Machine Learning: The Future of Sustainable Teacher Education is Here

[1] Inyega Hellen N.; [2] Inyega Justus O.
[1,2] *University of Nairobi, Kenya*
E-mail: [1]hellen.nasimiyuh@uonbi.ac.ke , [2] justu.inyega@uonbi.ac.ke

ABSTRACT

This paper explains machine learning and demonstrates its potential to improve teacher education. Machine learning, a branch of artificial intelligence, is a set of algorithms with ability to learn, act and adapt autonomously without being explicitly programmed. Machine learning provides systems with the ability to learn and act like humans, while also improving their learning over time through observations and real world interactions without being explicitly programmed. Machine learning can be applied in day-to-day lives. Industries are adopting it to improve their business models. Unfortunately the teacher education sector is notoriously slow in adopting change, including incorporation of machine learning in its programming. Yet machine learning has potential to support pedagogy, andragogy, heutagogy and adaptive learning by fabricating patterns from data and fashioning educational insights useful for personalizing students' learning paths. Such an approach ensures learning takes place based on the learner's pace of grasping concepts. In this paper we discuss implications of using machine learning to offer differentiated teacher education pedagogy and andragogy. We showcase its potential for heutagogy and self-paced learning, for identifying teachers' knowledge, skills and abilities in learning and for personalizing/customizing programmes based on teachers' unique needs, eye-balling students in need of remediation and for collecting assessment data on learning and professional development.

Key words: Andragogy, Cloud Lecturer, Deep Learning, Heutagogy, Machine Learning, Teacherbots and Teacher Education

I. INTRODUCTION

Machine learning, a concept started in 1956, is a subset of Artificial Intelligence (AI). AI is the development of computers that can complete tasks (which normally require human intelligence) by learning on their own and improving on past iterations. The notion behind artificial intelligence is that machines can exhibit human intelligence (Signorelli, 2018).

Machine learning is a set of algorithms that provide systems with the ability to learn and act like humans and adapt autonomously while also improving their learning over time through observations and real world interactions without being explicitly programmed (Mungai, 2018). Machine learning thus deals with teaching machines to learn about something without explicit programming (Yates & Chamberlain, 2017).

At the heart of machine learning is the idea of modeling and extracting useful information out of data. Algorithms are used to interpret data and take some action or to complete a task. Societal trends point to data as the resource of the future in the so called knowledge economy. Colleges and Universities are already swimming in data, and there is much more on the way.

Adopting a machine learning–centric data-science approach as a tool could be a game changer (Yates & Chamberlain 2017) for teacher education and institutions that adapt and adopt machine learning poised to have a bright future.

One cannot think about the future of teacher education, pedagogy, andragogy and heutagogy, without linking it with developments in new technologies and computing capacities of intelligent machines (Chawly & Singh, 2019). From traditional models of teaching to the advent of e-learning and Learning Management Systems (LMS), the process of learning has undergone revolution. It is now possible for one to reach a wider audience, even internationally, through online courses hosted on cloud-based LMS platforms. Students can access courses from anywhere in the world, at any time, anyhow by simply logging into an e-learning portal.

E-learning has become an insular and self-sustainable medium for designing and facilitating content to impart knowledge to students and assess their understanding online. E-learning is compatible with traditional face-to-face teaching thereby increasing an educator's potential to incorporate blended learning (Chawlay & Singh, 2019) into their repertoire of skills.

More recently lecturers have adopted digital tools to augment their teaching and for providing core and supplemental instructional materials and resources, quizzes and online discussions. Digital technologies have played a leading role in continuous education provision, especially during the COVID-19 pandemic period when learning institutions worldwide were abruptly closed in early 2020. COVID-19 is the tipping point that compelled Universities to become intentional in investing in infrastructure and capacity strengthening and/or upskilling of faculty and students in a calculated move to protect its academic programmes against future shocks (OECD, 2020). A set of emerging disruptive technologies is positioned to bring new advances in education thanks to breakthroughs achieved in Artificial Intelligence (AI)[1], Machine Learning (ML)[2] and Deep Learning (DL) as shown in Figure 1 (Wang, 2020). Teacher education programmes cannot afford to be left behind.

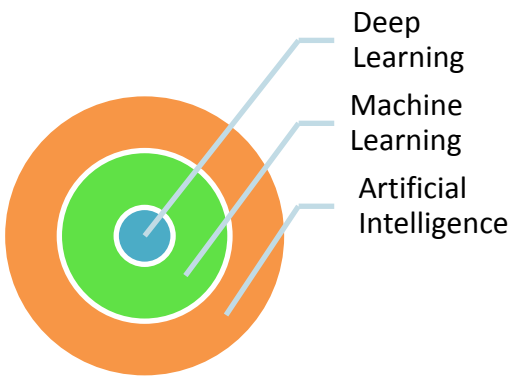

Figure 1: Relationship between Artificial Intelligence, Machine Learning and Deep Learning

[1] Artificial Intelligence: Capability of machines to solve problems, think, and make decisions on their own without being provided with a hard-coded algorithm. Intelligent machines solve problems similar to how humans do, and in some cases their results are even better than humans. It is called 'artificial' as opposed to the 'natural' intelligence that humans and other living beings possess.

