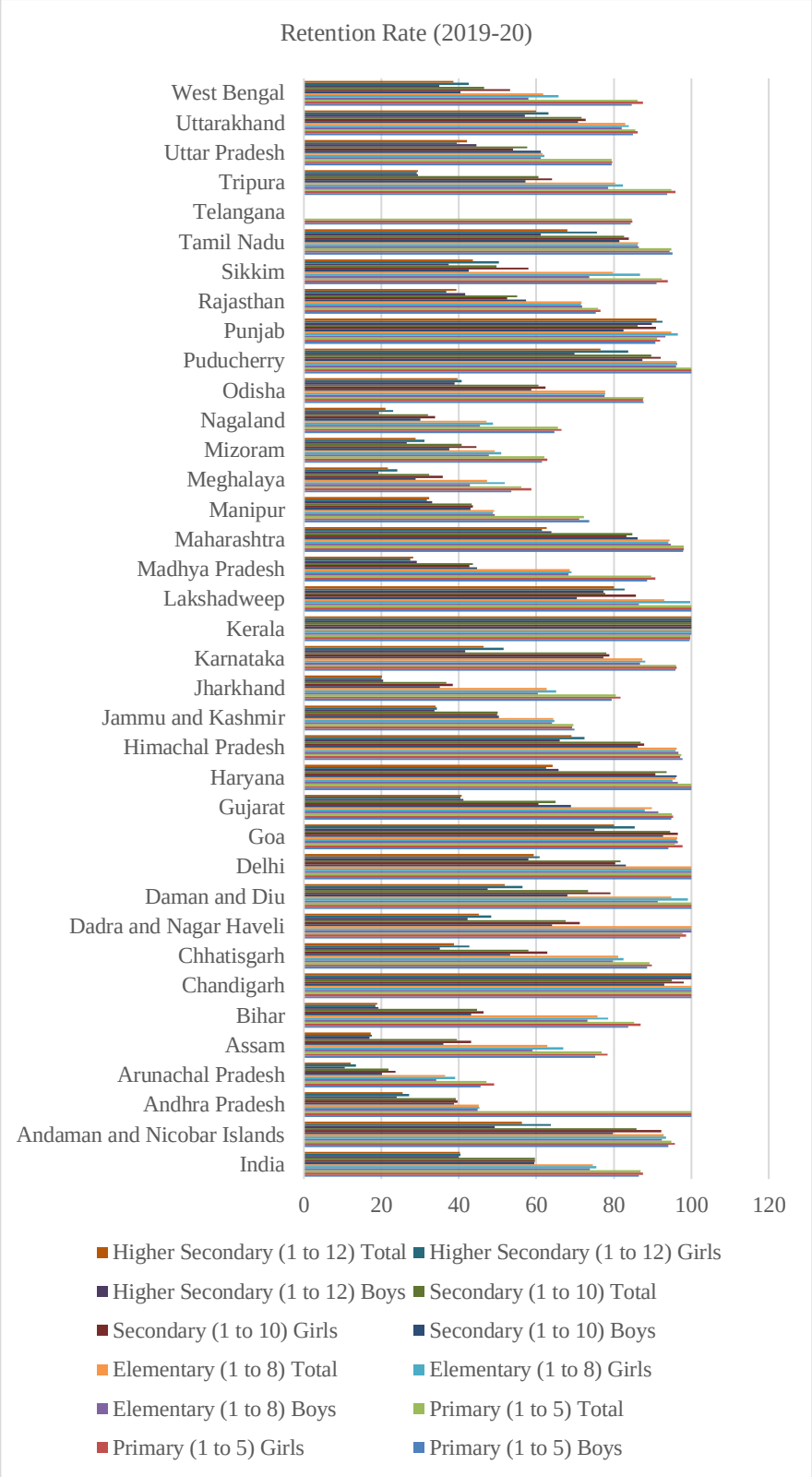

Fig 7: Retention Rate across states of India, as per grade classification (Source: UDISE)

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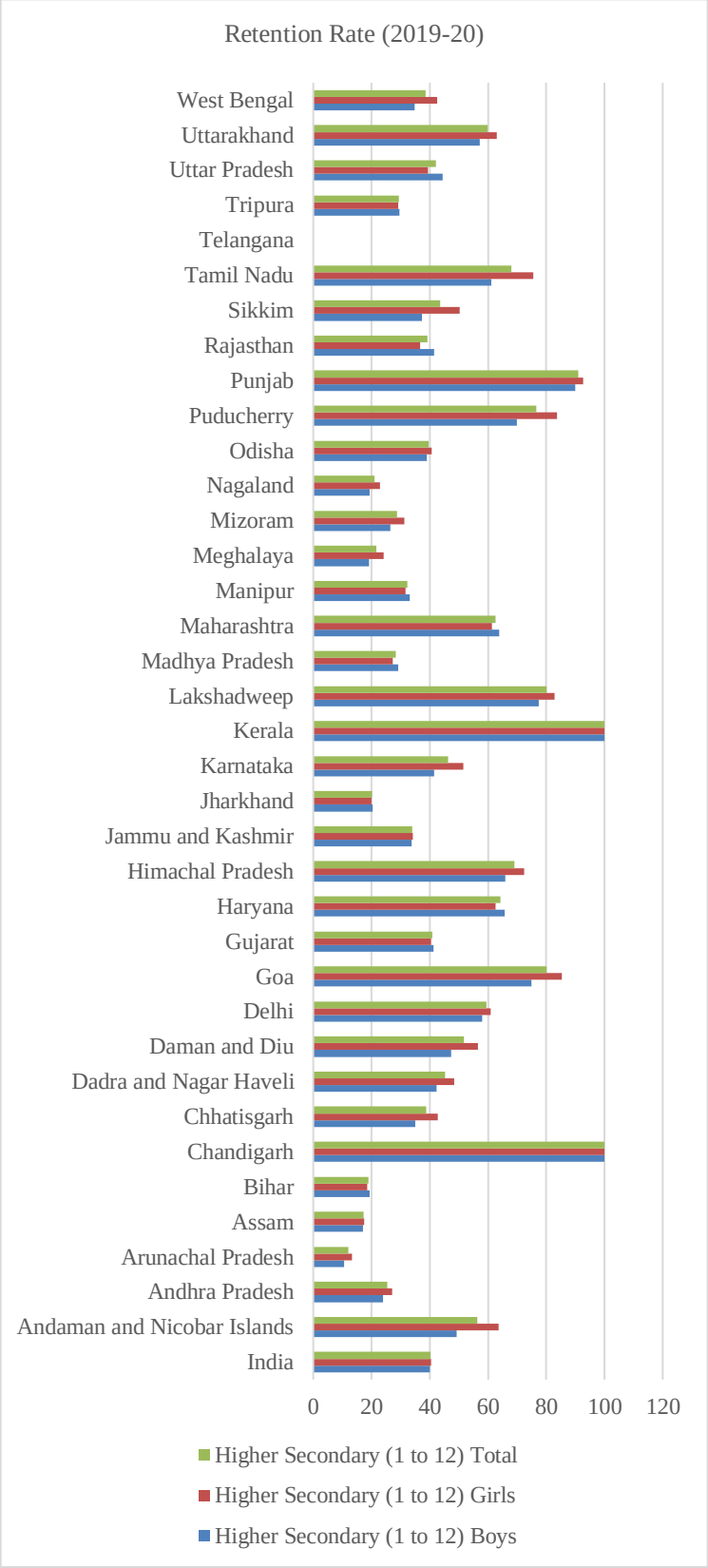

Fig 8: Retention Rate across the states of India, as per gender classification (Source: UDISE)

- **Non-personalized performance analysis**

Standardized aptitude tests and standardized achievement tests cannot measure all the unique skills that

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students possess. Non-personalized assessments put soft skills of students outside the testing boundaries. The standardized assessments do not evaluate a student's creativity, critical thinking, and collaboration ability. Moreover, students with special needs, dyslexia or exam fright may not be able to perform well, despite having knowledge of academic concepts and possessing distinctive capabilities. Their grades will not reflect their true potential or knowledge. This can severely impact the self confidence and self-esteem of students in their formative years.

The high Pupil-Teacher Ratio in Indian schools across all the states also makes personalized attention and assessments for students difficult, especially in Higher Secondary grades where the ratio is highest for most of the states. The UDISE data in Figure 9 highlights how high pupil-teacher ratio in states like Jharkhand, Odisha and Bihar can impede the endeavors for providing personalized attention and analysis for students' academic performance.

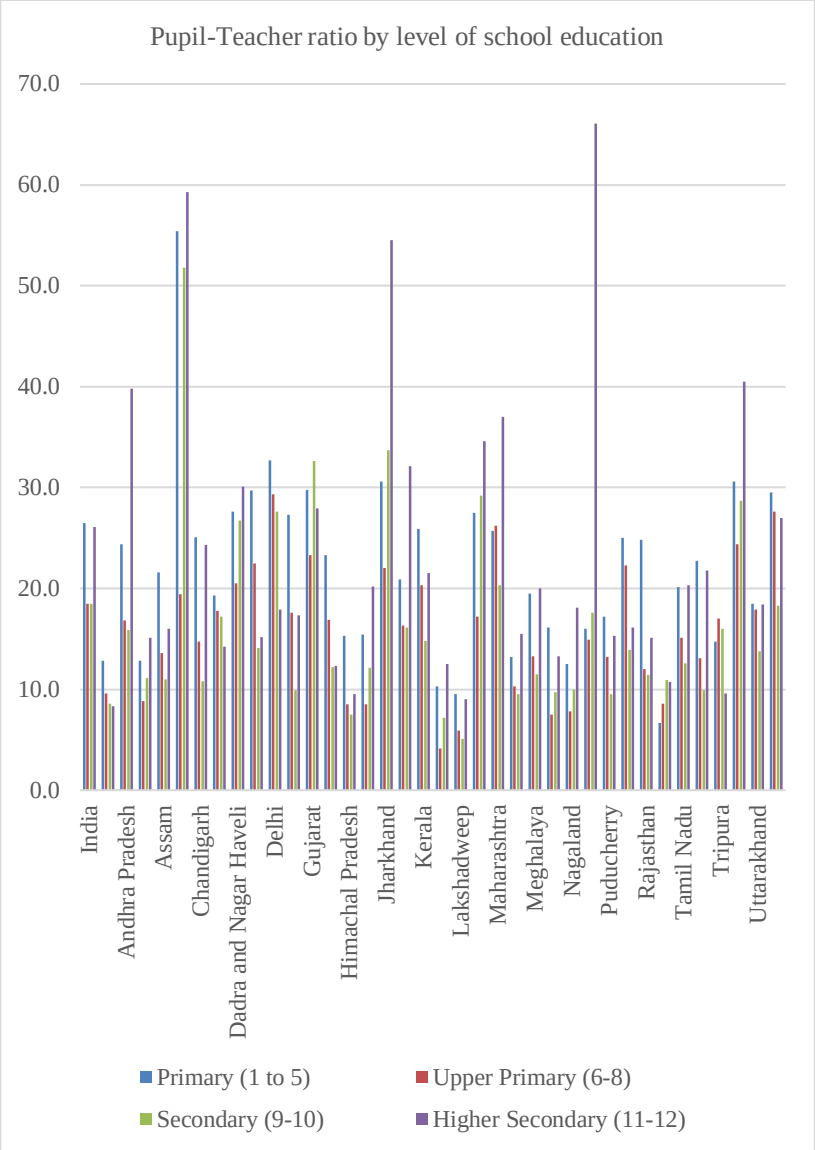

Fig 9: Pupil-Teacher Ratio by level of school education (Source: UDISE+ 2019-20)

The overall Pupil-Teacher ratio in India has, however, decreased over the years, as demonstrated by the UDISE data in Figure 10, that shows the conditions are improving in schools and can help teachers cater to a smaller set of students over the years, a practice that can be strengthened with AI-based tools for personalized performance analysis.

