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USING ARTIFICIAL INTELLIGENCE TECHNOLOGIES FOR PERSONALIZED LEARNING AND RESPONSIVE TEACHING: A SURVEY

Daisy Wadhwa

Assistant Professor in Computer Science and Applications, Guru Nanak Khalsa College for Women, Gujarkhan Campus, Model Town, Ludhiana, Punjab (India)

ABSTRACT

Artificial Intelligence has the potential to augment, improve and revolutionize the way education is delivered through traditional classrooms. Advances in AI have provided a broad array of techniques like Machine Learning, Deep Learning, Natural Language Processing (NLP) and Computer Vision which can be employed for impactful teaching and substantial learning. The integration of AI technologies in the education process allows teachers to streamline their instruction process and at the same time allows students to receive personalized help suited to their strengths and weaknesses. There has been a lot of progress in this field in past few years. Today, the principles of AI are being applied in on a range of innovative education systems such as, learning analytics and personalized learning platforms, intelligent tutoring systems, simulated and virtual reality systems. This paper provides insights into AI building blocks used to craft these new age learning systems. It traces the history of using AI in education. It also examines the benefits of AI powered learning environments. Finally, features of commercial AI based learning systems are presented.

Keywords: *Artificial Intelligence, AI techniques, education, intelligent tutoring, personalized learning*

I. INTRODUCTION

The prevailing education system is static, generalized and does not focus on individual self-development [1].It purely works on the principle "one-size-fits-all", where students with diverse interests and different progress rates learn together. Such a learning environment makes it difficult for teachers to identify and deal with educational needs of the students especially when class size is large. These gaps can be filled by adopting the new age Artificial Intelligence techniques in the teaching learning process. Artificial intelligence is a branch of computer science that deals with the development of intelligent machines that are able to perform tasks which normally require human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages [2]. The use of artificial intelligence technologies in the learning environments offers numerous benefits like, open, collaborative and lifelong learning. Apart from these benefits, one chief advantage that AI can offer to the education sector is the ability to provide personalized and adaptive learning. Personalized learning refers to a diverse variety of educational programs, learning experiences, instructional approaches, and academic-support strategies that are intended to address the distinct learning needs, interests,

aspirations, or cultural backgrounds of individual students [3]. The growth in educational technology has given rise to personalized learning systems that use AI to track information about the learning process of each student. These systems can record information about how students learn, analyze these findings and also generate warnings about certain students' slow progress. When this information is combined with the knowledge about students' behavioral patterns, it is possible to gain valuable insights into ways students' learn. A personalized learning system would recommend a different style of learning according to the subject being taught and the learning capability of the student. For example- It is possible that such a learning system would recommend self-paced learning if a student excels in history, while it may suggest teacher led learning for mathematics subject. These data-based learning systems allow teachers to provide individualized assignments, tutorials and practice exercises to students. At the heart of these personalize systems is a set of AI techniques like- machine learning, deep learning, natural language processing, and speech recognition. These AI techniques when synergized with traditional teaching methods can change the quality, delivery, and nature of education. This paper first examines the features of Artificial Intelligence building blocks. It further discusses the brief history and benefits of using AI in education. The major focus of this paper is on identifying AI powered learning systems that can redefine the teaching learning landscape. There are several projects already in work that use AI tools and techniques. This paper reviews the features of some popular AI driven smart education applications that are addressing the challenges of learning. The paper also suggests future directions for using AI in education.

II. ARTIFICIAL INTELLIGENCE BUILDING BLOCKS

Artificial intelligence is not a single technology. Rather, it is an amalgamation of a number of enabling technologies. The use of AI tools and techniques allows teachers to create sophisticated learning environments that are more personalized, flexible, inclusive, and engaging. This section discusses the features of AI building block technologies that the education sector can leverage.

- **Machine Learning**- Machine learning refers to the ability of computers to learn without being explicitly programmed. It entails algorithms that can recognize patterns in data, learn from these patterns, and subsequently make predictions based on these data [4]. Machine learning plays a key role in a personalized learning system. For example- A personalized learning system uses machine learning to keep a track of what students are searching, provide this information to teachers and also assess learning by providing quizzes on the topics the students have been searching and reading. At the same time, machine learning can support time consuming and difficult aspects of teaching and learning, such as individual project work, collaboration, tutorials and grading student assignments.
- **Deep Learning**- Another cutting edge technology that has gained much importance today is Deep learning. Machine Learning uses AI to solve real-world problems with neural networks designed to represent our own decision-making. However, Deep Learning uses Machine Learning tools and techniques to solve any problem which requires human thought. Deep Learning is a branch of machine learning that trains a computer to perform

human-like tasks, such as speech recognition, classifying images or making predictions. Deep learning technology is showing great promise in changing the face of education. For example- Deep learning is being used for auto captioning of videos. This feature is quite useful for students with hearing disability. This feature also makes possible to watch foreign language videos with subtitles.