[2] Machine learning: Collective field of all the algorithms and processes that are deployed to develop artificial intelligence in machines. These algorithms enable the machine or program to 'learn' from a set of data and use this learning to solve other tasks and problems. Machine learning trains a machine to learn from a wide set of input data and come up with an indigenous algorithm of its own to identify patterns and trends.

Advances in artificial intelligence open new possibilities and challenges for teaching and learning in higher education (Popenici and Kerr, 2017), with potential to change governance and the internal structure of those institutions. Higher education is placed at the cross-roads or center of this profound change, which brings with it both extraordinary opportunities and risks. This crossroad, important as it is, requires careful consideration and analysis from an academic perspective. Educators keen to stay abreast with the latest breakthroughs and advances in the field of education must understand AI, ML and DL and look at technological progress as a solution, and not replacement, for sound solutions to pedagogy, andragogy and heutagogy in education practice.

Disruptive change in this age of agility seeks to combine automation and artificial with important implications on the world of work. Some of the jobs we know today are at risk of disappearing (Wang, 2020) - the US estimates these to be about 16% of the jobs (Nelson, 2017). Those which do not disappear will be so radically restructured as to be unrecognizable. COVID-19 foregrounded hybrid models of remote work by Universities, which may persist in the foreseeable future. Findings of a survey of 800 business executives worldwide by McKinsey in June 2020,[3] point to a period of disruptive change ahead and affirm that COVID-19 is an opportunity for a great reset of economies to make them stronger than ever before. The pandemic may accelerate some teacher education workforce trends already underway, such as the adoption of automation and digitization.

Greater digitization and automation will increase demand for independent contractors and gig workers, and more remote work because of the perceived potential to deliver better productivity, lower costs, and enhance resilience (World Bank, 2018). Questions on the effect of the combined effect of digitization and automation on teacher education largely remain unanswered and in need of further inquiry. How, for instance, might a free-lance/contract/temporary lecturer or itinerant lecturer without borders look like? What is the domino effect of digitization and automation on educators' knowledge, skills, values, and character and attitude (or charactertude) as well as job satisfaction; improved work-life balance; teacher autonomy?

University lecturers should be willing to innovate in order to prepare students for this unpredictable future world of work (World Bank, 2019), where the students become comfortable with uncertainty, embrace flexibility, and reset their expectations about employment (Figure 2). Highly priced qualities of future educators will include ability to: unlearn and re-learn; have adaptive interpersonal behavior, take initiative and seamlessly integrate technology to manage teacher education programmes and ensure continuous learning. We should expect nothing less.

[3] https://www.mckinsey.com/featured-insights/future-of-work/what-800-executives-envision-for-the-postpandemic-workforce#