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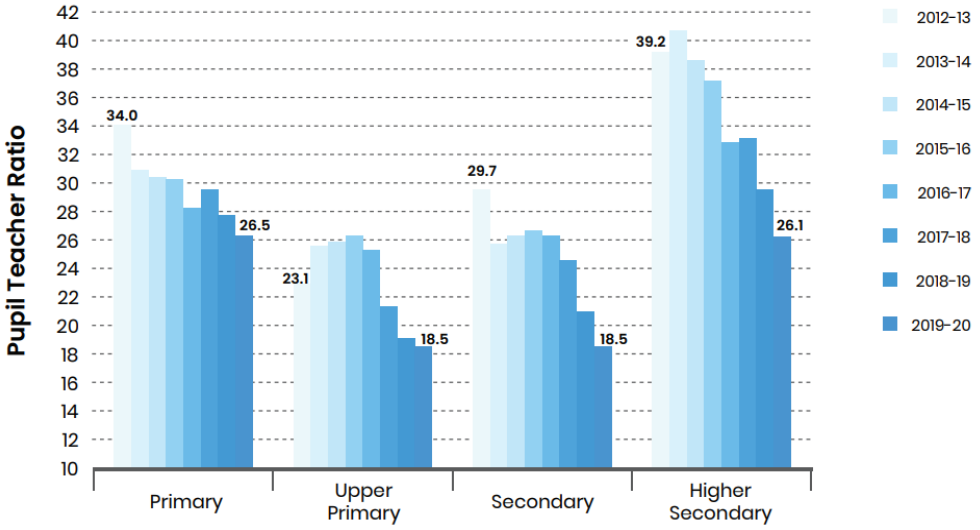

Fig 10: Pupil-Teacher Ratio in India over the years (Source: UDISE+ 2019-20)

Personalized and customized assessments will enable teachers to identify the unique strengths and areas of improvement of each student distinctly, which will equip the teacher with data on how to cater to the needs of each individual student in the classroom. Data-driven machine learning models can help automate the task to a certain extent, by mechanizing the data analytics aspect, while leaving the humanizing aspect to the human instructors.

- **Inefficiencies in existing caste-based reservations**

Link between caste and poverty and denial of opportunity based entirely on circumstances of the birth is a real problem in India. The challenges of reservation have to be addressed by generating opportunities for the disadvantaged children. This necessitates improvement of school education outcomes using a rational model of reservation that is equitable. Massive mobilization of 'Patels' in Gujarat for inclusion in caste-based reservation as OBC raises questions about the affirmative action programs in India. Studies show several benefits of reservation have been taken by fewer, better educated elites, whose socioeconomic status is better and falls in the 'creamy layer'.[xiv]

Despite reservation being applicable to the poor and rich or literate and illiterate alike, the advantages of reservation accrue for those already in possession of other advantages, such as wealth and education. This leaves the poor and disadvantaged Scheduled Caste (SCs), Scheduled Tribes (STs) and Other Backward Castes (OBCs) on the fringes and mired in poverty and social backwardness. Caste polarization is further deepened by political mobilization. The current system of granting reservation and the zero-sum approach have led to the deepening of caste divisions. In 2008, the apex court in India noted that the government's responsibility to revise the lists for providing reservations to ensure trickling of benefits to the needy. The long-standing challenge for sections of society supporting affirmative action is to end the phenomenon of reservations being an instrument of political mobilization, rather than a mechanism to ensure social justice. [xv]

OPPORTUNITIES WITH AI IN EDUCATION SECTOR

The inclusion of cutting-edge technologies in the education space, particularly AI and intelligent automation, is ushering waves of transformation in the design, delivery and continuous improvement of learning methods. AI has begun making inroads into the Indian education landscape and is enabling various

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use cases for adaptive learning, information visualization, digital lesson dissemination and bridging socio-economic & gender divide in education space. A study by Business Today showed that 47% of learning management tools by 2024 will be AI-enabled. The AI in Education market segment is estimated to grow with Compounded Annual Growth Rate (CAGR) of 40.3% between 2019 and 2025.[xvi] With the growing sophistication of Education Technology (Ed-Tech), AI is poised to aid the teachers in the classrooms, while also enabling personalized curriculum, tests, learning methods and delivery for students online and offline.

- **AI for optimizing reservations for marginalized population**

India needs to rebuild the essential link between social justice and caste-based reservations in the education sector. Reservations to the historically oppressed communities in India have been a contentious issue that has been seen in mixed light, as reservations have been alleged to promote discrimination, brain drain and mediocracy, instead of the original intention of bridging social stratification-led gaps. The ineffectiveness of the reservation system in reducing the discrimination against socially backward classes and castes has pointed towards the need for systems that benefit people based on condition, rather than caste. It has been found essential to prevent the wealthy creamy layer from undeservingly benefitting from reservations in education sector, while the genuinely needy population is prevented from such incentives due to other socio-economic challenges. AI holds potential for revamping the education sector in terms of reservations for the genuinely marginalized sections of the society, to make the system more targeted and effective in achieving its said intentions.

The current system of caste-based reservations is indifferent to the level of social disadvantage of those who are not members of a quota category and assumes that the disadvantages of those within each category are the same. At the same time, the system is also indifferent to the qualifications of quota candidates (except relative to each other), as long as they clear a low minimum.[xvii] Indian education setup needs a holistic system that can assess and assign a “Merit factor” and a “Disadvantage factor” to identify the students who are in dire need for reservations to improve their own and their family’s socioeconomic status. An AI-based system, as depicted in Figure 11, can perform a comprehensive assessment of the cognitive capabilities of the student, along with understanding how the socioeconomic conditions are proving to be an impediment in the student’s academic journey. The system also needs to identify the extent to which a student from a marginalized section of society needs financial and non-financial incentives for academic progress.

- The ‘Student Model’ in the system diagram will hold the crucial details of the student’s socioeconomic condition and scholastic competencies.
- Details like, family income, case, region of residence, family assets and tax returns data, must be compiled among other details. Analysis of these datapoints will help identify if the socioeconomic condition of the student necessitates reservation in education sector.
- An AI-based Automatic Grading System will perform a comprehensive analysis of the student’s academic performance and derive insights on the cognitive capability of the student.
- The Socioeconomic Data Compiler will compare the socioeconomic status of the student to identify how needful the student is for reservations, regardless of one’s caste. “Disadvantage Factor” will identify the magnitude of need for reservations base don a holistic set of parameters, instead of caste alone.
- Scores Compiler will assess the qualifications of the student. Merit Factor will identify the students who will be positively impacted through reservations and other public-sector interventions.
- The students displaying Merit Factor and Disadvantage Factor above a threshold will be shortlisted for reservations and will have their academic performance and socio-economic status monitored over the course of years by Y-o-Y (year-on-year) Comparator to assess if reservations in education sector improve their conditions.
- If results show that reservations improve socioeconomic conditions and literacy rate among the

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marginalized populations, without improving the academic scores, then institutionalization of AI-based Adaptive Curriculum will be encouraged in the schools.

AI will help perform rigorous data analysis over volumes of historical data to understand the effectiveness of reservations in improving the socioeconomic conditions of the beneficiaries and to identify the key areas of improvement in the existing system that has been found to fall short of meeting its intended objectives. The AI system will allow for fine-grained adjustments based on the latest social scientific evidence about the socioeconomic status of particular communities and the relative role of group or individual factors. Inclusion of AI in public incentive sector will change conversations around reservation from binary demands at the group level ("we are disadvantaged") to questions of scaling at the individual level ("how disadvantaged is this person relative to other people?").

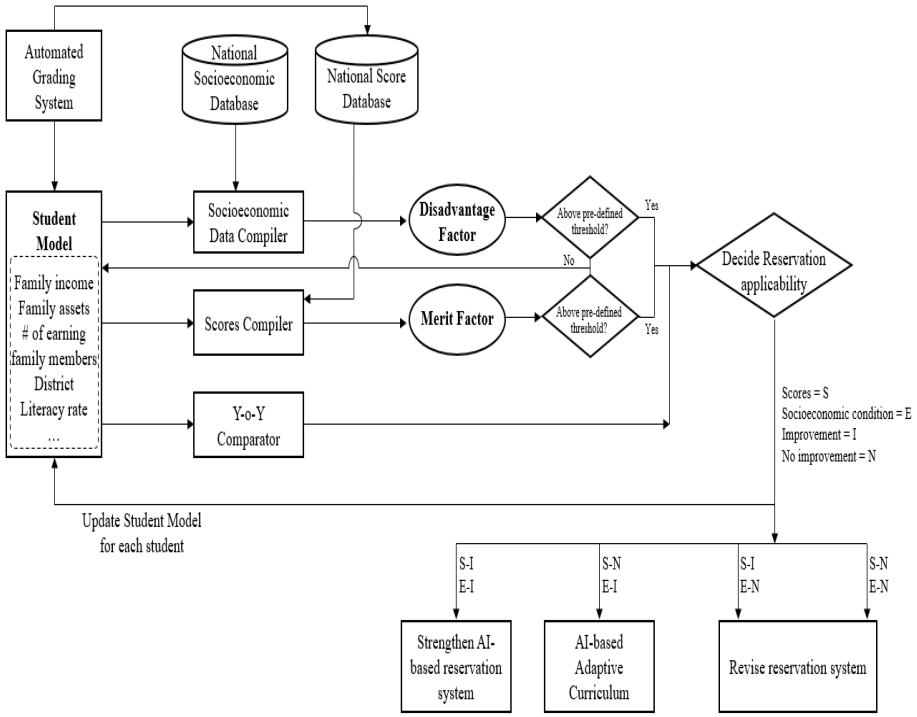

Fig 11: Reservation Optimization – System Diagram

- *Challenges in implementing AI based reservation optimization solution:* Design and implementation of AI-based solution for identifying the deserving candidates for reservations is bound to invite resistance and criticism from the sections of population that are left out despite their otherwise eligible caste. Since the poverty prevailing among the Scheduled Castes, Scheduled Tribes and Other Backward Castes has its origins in the social-religious deprivations of the social stratification system, reservation based on economic condition of students/families may not emerge as a viable alternative to caste-based reservation. The scale of the resistance can be estimated to be huge, as the SC/ ST/ OBC population constitute more than 65% of India's population.[xviii] Since the objective of caste-based reservations is not to end poverty, but to end the caste-based monopoly of organized sector jobs, especially of the public sector[xix], economic condition-based reservations may be protested against in India. Any AI solution in this regard will need to be humanized before being institutionalized in the country.

- **Intelligent Tutoring System using adaptive hypermedia**

Learning characteristics vary for individual learners as students prefer diverse learning resources in distinct

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ways. The cognitive capability, knowledge background and desired outcome from education play a major role in determining the learning effectiveness. Since each of these factors is specifically unique for each student, an ideal learning system cannot have a one-size-fits-all approach and must adapt to the students' needs.[xx] By catering to the specific learning needs of each individual student, an educational curriculum's effectiveness and student's satisfaction can be achieved. AI-based adaptive learning techniques, delivered through adaptive hypermedia can help to build the next-generation Intelligent Tutoring Systems that aid teachers in the classrooms, instead of substituting them, and customize the learning path for students in real-time based on their level of comprehension and cognition.

Hypermedia is an extension of the term 'hypertext' and is a non-linear medium of information which includes graphics, audio, video, hyperlinks and plain text. It differs from multimedia, as the latter does not necessarily involve interactive elements.[xxi] Adaptive hypermedia leverages hypermedia that can adapt according to a user model, and renders tailored content based on a model comprising user's goals, knowledge, abilities, interests and preferences.[xxii] An Intelligent Tutoring System (ITS) driven by AI represents the content in a tailored manner, implements the instructional strategy and offers a mechanism for assessing the student's performance and progress. Artificial Intelligence is the underlying technology that makes the ITS adaptive and agile to student's needs, by using a Curriculum Sequencing technology.