- **Speech Recognition-** Speech recognition refers to converting spoken words to text. Personalized learning systems come with built-in speech recognition ability. For example- Speech recognition technology can make computers act as virtual peers (chatbots) with which students can collaborate and work on assignments. Speech recognition technology can also help students learn new languages. Teachers can employ speech recognition technology in classroom to assist students with physical and learning disabilities. Advances in speech recognition technology have resulted in learning environments where a student can read to a computer and the learning tool can evaluate the student's reading ability.
- **Natural Language Processing (NLP)**- Natural language processing (NLP) systems are used to understand the meaning of words in conversations and written text. For a computer program to understand human language, it must know syntax (grammar), semantics (word meaning), morphology (tense) and pragmatics (conversation) of the language. For example- Today, NLP and deep learning AI technologies are being used to read text on a webpage, interpret its meaning and translate it to another language. A number of foreign language learning applications use NLP to provide a deeply immersive, engaging and personalized learning environment to the students. In an AI based learning system, NLP is being used to grade student assignments and provide detailed feedback on student drafts.
- **Computer Vision-** Computer vision is a field of artificial intelligence that works on enabling computers to see, identify and process images in the same way that human vision does, and then provide appropriate analysis of the output. It refers to imparting human intelligence and instincts to a computer to recognize images of different objects [5]. The concept of computer vision is being employed in a personalized learning system where the system can estimate the learner's responses through continuously monitoring the individual's attention spans, facial orientation, and eye movements while viewing online course materials such as some educational videos [6].

III. A BRIEF HISTORY OF USING ARTIFICIAL INTELLIGENCE IN TEACHING AND LEARNING

AI has a long history with education. The vision for using Artificial Intelligence in building personalized teaching machines was highlighted by the AI pioneer, Marvin Minsky and his colleagues in an article published in the AI Magazine in 2004. They suggested the use of AI techniques in developing a machine that would adapt itself to someone's particular circumstances, difficulties, and needs. The inspiration for building such a machine came from "The Diamond Age", a novel by Neil Stephenson. This novel envisioned an "intelligent book"-The Young Ladies Illustrated Primer, that, when given to a young girl, would immediately bond with her and come to understand her so well as to become a powerful personal tutor and mentor[7]. The integration of Artificial

Intelligence techniques into education dates back to early 1970s. The early research work focused on using AI in Computer Assisted Instruction (CAI) and Intelligent Tutoring systems (ITS). The following table traces the major historical developments in the growth of use of AI in education.

Table 1: Research and Development work done related to use of AI in Education

Year	Research and Development Work
1950	1950's saw the emergence of Computer Assisted Instruction (CAI), a learning technique that uses computers to present training methods including simulations, games and tutorials to the students. CAI also offered the ability of self-paced learning.
1970	Intelligent Tutoring Systems evolved from CAI. Computer Assisted Instruction programs followed a linear approach in guiding students to reach a specified behavior. These systems did not provide a targeted feedback or individualized support. To address these issues, Jaime Carbonell developed Scholar, the first Intelligent Tutoring System (ITS). Scholar was more powerful type of computer-assisted instruction (CAI) and was based on extensive application of artificial-intelligence (AI) techniques [8].
1983	One particularly well-known and fruitful line of work began with development of John Anderson's ACT-R theory. This theory models how people learn to solve problems in terms of if-then rules, called productions rules. ACT-R has been the basis for the development of many intelligent tutors [9]. This line of work gave birth to a type of Intelligent Tutor System (ITS) called the Cognitive Tutor. Cognitive Tutor utilizes a cognitive model to provide feedback to students as they are working through problems. This feedback will immediately inform students of the correctness, or incorrectness, of their actions in the tutor interface. Cognitive Tutors also have the ability to provide context-sensitive hints and instruction to guide students towards reasonable next steps [10].
1984	Educational Psychologist, Benjamin Bloom proposed the development of one to one tutoring systems that that could offer effectiveness of individualized tutoring with curriculum organized around a student's progress, combined with timely targeted feedback and immediate opportunities for corrected practice. Developing a one-on-one tutoring system that can provide these elements has been a coveted goal of AI researchers [11].