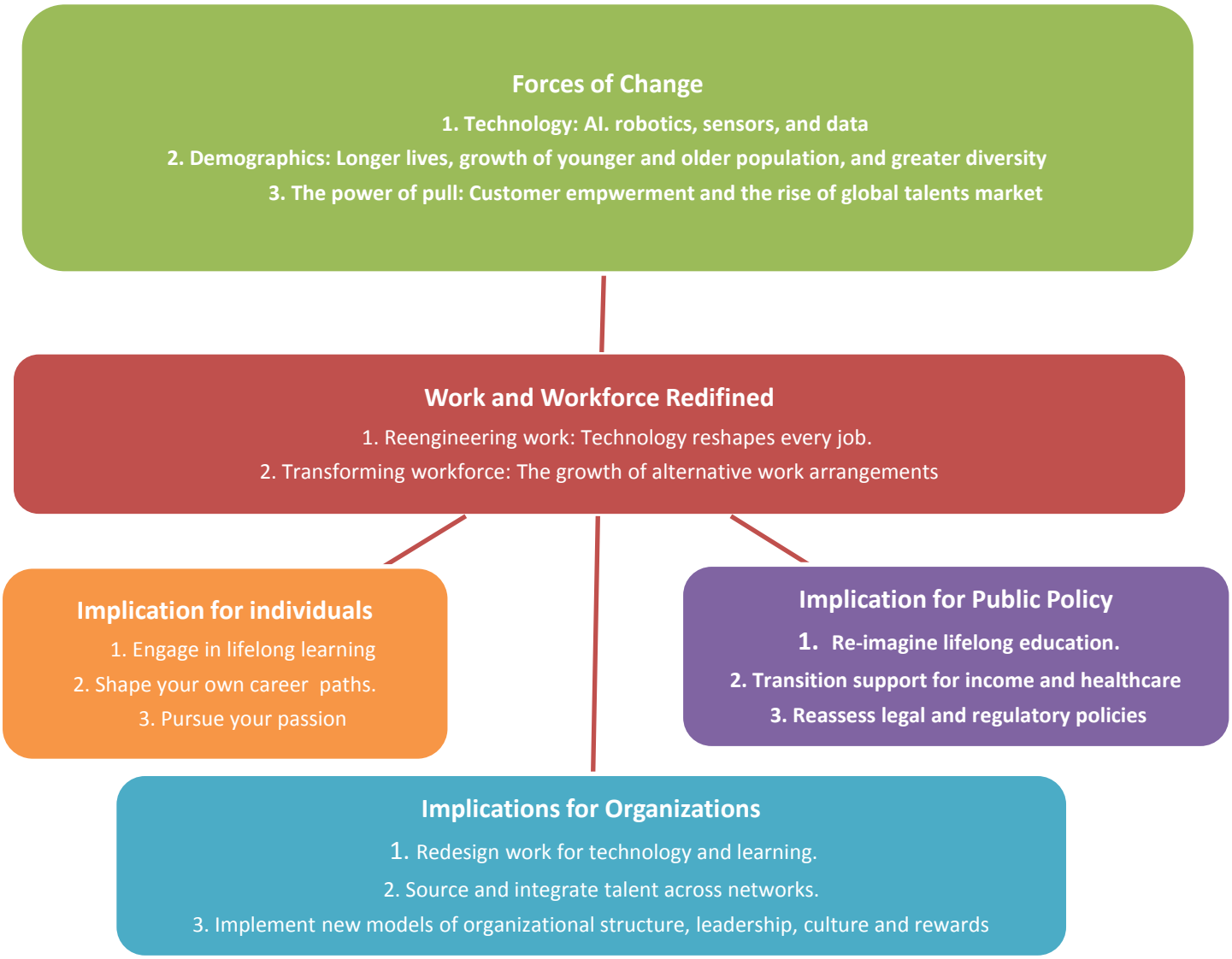

Figure 2: Framework for Understanding the Future of Work.
Source: http://www.gettingsmart.com/2017/10/america-succeeds-reports-education-pathways-future-work/

The following example illustrates the potential of machine learning. During the 2016–17 year, Chamberlain and colleagues (2017) undertook a clustering analysis parallel to k-nearest neighbor (kNN), a technique for assisting in finding patterns in larger data for analysts. Chamberlain sought to answer this question posed by a donor: *"Can we identify a group of students who need an additional scholarship that would eventually lead to increased retention?"*

Through thorough analysis of several data sets and rigorous research, Chamberlain and his team identified a group of students who needed financial assistance to remain enrolled. The assumption then was that increasing retention for this group of students was almost insurmountable. However, after awarding the students additional scholarships, retention rose from approximately 64% to about 90%.

The research, using machine learning, contributed to the continued success of those students. Even more important for the institution was that it resulted in about $200,000 in additional net tuition revenue from an investment of about $50,000 in scholarships.

By conducting basic machine learning to find patterns in the data and testing hypotheses, Chamberlain and his team were able to help students and the university. The research illustrates further that once machine learning and education begin interacting more often, simple research activities can evolve into larger data sets with larger solutions.

Kenya could benefit from such research informing student retention in teacher education and attracting further funding to teacher education programs. Teacher education programs in public Universities have barely scratched the surface of the potential for machine learning. Though some aspects of those programs (such as enrolment management) have embraced machine learning, there is still room to do more especially in teacher education curricula modeling and preparation of career ready and life ready teachers. Data science (Liu & Huang, 2017; Wang, 2020) becomes invaluable in tracking student enrolment and success – both within the teacher education program and beyond – into the classroom and world of work. Using machine learning, teacher educators can hone in on student retention and persistence in their academic programs and identify factors that influence student success.

The focus of this paper is a discussion on potential benefits and recommendations for adopting machine learning as a tool in teacher education. The paper also examines potential limitations and ethical considerations for this adoption. An in-depth discussion of these issues is beyond the scope of the paper. The researchers only wish to catalyze a conversation among teacher educators, regarding the potential of machine learning to help them make more-informed and better decisions (Agasisti & Bowers, 2017). Getting people interested in machine learning is a critical first step to embracing and trying out an innovation. It is, however, necessary but not sufficient until we get a critical mass demanding its use from an informed vantage point.

II. METHODOLOGY

Systematic review approach (Snyder, 2019) was employed in preparation of this paper. Specifically, the systematic review approach involved synthesis of literature on machine learning and teacher education from multiple web sources of: governments, education networks, academia and international bodies. Through source triangulation, data were blended with the synthesis of literature and the literature interrogated to isolate benefits of machine learning and limitations thereof. Conclusions and recommendations made in the paper are thus drawn from these varied data sources and an appraisal made of how machine learning can be a driver to academic excellence in teacher education programmes.

III. DISCUSSION OF FINDINGS OIN MACHINE LEARNING AND TEACHER EDUCATION

Artificial Intelligence (AI) is currently being used in communication (Zerfass, Hagelstein & Tench 2020), and especially email communication. Spam filters, powered by AI, streamline the amount of spam appearing in an email user's inbox. As email senders (real or automated) become more careful with selecting words which have not been flagged previously, the filters adapt and continue to learn based on words that the user also flags. There is an added component of ML in this, in that through the algorithms already in place by the email provider, additional filters are then created. Google takes it even further by continuously learning the types of email messages which are marked as "important" or "urgent" for instance. AI increases cyber security on email communication.

AI is used in travel (Samala *et al*., 2020). Anyone who has used Uber, Bolt, Little Cab or Taxify, has experienced ML which is used to predict rider demand and to calculate Estimated Time of Arrival (ETA). The airline industry uses AI, since autopilot qualifies as AI, where it is estimated that "human steered" flight time is only seven minutes of actual flight length.