Curriculum sequencing works on the principle of mapping out the knowledge (declarative knowledge) and skills (procedural knowledge) of students for designing the customized curriculum for each individual. This helps the students to learn by building on what they have learned before. However, this requires the school to identify the key macro concepts they want to teach students within each curriculum subject and then break it down to smaller micro components that make the learning process manageable for the targeted student audience. Following which, these individual micro components have to be sequenced to allow students to gradually build their knowledge of the macro concepts.[xxiii]

The first step in adaptive learning is to equip students with digital technologies that bring educational content on a web-based platform. The entire course material – including video lessons, assessments, discussion forums, virtual simulators and quizzes – is to be hosted online. Based on the pace of learning, pace of progress through the course materials, performance in micro assessments, evaluation of full-scale examinations and performance in learning activities, a student's cognitive capability can be assessed in real time. Based on how well a student is learning and building on what's learned previously, the course can recalibrate its speed, difficulty level of content and additional academic support on a continuous basis. With time, the system grows more attuned to the individual student's needs and can tailor the learning material to keep the student engaged and help in achieving educational outcomes.

Adaptive learning enables a student to wield greater sense of autonomy in the learning path, as the curriculum is specifically tailored to their needs, based on real-time feedback from periodic assessments and pace of course progress. It also promotes inclusive teaching, as digital learning content is provided over the web and can help students learn remotely at their own comfortable pace.

Figure 12 shows how Intelligent Tutoring System works.

- A teacher records his/her lectures and stores them on cloud from a centralized location. The same can be substituted by live lectures that are delivered over the Edge networks to the students located remotely.
- The video lectures will be stitched with the associated quizzes and lesson plans, which will be delivered over the telecom infrastructure to the student.
- The Content Delivery Engine is responsible for bringing all the hypermedia content on a digital portal (website/app/web app).
- Behavior Monitors will run on the Content Delivery Engine and will monitor the head movement, eye

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movements, level of dizziness and other facial parameters to track the attention level of the student throughout the session.

Student may come up with a query during the ongoing lecture and can post it in the Query chat window, which will be automatically responded to by the AI-driven chatbot, enabled with Natural Language Processing capabilities. The Query Translator will correct the grammatical errors in the query and will parse it for text analytics and for response generation. Text analytics will highlight at the backend the keywords or concepts witnessing maximum queries from students, for informing the teacher to stress further on these topics.

- Any quiz or question presented by the teacher will invite responses from the students and the Response Checker will analyze the pace, originality and veracity of the student's answer.
- Similarly, assessments from Assessments Database will be customized as per comprehension and performance level of the student and will be graded automatically.
- Based on student's performance, the Student Model will be updated with key insights on each student's performance against each Key performance Indicator (KPI).
- Interface analysis will evaluate the effectiveness of Content Delivery Engine, while the Affective analysis will feed data for behavioral analysis and performance of the student.

The Curriculum Model will be updated for each student individually based on the performance feedback generated, which will help recommend additional personalized academic support to the student, along with customizing the lesson plan.

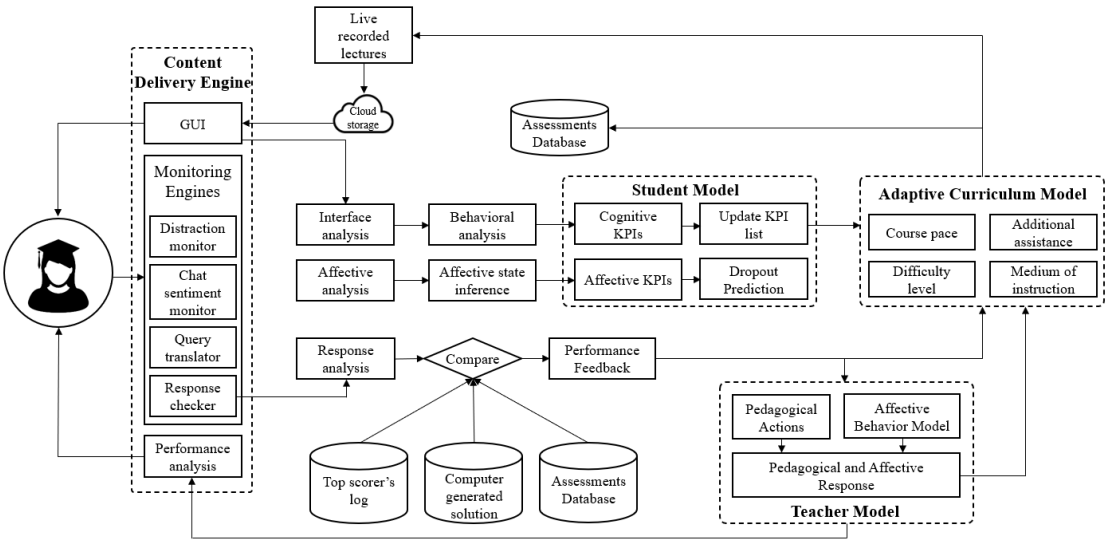

Fig 12: Intelligent Tutoring System – System Diagram

On-ground evidence exist to substantiate the effectiveness of ITS in developed and developing world settings. Existing literature suggests positive impact of ITS on children's education and learning outcomes. A 2007 study by Keleş titled, "Artificial Intelligence and web-based ITS design, and an application in mathematics teaching during Learning-Teaching process" was conducted with 42 second graders in the United States. It was observed that the learning performance of the students learning with the classical method was 66% and the learning performance of the students learning with ITSMAT system was 90%. In 2011, Aktaş and Doğan developed a regulatory module application for web-based intelligent tutoring system, named PROMATH. The system was observed to successfully eliminate from the regulatory module the static structures between the instruction and student modules. A 2004 study by Dağ and Erkan aimed at improving the studies in ITS field in Turkey demonstrated that the developed ITS enabled students to learn

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more easily and effectively.[xxiv]

Latham, Crockett and McLean in 2014 conducted an experimental study with 72 university students and observed that the lessons taught according to the intelligent tutoring system developed to adapt to the learning styles during the course were likely to improve learning positively. In 2017, Crockett, Latham, and Whitton developed a speaker intelligent course system, named OSCAR. The system models the learning style of students who use natural language dialogue during the course to dynamically predict and personalize their special courses. The results show that OSCAR system increased predictability and facilitated the discovery of relationships between behavior variables in the four learning styles for students using the system.[xxv]

- *Indian organizations in ITS domain:* ITS systems for personalized education are existent in Indian landscape and a number of emerging corporate entities are offering adaptive curriculum and personalized learning support to students across various age groups. The AI-driven EdTech space is emerging as a viable option for parents to opt for enhancing the learning journey of their children.

Byju's provides engaging video lessons, personalized learner journeys, infinite practice sessions and customized questionnaire for assessments for students belonging to a wide range of grades – Grade 4 till high school completion.

Embibe uses AI and data analytics to offer personalized feedback to students based on their assessments and help students to identify their strength and key areas of improvement. With personalized mentoring and adaptive guidance, Embibe also enables students with customized learning journeys for competitive exams in India.

Vedantu leverages AI to assist teachers in identifying a student's attention level, increasing student-teacher interaction, solving students' queries, facilitating participation in gamified quizzes, and customizing teaching patterns owing to constant feedback. The personalized live online tutoring adapts to every student's learning pace and abilities. The customized teaching methodologies include two-way audio, video, and white-boarding technologies to enhance the learning outcomes with live interactions.

Toppr makes extensive use of technologies like AI and machine learning to analyze student behavior and accordingly adapt the online education curriculum.

Cuemath, founded in 2013, is an after-school personalized math and coding tutoring service for children between kindergarten and grade 10. It offers a mix of home-based centers and an online portal based on the child's grade.

ConveGenius offers "CG Slate", which is a personalized and adaptive learning platform that identifies an individual student's educational learning needs & offers content recommendations, helping the student learn content at an adaptive pace. The real-time dashboards supply actionable data to partners, with visualizations to make sense of learning and operational data.

- *Barriers to Intelligent Tutoring Systems:* Developing world poses a multitude of barriers to the adoption of Intelligent Tutoring Systems in the regular education programs for students. Implementation of ITS in the Indian context has dependencies on the technical soundness of the stakeholders and the availability of policies & infrastructure to enable the AI-based application.

Lack of basic ICT skills in students – Success of ITS initiatives in India is largely dependent on the magnitude of mobile access across the various strata of population and the ability of students to navigate through software applications quickly. Learning to use ITS is, however a minor issue before the challenge of

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setting up the devices. The responsibility of maintaining the infrastructure in classroom and institutional settings rests on the technical support staff. Two factors appear to mitigate lack of basic ICT skills by students: peer support and initial device setup – which includes operating system setup, internet and network connectivity. Peer groups can be beneficial as a small number of technically-adept learners can help inexperienced peers perform basic setup tasks. In some cases, technically-proficient learners have also helped teachers with limited ICT skills. However, the unavailability of peer support groups in remote learning environments is a challenge.

Hardware sharing challenges – ITS assumes that one machine enabled with the ITS system is mapped to one student alone and measures his/her performance alone. However, in developing nations, ICT-driven tutoring systems don't have 1:1 user mapping to computers. Findings by the Cognitive Tutor project show that computer sharing accounts for over 60 % of use in developing areas, with students leaving their own machines to share a machine instead.[xxvi] Existing software techniques for disentangling multiple users sharing an input device are not mature yet. Moreover, such a software solution would reduce the power of knowledge assessments by adding uncertainty about user identity. Currently, user models that account for collaboration are worth exploring, but they may only offer a partial solution. A possible solution is to deploy solutions that allow multiuser interaction using a single device. MultiLearn+ split a laptop display into quadrants, each with their own keypad. Single Display Groupware went further, with a whole class sharing a single projection and one mouse per student.[xxvii] However, hardware sharing offers sound advantages for classroom and institutional context. By using a single machine, teachers can facilitate collaboration, since the data for multiple users is already in a single system. Since input devices (mouse, keyboard, etc.) are inexpensive compared to processors or displays, a four-user system like MultiLearn+ lowers the cost-per-student by almost three-quarters.

Inefficiency of Mobile ITS – Delivery of ITS over handheld mobile devices relies on dedicated applications designed specifically for mobile devices. ITS applications designed for high-end smartphones cannot be easily transferred to low-end mobile devices limited to 2G data speeds. The smaller display, processor limitations and unavailability of adequate number of buttons & controls on mobile devices make transition of traditional ITS from desktops to mobile devices difficult.[xxviii] This can pose challenges for Indian demography as parents in rural and low-income regions may face hurdles in affording laptop and desktops for remote education of their children. For dealing with lack of sophisticated ITS interface on mobile devices, voice input can act as a substitute, allowing users to interact with ITS using voice commands in English or any other supported regional language. However, current speech recognition systems are imperfect for noisy environments, which is common in rural and low-income households. Supporting multiple users through hardware sharing will be impractical, especially if speaker identification and authentication is required.

High data expense – High data costs and unavailability of internet infrastructure in India can offset the potential of ITS for personalized education. Internet penetration in India is low but growing albeit. Moreover, data costs are decreasing with the emergence and rising market penetration of leading telecom players in the country. Fixed-price broadband connections (e.g., cable, routers, satellite dishes) can provide Wi-Fi internet access and act as "wells" for mobile data for multiple users in a local area, thereby creating a microcosm of remote learners. In a classroom setting, Bluetooth and similar protocols allow instructors and students to transmit tutoring modules to each other. Internet reliability is another major challenge, and any minor interruption in internet access can lead to major disruption in a student's learning path. Web-reliant ITS appear unsuitable for most developing world classrooms. However, they can still be effective outside of a school setting if their data usage is handled appropriately.[xxix]

Cultural localization issues – Diversity of language, medium of instruction and cultural aspects pose challenges to a one-size-fits-all approach for ITS. Multicultural regions and institutions need to be sensitive

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about the language, diction, accent and visualization of information communicated to students. Localization of content needs to expand to icons, graphics, and mother media, while also supporting users with different native languages.[xxx] Design patterns that separate graphics and text as replaceable assets can ease this process. Services such as Amazon's Mechanical Turk could provide a low-cost solution to localize content or verify that content has been localized effectively.[xxxi] A central principle of localization is to localize only the authoring tools, documentation, and certain code functionality, instead of the content. The natural language processing functionality must be able to translate and localize the content in real-time, as per the convenience and cognitive capability of the student.

