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Potential of Artificial Intelligence for transformation of the education system in India

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ABSTRACT

The use of Artificial Intelligence (AI) in developing new teaching-learning solutions is gaining momentum towards transforming the education system in India. Schools are beginning to shift from conventional methods of teaching to smart education to enhance students' learning experiences. Reviewing the literature on machine learning, personalized learning, and Bloom's taxonomy, we set out to examine the following: How are the educational technology firms in India using AI to change the ways teachers teach and students learn? What are the untapped AI-technologies that have the potential to transform the Indian education system? We conducted in-depth interviews with four subject matter experts working on AI-related technologies and four senior managers from leading Indian educational technology firms that have developed AI-based applications for schools. Deploying grounded theory, we found that personalized learning, recommendation systems, and adaptive assessments are helping students and supporting teachers. In an emerging country context, we demonstrate the educational technology firms' view of AI and the experts' view of AI. The gaps between these views indicate the immense potential of AI which can be tapped by educational technology firms in their future applications. The study has practical implications for the transformation of the education system in emerging countries.

Keywords: *artificial intelligence; personalized learning; school; smart education*

INTRODUCTION

Recent years have witnessed burgeoning changes in the development of learning pedagogy significantly enabled by information and communication technology (ICT) (Sinha & Bagarukayo, 2019; Tijani, Obielodan, & Akingbemisilu, 2020). By providing an enriched environment, technology has created a profound influence on the learning experiences of individuals. Using technology, students attain a blended experience of in-class and outside classroom learning. With intelligent tutoring systems, technological architecture, and Artificial Intelligence (AI) capabilities, new teaching and learning solutions are being developed and tested globally (Chen, MdYunus, Ali, & Bakar, 2008; Pedro, Subosa, Rivas, & Valverde 2019). This new ecosystem is being created by innovators towards the development of a holistic learning environment. Such advancement in the education system is necessary because education aims to develop an individual to drive future growth, thus, ensuring that communities and nations thrive (King 2011). The future of work is highly dynamic, volatile, uncertain, complex, and ambiguous. To be able to thrive in such turbulent times there is need for individuals to be agile and adaptive. Skills such as critical thinking, leadership, communication, and teamwork, are crucial as young minds are nurtured. Further, students have to be encouraged toward lifelong or continuous learning which will help them adapt to the changing work and life environment (United Nations 2019). This young talent represents the future workforce. Thus, the development of these competencies to keep pace with the fast-changing world is imperative for the education system.

ICT powered learning management systems help teachers enhance students' learning experience (Sandhu, Sankey, & Donald, 2019). For instance, it was found that when the economics teacher engaged the students using a computer-assisted method, they took half the time to finish the course curriculum as compared to the traditional method of teaching and the students' performance was

comparable in both the methods (Shute, Glaser, & Raghavan 1998). These tutoring systems are developed by integrating the disciplines of psychology, computer science, and education (Thai-Nghe 2011). While psychology throws light on how individuals think, learn, and behave, artificially intelligent algorithms deem to learn from human intelligence. This computer-enabled learning augments the teaching-learning process by predicting student performance and carving personalized learning experiences (Thai-Nghe, Drumond, Krohn-Grimberghe, & Schmidt-Thieme 2010).

Proponents of AI and machine learning hold considerable promise for enhancing the field of education; however, its present application is limited. At the core of AI-technology application lies classification and decision making. Though the present learning management systems are user-friendly, they lack the adaptive capability of self-learning which forms the nucleus of artificial intelligence. An artificially intelligent system in its true sense should be dynamic and capable of updating itself through constant interactions with the learners and the dynamic resources in its environment (Mitchell 2017; Pedro et al. 2019). While this self-improvable adaptive instructional system would be the pinnacle of AI-application in education, educational technology (Edtech) firms have made some modest beginnings.

Thus, the key research questions (RQ) for the present study are:

RQ1: *How are the educational technology firms in India using artificial intelligence to change the ways teachers teach and students learn?*

RQ2: *What are the untapped AI-technologies that have the potential to transform the Indian education system?*

This paper contributes to the extant literature in two ways: First, we highlight the role of Edtech firms in supporting students and teachers towards improved experiences in the teaching-learning process. We identify the AI-related principles that find practical applications in the present educational scenario. Second, despite the usage of data-driven techniques, we bring to light the high potential of AI concepts and technologies that currently remain untapped by the education industry. The study holds key implications for the most critical drivers of the education system, that is, students and teachers. With continuously developing learning models, students gain key insights into their strengths, areas of improvement, learning style, and pace. Further, the change in the role of teacher gains paramount importance as teachers need to develop digital platform skills to support ICT-mediated learning and to focus more on harnessing soft skills and life skills among students.