AI is invaluable in social networking (Catauta, N.D.). Those on social media, including Facebook, often share photos. AI detects faces in the picture and will suggest names to tag the person or people. Facebook can generate a more personalized and interactive user experience. Even Twitter and LinkedIn generate lists of accounts for the user to follow or which chats to join and news feeds of interest based on an analysis of user input, searches and data.

Online Shopping, including purchase of tickets for local and international travel and hotel accommodation bookings, can now be done online (Catauta, N.D). Soon after a purchase, a user's email may be awash with suggestions to purchase cheap tickets or special offers in hotels they have been to. Whenever one shops using a debit card, they get an alert on their phone and later before midnight there get an email alert with the rider that if the account holder has not made the transaction they should alert their bank immediately through their 24-hour hotline. Systems are thus in place to protect consumers against fraud, with alerts being sent almost simultaneously especially if one transacts in a new geographical location such as a different town from their residence. According to Catauta, the only way to counteract deleterious and destructive actors is through Bots which comb through data, find spam, find and filter inappropriate content, and ban users who breach the user agreement.

In education most graduate students use a wide range of tools including Google Searches. Anyone who has used such search engines will notice that as soon as you begin to type in a phrase, alternate search terms are instantly suggested or the search engine scours the entire internet to find the most relevant search result for every search query (Kaput, 2021). An astounding amount of information is generated instantly, far more

advanced from thirty years ago when we relied on card catalogues.

For AI to find its way into the lecture room, educators must ask the following questions: What are some of the tasks that are typically done in my lectures? How are my students and I spending our lecture time? What are some ways that I could get some of that time back by using AI? These questions provide a perfect segue to the discussion on benefits of machine learning. Teacher educators must take the first steps into the unchartered territory of the possibilities opened by AI in teaching, learning, and research (Popenici & Kerr, 2017).

Some of the most time-consuming tasks in teacher education programmes include marking students' scripts and providing formative feedback on their practicums, projects and theses. Can AI help in marking (Ramalingam, Pandian, Chetry & Nigam, 2018) or at least monitor marking to improve it (Black, 2020)? Can AI identify an inconsistent marker or spot an erroneous mark from an otherwise good and consistent marker? It is even harder to find consultation hours to work with individual students because of the high Lecturer-Student-Ratio that punctuates Universities' teacher education programmes. It is even harder to create and review assessments or assignments or set good examinations. There is little time for tutorials and appropriate supplemental activities that cater for individual differences. Much less is the opportunity to offer more engaging and immersive learning experiences for students.

AI holds great promise in addressing these and other issues in teacher education and increasing time for more interactive lecture sessions, building of meaningful relationships with students and personalizing instruction to individual students' unique needs (Wang, 2020).

Teacher education programmes can adopt instruction modelling approaches to remedy gaps in student knowledge, to decide the difficulty level of problems to give students, and to scaffold pedagogy, andragogy and heutagogy (Uday, 2019). Successful implementation however requires teacher educators to take an active role in student learning. Machines cannot replace the teacher in the classroom!

Machine learning allows for differentiation and personalization of teaching and learning (Carpenter, 2020) opportunities ***with***, ***for*** and ***by*** students. These systems can respond to the unique needs of the student in several ways. For instance, they can put greater emphasis on certain topics that students find problematic, repeat things that they have not mastered and help them work at their own pace, whatever that may be.

The system can custom-tailor education to help students at different levels work together in one classroom (Carpenter, 2020). To this end, the educator becomes a facilitator of the learning, offering help and support when needed.

Teacher educators can get timely information on how they are working with students and how, together, they can quickly create new learning opportunities that relate directly to student needs and offer authentic and timely feedback.

Students can potentially access one-to-one tutoring (Carpenter, 2020) and create more authentic learning experiences (Wang, 2020). The students can easily be paired up with their peers virtually to expand and personalize their learning networks and make those networks more authentic to students' unique needs and interests. AI programs can enable and sustain instantaneous lecturer-student, student-student and university-community communication around learning.

AI exploits opportunities inherent in augmented and virtual reality to create more immersive learning experiences (Lampropoulos, Keramopoulos & Diamantaras, 2020). AI can analyze students' responses in the tasks assigned to them to determine their areas of need and interest, and find resources or even create new questions to help them to better understand the content. Teacher educators can thus connect students to resources needed exactly when needed. On their part students can learn anytime, anywhere, and anyhow because the entire internet of resources is literally at their fingertips accessible within seconds.

Quick access to learning data and opportunity for the system to analyze the data is an added advantage for the student to learn and grow (Wang, 2020) and for streamlining assessments and grading processes. Valuable time meant for diagnosis and identification of learning gaps in students is thus saved and channeled towards more lecturer-student, and student-student interactions.

Machine learning is helpful for organizing the content for lectures and curricula in a better way (Carpenter, 2020). This is because the machine system analyzes what works best and which concepts are understood better with certain techniques. In that way, efficiency of the teacher education system will enable students to grow significantly and to be happier because they will learn important things in a way that they are comfortable with. Computers can be used to deliver customized lectures to each student. Customization of content to each learner seems an enormous task upfront. However, in the long haul it will take a significant workload off lecturers and free them up to work one-on-one with students (Wang, 2020); solve more complicated problems or students' misconceptions.