- **Intelligent delivery of 'glocalized' remote education**

The rapid spread of COVID-19 and the resulting closure of schools and educational institutions across major economies of the world has necessitated the need for remote education infrastructure. AI can usher in a new era of ubiquitous remote education, especially in the developing and underdeveloped economies, where language barriers and teacher shortage exists. With inclusion of AI, the education sector can reach out to a larger number of students, compared to the traditional education infrastructure, while also automating the major functions of teaching, which cannot and are not handled by a human instructor.

Use of computer-based content translation technologies can help create higher engagement among students, when the students are not conversant in the primary medium of instruction. Course instructed by a single teacher can be recorded and broadcasted live to students over a large geographical region, thereby enabling mass education during times of crisis, similar to COVID-19 pandemic. At the students' end, AI solutions installed in the learning devices (laptops, desktops, tablets, mobile phones, etc.) can translate the spoken words of the teacher in real-time, while also providing auto-generated subtitles for easier comprehension. For digital textbooks and study materials provided from a central repository, machine learning algorithms along with text translation can help in creating systems that are personalized for each student's requirements. The AI-based text summarization and voice transcription solutions installed in the learning devices can help to transcribe complete lectures into comprehensible paragraphs with great accuracy in multiple languages.[xxxii] This implies that a lecture delivered centrally can be customized for students through distributed decentralized content translation and transcription systems.

Technologies using facial recognition, voice recognition, and sentiment analysis can measure levels of student engagement, emotions, and attention spans, while also estimating their magnitude of comprehension and confidence. AI can enable teachers to access the best content available globally and personalize it for each student in their local language.

AI has begun to make inroads in making education interactive for students, by leveraging Augmented Reality (AR) and Virtual Reality (VR) – combined under the umbrella of Enhanced Reality. Using Optical Character Recognition (OCR), web scraping techniques and object detection modules, to augment the learning experience of students with 3D multimedia elements for assisted comprehension. A student scans a 2D image in a textbook or on the screen of the learning device, following which the AR content will be superimposed on it. If the student wants additional information, the student can enter VR mode, following which live data from web scraping tool is presented for additional guidance on the concerned topic. In case the student deviates towards profane and inappropriate content, the server can flag the same.[xxxiii]

Enhanced reality has wider opportunities in the education sector. AI-based Virtual Facilitators hold the promise of bridging the gap between requirement and availability of teachers. Virtual characters designed by AI can substitute human instructors in the digital platforms and the web application for remote learning can feature an AI-designed 3D virtual character that translates text from digital textbooks to speech for teaching students online in a personalized manner. Remote education often faces the challenge of lack of personal touch in the learning process, as students lack an effective touchpoint. However, this challenge can be

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mitigated with AI-based conversational assistants, also called chatbots, which can take queries of students in real-time and respond to them based on predefined query-response models, without overwhelming a single teacher with multitude of queries from students spread over a large geographical area.

Using AI-based solutions, students can leverage Natural Language Processing systems models to create assignment documents, spreadsheets, presentations and emails by speaking naturally. The AI-based solutions, like Nuance, is already helping students to type 3 times faster compared to traditional typing speed, with 99% accuracy.[xxxiv]

Data availability on effectiveness of AR/VR in the Indian education system is inadequate in existing literature. However, studies have been conducted in the United States, that highlight the impact of enhanced reality on learning capabilities of students in schools.

A study conducted by Maryland on VR and memory reveals that students' recall improved by 8.8 percent while studying in an immersive environment in comparison to flat computer screens. More than 40 percent of the study's participants showed an increase of 10 percent or more recall while using VR.[xxxv]

A 2020 survey from Perkins Coie and the XR Association showed that education is the second most likely sector to be disrupted by immersive technologies in the near future.[xxxvi] Common Sense Media conducted a study in 2018, which found that 62 percent of parents believed VR could provide their children with educational experiences.[xxxvii]

In a 2016 survey by GfK and Samsung Electronics, conducted with 1,000 teachers in the United States, 93 percent of teachers said their students would be excited to use VR, while 83 percent opined that enhanced reality technologies could help improve learning outcomes.[xxxviii]

Public sector investments are increasing in this area. Government of India initiative, RISE (Revitalizing Infrastructure and Systems in Education), has a budget of more than INR 1 trillion for modernizing the education system with the help of immersive technologies such as VR, AR & even AI (Artificial Intelligence), these will play a significant role in improving India's overall education scenario.[xxxix] Meta announced in 2021 that it will train 10 million Indian students and 1 million teachers in Augmented Reality, Meta to Train 10 Million Indian Students, 1 Million Teachers in Augmented Reality, in partnership with Central Board of Secondary Education (CBSE). Meta and CBSE are expected to collaborate on content curation and development of curriculum integrating immersive technologies, Augmented Reality (AR) and Virtual Reality (VR) which are relevant for the evolving digital landscape by introducing these as skills subjects for students. The plan for immersive education will also enable students with different learning challenges and lack of access to lab resources to learn in an engaging manner. Through this initiative, CBSE will aim to empower students in the under-served regions of India through its community skill centers making these new-age skills available to the youth and helping them become creators in the digital economy through equitable access to resources.[xl]

- *Indian organizations in XR-based education technology:* Few organizations exist in India that are working on Augmented Reality and Virtual Reality for education sector.

Practically offers AR-based STEM learning solutions for students. Its platform is an immersive learning app which leverages AR, simulations and 3D videos for enabling experiential STEM learning for students from grade 6 to 12. The teacher's version of the app provides access to videos, simulations, AR, reports, test-preps, polls, analytics, and assignments. AI assistant and realistic video content facilitates conceptual understanding and retention.[xli]

Shifu is another organization that provides augmented reality-based STEM educational games for classroom

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and remote education. 'Shifu Orboot' is an AR-based globe, while 'Shifu Plugo' is an AR-based gaming system. which can be integrated with the classroom learning experience.[xlii]

Digital Teacher is an AR-based teaching tool for instructors in Indian schools. Developed in accordance with the State Government Curriculum Policy, The application helps in better comprehension of STEM concepts, while also helping teachers to save time and efforts in preparing content for the classroom. The solution provides an easy to navigate Graphical User Interface with navigation instructions, rich graphics and 2D/3D animations, and AR videos for easy understanding of concept. The content has been customized as per the curriculum designed by Central Board of Secondary Education, Andhra Pradesh State Education Board, Telangana State Education Board, Cambridge English Teaching Framework and Common European Framework of Reference.[xliii]

GeoGebra 3D Calculator helps students to solve 3D math problems, graph 3D functions and surfaces, create geometric constructions in 3D, save and share results with peers. With Augmented Reality enabled, students can place math objects on any surface and walk around them for better comprehension.[xliv]

Insight Heart aids medical education by assisting users to easily scan their physical surroundings and place the three-dimensional heart without the need of predefined markers. The virtual assistant ANI guides users through various states of the heart. Students can visualize normal heart rate, myocardial infarction, arterial hypertension, atrial fibrillation, coronary artery disease and atrial fibrillation.[xlv]

- *Barriers to AR-based learning programs:* Implementation of augmented reality driven educational content in classrooms and remote learning setups is fraught with challenges, with most challenges related to infrastructure and financial constraints.

Cultural diversity of India – Owing to the miscellany of socio-economic, cultural and linguistic conditions in India, development of a standardized and uniform AR-based school curriculum is challenging. Creation of AR content across multiple languages and checking their culture fitment will increase the cost of AR-based content and will make such programs expensive. Public-private partnership will need encouragement to localize the content and to reduce the cost, while state government subsidies will be required for the purchase of cost-intensive AR-based learning materials.[xlvi]

Procurement bottlenecks – A large variety of hardware exist for realizing VR and AR, for example, head-mounted displays (HMDs), stereo projections, controllers, tracking systems, haptic feedback devices, depth sensors, and motion platforms. A wide range of setups are also available, such as a 3D power wall, a CAVE, a virtual workbench, AR with video-see-through on a handheld smart device, AR with direct-see-through employing AR HMDs, etc. Assessing the efficacy of each setup for different socioeconomic settings in India and providing students an opportunity to experience them is time-consuming. Moreover, lack of AR devices among each and every student in remote learning setup raises issues of socioeconomic divides in India.[xlvii]

Financial constraints – Cash-strapped public schools in India will need financial incentives to implement AR infrastructure and purchase AR-based devices to help students visualize the concepts being taught for better comprehension. State-run schools outnumber the privately-owned schools in India and therefore, the financial support is necessary to make AI-based AR education infrastructure ubiquitous; otherwise, the infrastructure asymmetry between equipped and non-equipped schools will widen the socioeconomic gaps in India's education landscape.[xlviii]

Time constraints – Developing the demonstration of VR/AR hardware with the according application examples can consume a large amount of time. Efforts involved in setting up the VR/AR demonstration before a lesson and disintegrating it after the lesson might be significant. This time burden associated with VR/AR demonstrations could force educators to give up on the idea of integrating VR/AR demonstrations

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in their courses.

Logistical challenges – Lack of space in classroom settings and home can be a challenge for implementing and scaling AR-based education methodologies. VR and AR setups may need significant floor space and control of environmental conditions (e.g., window blinds to limit direct sunlight). The lecture room might not be able to accommodate several setups in parallel or some setups at all limiting the opportunity for hands-on experiences.[xlix]

Content and instruction proficiency – The level of engagement that AR content can inspire depends on the quality, comprehensiveness and diversity of the content. Moreover, a lack of educators' familiarity is a challenge despite their positive attitude towards AR/VR. Educators may be unaware of the best practice examples or lack basic teaching material such as textbooks to complement the AR content. This can result in low self-efficacy to use VR in teaching in general.

Outlook of students towards technology also plays a major role in assessing how receptive students will be to AI-based AR/VR applications and if the enhanced reality-based learning program will be effective. Sarkar and Pillai, from Indian Institute of Technology Mumbai, conducted a study among Indian students to identify their outlook towards technology and AR/VR in particular, as shown in Figure 13. All these surveyed students were exposed to the use of smartboard in class. 44.1% of the participating students had heard about or played the AR-based game, PokemonGo, which highlights their awareness about AR technology. However, only four students of grades 8 and 9 knew what AR is, but they had not played the game or had not used any other AR-based application.[l]

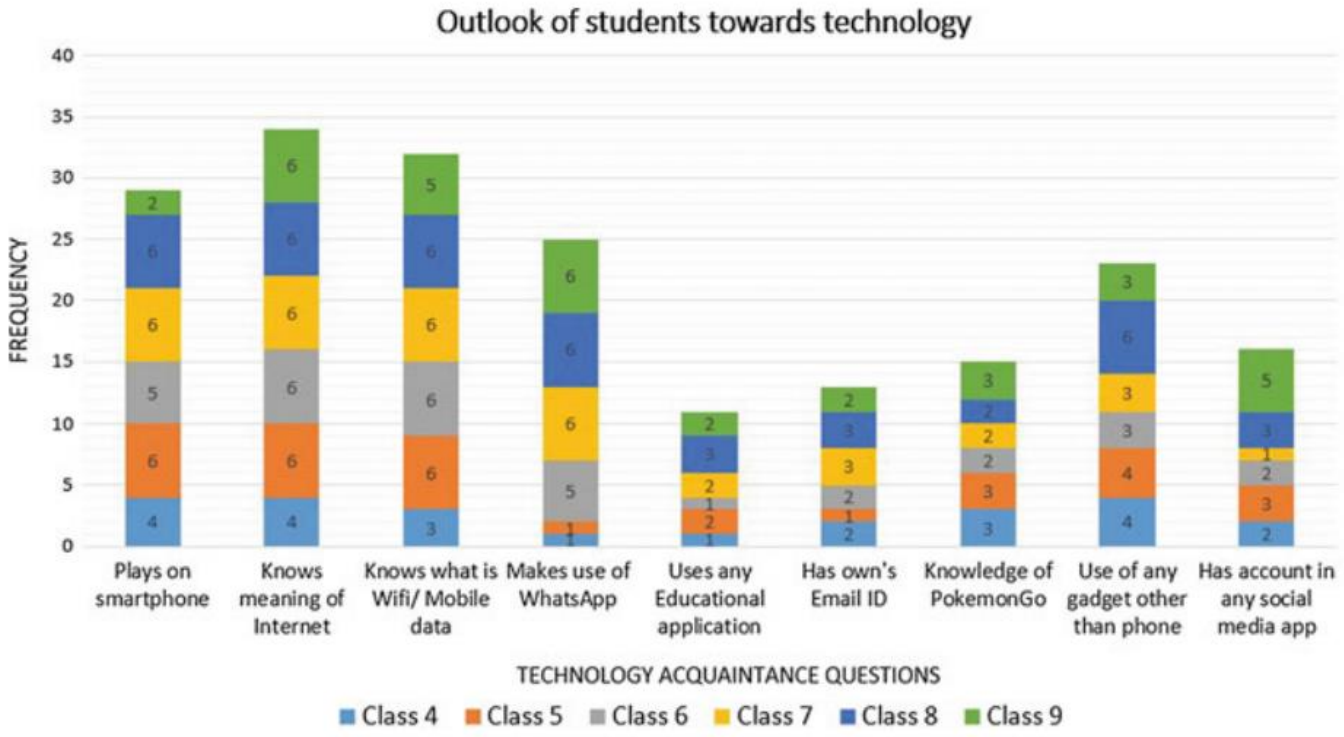

Fig 13: Technology acquaintance questions to assess students' affinity to technology solutions