In this study, we review the current advancements in students' learning methods powered by technology and AI systems in the Indian context. Next, we analyze the qualitative data to help us understand how AI is being applied in the educational context, how AI has changed the ways teachers teach and students learn and highlight the potential of AI-applications yet untapped. Finally, we outline the implications of our findings, discuss the possible challenges of sustainable development and implementation of AI-powered systems in the education sector, and indicate directions for future work.

LITERATURE REVIEW

Artificial Intelligence

Artificial Intelligence is defined as a set of computer programs and technologies that mimic the human's brain functioning and intelligence (Huang, Rust, & Maksimovic 2019). AI-systems are

mechanically-intelligent, performing repetitive tasks efficiently, and/or thinking-intelligent which self learn from the data and adapt their performance. Systems have become intelligent by learning from a variety of data (text, audio, or video). This repository of big data enables AI-systems to learn from data through various computational methods such as machine learning and deep learning. Machines that have the ability to learn from big-data, and update their predictions and actions, comprise artificially intelligent systems.

Machine Learning (ML) is the study of algorithms that construct computer programs to improve automatically through experience (Mitchell 2017). ML uses computers to simulate human learning by identifying and acquiring knowledge from the real world and improving performance based on this new knowledge. Within the AI domain, ML is the most widely used technique among researchers who develop algorithms for applications such as recommendation systems, autonomous vehicle control, image recognition, computer vision, and natural language processing. This is because researchers have realized that it is much easier to train a system with data of desired inputs and outputs than to manually program the system by predicting desired outputs for all possible inputs (Jordan & Mitchell, 2015).

ML methods include supervised learning, unsupervised learning, reinforcement learning, and deep learning (Mohammed & Bashier 2017). Supervised learning is the most commonly used ML technique that trains the system using labeled sets of input-output data to predict the output for new unlabeled input. Unsupervised learning trains the system on unlabeled data for prediction. In reinforcement learning, instead of training the system with data, the system learns from its actions which produce correct or incorrect results (Nurakhmetov 2019). Deep learning algorithms, which are the most complex ones, discover intricate structures in large data sets by processing multiple layers of representation. This ML technique helps the model to self-learn and change its internal parameters towards analyzing multiple levels of abstraction (Lecun, Bengio, & Hinton 2015). ML algorithms, especially supervised learning, are being extensively used across varied industries that generate massive amounts of data, such as e-commerce, consumer products, healthcare diagnostics, and supply chains.

One progressive step in the application of AI is in recommendation systems (Portugal, Alencar, & Cowan 2018; Thai-Nghe et al. 2010). Recommendation systems use ML algorithms to learn from the user's information and provide personalized recommendations for them. These systems tailor the content based on the unique identity and characteristics of the user. For instance, video streaming services such as Youtube or e-commerce firms such as Amazon identify users with similar browsing history and suggest the individual video/item they are likely to be interested in. Conversational assistant Alexa analyzes a large number of requests (and rephrased requests) to provide customers with personalized query responses and recommendations (Sarikaya 2020). Thus, recommendation systems use machine learning to personalize recommendations based on the user's preferences and characteristics.

Evolution of Learning Systems

The Taxonomy of Educational Objectives (Krathwohl 2002), popularly known as Bloom's taxonomy, is a framework for classifying learning objectives that the educators intend their students to learn in the teaching-learning process. Bloom's taxonomy differentiates between various intellectual processes ranging from lower-order skills (remember, understand and apply) that require less cognitive processing to higher-order skills (analyze, evaluate and create) that require deeper learning and transfer of the learning to create something novel or original. Thus, educators continually seek insights into how various pedagogical techniques engage students and impact their learning.

Humans learn and acquire knowledge from experience due to their ability to think and reason, whereas, computers learn with algorithms (Portugal et al. 2018). With the application of ICT in education, teaching-learning methods have undergone tremendous changes. Technology-mediated learning deems to enhance learning outcomes through an environment in which students' interaction with learning material, classmates, or teachers is mediated by technology (Janson, Sollner, & Leimeister 2019). Technology-powered systems include blended learning methods such as web or computer-based, instructor-led or self-paced, and individual or team-based learning (Gupta & Bostrom, 2009). These systems help teachers enhance students' learning experience by detecting their learning paths. The differences in the learning process arise as learning entails the construction of new ideas or concepts by the individual based on their knowledge, skills, abilities, and/or experience. Artificially intelligent systems acknowledge these differences and adapt to the differential learning styles and aptitudes of the students (Gupta & Bostrom, 2009).
The understanding that different individuals learn in different ways provides a foundation for personalized learning. Personalization means delivering the content that specifically caters to the student's needs, individual differences, circumstances, preferences, and competencies. Personalized learning can be achieved by creating learning objects that are small units of customizable digital resources with appropriate information for the given student (Gupta & Bostrom 2009). Personalization of content is done by ML algorithms which improve the prediction abilities of the model with every interaction (Gregory, Henfridsson,Kaganer, & Kyriakou 2020). Thus, personalized learning is a promising domain for academics and practitioners as it provides meaningful experiences to the learners.