Lecturers do not have to *'teach to the middle'* of the class. They will no longer worry about the *'normal curve'* (which is responsible for assessment structures where the bulk of students are average; with a few outliers doing well or failing).

All students' needs can be met. The quality of teacher education curriculum and learning outcomes will improve when machine learning is implemented with fidelity.

Machine learning enable administration (Carpenter, 2020) and instant grading of e-assessments yield formative data immediately. Nearly all kinds of multiple choice, matching, and fill-in-the-blank test items can be automated. Automated grading of student writing, though still in its infancy stage, has potential with the use of robo-graders. Turnitin's revision assistant program not only reviews students' essays, projects and theses but also detects plagiarism in them (Wang 2020). The results of the analysis determine the score on the assignment. In addition, students get to see what parts should be changed or edited to make their text better and more personal to them. In a few years marking of essay-type assessments will be fully automated and allow teacher educators to focus more on in-class activities and student interaction than on grading. Educators will also no longer wait until a quiz or test has been administered and marked to find out that students are struggling and also to correct misconceptions in good time. The machine will check students' assignments. Scores and grades will not be affected by our attitude toward students (we're all people after all) but will be based exclusively on their performance.

Machine learning will be leveraged to improve student engagement and enable deep learning (Anderson, 2018).

When students spend more instructional time searching for information on-line, they will be able to improve in their knowledge skills and attitudes. Machines could serve as a place where students go to ask questions and find information. For very basic course materials, machines could potentially take the place of teachers. Software will be used to predict how well a student will do at school and what chances they have of dropping out. This will be based on the repetitive actions of the student, which the program will use to identify their weaknesses and analyze whether those behaviors can lead to expulsion.

AI makes trial and error learning less intimidating. Machine learning can allow students to experiment and learn in a relatively judgment-free environment. It is the perfect format for this type of learning that encourages risk-taking. Even the AI systems thrive on trial and error!

Lecturers may not always be aware of gaps in their educational materials and/or lectures that may leave students confused about certain concepts. Machine learning offers a way to solve that problem. If for instance many students are found to submit the wrong answer to a homework assignment, the system can alert the lecturer on the one hand and, on the other, provide future students a customized message that offers hints to the correct answer. Students are able to fill in the gaps in explanation that occur in lectures and, in that way, build the same conceptual foundation.

They do not need to wait to hear back from the professor because they get immediate feedback that helps them to understand a concept and remember how to do it correctly the next time around.

With the signing of the Finance Bill 2018 by the President of the Republic of Kenya and attendant austerity measures taken by Government, public funding for universities has been cut substantially. This translates into a real need to cut costs within universities. Machine learning does unveil the tempting solution for many university administrators to cut costs by either reducing expensive academic teaching staff or substituting them with machine learning applications. It is not far-fetched to imagine a future with a constant shift towards casual and short-term contracts. Lecturers must find new dimensions, functions, and radically new pedagogies for a different context for learning and teaching to stay afloat.

Innovation in education will no longer just be a matter of putting more technology into more classrooms. It will be about changing approaches to teaching so that students acquire the skills they need to thrive in competitive global economies (Schleicher, 2015). Widening participation in higher education and the continuous increase in the number of students, class sizes, staff costs, and broader financial pressures on universities make the use of technology or 'Teacherbots' (Bayne 2015) or 'Cloud-Lecturer' (Popenici & Kerr, 2017) a very attractive solution.

According to Popenici and Kerr posit that teacherbot[4] – the computing solutions for the administrative part of teaching, dealing mainly with content delivery, basic and administrative feedback and supervision—are already presenting as a disruptive alternative to traditional teaching assistants. What are the possibilities of teacherbots? How do we maximize the use of Teacherbots for the benefit of students? At this point, we can see a teacherbot as a complex algorithmic interface able to use artificial intelligence for personalized education, able to provide bespoke content, supervision, and guidance for students and help for teachers. Teacherbots can facilitate, monitor, assess, and manage student learning within the online learning space. These solutions are even more real to many teacher educators in wake of COVID-19 pandemic. Tinkering with the old system of transmitting information to passive students, in class or in front of computers, is open to disruption from highly personalized, scaleable, and affordable alternative AI solutions. Intelligent machines can be used by all to meet the learning and support needs of massive numbers of students. AI solutions are currently monitoring choices, preferences, and movements people make online to determine their digital footprint;, measure their strengths, and weaknesses; or provide feedback, encouragement, badges, comparative analytics, customized news feeds,

[4] Teacherbots can also be any machine-based software or hardware that assumes the role traditionally performed by a teacher assistant in organizing information and providing fast answers to a wide set of predictable questions.

alerts, and predictive text. Depending on how you look at it, AI may be projected as a boon or bane in teacher education programmes.