- **AI-based personalized and automated assessments**

A survey by Telegraph in 2019 showed that teachers spend 31% of their time planning lessons, grading tests and performing administrative functions.[li] AI-based support automation tools can automate the function of

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grading assignments and examination papers, while also conducting performance analytics for students, thereby identifying their key areas of strength and weakness. An Automated Grading System (AGS) scans human graded assignments and examinations as training dataset, to identify the key parameters of evaluation. Human-graded documents (including essays, research papers, classroom assignments and quizzes) will have to be provided as training dataset, following which these documents will be stored in a central database. Once the grading model is robust enough to provide automated assessments much closer to human graded assessments, it can compare the future documents with centrally stored documents and provide its assessment.[lii] The AI application uses handwriting analysis tool or an optical character recognition tool to interpret the documents written or typed in a variety of languages. Such AI systems can group students as per their key strengths – for example, in groups of academic high performers, quick thinkers, top essayists, etc. This is known as Adaptive Group Formation. This step helps to identify the areas of strength and improvement of each student, which helps in personalizing their learning path even further. With increasing number of documents being graded, the accuracy of the grading technique improves, and it ensures that the grading technique does not grow outmoded.[liii]

AI-based grading systems are important for bridging the socio-economic inequities in the Indian education sector. An acute shortage of teachers in schools compounded by the issue of 31% of available teachers' time getting wasted in unproductive functions, stifles the growth and improvement of education system. AI-based automated grading systems in schools located in remote areas, rural regions and underprivileged urban settlements can free up teachers' time, enabling them to focus on in-classroom activities and offering personal attention to each student. Moreover, it also makes assessments and grading independent of human bias and manual errors, while also providing assessment of each student relative to the performance of students across the city, district or the nation. This will be possible only when the centralized AGS possesses training and test datasets from across the nation. The inequity in quality of assessment and academic analysis because of socio-economic divides in India can be bridged by AI-based AGS.

Figure 14 shows how Automatic Grading System works.

- Teacher feeds assessment questions along with reference answers for each through the Teacher's Interface, which accepts the text-based and image-based entries through a web-based portal.
- Reference answers are mapped by the teacher for each question entered into the system.
- Student receives the assessment questions through the Student Interface, which invites answers typed or handwritten by the student.
- The Student Interface comprises of Behavior Monitoring Tools and Optical Character Recognition (OCR) module, along with a web-based form for the student to input the answers into.
- OCR module helps to interpret the student's handwritten characters from the sheet of paper and convert them to digital text.
- Answer Rewriter Engine removes any typos or grammatical errors, while adding penalty for each mistake in the Grading Engine. These reformatted answers are made available to the teachers through the Teacher Interface, for manual evaluation.
- The student's answers and the AI-shortlisted best reference answers are compared by Compiler for evaluation of student's performance. The difference between the reference answer and the student's answer will assist in evaluation and grading.
- In the event of student's answer being superior to reference answer, the AI engine will update and improve the reference answer automatically.
- Domain Synonym Dictionary and Local Dictionary will help in resolution of complex terms and will reduce them to simpler words, that assist in better evaluation.
- The best grade is assigned to the student's answers, while keeping the system open to student's and teacher's feedback.

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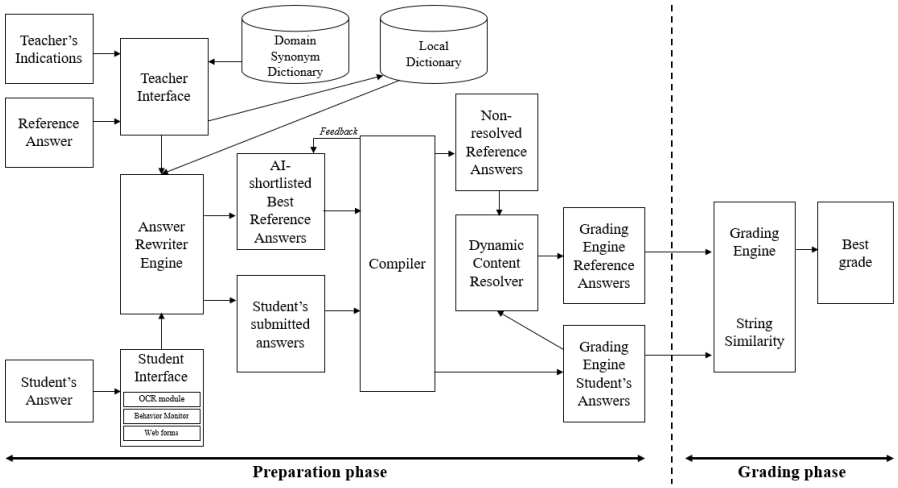

Fig 14: Automated grading Application – System Diagram

Available literature does not highlight, in particular, the quantitative advantages of AI-based assessment systems. However, case studies from developed and developing world point towards the enormous potential that AGS hold in the area of education transformation.

In the United Kingdom, students attempt A-level exams, in which their handwritten answers are scanned, segmented and sent to different examiners for online scoring. The system helps with safe delivery, speed of scoring, real-time tracking of grading and quality assurance.[liv] Gradescope is an alternative AI grading system in the United States, which has been developed at University of California Berkeley for reducing teacher's turnaround time for grading papers. The AI-based solution has assessed 10 million answers to 100,000 questions across diverse curricula to date.[lv]

In India, OLABS has been funded by the Ministry of Electronics and Information Technology. OLABS offers intelligent tutoring systems and AI teaching assistants to students. Enabled with live chat bots, these solutions help improve the loop of student feedback for teachers and graders. It allows for real-time data to be collected and filtered as per students' profiles, which assists in making significant changes in the assessment process.[lvi]

- *Indian organizations developing AI-based AGS:* Private sector in India has forayed into the Automated Grading System landscape. Though the number of private sector entities in this area is less, yet public sector's support and backing received from parents a& teachers make AGS a fertile ground for many more private sector players to emerge.

In India, the **Telangana State Board of Intermediate Education** has announced the plan to use AI for increasing accuracy in exam assessments and results, considering the wide discrepancies in evaluation that led to the suicides of many students in 2019. An Economic Times report said that the board has happened to find various errors in the assessment of Optical Mark Recognition (OMR) sheets due to a private player's flawed technology. The plan is to follow the OMR sheet scanning with analysis of descriptive answers by Intelligent Character Recognition (ICR) to double check the handwritten remarks and scores assigned to each answer. It is estimated that over 0.9 million students appear annually for the two-year intermediate course examination in the state of Telangana alone and therefore, the application of AGS can impact 0.9 million students each year.[lvii]

ConveGenius has acquired Gray Matters India to provide an impetus to its AI-based assessment products. ConveGenius' EdTech for "Naya Bharat" campaign, launched in 2020, aims to empower 100 million

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students at the bottom of the education funnel. ConveGenius plans to leverage the AI-based measurement science with its automated learning capabilities and assist under-served students diagnose their remediation requirement for missing skills and knowledge through a tailored set of instructions. Grey Matters' platform has key data points about 6 million children spread across 15 states in India. The platform will help to visualize an underlying super taxonomy of cognitive learning and foundational skills, to create an interoperable architecture for learning according to the NEP 2020.[lviii]

Jungroo is an AI-powered assessments, evaluation, and learning platform for student's education. Jungroo's platform helps to digitize the education needs of students. The award-winning AI algorithms give personalized practice and learning solutions to learners. Over 80163 assessments have been handled by the platform, with more than 1.2 million evaluations for over 13360 students. Teachers can derive analytics with rankings, subject/class/assessment wise scores, student performance at question level and topic level etc. Various analytical reports are offered for deeper analysis, like subject-wise performance report, assessment-wise performance reports, class-wise/section-wise progress reports, question-wise student performance report, student-wise attainments details.[lix]

HireMee has developed an AI-enabled remote testing platform that detects and prevents proxy test takers effectively and performs reliably on inconsistent internet network in rural areas as it operates optimally with low bandwidth. The AI-ML algorithm leverages digital face recognition to swiftly detect any form of external help taken by test takers. Its implementation in Desh Bhagat University, Patiala and BNM Institute of Technology, Bengaluru helped 6 faculty members manage 0.1 million online examinations in couple of days. The platform has integrated features, like randomization and auto-selection of questions, navigation control, and image & window proctoring.[lx]

PepStudy provides an AI-based assessment to automate the manual work of teachers, like setting the paper, providing results and analyzing academic gaps at the micro level for each student. PepStudy offers easy to use features to identify deep topic level gaps, pinpoint areas of improvement for students and highlight topics that are conceptually mastered by student. The insights are made available to teachers and students through a dashboard.[lxi]

- *Barriers to implementation of AGS:* Challenges exist for the implementation of AGS, as much more technological standpoint as from a human behavior perspective. Acceptance of AGS among the students and parents is a contentious issue, with incidents from across the world serving as stark reminders of cases where AGS can lead to discontent and damage to education infrastructure.

Unexplained low scores – International Baccalaureate Organization (IBO) had opted for AI-based grading in 2020 to determine overall scores for high-school students, on the basis of historical data and students' past performance. However, thousands of students and their parents went on a protest campaign as the students with low scores faced challenges while applying to world's leading universities. Tens of thousands of affected students worldwide received grades that deviated substantially from their predicted grades in unexplainable ways.[lxii]

Cheat-prone engine – During the pandemic in the United States in 2020, students were reported to have deceived Edgenuity's AI-based assessment engine after identifying that the engine scanned for specific keywords that were expected in students' answers. The students simply stuffed their answers with a disjointed set of keywords, that looked relevant to the question.[lxiii]

Algorithmic bias – In 2020, high-school students in the United Kingdom went on a protest as an AI algorithm lowered the A-level results of approximately 40% of students who could not attend the exams due to COVID-19 pandemic. Around 39% of A-level results were downgraded by exam regulator Ofqual's algorithm. Students alleged that the algorithm favored students from private schools and affluent areas,

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while leaving out high-achievers from free, state-schools disproportionately affected. While many students have had their university admission places revoked due to the downgraded exam results, the opposition Labour party termed the algorithm as "unlawful", stating that it breached anti-discrimination legislation as well as laws requiring it to uphold standards.[lxiv]

High infrastructure investments – Scaling the Automated Grading System facilities to the economically diverse population of India will be equally challenging because of the high technological investments and the consequent high financial resource mobilization requirements. Students and schools will need functional computers or laptops, technically sound proctors for troubleshooting, high-speed internet connection, and accessories such as a webcam and speakers. Unreliable internet connectivity and poor infrastructure in remote regions of India can restrict access to this model, since a disrupted internet connection may not allow students to login in at the same time and complete the exam together.

- **Enabling higher student retention**

Developing nations with wide inequalities between various sections of the society face a challenge with ensuring literacy among children in marginalized sections of the society. The factors can range from poor quality of classroom instruction, poor school infrastructure and gaps in medium of instruction, to lack of teachers' instruction skills and low motivation factors. AI-based systems can analyze complex insights-rich datasets that include information on enrollment, gender, student performance, socio-economic demographics and school infrastructure. Data analytics driven by machine learning models can help to identify the predictive patterns behind why students drop out, and also pinpoint the students showing tendency of dropping out the following year. This helps to make necessary interventions in a proactive, instead of reactive, manner. These interventions can take the form of counseling, financial assistance, reskilling of teachers and revamp of school infrastructure.