Thus, this study aims to analyze how AI-based technologies are being used by the Edtech firms in changing the ways teachers teach and students learn. Further, given that AI and ML methods vary in their degree of complexity, we assess the complexity of AI-technology currently being used by the Edtech firms. We also discuss the way forward for these firms with respect to leveraging the untapped potential of AI technologies.

METHOD

Indian Education Context

The education sector of the emerging economy in India educates 340 million students in 800 universities, 40,000 colleges, 12,000 stand-alone higher educational institutions, and 0.15 million schools (Press Trust of India 2020). Though India's demographic dividend is estimated to provide the country with a competitive edge, the education system needs a massive transformation to cater to the demands of the future work (Sinha & Bagarukayo, 2019). The future workforce requires multi-skilled and smart professionals who can work seamlessly with machines, data, and algorithms, to enhance performance. Towards preparing the young minds for an uncertain future work environment, firms in India have initiated a technological revolution in the smart education space. The use of technology addresses the challenges of India's education system concerning inequity, low access, and poor quality of education (Mitra & Jhingan 2009). Technology must be leveraged to provide access to good quality content and educators, thus, leading to socio-economic inclusion and equity. Further, acknowledging that students have differential learning needs, styles, and pace, educational technology firms provide personalized learning paths to students.

Data Collection Approach

Using a qualitative method of data inquiry, we conducted in-depth interviews with two distinct categories of individuals. The first category comprised four subject matter experts who work closely with AI, ML, and related technologies. They were interviewed to develop an understanding of how these machines systems are designed and how they work. The second category comprised senior managers from four leading Indian educational technology firms who have developed AI-based products for K-12 education. Though these firms are start-ups, they have gained a massive

outreach to millions of students across the country due to technology proliferation. Table I summarizes the interviewee characteristics including Subject Matter Experts and representatives from Educational Technology firms.

Table 1: *Interviewee characteristics*

Subject Matter Experts			
Current employment	**Educational Background**	**Area(s) of expertise**	**Work experience (in years)**
Faculty of Computer Science in a top-ranked Indian engineering institute	Doctoral degree in Computer Science (Machine Learning)	Artificial Intelligence, Statistical Machine Translation, Deep learning, Natural language Processing	18
Data scientist in a large multinational energy sector company	Doctoral degree in Information Systems from a top-ranked Indian engineering institute	Personalization in e-commerce	8
Data scientist in a multinational investment bank	Doctoral degree in Operations Research from a top-ranked Indian management institute	Reinforcement Learning	7
Research Scholar in Information Systems in a top-ranked Indian management institute	Engineering in Computer Science	Recommendation systems	3

Educational Technology Firms			
Functional expertise	**Work experience (in years)**	**Firm age (in years)**	**Number of users**
Product manager	16	7	1.2 million students
Sales head	12	13	1.0 million students
Chief Executive Officer	24	4	60000 students
Academic manager	11	9	0.8 million students

We sought an appointment for conducting the interview after providing the purpose of the study. Adhering to the ethical guidelines for conducting interviews, participants were assured of the confidentiality and anonymity of their responses. Further to their informed consent to participate in the study, an in-depth interview was conducted. The interview design was semi-structured guided by an indicative list of questions. Interviewees were given the flexibility to attain deeper insights into the study purpose. While conducting the interview, we refrained from including personal questions and leading words. Each interview lasted for 40-45 minutes.

Analysis

The interview accounts were transcribed. Given the interpretive nature of the study, we followed a grounded theory approach outlined as open, axial, and selective coding (Corbin & Strauss 1990). Open coding allows for a higher level of abstraction for an iterative coding process that began by fracturing the transcribed data sentence-by-sentence. Convergent and divergent themes emerged from the qualitiative data. For example, when coding for personalized learning, responses from different interviewees were sorted and categorized. Similar or different concepts were identified; ideas were grouped together and conceptually labeled to form categories that were integral to the data (for example, how Edtech firms use AI to help students, how Edtech firms use AI to support teachers). Once the categories were identified and their properties broadly defined, the categories became the basis for further in-depth development.

Next, axial coding was employed to subcategorize the data within each category (for example, personalized learning, adaptive assessment). Finally, through selective coding, all categories were unified around a core category representing the central phenomenon of the study, that is, how AI-based technologies are being used by the Edtech firms to change the ways teachers teach and students learn and what is the untapped potential of AI not harnessed yet by these firms. This grounded theory approach allowed factors to emerge more inductively with respect to the study context and the constant comparative method ensured consistency in the qualitative process.

FINDINGS

Results of the preceding data analysis were categorized as follows: how educational technology firms use AI to help students, how educational technology firms use AI to support teachers, the expert's view of AI in education, and the untapped potential of AI for Edtech firms. Each category is described below with sub-categories and illustrative quotations from the interviews. Figure 1 summarises the major findings of the study.