So far we have determined that machine learning is powerful. It provides analysts and decision makers with previously undreamed of powers due to its ability to find patterns, make predictions, and draw inferences. It holds forth great promise for the future of teacher education. That said, relying only on computers—even the best—would be a big mistake. Losing sight of the downsides of a new technology or tool would be foolhardy. Teacher educators must remind themselves that there are limits to what machines can do. Artificial intelligence has already surpassed human skill in some fields; but teaching is a far more complex activity. Teacher educators know that teaching students is not a uni-linear process.

The main limitations behind the usage of machine learning in the lecture-room tends to revolve around this difference. Learning is an inherently cultural process[5]. Computers do help to streamline and improve this process. However, they cannot replace the cultural element of learning, which can only come from another human.

Blended learning options are more promising in providing space for both the computer and the teacher to do what each can do best. In any case, educators know and understand their students in a way that computers simply cannot[6]. A machine program will definitely provide a strong curriculum and differentiation.

But it is educators who must ensure that students receive personalized instruction and support they needed to progress and transition to the world of work. Even the most advanced computer program would not replace this human understanding, even if that computer provides detailed information on what the student knows and does not know. The computer will not provide authentic feedback and encouragement to students on their progress. Neither can authentic discussions, and questioning- and peer sessions be automated. Machines cannot provide Social and Emotional Learning (SEL), a process through which children and adults acquire and effectively apply the knowledge, attitudes, and skills necessary to understand and manage emotions, set and achieve positive goals, feel and show empathy for others, establish and maintain positive relationships, and make responsible decisions. In all honesty, we cannot yet envisage a future where algorithms can really replace the complexity of the human mind.

Learning is much more than just downloading knowledge or passing an exam. Developing a sense of purpose is critical to heutagogy and self-directed learning. Computers may suggest what a learner likes. But developing purpose to study and helping others to be purposeful in their academic endeavor is an exclusively human activity facilitated by pedagogy and andragogy.

Machine learning so far are really not ideal for helping students learn high-order thinking and creativity. That is where real-world teachers are still required to facilitate.

[5] Steigler and Hibert. The teaching gap.
[6] Fleisher, G. Reasoning mind.

That said and with the rapid pace of technological advancement that has marked the past few decades, advanced tutoring systems may not be a pipe dream.

The rise of techlords and the quasi-monopoly of few tech giants also come with questions regarding the importance of privacy and the possibility of a dystopian future. COVID-19 has exposed some of these techlords who have pushed their agenda where emerging digital technologies, automation and robotics are concerned and jostled to maintain a bigger share in this emerging market of internet of things. These issues deserve a special attention as universities undertakes risk assessment of embracing technological changes and devise mitigation measures towards a sustainable future in academia.

Many sets of tasks currently at the core of teaching practice in higher education will be replaced by AI software based on complex algorithms designed by programmers. Unfortunately such programmers may transmit their own biases or agendas in operating systems. An ongoing critique and inquiry into 'innovative' solution remains critical to guarantee that universities remain institutions able to maintain civilization, and promote and develop knowledge and wisdom.

There is a need for research on the ethical implications of the current control on developments of AI, and the possibility of withering the wealth of human knowledge and perspectives, with the monopoly of few entities.

The focus of further research can also be on the new roles of teacher educators on new learning pathways for university students, with a new set of graduate attributes, on imagination, creativity, and innovation; the set of abilities and skills that can hardly be ever replicated by machines.

Many universities may have data scientists or a team of experts to apply machine learning in an official capacity and are thus missing opportunities that machine learning provides. There is an opportunity here to build the capacity of teacher educators themselves, particularly those with mathematical, statistical, and computer science backgrounds.

There should be watertight guarantee that even with machine learning students' privacy and confidentiality will be maintained. This is one of the more difficult challenge to overcome. Consider a case where a student is on a downward spiral academically and seems unlikely to complete their studies. How should such information be communicated to the said student and their 'Significant Others (e.g., parents and guardians) while at the same time respecting the student's right to privacy? When does one draw the line of what is allowable and what are the downsides of such disclosure? The ultimate goal should be to reduce bias and prejudice in human society, not potentially promote it.

There is need to interrogate the real goal of machine learning. Are they in use to potentially profile certain groups of people? Chamberlain and colleagues (2017) report about some controversial research whose goal was to detect criminality based on someone's facial features (still face

images) using common machine learning techniques. Or take the case where two researchers from Stanford University, using data from dating websites, trained an AI system to detect patterns in facial features and successfully used that data to identify the sexual orientation of a random male (with accuracy of 81%) and for a random woman (71% accurate). Interestingly, the findings were much higher than the reported capability of humans. The last example is where US store (Target) sent coupons to a woman it determined (through machine learning techniques) was likely to be pregnant. The woman's father went to Target and inquired why they sent coupons to his teenage daughter with advertisements for maternity clothing and baby furniture. Target apologized. Interesting, the father later contacted them and apologized when he learned his daughter was indeed pregnant. How did the store know the teenager was pregnant? Well, it is easy, being creatures of habit, for our digital footprint to be mapped up with a very high success rate. What are the ethical implications based on these examples? Yates and Chamberlain (2017) caution that we must be careful that machine learning is not abused, resulting in either intentional or unintentional biases or exclusionary analyses, predictions, and artificial intelligence systems. They further state that machine learning must be carefully, responsibly, and maturely applied. This implies further that clear standards must be defined so that machine learning projects do not violate ethical standards but stay true to teacher education program goals and high standards. This way, machine learning will be a tool for social and moral good.