India experimented with an AI solution in 2019 to predict school dropout rate in the state of Andhra Pradesh, by taking a sample set of over 200,000 students spread across 2,800 public schools. The AI-based solution identified more than 60 patterns that helped in tracking dropouts. In the year 2018-19, the AI platform identified more than 19,500 probable dropouts from Vishakhapatnam district. Insufficient furniture and lack of toilets were found to be the key factors. Other influencing factors identified through the application were: learning outcomes (57%), infrastructure (31%), transition (7%), age inappropriateness (4%) and social category (1%).[lxv]

Another example is of Student Mapping Tool (SMT) implemented in Victoria, Australia, where a simple tool provides educational institutions with better student information to prevent dropouts. This AI-based tool reinforces the design of actions taken to prevent dropouts, thereby permitting tracking and evaluation.[lxvi] India can also take a cue from Toronto, Canada. Administrators increased graduation rates of 78% by 2014 from 55% in 2010, with the help of Azure Machine Learning. Student data spanning five years was uploaded to Azure for analysis. This dataset included demographic, academic and student performance information. Azure was able to predict if a student was at risk of dropping out during the following semester. This enabled schools to work with the students to support them to stay in school and complete their studies.[lxvii]

Figure 15 shows how Student Dropout Prediction System works.

- Student registers for admission in the school, and submits all details related to socio-economic status and personal features.
- Details regarding family income, family assets, number of earning family members, district of residence, family literacy, etc. are accounted for. Moreover, the details on gender, age, race, family income, state of origin and regional literacy levels are documented. The assortment of all these details

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provides a holistic view of the student and helps to track each KPI related to the individual.

- Following a year's course and assessments, the feedback on the student's performance and learning progress is fed to the AI system.
- After a year, the student's retention status is checked and fed to the AI system, to enable it with training data.
- Based on the training data, the Dropout Prediction System forecasts the probability of another student staying or dropping out of formal education system.
- A repository of remedial actions is prepared with their associated effectiveness scores, and is supplied to the Education Manager to take corrective actions for mitigating the dropout probability.

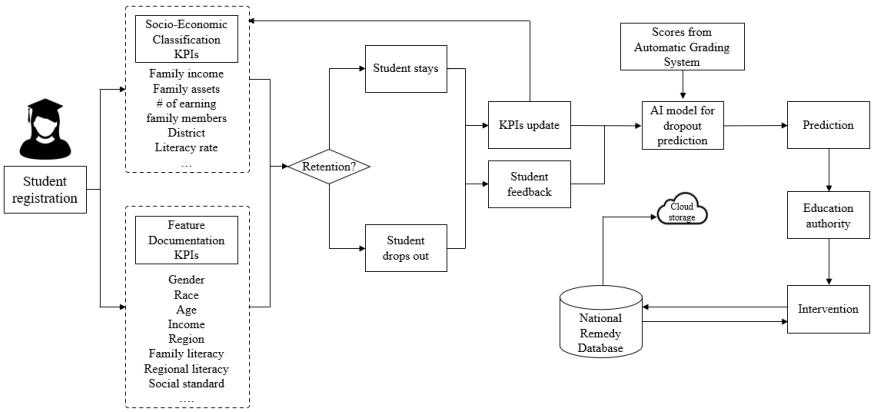

Fig 15: Dropout Prediction Module – System Diagram

Case studies from around the developed and developing world highlight the potential that AI system hold in predicting student dropouts and increasing student retention. The University of New England reduced student attrition to 12% using AI-based learning analysis tool, which helped foster among the students a growing sense of belonging to the classroom and the learning community.[lxviii] IoT System developed by Freitas et al., for school dropout prediction based on 1549 socioeconomic records of 1318 students in underdeveloped countries showed 99.34% accuracy, 100% recall, and 98.69% precision using Decision Tree analysis.[lxix] In December 2015, the Andhra Pradesh Government in India leveraged an AI-based application developed using Microsoft's Azure machine learning platform, to assist the state education department predict school dropouts. More than 60 patterns were identified for tracking dropouts, based on data related to student performance, enrollment, socio-economic demographics, gender, school infrastructure and teachers' skills.[lxx]

Neural network developed by Kalegele K. at Open University of Tanzania, helps proactively predict and manage student dropout in Tanzania. The performance of the prediction algorithms is equivalent to an accuracy of 75.61%.[lxxi] Tanzania, one among developing nations, introduced an Education Sector Development Plan (ESDP) and Education Training Policy (ETP). These measures were instituted to focus on access, capacity development, quality improvement and direct funding to secondary schools.[lxxii]

- *Organizations building student dropout prediction systems:* Though partnerships between the Government of India and private layers, such as Microsoft and World Economic Forum have been established for predicting student dropouts in India, proprietary solutions from corporate entities are yet to emerge in this area. The AI-based application leveraged by the Andhra Pradesh Government has been supported by the Wadhwani Foundation. By processing complex data sets with over 10 metrics, student dropout patterns were modeled.[lxxiii] Microsoft acted as the technology partner for the project.
- *Barriers to implementation of AI-based student prediction systems:* Like any other use case of AI,

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student prediction system has its fair share of challenges, which need to be addressed by the public and private sector entities working in this area, to reap the outcomes post the implementation of such systems.

Training data bias – Majority of the student dropout prediction algorithms have been developed and tested in the developed nations, using already existing datasets generated from developed regions. Currently, Massive Open Online Courseware (MOOC) and Moodle are among the most widely used platforms for public datasets that are used for training AI models for addressing the student dropout problem. The lack of public datasets from developing countries highlights the bias in training data and the need to develop datasets from diverse geographical locations.[lxxiv] Transforming registration information of students with ongoing academic progress from paper-based approach into electronic storage also needs to be catered to.

Dataset unsuitability – Majority of existing studies on student dropouts ignore the fact that the recorded dropout rate is often low in existing datasets. This creates a serious concern in the context of student retention.[lxxv]

High monetary investments – Developing nations face several challenges on generating public datasets to be used on addressing the issue of student dropouts. High cost of data acquisition, transformation & storage, and the associated time consumption are key factors making collection process very difficult.

Dataset bias – Existing studies focus on mitigating student dropout using student level datasets. However, it is imperative for developing nations to include school level datasets for addressing this issue because of the issue of limited resources which face many school districts. These school level factors can include metrics like Pupil Teacher Ratio (PTR), which is easy to be monitored by the authorities. This necessitates the use of new sources school level data, which consider school needs related features and apply additional machine learning approaches to improve predictive power of the proposed algorithm.[lxxvi] Such algorithms can enable relevant public authorities to effectively plan and formulate policies and take decisions to address the problem.

- **AI for job generation and youth reskilling**

There exists a huge opportunity for AI's application in the youth reskilling and employment generation sector. AI's intervention will prove to be impactful in the post-education phase, when students have to transition from knowledge acquisition to knowledge application. A report by International Finance Corporation (IFC) highlights how the application of AI can improve efficiency, access and relevance of youth services in emerging economies.[lxxvii] Besides indicating that the global market for AI in learning and education will expand at an annual growth rate of 38% to reach $2 billion by 2023, it also states that shrinking job opportunities and mobility issues due to COVID-19 can increase demand for sophisticated technology for youth employment, training, access to finance and job matching.[lxxviii] An increasing mobile penetration rate also increases the access to the AI solutions through mobile applications.

The first use case for AI in the area of employment generation is 'holistic competence-based skill profiling' and automated job matching. AI-based competence-matching systems transitions from mere collection of candidate information to skill-based and opportunity and role matching, based on cultural fitment and capability alignment. This can save time for recruiters in mapping of candidates to applicable roles and in identification of key competency metrics that make a candidate fit for a job opportunity. Vulnerable youth, like refugees, migrants and those from marginalized sections of society, often struggle with traditional employment services due to lack of formal certifications, language barriers, and information asymmetry. AI-based profiling tools can capture these youth's competencies in their local language using a conversational 'chatbot' approach. Skillab's mobile-phone application achieves this outcome by leveraging an AI engine to predict proximate "competency clusters" as per the 13,000 skills mentioned in European Skills,

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Competences, Qualifications, and Occupations (ESCO) framework.[lxxix]

AI can help bring just in time information on the job market trends. AI applications can help rapidly analyze unstructured data from varied sources like job postings, social media, government websites to predict jobs demand in the near future. For example, My Careers Future in Singapore analyzes real-time online labor market information from a multitude of job boards to forecast job and skills requirements in the public sector. The robust access to just-in-time market trends can help education and training institutions to adapt their curriculum with the needs of employers, while influencing government policies and investment, and improving the overall efficiency of the workforce development system.[xxix]

Figure 16 explains how AI can help in youth reskilling and job generation for emerging economies, like India.

- Resume submitted by the candidate will be fed to a Tokenization program. Tokenization is the process of breaking raw text into smaller chunks, to extract words, sentences, etc., called tokens. These tokens aid in understanding the context or developing the model for the Natural Language Processing (NLP). The process of tokenization helps in interpreting the meaning of the text by analyzing the sequence of the words.
- After tokenization is complete, the stop words are eliminated from the resume and Lemmatization happens in parallel. Lemmatization brings order to the process with the use of a vocabulary and morphological analysis of words, aiming to remove inflectional endings only and to return the base or dictionary form of a word, which is known as the lemma.
- Post the text analytics phase, the resume is added to a specific cluster of resumes based on the adjectives, adverbs and other relevant terms identified, which helps to categorize the resume as per its suitability and applicability to a job profile.
- The AI Engine measures the magnitude of closeness of the resume with the concerned job description and identifies the level of fitment of the candidate's profile to the job requirement.
- The quality of the resume is also assessed against the nation-wide database of resumes from the best candidates.
- In case the candidate is hired, the parameters favoring the hiring outcome is stored in the National Skills Register, which helps in forecasting the skills and jobs that will be in demand going ahead.
- In case the hiring outcome is negative, the factors behind rejection are identified and supplied to the candidate along with recommendations for improving the resume and programs for reskilling oneself.

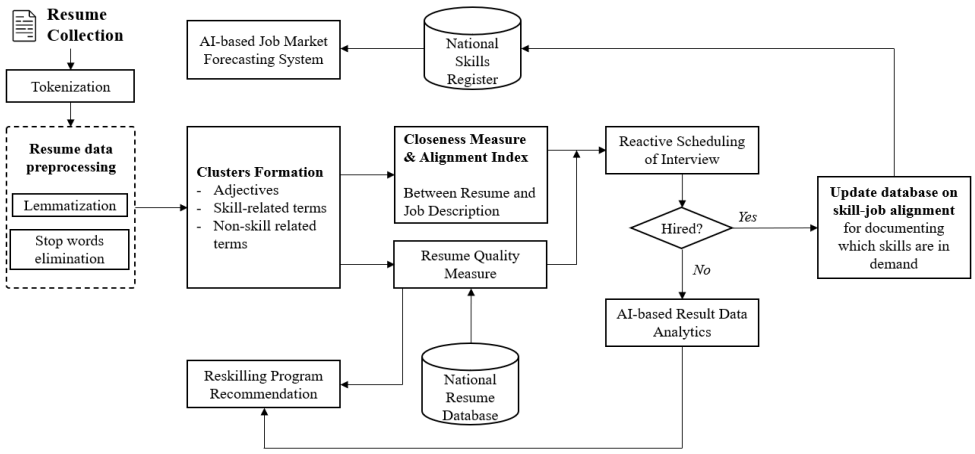

Fig 16: AI-based job mapping and reskilling system

- *Indian organizations leveraging AI for reskilling and job generation:* **Edsanta Education**, an India-