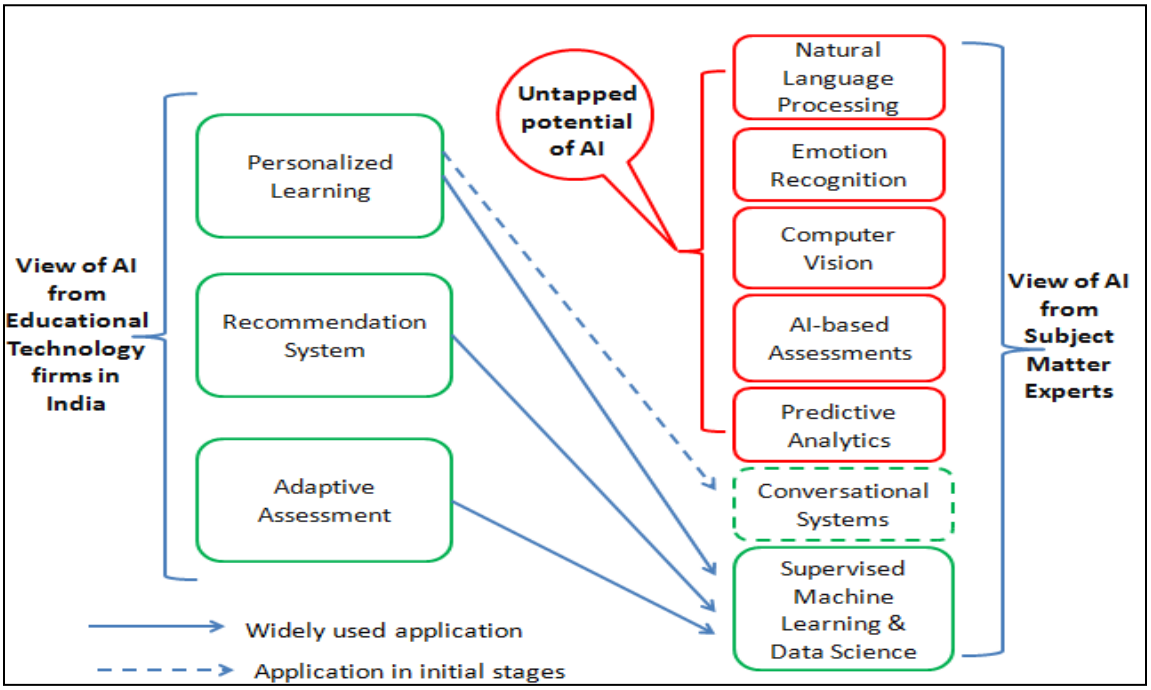

Figure I: Artificial Intelligence in the Indian education system: State-of-the-art and future prospects

How Edtech Firms Use AI To Help Students

Personalized learning and recommendation system

AI in education is most widely used to personalize learning as noted by all respondents from the Edtech firms. Teachers play a significant role in the learning experience of students. However, with increasing classroom strengths, it is difficult for teachers to focus on each student's development on a continuous basis. Further, students have different learning styles and pace. Thus, a one-size-fits-all learning approach may not be the best method for all students. One respondent noted:

> "*With our smart technology platform, we ensure that every student has an excellent teacher who personalizes the entire journey of the student".*

Towards this, educational technology firms use rule-based algorithms to detect a student's learning path and provide customized learning content. These firms have a comprehensive database of millions of questions, elaborate coverage of concepts depending on the education level of the student, animated videos, gamified quizzes, and flashcards. One respondent explain ed as follows:

> "*The teacher explains the concepts….each concept is tagged according to the difficulty level….students take a quick quiz and instantly know the result….for the questions where they went wrong, they get motivating remedial methods to strengthen their concepts. This creates a smooth learning curve, keeps them motivated, and improves their learning experience*".

Further, the personalization system provides avenues to a student to practice more questions on a topic chosen by the student, or take chapter tests. From its repository of millions of questions, the system retrieves relevant questions and the student gets to practice. One respondent noted:

> "*AI helps in identifying the right practice question from your set of questions*".

Thus, the personalization of content is enabled by subject matter experts coupled with the power of data science.

Based on the individual's strengths and weaknesses, appropriate recommendations are provided by the AI-system. There is an overlap between the personalization engine and recommendation system as recommendations are personalized to the student's problem areas. Recommendations include practice questions similar to the questions wrongly answered by the student, remedial videos, and suggestions to refer to particular sections in the textbook to improve the learner's understanding. Further, these technology platforms offer customization in terms of the number of questions the learner must answer to grasp the particular concept. There is no pre-determined set of questions per concept. Depending on the student's response, the algorithm figures out if the student needs to practice more similar questions or move to a higher or lower level of difficulty. Thus, personalized recommendations aim to improve the understanding of the student with respect to the specific problem area for that individual. As one respondent noted, firms continuously aim to answer:

> "*how do I recommend better content to the student*", as indicated by one of the respondents.