1988	Kurt VanLehn suggested the use of AI techniques for finding a solution to student modeling problem. He designed a solution that could diagnose misconceptions and estimate the learner's understanding of the domain [12].
2001	A.Corbett and J. Anderson found that efficient learning is possible by providing immediate feedback and immediate error correction, rather than giving feedback only on the correctness of the entire problem solution to the student. AI technologies are a good choice for implementing step-based feedback on a computer [13].
2005	It was found that in an AI supported learning environment, Metacognitive scaffolding can help students to adequately control and monitor their learning and promote productive learning behaviors, such as self-regulation, self-monitoring, and self-explanation [14].
2006	Kurt VanLehn emphasized the use of AI techniques in building learning systems that prescribe learning activities at the right level of difficulty to the learners and present personalized learning material to the learners [15].
2008	In 2008, V. Shute suggested providing timely guidance, feedback and explanations to improve the quality of computer based learning systems. He advocated the need of providing formative feedback which is non-evaluative, supportive, timely and specific [16].
2009	Through his book, B. Woolf provided a thorough description of the use of Artificial Intelligence in education. The book is a bible for designing and building adaptive, personalized and collaborative learning systems using Artificial Intelligence techniques [17].
2011	It has been statistically proven that AI based intelligent tutoring systems are as effective as human experts [18].
2013	The Fall and Winter issues of AI Magazine presented some of the best work at the intersection of AI and education in a way that highlights the power of AI to promote human learning. The issues included articles that focus on the potential of using AI in creating unique learning pathways in Massive Online Open Courses (MOOCs) and in building efficient personalized learning systems [19].

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IV. BENEFITS OF USING ARTIFICIAL INTELLIGENCE IN EDUCATION

The use Artificial Intelligence tools and techniques can perfect the teacher's skills and revolutionize the education process. According to Bill Gates, founder of Microsoft and a great proponent of using AI in education- "AI will improve education in many ways, but that providing more personalized learning for students will be the greatest benefit". Some of the benefits of using AI in education are-

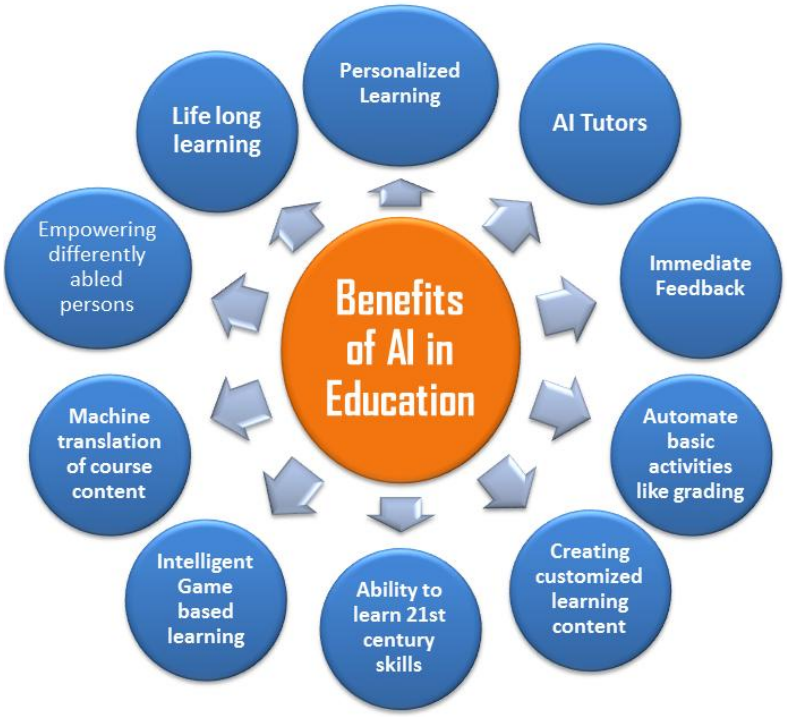

Figure 1: Benefits of AI in education

• **Personalized Learning-** Personalized education systems use AI to provide customized educational paths according to the learning capabilities of a student.

• **AI Tutors/ Virtual Mentors/ Chatbots-** Several highly qualified and omnipresent AI tutors help students master specific subjects. These virtual mentors engage with a child's emotions through speech interaction, support problem-solving and develop much more targeted learning paths for each student.