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based Edtech startup, partnered with Nettur Technical Training Foundation (NTTF) in 2021 for offering an AI powered E-learning platform for NTTF's students. The Digital NTTF platform is powered by 'ELITE', an AI solution by Edsanta that incorporates NTTF's curriculum and empowers students for identifying career paths, detect skill gaps and overcome the gaps with relevant and tailored learning content. The simulated digital service intends to upskill the youth and design a customized career path for them. The platform has been made available in over 60 locations of NTTF and accessible by 600 faculty and 55,000 students across seven diploma programmes. The AI powered upskilling platform, 'ELITE' is customizable to suit each student's personalized requirement. Since each student has an independent learning style, AI technology has been leveraged efficiently to bridge this need for adaptive upskilling curricula.[lxxx]

nTalents is an Indian private sector entity leveraging AI for candidates' skill mapping and job placement. Its Talent Framework generates a job-fitment indicator that accurately predicts performance. The platform creates an all-round skill profile of candidates using videos, case studies, audios, and multiple-choice questions for assessing psychometric traits, personality and soft skills.[lxxxi]

Vasitum is an Indian private sector organization that offers an AI Powered Recruitment Assistant, named Vasi. The AI-enabled platform identifies the strongest alignment of candidates with job requirements and pairs them with the roles & opportunities relevant for them.[lxxxii]

- *Barriers to implementation of AI solutions for youth reskilling:* **Dependence on keywords** – The AI solutions developed for job profiling and candidate evaluation are heavily dependent on certain keywords that they use for mapping candidates to job opportunities. This encourages keyword stuffing by the candidates in their resume and makes the AI systems prone to bias and deceit by the unscrupulous candidates. AI-enabled candidate screening systems may happen to reject candidates who don't meet all criteria of the concerned job description, despite their skillset and experience greatly overcompensating for the lack of a certain qualification.[lxxxiii]

Algorithmic bias –A number of matching engines are optimized for generating applications and these systems generally base their recommendations on three data categories: information provided by the candidate directly to the platform; data assigned to the candidate based on others with similar skills, interests & experiences, and behavioral data, such as frequency of response to messages or interactions with job postings.[lxxxiv] Some international companies, like ZipRecruiter, classify candidates based on 64 types of information, including geographical data. However, the algorithms are not externally audited, owing to intellectual-property concerns.

Impersonal nature of AI – Research shows that 80% of job seekers prefer to have human interaction over an interaction with a bot. AI-enabled machines still face limitations in processing human emotions and slang terms too. 77 percent of 1,000 job applicants surveyed in the United States said they would prefer human interaction over bot interaction during the job-hunting process, according to a survey from the American Staffing Association (ASA).[lxxxv]

Localization limitations – A culturally and linguistically diverse country like India has youth that speaks in a wide variety of languages, with each having several dialects. Moreover, the proficiency of job applicants in spoken English language varies based on their medium of education, social circles and socioeconomic background. A one-size-fits-all AI platform for job mapping and candidate profiling will fall short of its intended outcomes and will be discriminatory towards youth who are not adept in English language. Moreover, designing a separate localized version of the AI solution for each language in India will be challenging from cost, resource, technological and testing perspective.

Ignorance of intangibles – AI systems have been found to be inept to some extent at accurately assessing

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the soft skills, personality, and potential cultural fit within the organization. AI solutions need to analyze data on metrics, such as cognitive aptitude and personality tests to inform your AI system.[lxxxvi]

FRAMEWORK FOR AI INCLUSION IN INDIAN EDUCATION SECTOR

A meticulous framework for AI adoption in the education sector is required to enable a phase-wise implementation process. The challenges in AI adoption discussed in the preceding section necessitate a structured, milestone-based approach to help India realize the vision of AI-enabled personalized education model. The "5-I Framework" recommended henceforth, covers the end-to-end journey for humanizing the Smart Education Program before institutionalizing it in the country.

The framework also acknowledges and integrates the reality that not all cities, towns and villages in India are ready for incorporating AI in the education process. Therefore, the AI implementation must happen in a phase wise fashion which has to start from select pilot cities, and then expand further to other regions based on the feedback of the pilot phase and readiness of regions and schools for AI use cases. Initiation of AI implementation will require identification of the AI applications that have to be deployed for assessing the effectiveness and impact of the technology in education sector, along with convenience factor for the students, teachers, parents and other stakeholders.

- **Phase 1: Identify**

This phase deals with identification of the need for AI in the Indian education sector and understanding of the impact that AI can generate in this space. Moreover, this phase will also deal with getting the necessary buy-ins from the key stakeholders to launch the pilot phase of AI implementation in the education curriculum for students.

Government of India think tank, NITI Aayog will need to discover the relevant use cases that are relevant for the Indian secondary and higher secondary education landscape. Moreover, through collaboration with Ministry of Education, the critical areas for AI will have to be identified and prioritized.

The problem statements will have to be defined for the Ministry of Education, Education Boards, National Center for Education, Research and Training (NCERT) and eminent educationist bodies to take action on through the application of AI use cases.

Use cases identified for Indian education landscape will have to be prioritized as per their feasibility and criticality of need. Use cases that feature as non-critical and non-feasible must be eliminated, while focus needs to be placed on the critical and feasible use cases. This step will help segment the AI use cases on the implementation timeline, while also spreading out the AI initiatives over a broad time horizon, instead of implementing everything at once.

Next, the key stakeholders for assessing, reviewing, deploying and testing the AI use cases have to be identified. This will ensure that the AI for Education strategy meets the objectives of all stakeholders in the process and is also evaluated from the viewpoint of all parties concerned. Student bodies, teacher bodies and parents' organizations need to be onboarded to invite and validate their inputs and to foster cross-pollination of ideas and recommendations, while pooling the efforts and resources from all concerned parties.

The KPIs have to be identified for evaluating the progress, effectiveness, robustness, availability, scalability, and impact of the identified and shortlisted AI use cases. A project plan with milestones and timelines has to be institutionalized.

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- **Phase 2: Inform**

The second phase deals with enabling the setup with capabilities, resources, and financial estimates to make the AI strategy robust and relevant for the targeted audience. This step will ensure that the national-level strategy is aligned to the expectations of the schools and students, while also building on the competencies of the key enablers, like the Education Boards and public organizations.

Cities and districts will be assessed for their readiness towards AI applications. The AI Readiness Framework shall include factors like telecom infrastructure of the selected regions, local government support, number of technology services firms, literacy rate and tech-savviness of the population, and outlook of students & teachers towards smart education technologies. This will help shortlist the 3-5 cities where the pilot phase will be launched in select schools.

The recipients of the AI services – students, parents and teachers – will have to sensitized and educated on the value of AI in education space and the benefit that students can derive out of it. Public authorities making investments in this space will also need to be onboarded.

Value case will need to be prepared to estimate the tentative cost of technology development & implementation, prospective benefits, coverage of students, number of schools enabled and quantitative increase in cognition capabilities among targeted students. The Returns on Investments can also be qualitative in nature and can have a Net Present Value over a longer period, like 5-10 years.

Funds for establishing AI infrastructure will have to be appropriated from the Consolidated Fund of India, which may require passing of bills in the central legislature and will need approval of the Parliament of India.

- **Phase 3: Implement**

The third phase drives the implementation of the AI-based projects in select schools, and involves design, development, testing, deployment and evaluation of the AI use cases.

Teachers in the select schools, who will be working on the AI applications, will need to be trained through dedicated workshops and upskilling sessions, organized by the Ministry of Education, in collaboration with the Information and Communication technology (ICT) partners.

The government will need to partner with technology vendors/ IT service firms to build AI applications and deploy them following the testing phase.

Assist schools and teachers with round-the-clock tech support from IT service vendors that have developed the applications. Keep AI-based interventions and recommendations non-binding on teachers, students, parents & schools in the pilot phase, in the view of lack of evidence of AI’s effectiveness during the pilot phase.

- **Phase 4: Improve and Assess**

Impact evaluation will comprise the fourth phase of the framework, wherein the effectiveness, quantitative & qualitative results and stakeholder feedbacks are to be assessed and acted upon.

1. Post completion of one academic year, the KPIs are to be evaluated to measure the impact of the AI program and AI-based academic interventions.
2. The required changes and upgrades in AI application are to be documented.

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3. AI Readiness Index for districts, cities & individual schools to be reevaluated.
4. Along with identifying and mitigating challenges, performance benchmarks of AI program are to be communicated to key stakeholders.

- **Phase 5: Iterate**

Post revising the AI strategy and making the necessary improvements, the program has to be scaled to additional districts and cities. The following steps need to be undertaken to scale the program across the nation in phases.

1. Prioritize the next set of districts/cities/schools for phase 2 of project, as per the updated AI Readiness Index, and carry forward the key learnings and best practices from phase 1.
2. Independent audit firms to be hired for KPI evaluation, and to publish the documented impact assessments.
3. An ecosystem of AI-enabled schools & cities need to be built and expanded to enable cross-pollination of ideas, best practices and academic support.
4. Integrate AI in Education as key element of Smart cities program, to make it a key priority in the development agenda.

On having sufficient evidence of intended impact and quantified benefits, AI interventions can be made partially binding for schools.

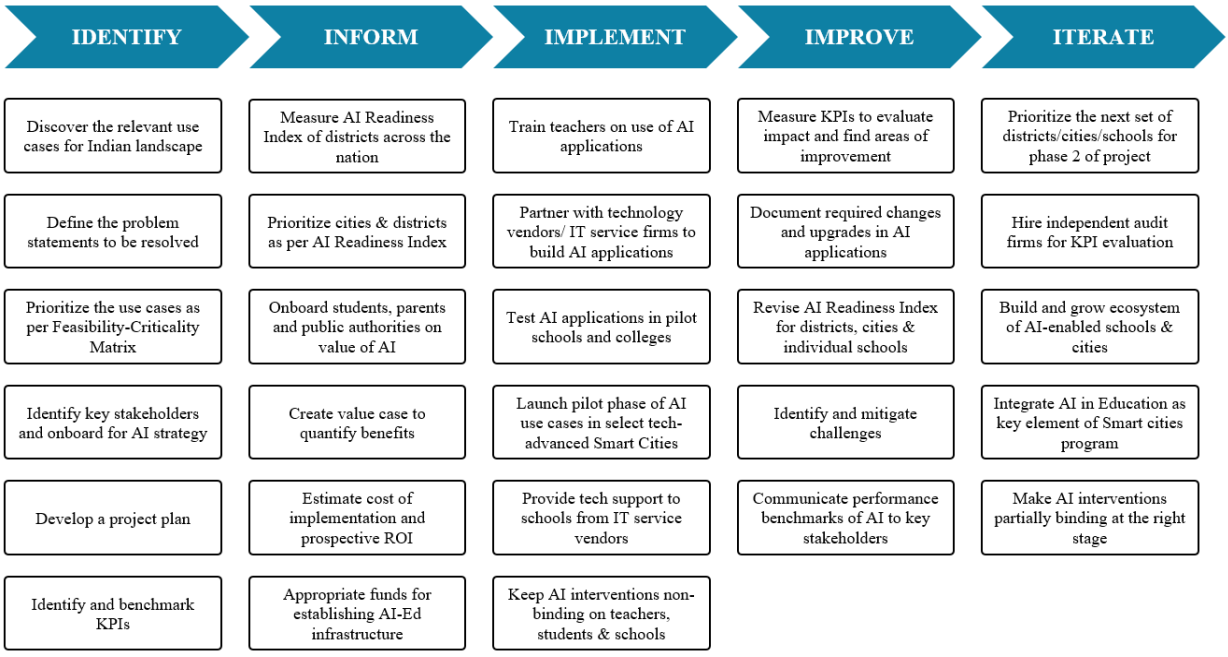

Fig 17: 5-I framework for implementation of AI use cases in Indian education sector

- **Drawing parallel with India's AI investments**

India's educational landscape is undergoing a transformative shift propelled by advancements in Artificial Intelligence (AI). Aligned with the National Policy on AI, India is leveraging AI technologies to revolutionize its education system, aiming to build an adaptive learning ecosystem that caters to the diverse needs of its learners.

Identify: The endeavor to integrate AI into education entails capturing vast volumes of curricular resources

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along with relevant metadata to facilitate personalized learning experiences. The National Council of Educational Research and Training (NCERT) has spearheaded efforts to tag metadata elements to educational resources within the National Repository of Open Educational Resources (NROER)[lxxxvii]. Furthermore, AI applications are tasked with monitoring the usage of these resources, analyzing teachingmethodologies, and assessing student responses to optimize learning outcomes.