Adaptive assessment

While most Edtech firms provide personalization and recommendations to students, few firms also offer adaptive assessments. When the assessment is initiated, the system will consider all students as average performers and display a question of the average level of difficulty, known as "cold start". Based on the response to the first question, the next question appears for the student. If the first answer is wrong, the system provides the next question at a lower level of difficulty, whereas,

if the first answer is correct, the system provides the next question at a higher level of difficulty. The questions are retrieved randomly by the system from the larger pool of questions in the database based on the level of difficulty. This process goes on until the stipulated number of questions (determined by the teacher) is reached. The weighting of questions depends on the level of difficulty. One respondent illustrated as follows:

> "*Say, for example, there is a bright student and he/she picked the correct answer. Then the system will take him/her to the next intermediary difficulty level of question…again he/she picked the correct answer, then it will take him/her to the higher difficulty level*".

Thus, the assessment is adapted and personalized based on the level of the student's understanding and problem-solving capability.

Edtech firms integrate personalization engines into smart classes and the learning management system of the school to provide analysis and recommendations suitable for each student's learning style. This customization is based on student's learning profiles that include their strengths and areas of improvement. The firms have reported increased student engagement and performance across varied levels of K-12 education owing to the personalization of the learning journey. Further, the adaptive method of assessment provides an instant result to the students, highlights their mistakes, recommends methods for improvement, and demonstrates each student's position relative to others in the class. The report also maps students' understanding to Bloom's taxonomy and provides detailed solutions for all questions. Continuous evaluation and sharing of reports keep students engaged and they are aware of their performance levels. In addition, remedial measures provide students with actionable plans and areas to improve upon.

How Edtech Firms Use AI To Support Teachers

Personalized learning and recommendation system

In addition to providing a personalised learning experience to students, the educational technology firms also provide elaborate reports for teachers with the feedback of student's performance on a continuous basis. AI-enabled systems track information of each student such as time spent on each problem, the number of times hints were requested, wrong/correct answers, preferred learning style, and overall performance. When a teacher conducts a quiz in class, these systems also provide analytics to the teacher in terms of metrics such as the number of students who could (and could not) answer each of the quiz questions and which questions most students could (and could not) answer. As noted by one of the firm respondents:

> "*Teachers can log in to their dashboard, check individual student's performance, view their mistakes, and see if there are any repeated mistakes, and so on. Teachers can also have a summary of the overall performance of the class on one concept or chapter or unit."*

These metrics provide a detailed view to the teacher with regard to their students' overall understanding of the topic and any specific concepts which most students found difficult to understand, thus, it must be repeated by the teacher. Further, reports for individual students help the teacher identify specific problem areas for the individual learner. Thus, the teacher can personalize the teaching content and recommendations for each student based on the requirement of the student.

Adaptive assessment

The adaptive assessment system relieves the teacher from various repetitive tasks, standardizes evaluations, and minimizes human error. An intelligent adaptive system helps save a considerable amount of the teacher's time by preparing a dynamic question paper for each student and

automating the repetitive and monotonous task of answer sheet correction. One firm respondent noted:

> "*Our results show that teachers save up to 90% of their time in objective-type assessments and up to 70% of their time in subjective-type assessments*".

The assessment report provides insights in terms of variation in students' performance, key areas where students lack understanding, and remedial measures for improvement. Further, reports provide a time-versus-marks distribution, that is, the amount of time (in seconds) the student has taken to respond to each question. This helps the teacher to judge whether the student has guessed the answers or understood and responded to the question. Teachers can expend more time and effort in providing personalized learning experiences to the students. Thus, AI-enabled systems help teachers gain insights into students' performance and take decisions for customizing their teaching methods.

Experts' View of AI in Edtech

Present level of AI

The past few decades have witnessed the advancement of AI from simple rule-based search problems (such as the best move for tic-tac-toe) to knowledge representation systems (such as identifying relationships) to sequential decision making (series of complex decisions to be taken). In the traditional rule-based AI system, computers did not learn. However, as systems progressed to knowledge representation and decision making, machine learning algorithms began self-learning from the data. Experts in the domain of AI consider the personalized learning approach of Edtech firms as a traditional form of AI or data science that entails data collection, data cleaning, analysis, and reporting. Statistical analysis done by the Edtech firms can at best be considered as supervised machine learning or a starting point for AI. This is because the algorithms used by the firms basically train the application on historical data to develop personalized responses and unless retrained, the personalization remains the same.

An expert noted as follows:

> "*What these companies do is, for instance, you are weak in statistics so check these videos to understand better. This is purely data science that runs on rule-based systems. The true application of AI is when rules are not known and the system discovers it from the data…for that system needs a massive amount of data that is not available yet…but companies use data science and AI interchangeably"*.