Petrilli (2018) assert that big hurdles remain; and the biggest is political not technological. Chronicling classrooms in minute detail will not go well with all teachers, even if researchers promise that the data will be used for research purposes only. Nor will privacy-minded parents be thrilled; security protocols will need to be established that give everyone involved confidence that audio recordings of their thoughts about a research phenomenon will not fall into the wrong hands. And scholars will need to be careful not to make causal claims based on data sets that are not subject to experimental designs; the sheer quantity of data can't make up for the lack of controls and random assignment. Big data alone can be a boon to 'hypothesis generation,' but we will still need traditional studies in which teacher educators are asked to adopt new practices to learn whether the practices work. That said, the power duo of big data and machine learning is an enabler to building research enterprise that actually improves classroom instruction, regardless of how traditional or technology-infused the instruction might be. That is enough to make a computer smile.

So far the paper has discussed benefits and limitations of machine learning. What does the future of teacher education look like in the face of machine learning and AI? As educators embrace machine learning, several questions will continue to be asked. For instance, will machine learning replace teachers and teacher educators?

Does machine learning in the classroom have any negative impacts on student learning? It is true that in some cases teachers and teacher educators may be replaced - for better or for worse. What a teacher's role is and what it entails may change due to digitization, automation and robotics. Teachers will need to be assured that machines will not replace them (Popenici & Kerr, 2017) but instead augment and enhance their capabilities. In addition, they will be informed that machines have limitations. They cannot, for instance, help students to build skills and learn from human interactions, which are vital components of relationships in the classrooms.

Machine learning is beneficial to students, teacher educators and parents (Carpenter, 2020). It can interpret a student's unique needs and design an assessment tailor-made for that student. Machine learning can show students' mastery of content, even repeat lessons as needed as well as design a personalized learning plan for each student. Individual educational programmes and pathways will be a possibility even as we embrace the competency-based curriculum. There are possibilities for teacher educators to have virtual teaching assistants that will free up their time to facilitate learning.

Machine learning can involve parents in their children's learning and academic progress(Carpenter, 2020). They can be provided with information on how their children are being successful in their academic work. Machine learning can stump out the phenomena of 'missing marks.' This is because everyone (including parents) will have access to assessment data in a timely manner and not be surprised at the end whether or not a student is graduating.

Students will need to remain agile to find different work and take full ownership of a continuous cycle of learning, finding work and re-learning (World Bank, 2019). Students will need to be critical thinkers and problem solvers with the ability to balance perspectives while inspiring confidence in others. They will need to put forth cogent, persuasive arguments in their oral and/or written communication to demonstrate their scholarly prowess.

Education systems will need to do more resilient, integrated and inclusive to enhance access to lifelong education and (re)training, including practical hands-on experience to ensure to help young people gain diverse perspectives about life (World Bank, 2019). The teacher educators need to establish education policies that better align the knowledge, skills, and behaviors they teach students with the actual needs of the local and global workforce.

Teacher educators need to brainstorm and set clear expectations of institutional needs, goals, and requirements. What does it take for students to pass some of the more difficult units such as statistics and research methods? Are there discernable patterns that can be used to predict which students will pass those courses? Can machine learning predict enrollment in specific courses?

Conversely, are there patterns in teacher education data to help in predicting which students are likely to earn degrees within the stipulated four-year period by using clustering analysis of some type? What will be the goal for potential findings? How can the university use these results to enhance students' success, boost retention, and enhance student enrollment?

Do we have experts we can go to for an informed opinion about whether the questions we ask in teacher education can all be solved by machine learning? The truth is that some of the problems are easy and inexpensive to solve, and others are not . Teacher educators should not be afraid to go back to the drawing board, in a bid to improve universities' teacher education programs. To this end interdisciplinary collaboration may be sought with for instance, the school of computing and informatics, to solve many of the challenges identified.

As we peer into the future of teacher education programs, do we have finances to employ machine learning? Can we invest in machine teaching? Or is it more feasible to fall back on an inter-disciplinary team who are keen to do this work? The cost can be both in cash and in-kind so long us members of the team are willing to make in-time investment. Some thought should be given to whether investment in computing or storage may be required depending on how up-to-date the technology infrastructure in Universities' teacher education programmes.

Work related to machine learning (and teaching) does take time and can be complicated. Teacher educators should be willing to undertake a cost-benefit analysis to temper expectations about the power and promise of machine learning. In addition, how much and how accessible is the data already in Universities' teacher education databases for proper data analysis? What technical hurdles are there in accessing those data? Such Questions such as these are not for the fainthearted. They demand patience and strategic actions.

As teacher educators plan to embrace machine learning, they must consider data security and privacy. How secure are the ICT systems? In what ways can the data be safeguarded? Ethical considerations demand that all data must be secured and the privacy of all individuals protected. Data processing, cleaning and storage should be in such a way that no individually discernable information may be gleaned out of it, unless otherwise stated by the said individuals through informed consent.