• **Immediate Feedback-** AI powered learning systems provide step wise immediate feedback to the students which help improve their performance. Moreover, AI's ability to analyze large amounts of student performance data in real-time provides feedback to the teachers and allows them to better understand student performance and orchestrate more effective personalized learning plans.

• **Automate basic activities like grading-** Grading student assignments consumes a lot of time. By delegating this task to AI grading systems, teachers can focus more on student interaction, class preparation and research activities.

• **Creating customized learning content-** AI helps teachers to craft course material that is customized according to the learning capabilities of every student.

• **Ability to learn 21st century skills-** The new age AI based learning environments focus toward measuring students' critical thinking and problem-solving skills and preparing them for college and career success. These systems help in building self-direction, self-assessment and teamwork qualities in students.

• **Intelligent Game based learning environment-** Intelligent game-based learning environments integrate commercial game technologies with AI methods to motivate learners, improve retention while making the learning experience fun. It also makes use of data mining and machine learning to arrive at insights regarding the way students learn best.

• **Machine translation of course content-** Today's automatic language translation systems use NLP techniques. These systems allow students to access study material from anywhere in the world and in any language thus bridging the language gap. The machine translation feature also gives an opportunity to learn new foreign languages.

• **Empowering differently abled persons-** AI programs and Virtual Reality systems can augment the educational experience for the learners with special needs.

• **Life long and life wide learning-** AI learning platforms are increasing opportunities for learning continuously over the entirety of one's life (lifelong) and across all aspects of that life (lifewide).

V. EXAMPLES OF AI POWERED LEARNING SYSTEMS

The scope of AI to advance the field of education is becoming apparent and a great deal of research is being done in this area. A number of AI systems are now commercially available which can mimic the effect of one-to-one tutoring by being able to understand the skill level of a student and tailor material to suit their skill level. Some systems can also understand how a student thinks during problem solving and provide feedback and guidance to the student, in addition to correcting erroneous behavior. AI is also being used in the field of content delivery where educators can create a syllabus and use AI to then fill in the core content of a book that holds true to the syllabus [20]. Following is the list of some popular applications that utilize Artificial Intelligence technologies to transform the education process.

• **Thinkster Math** is a math learning program that combines world-class curriculum with personalization from real, experienced teachers and Artificial Intelligence technologies. Thinkster Math provides students with different problems appropriate to their skill set. It provides world class teachers and also uses AI and machine learning to visualize how a student is thinking while he or she works on a problem. The use of AI techniques helps improve how fast and how well the teachers can address problem areas. Thinkster Math improves each student's logic process by providing video assistance for stuck students and immediate, personalized feedback. The program also includes a feature that allows parents to track their kid's progress [21].

• **Content Technologies, Inc (CTI)**- Unlike, hard printed student textbooks, digital learning content can be adapted for a particular student and a particular learning situation. Content Technologies, Inc (CTI) is a

company that is leveraging Artificial Intelligence's Deep Learning technology, to create and assemble custom textbooks. The firm has created a suite of smart content services for secondary education. CTI's, Cram101, for example, uses AI to help disseminate and breakdown textbook content into digestible "smart" study guide that includes chapter summaries, true-false and multiple choice practice tests, and flashcards. After educators import their syllabus and material into CTI's engine, the system reads and masters the content, and finds new patterns. The algorithms then use the gained knowledge to create textbooks and classroom material based on the core concepts. CTI's another software, JustTheFacts101, can turn any textbook into a concise summary of the most important facts and concepts. It highlights and generates book and chapter specific summaries on the spot [22].