Data science tools generate digital records of each student that help in identifying the problem areas within individual students or groups of students. Another expert noted:

> "*AI can help identify issues, suggest corrective measures, but it cannot fix them… it can only recommend solutions to students but cannot follow-up on the student's actions…thus, the role of the teacher becomes extremely crucial"*.

These insights may augment a human tutor's understanding of how to mitigate problem areas and improve the learning experiences of students.

AI-powered conversational systems are helping educators in rote learning and basic/repeated conversations with students. For instance, a school in India is using a robot to deliver lectures in class. These systems work well but in a very narrow and constrained domain. Concepts, questions, and their respective answers in a specific chapter are limited. Hence, mundane or repetitive queries can be easily handled by the conversational tools and personalization engines. Further, adaptive

assessments are gaining immense popularity in conducting exams based on existing question banks, in correcting answer sheets and providing feedback on relevant resources to refer to, in order to improve. However, these systems are fixed and not very intelligent. One expert noted:

> "…*suppose a student answers something in his/her own words which is right but different from the textbook …existing AI systems only match the strings and are not trained enough for such a deep understanding*".

The nature of algorithms used by Edtech firms is static, unlike human intelligence which dynamically processes and updates itself.

> "*AI is when the system exactly mimics a human response…existing systems are far from that…*", asserted an expert.

Untapped potential of AI

AI-systems augment human capabilities by sensing, comprehending, learning, and acting (Daugherty & Wilson, 2018). Such heightened computational power has enabled advanced levels of data analysis towards complex and context-specific decision making. There have been burgeoning advances in the domains of image processing, pattern recognition, and natural language processing over the past few years. Deep learning and reinforcement learning have become increasingly common in data-rich contexts and brought AI closer to true intelligence which is the ability of machines to mimic human intelligence. However, with respect to the technology firms in the Indian education sector, most firms are in their infancy stage of AI. This is because these organizations are focusing primarily on data science and supervised learning based on pre-classified datasets.

While there are evident advantages of an adaptive assessment system, the dynamism is only to the extent that the system is pre-programmed. The system follows a rule-based algorithm of gauging the level of the student by the response to the questions asked. Questions are dynamically retrieved by the system from the existing repository or question bank. However, if a new question is added to the system which may be similar to some existing questions in the question bank, the system will not be able to self-determine the level of difficulty of this question. The content developer or subject matter expert must establish the level of difficulty of the new question. Further, the system does not prompt the student for repeat evaluation of topics that he/she did not do well in the past. Thus, AI-based assessments needs to be further developed. In terms of predictive analytics too, the existing Edtech systems have not developed advanced capabilities. Extant systems neither predict student's future performance based on their present performance nor suggest them to take decisions, for example, choosing a career based on their performance. Some of these limitations demonstrate that despite its dynamic nature, the present AI-enabled systems fare low with respect to AI-technology complexity.

AI has been remarkably successful in computer vision plotting, that is, detecting the face and the outline of the human body or any object as noted by one of the experts:

> "*Face recognition systems and eye-movement detectors used in some institutes abroad provide accurate information regarding the attention levels of students*".

Likewise, natural language processing is one of the most promising applications of AI; however, it is highly complex due to its complicated and unstructured nature. Moreover:

> "..*in the Indian context, look at our languages and accent, we mix our languages while speaking; and so on…it is very difficult for a computer program to process the nuances of language like humans do*".

Thus, any technology functioning on unstructured data such as image, voice, or video, would entail a high level of AI complexity. While these AI-technologies are available in the computer science domain and are being used in some developed countries, they have not been yet synchronized by the Edtech firms into their products in India.

Thus, in its present application in Edtech firms and scope for future growth, an expert noted:

> "*AI is a statistical technology that gives the right picture of the population in a graphical form but only a good teacher will help students overcome the learning struggle. If AI systems have a knowledge base beyond what exists in the teacher's head and enter a mode of self-learning, only then AI systems will augment the teaching-learning process in true sense*".

AI has the potential to transform systems and processes to complement and augment teaching capabilities. Teachers will find more time to engage in resolving ambiguities among students, emphasizing deep learning, exercising judgment in difficult cases, and dealing with different types of students, towards delivering better teaching outcomes. As data-driven interfaces will perform analysis of student data and recommend knowledge bytes, teachers will gravitate towards developing humane aspects in students such as life skills, interpersonal skills, creativity, and empathy.