Inform: India's commitment to fostering AI innovation in education is exemplified by the establishment of three AI Centers of Excellence (CoEs) in top educational institutions, as outlined in the Budget Announcement 2023-24[lxxxviii]. The Ministry of Education invited proposals from Higher Education Institutions (HEIs) ranked within the top 100 in the Overall Category by the National Institutional Ranking Framework (NIRF). Fifteen consortiums were selected, each receiving an initial funding of Rs 2 crore, to develop Proof of Concepts (POCs) for setting up AI CoEs.

Implement: The National Education Policy (NEP) underscores the integration of technology, including AI, to enhance teaching and learning practices. AI-powered adaptive learning platforms are poised to revolutionize education by personalizing learning experiences, analyzing student progress, and offering tailored educational content. For instance, AI applications in Andhra Pradesh processed student data to predict dropouts and suggest vocational studies, demonstrating AI's potential to inform proactive interventions[lxxxix].

Improve: AI's role in education extends beyond content delivery to enhancing teaching efficiencies and effectiveness. By analyzing learner feedback and transactional approaches, AI algorithms can identify optimal learning resources and methods tailored to individual contexts. This iterative process of refinement aims to improve teaching outcomes and ensure that every learner receives an education suited to their unique needs and capabilities.

Iterate: Upon the successful implementation and evaluation of AI CoEs, India plans to scale up AI-based educational services nationwide, thereby extending the benefits of AI-driven learning to a broader spectrum of learners. This iterative approach underscores India's commitment to leveraging AI as a catalyst for educational transformation, empowering learners and educators alike to thrive in the digital age.

Through strategic investments and collaborative efforts, India is poised to harness the transformative potential of AI to reshape its education landscape, fostering innovation, inclusion, and excellence.

POLICY CHALLENGES FOR AI ADOPTION IN INDIAN EDUCATION SPACE

Multiple challenges exist in the area of AI adoption for education space in India. The challenges are primarily technological, social and monetary in nature. These roadblocks can delay the onset of AI applications in the education sector and impede the digitization & decentralization of smart education in India.

- **Need for explainable AI for teachers**

Training and upskilling of teachers for integrating AI applications in their teaching methodologies and pedagogical tools will be crucial to onboard the instructors in the AI-enabled education programs. Unless the teachers are trained on how to leverage the AI's capabilities in their pedagogical techniques, the inclusion of AI in education will always fall short of achieving its intended outcomes. Given the knowledge barrier with regards to technology among the teachers in rural regions, upskilling them on how to use the AI applications and how to measure the impact will take considerable time. The AI systems must be easy for teachers to comprehend, and the functionalities must be simplistic enough for being explainable to teachers from any background. "Explainable AI" will need to be the focus for inclusion of AI in education.

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The poor state of teachers' competence with computer applications in schools is evident from the UDISE+ data for 2019-20, as shown in Figure 18, which highlights the shortage of teachers with adequate computer training, which can imply that teachers are largely incapable of handling AI-based applications in schools.

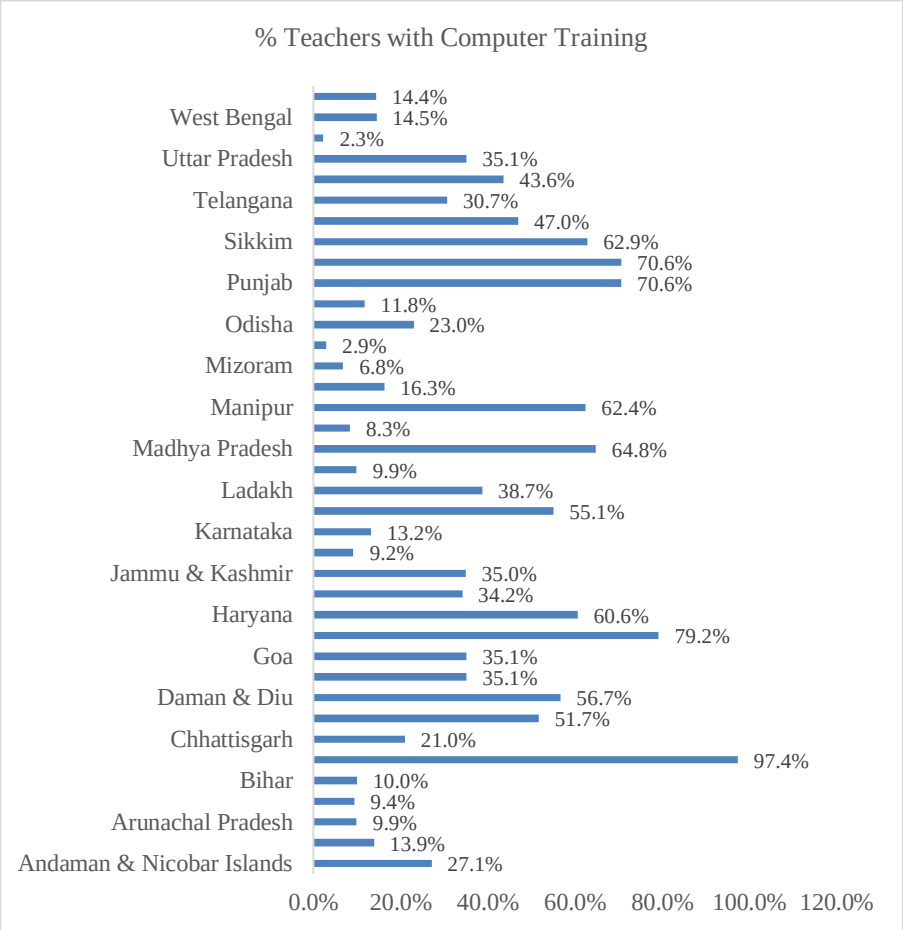

Fig 18: Percentage of teachers with computer training across major states in India (Source: UDISE+ 2019-20)

- **Poor telecommunication infrastructure**

A robust backend telecommunication infrastructure is integral to strengthening the availability of connectivity in the nation. The internet penetration in India in 2019 was 41%. The number of active Internet users in India is expected to increase by 45% in the over 2021-25 and touch 900 million by 2025 from around 622 million in 2020, according to the IAMAI-Kantar ICUBE 2020 report. This surge in internet penetration is expected to be driven by higher adoption in rural India, with a 13% growth, reaching 299 million internet users over the past year. this translates to 31% of India's rural population, the report said. Small towns currently account for almost two out of every five active internet users in the country.[xc]

However, despite rising internet connectivity and adoption of mobile internet, the digital infrastructure for schools & colleges, and for remote education are not sufficient. Men constitute approximately 57% of active Internet users in urban India, while women comprise 43%. Only 17% of India's active users access the Internet using a personal computer while only 6% access it through tablets, streaming devices, smart speakers, and smart televisions.[xci] While schools largely lack basic tech facilities required to adopt any modern AI, ML system, in tier-2 and tier-3 cities and towns, students don't have access to hardware required to access online classes from home.

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- **Low GDP spend to education sector**

Significant changes in the education system requires monetary support from the government in the form of expenditure and technology spend. The Economic Survey of India 2022 shows that the spend of the Indian government as a percentage of GDP on the education sector has decreased in the past 10 years, with only 10.4% of total government expenditure in 2020-21, compared to 11.4% 2011-12.[xcii] The expenditure on education is limited to below 3.5% of India's GDP. In 2011-12, spending on education was 3.2% of the GDP, which stood at 2.8% in 2018-19.[xxix]

Without a considerable increase in GDP spend in the education sector, the inclusion and implementation of AI in education will remain a distant reality and will impede education sector's journey towards becoming agile and responsive to the changing needs and requirements of the upcoming generations.

- **Unquantified value for stakeholders**

Inclusion of AI in education will have to be justified with a meticulous value case derivation which shows the prospective quantitative and qualitative benefits to teachers, parents, students, schools, policymakers, thought leaders and Ministry of Educators, among other stakeholders. The number of students reachable by the AI applications, number of schools impacted, magnitude of gender divide bridged, magnitude of socio-economic divides bridged and increase of student satisfaction with new personalized curricula will have to be quantified, in order to justify investments in this sector.

The lack of comprehensive quantification and uncertainty of benefits, in the face of massive cost of implementation, will continue to be a major roadblock for inclusion of AI in education. Education policymakers and thought leaders may have a tough time encouraging public sector investments to bring AI-based use cases to fruition in the education space.

- **Ethical considerations and data privacy concerns**

AI has revolutionized various aspects of modern society, from healthcare to finance. However, the widespread adoption of AI algorithms has raised significant ethical concerns regarding data privacy, fairness, and potential biases. Ethical considerations in AI encompass a wide range of principles and values that govern the design, development, and use of AI systems. Central to ethical AI are principles such as transparency, accountability, fairness, privacy, and safety. Transparency refers to the need for AI systems to be explainable and understandable, enabling users to comprehend how decisions are made. Accountability entails holding developers and users of AI systems responsible for their actions and the consequences of AI-driven decisions. Fairness emphasizes the importance of ensuring that AI algorithms do not discriminate against individuals or groups based on factors such as race, gender, or socioeconomic status. Privacy concerns arise from the collection, storage, and use of personal data by AI systems, necessitating robust data protection mechanisms to safeguard individuals' privacy rights. Safety considerations involve ensuring that AI systems operate reliably and securely, minimizing the risk of harm to users or society.

Data privacy issues are a significant concern in AI development and deployment, particularly regarding the collection, storage, and utilization of personal data. AI algorithms often rely on vast amounts of data to train and improve their performance, raising questions about consent, data ownership, and user control over their personal information. Inadequate data privacy protections may result in unauthorized access, misuse, or exploitation of sensitive data, leading to privacy breaches and violations of individuals' privacy rights. Moreover, the proliferation of AI-driven surveillance technologies poses additional privacy risks, infringing upon individuals' rights to privacy and autonomy. Addressing data privacy issues requires implementing robust data protection measures, such as data anonymization, encryption, access controls, and privacy-

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enhancing technologies, to ensure the confidentiality and integrity of personal data. AI algorithms are susceptible to various forms of bias, including algorithmic bias, data bias, and societal bias. Algorithmic bias refers to the inherent biases encoded in AI algorithms due to the data used for training or the design choices made by developers.

Data bias arises from the underrepresentation or misrepresentation of certain groups in training data, leading to biased predictions or decisions that disproportionately impact marginalized communities. Societal bias reflects broader social inequalities and prejudices that may be perpetuated or amplified by AI systems, reinforcing existing biases and disparities. Biased AI algorithms can result in discriminatory outcomes, exacerbating disparities in areas such as hiring, lending, criminal justice, and healthcare. Mitigating bias in AI requires adopting diverse and inclusive datasets, implementing bias detection and mitigation techniques, and promoting ethical AI principles throughout the AI development lifecycle.

CONCLUSION

Artificial Intelligence holds a huge potential in driving transformation in the education sector, especially in developing economies like India. Various challenges exist in the Indian landscape, ranging from one-size-fits-all approach and poor infrastructure for remote education, to high rate of dropout in schools and non-personalized academic assessment for students. The inclusion of AI holds the promise of digitizing, automating and adding intelligence to several academic functions currently handled by teachers, based on their subjective assessment of their students. Applications like Intelligent tutoring System, AI-driven remote education infrastructure, personalized assessment and automated grading can help make the education system adaptive to students' need, while enabling the teachers with tools and insights to get a deeper understanding of the necessary and individualized interventions required for each student.

A well-thought comprehensive framework is required to enable and drive the inclusion of AI in the education space. With focus on a developing economy like India, where vast socio-economic inequities exist and disproportion in telecommunication infrastructure pervades across the nation, it is important for the public sector organizations and private sector entities to collaborate and incorporate the benefits of AI in education in a phase-wise manner. The potential for AI in education space is massive, but it can be reaped only with a comprehensive approach that stitches the ground realities with the stakeholder expectations, public sector investments and prioritized areas for AI intervention.

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