- **Carnegie Learning, Inc.** is a leading provider of innovative research-proven math products and services. Carnegie Learning combines cognitive and learning science and technology with practical instructions to develop conceptual understanding, as well as deeper learning skills like communication, collaboration, perseverance and critical-thinking. The company offers student-centered consumable textbooks and intelligent software. Carnegie Learning's "Mika" software provides personalized tutoring and real-time feedback for students using AI and cognitive science. The application is guided by each student's unique learning process, keeping users aware of their daily progress and adapting lessons to each student's specific requirements [23].
- **Brainly**, a social media site for classroom questions that helps millions of students collaborate, is exploring the power of AI on its platform. Using Machine Learning algorithms to filter out spam, Brainly allows users to ask homework questions and receive automatic, verified answers from fellow students. The site even helps students collaborate to come up with correct answers on their own. In order to make sure it is serving quality content, Brainly uses a team of over a thousand moderators to help verify questions and answers users put on the platform. It uses AI algorithms to personalize its platform's networking features. It enhances the user experience by making friend suggestions based on areas where students need help [24].
- **Netex Learning** lets teachers design curriculum across a variety of digital platforms and devices. The site helps educators incorporate interactive elements like audio, video, and self-assessments to their digital lesson plans, all within a personalized learning cloud platform. With Netex, teachers can create customized student materials to be published on any digital platform while providing tools for video conferences, digital discussions, personalized assignments, and learning analytics that show visual representations of each student's personal growth [25].
- **Embibe** is India's leading online education platform with a keen focus on improving learning outcomes, using personalized data analytics, for students across all level of ability and access. Embibe uses advanced-level analytics besides its core AI engine, including self-learning algorithms, machine learning and cognitive computing to help aspirants of competitive exams like IIT-JEE, NEET, AIPMT score high marks. Embibe offers questions that were asked in competitive exams like IIT JEE and BITSAT over the previous years to students. The platform then evaluates their answers and informs the students where they stand in terms of accuracy, attempt and coverage. It measures reports and identifies gaps in a student's practice [26].

- **The Learning Navigator- Gooru** is a free, online tool that offers personalized pathways to help students reach their learning goals. Gooru enables teachers to find, remix, and share collections of web resources for school students. With millions of free multimedia resources, quiz questions, and data analytics, Gooru makes it easy for teachers to address individual students' needs [27].
- **Duolingo** is a free language learning application which uses AI techniques to personalize learning. Duolingo uses Automatic Speech Recognition (ASR) and NLP techniques to recognize language errors and help users correct them. It also uses machine learning to analyze users' activity and progression to develop personalized lesson plans, as well as regularly test new strategies for instruction to evaluate their effectiveness. Duolingo contains three chatbots that a user can talk with and ask questions to in order to learn how to say something in French, Spanish, or German. The bots use AI technology that allows the software to react differently to thousands of possible answers [28].
- **BYJU's** is a learning app offering highly adaptive, engaging and effective learning programs. Byju's teaches with engaging videos, chapter-wise tests with feedback and analysis in the same place, real time progress updates, in-depth solutions, and feedback and recommendations on the go. It allows simple visualization of complex concepts. This application uses AI algorithms to create a smooth learning curve for the student so that they feel challenged yet motivated. This app works in a way similar fashion like a personal tutor and addresses the student's learning gap in a more effective way backed by deep insights [29].
- **WriteToLearn** is an automatically scored web-based personalized tool developed by educational company Pearson for building writing skills and reading comprehension. With WriteToLearn, teachers can assign students more reading, writing, and vocabulary practice while reducing time spent on laborious editing and scoring. As a result, they can spend more time on lesson planning and focused, individualized instruction. The technology underlying WriteToLearn is based on the Knowledge Analysis Technologies (KAT) engine that evaluates the meaning, coherence and relevance of text, in addition to correctness of spellings and grammar [30].

VI. FUTURE DIRECTIONS FOR USING AI IN EDUCATION

Artificial Intelligence is set to herald a promising future for education. It has the potential to bring a massive change in the way education is delivered today, making it more personalized. The integration of AI into the classroom will help teachers address the gaps of traditional methods of teaching a group of students with diverse needs. In such a traditional learning environment, teachers are not able to cater to the demands of every student. AI can aid teachers by identifying factors of successful learning for each student that are not possible to capture otherwise. A personalized learning environment can analyze student performance data in real time and automatically provide customized content, learning parameters and feedback. It also allows teachers to better understand student performance and as a result, teachers can design effective learning plans for their students. Education is a domain largely ruled by human-human interaction. It is difficult to develop learning systems that exhibit human-like attributes of responsiveness, adaptability and understanding. Yet, the advances in educational technology have brought in a plenty of smart learning systems which have utilized AI's inherent

strengths to meet the ever growing demands of the new age learners. Though it may seem that these AI backed smart learning systems will replace teachers in foreseeable future and render them jobless. In fact, the future of learning with AI will give rise to a hybrid approach where AI will assist teachers in effectively meeting the varied needs of many students simultaneously. In future, the role of teachers will evolve. Human educators will be able to spend their time more efficiently and effectively in teaching and research. Mundane and repetitive roles of a teacher will be relegated to AI and complex and creative tasks will be performed by humans. By using AI in their classrooms, teachers will not only be able to teach their subjects with greater depth but will also be able to cultivate curiosity and creativity among students. Teacher will play a pivotal role in creating personalized learning environments that are dynamic, scalable, robust and economically viable.

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