DISCUSSION

RQ1: *How are the educational technology firms in India using artificial intelligence to change the ways teachers teach and students learn?*

In an emerging economy context, it is quite impressive that Edtech firms are deploying intelligent systems to detect students' learning paths. Since each student has a different learning pace and style, these educational platforms provide personalized learning content to suit the differential needs of learners. The aim of adaptive systems is not just to provide solutions to learners so that they get good marks in exams but to motivate them to learn, to discover their strengths in learning abilities, and to identify areas of improvement. Personalized learning enabled by artificially intelligent systems acknowledge the learning differences among students and adapt to the varied learning aptitudes of students. Personalization of content is driven by machine learning algorithms which improve the predictive abilities of the model with each interaction. Association rule mining is used to discover student performance through data in the form of "if-then" rules which are used to generate recommendations for students. In this way, data-driven adaptive systems help students by providing them with tailored learning content and improving the quality of education. Further, adaptive assessments judge the knowledge level of the student based on the first few questions. Depending on the student's response to the initial set of questions, the adaptive system retrieves further questions from its question bank. Sourcing of questions depends on the level of difficulty achieved by the learner. Thus, educational technology firms deploy adaptive systems in their learning platforms to enable personalized learning solutions to school students.

Data-driven technologies are not only beneficial for students but also augment the teaching-learning process by supporting teachers. AI-enabled systems conduct analytics and present elaborate reports to teachers that include the overall understanding and performance of the class as well as the understanding and performance of each learner. These metrics provide a holistic view to the teacher in terms of the concepts understood by the students, or specific topics that the teacher needs to revise for the whole class. If the majority of students faced difficulty in understanding certain topics or answering certain types of questions, it indicates that the teaching pedagogy needs to be revisited to improve the understanding of the students. In addition, metrics for individual students highlight specific strengths and problem areas for individual learners. Once the teacher understands the weak spots of the student or the recurrent mistakes made, they can

personalize their feedback and recommend appropriate study material for each student. The teacher can also track the progress of the student and gauge whether the previous recommendations helped in improving the student's understanding and subsequent performance. Thus, there are two key considerations in understanding and predicting student performance, that is, student performance is cumulative and improves with time, and when students repeat the questions, their performance improves on average. Therefore, Edtech systems not only take the temporal effects into account but also the multiple interactions between the student and the tasks performed.

RQ2: *What are the untapped AI-technologies that have the potential to transform the Indian education system?*

While the current state of Edtech firms indicates personalized learning, recommendation systems, and adaptive assessments as the three major applications of AI, several futuristic technologies such as sensor technology, image processing, and emotion/behavior recognition will help augment the teaching-learning process by providing real-time feedback to the teacher. Digital records would include various aspects such as eye-movement, attention level of students, level of understanding, and emotion recognition through image processing of facial expressions, physiological signals, speech recognition, non-verbal behaviors, body language, and level of engagement (Behera, Matthew, Keidel, Vangorp, Fang, & Canning 2020; Busso et al. 2004; Egger, Ley, & Hanke 2019).

Research indicates that human affective states can be recognized with high accuracy by the use of audio and visual modalities (Busso et al. 2004). AI-human interfaces can perceive humans' verbal and non-verbal feedback on emotional states with high precision, thus, providing deeper scope for teachers' intervention. Thus, datafication or individual information footprints that help model and predict human behavior must gain prevalence in the education sector in the future (Pedro et al. 2019). For example, a deep neural network can be used for recognizing hand-over-face gestures appearing in the teaching-learning environment. These algorithms will suggest appropriate corrective actions such as notifying the teachers to simplify the content, modify the pace of delivery, or repeat the topic. These advanced technologies will also provide meaningful insights for enhancing individual levels of engagement and improve the overall tutoring process.

AI-enabled systems augment the teaching process by relieving the teacher from manual mundane tasks such as attendance, tracking the student performance, and correcting papers. The teacher can devote more time to feeling tasks that cannot be emulated by AI. Feeling tasks are person-centric and include the softer aspects of the teacher's role such as communication, empathy, and developing social skills. It is not only important for students to perform well in the curriculum but they must also develop life skills for holistic growth. Thus, teachers can expend more time and energy resources towards developing the overall personality of each student.

Practical Implications

Learning management platforms that blend AI-adaptive systems and human teaching have key implications for students and teachers. First, it will help students to discover their strengths, interests, areas of improvement, learning style, and personality types. Personalized content engages a student more with the subject as recommendations related to their weakness helps address specific problem areas. While personalization of learning primarily focuses on the recommendation of remedial measures for the topics or concepts the student is weak in, it also gives insights into the areas where the student is strong and is likely to perform well. Thus, the teacher's support in leveraging students' strengths and personality traits will hone the inherent skills of the students. Besides these prominent advantages of adaptive learning systems, Edtech firms need to focus on system-driven repeat evaluation of weak areas of students. Depending on the

importance and difficulty of the topic, algorithms must prompt the student for a revision after an appropriate time gap. This will help reinforce the concepts which the student may have partially forgotten.

Second, the datafication of education will improve the quality of the curriculum by enabling teachers to customize their teaching goals according to the students' needs and understanding. Teachers need to be transformed from being an instructor to a psychological tutor (Pedro et al. 2019). This is because the learning processes, attention spans, and engagement levels, vary considerably from one student to another. Teachers need to develop fusion skills (Daugherty & Wilson 2018) of working together with AI-enabled technologies to create new learning opportunities and experiences for students. With continuously developing technology-enabled learning platforms, the teacher's role must also evolve accordingly. Thus, institutional heads should invest in training their teachers to develop digital platform skills to use digital techniques in a meaningful way (Sandhu, Sankey, & Donald, 2019). Teachers must learn how to use student learning analytics to gain insights into the learning curves of different students and take decisions regarding optimal student development. Edtech firms must work closely with teachers to create technology solutions that are sustainable in practical environments.

Further, due to AI-powered platforms, teachers will have more time to emphasize on the assurance of learning by enhancing soft skills of students such as emotional intelligence, leadership, and interpersonal skills. Assurance of learning is evaluated by assessing "written and oral communication skills, teamwork skills, ethical decision making, critical thinking, and the ability to apply knowledge in real-world settings" (NASEM 2018, pp. 40-41). Since students are the key drivers of the future workforce, developing higher-order thinking, problem-solving, social and life skills, at the early stages of learning and development are critical for enhancing their employability in the future. Thus, AI has the potential to modify the way teachers teach and students learn. This change has the likelihood to maximize student success and prepare them for the future (Ayoub 2020).

Limitations and Scope for Future Work

The data for the present study were collected from subject matter experts and vendors in the Edtech domain. Though the firms have presented an optimistic view of how the intelligent learning management systems have transformed the way teachers teach and students learn, the real picture of how successful these firms are will be obtained when data from students is collected. Students would be the appropriate respondents to indicate the extent to which personalization and recommendation helped them learn the subjects better and how adaptive assessments helped in testing their learning. Further, data from teachers, parents, and school administrators, would provide a holistic view of the value of these AI-based products. Towards ensuring inclusion and equity in education and reducing the socio-economic divide, the role of digitally-powered products needs to be explored (Singhavi & Basargekar, 2019). Thus, future work must explore the value addition of technology-based education from varied stakeholders to provide a comprehensive understanding of the usefulness of AI in education.

Our study findings highlight that ICT-enabled education personalizes the learning process with feedback and recommendations based on student's performance. While instant feedback and corrective measures are welcoming, the abundance of remedial resources may be overwhelming for students. The student learning process is not only demanding in terms of time, physical and mental energy but also draws immense emotional energy through negative feelings of fear, anxiety, or disappointment, and positive feelings of appreciation, delight, or pride. Students may be more contented with the learning process that balances both cognitive and affective outcomes such as domain knowledge and satisfaction, respectively. This critical balance between the cognitive and

affective needs of the learners must be accounted for in future studies. Further, data-driven learning management systems can indicate appropriate career choices for students based on their personality profile and performance data. End-to-end employability solutions, if embedded in tutoring systems, will enable students to identify skill requirements for a variety of career choices. Students with the help of teachers can focus on getting trained in relevant skills for the future and enhance their readiness, thus, resulting in an industry-ready talent pool.

CONCLUSION

Education plays a critical role in molding the workforce for the future. Relevant education necessitates redesigning study content, recreating methods of delivery, and adopting powerful technologies to facilitate learning. In emerging country context, Indian educational technology firms have made modest advances in recrafting some of these deliverables. Personalization of learning and recommendation of study material tailored to the student's needs is an important outcome of AI-driven learning platforms. In addition to helping students, these platforms support the teachers in providing student analytics and adaptive assessments. While these are significant advancements in the context of an emerging economy, the study brings to light some high potential AI-technologies such as facial recognition, emotion recognition, natural language processing, and image processing, which are yet untapped by the Indian Edtech firms. These technologies are being used in developed countries and integration of full spectrum of these technologies will improve the teaching-learning process remarkably. Nevertheless, the present study highlights how a combination of human teaching skills and AI-capabilities has the potential to enhance the experiences of students and teachers and transform the teaching-learning process. These improved experiences will not only serve the holistic and long-term development of students but also enhance the quality of overall education.

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APPENDIX 1: Interview Schedule

Subject Matter Experts

1. How is AI being used in the education sector to improve teaching-learning outcomes?
2. Please tell us about the AI technologies that have not been implemented yet but have the potential to transfrom the education system?
3. Personal information: Current employment, educational background, area(s) of expertise, and work experience (in years).

Educational Technology Firms

1. How does your firm use technology in the teaching-learning process? Do you use AI in your products? If yes, how?
2. How has AI changed the way students learn?
3. How has AI changed the way teachers teach?
4. Who develops the content? How is the content updated?
5. Company's information: Firm age (in years) and the number of users.
6. Personal information: Functional expertise and work experience (in years).