Teacher education programs have attracted imaginative, creative, and capable tech-savvy lecturers, willing to take calculated ICT risks. These are the people we can rely on to try out new applications and innovations. It is prudent to invest in them to do machine learning. There must be online programs that teach data science. Their resources and data science tools may be free and their entry requirements attainable. This is an opportunity we should not pass.

IV. CONCLUSION

The focus of this paper has been on the urgent need to embrace emerging technologies including machine learning. The paper has posited, and hopefully convinced the reader on some of the benefits of adopting machine learning in teacher education. The researchers think the benefits of machine learning far outweigh its limitation. The real potential of technology in teacher education is—when properly used—to extend human capabilities and possibilities of teaching, learning, and research. Machine learning is not an unquestioned panacea so it makes sense to maintain healthy academic skepticism (Popenici & Kerr, 2017) that the aim of education is to build educated minds and responsible citizens that are attached to general values of humanism. The fact is that the education landscape is set to look a whole lot different from now. Teacher educators must thus brace themselves for new times of machine learning, its possibilities and risks notwithstanding. Teacher educators should familiarize themselves with the benefits of machine learning because it will, undoubtedly, bring important, needed improvements in education. Teacher educators would be unwise to overlook the wisdom humans have developed, accumulated and passed down from generation to generation in education. indeed, education is eminently a human-centric endeavor, not a technology centric solution. Furthermore, the classroom is a complex environment and will always have human elements that no computer, even the smarted, can replace. Teacher educators should definitely harness the potential of data mining systems. If nothing else, this paper has rekindled scholarly discussions on the potential of machine learning in teacher education.

Lastly, the paper maintains the focus on identifying problems, critiquing them, identifying risks, and asking important questions on issues such as privacy, power structures, and control to the requirement of nurturing creativity and leaving an open door to serendipity and unexpected paths in teaching and learning. This discourse should thus be explored to the fullest extent possible to get to the heart of the matter that is machine learning.

REFERENCES

1. Agasisti & Bowers, (2017). Data analytics and decision-making in education: Towards the educational data scientist as a key actor in schools and higher education institutions. Retrieved on 3rd June, 2021 from file:///C:/Users/EGRICK~1/AppData/Local/Temp/Agasisti%20and%20Bowers%202017%20-%20Data%20Analytics%20in%20Education-2.pdf
2. Anderson, K. 2018. A primer on machine learning and deep learning for educators. Retrieved on 27th September, 2018 from https://www.emergingedtech.com/2018/06/a-primer-on-machine-learning-and-deep-learning-for-educators/
3. Black B. (2020). Exploring the potential use of AI in marking. Retrieved on 3rd June, 2021 from https://ofqual.blog.gov.uk/2020/01/09/exploring-the-potential-use-of-ai-in-marking/
4. Bayne, S. (2015). Teacherbot: interventions in automated teaching. Teaching in Higher Education, 20(4). doi:10.1080/13562517.2015.1020783.
5. Catauta, S. (N.D). 5 Ways AI has massively influenced social media. https://social-hire.com/blog/small-business/5-ways-ai-has-massively-influenced-social-media
6. Carpenter, J. (2020). How AI will change the future of education. Retrieved on 3rd June, 2021 from https://www.nvpita.com/post/how-ai-will-change-the-future-of-education
7. Chawla, Y., & Singh, R.S. P. (2019). Pedagogy to andgragogy to heutagogy – a compulsive journey. Retrieved on 3rd June, 2021 from https://www.researchgate.net/publication/331276839_Pedagogy_to_Andragogy_to_Heutagogy-a_compulsive_journey/citation/download
8. Kaput, M. (2021). how search engines use artificial intelligence. Retrieved on 3rd June, 2021 from https://www.marketingaiinstitute.com/blog/how-search-engines-use-artificial-intelligence
9. Lampropoulos, G., Keramopoulos, E., & Diamantaras, K. (2020). Enhancing the functionality of augmented reality using deep learning, semantic web and knowledge graphs: A review. ScienceDirect.
10. Liu, M.C., & Huang, Y.M. (2017). The use of data science for education: The case of social-emotional learning. *Smart Learn. Environ, 4(1).* https://doi.org/10.1186/s40561-016-0040-4
11. OECD. (2020). Strengthening online learning when schools are closed: The role of families and teachers in supporting students during the COVID-19 crisis. Retrieved on 3rd June, 2021 from https://www.oecd.org/coronavirus/policy-responses/strengthening-online-learning-when-schools-are-closed-the-role-of-families-and-teachers-in-supporting-students-during-the-covid-19-crisis-c4ecba6c/
12. Petrilli, M. J. (2018). Big data transforms education research: Can Machine Learning Unlock the keys to great teaching? Education Next. www.educationnext.org
13. Popenici, S., & Kerr, S. (2017). Exploring the impact of artificial intelligence on teaching and learning in higher education *Research and Practice in Technology Enhanced Learning 12(1),* 22 DOI:10.1186/s41039-017-0062-8
14. Nelson, K. (2017). Eight ways machine learning will improve education. Retrieved on 27th September, 2018 from http://bigdata-madesimple.com/8-ways-machine-learning-will-improve-education/
15. Ramalingam, V.V., Pandian, A., Chetry, P. & Nigam, H. (2018). Automated Essay

Grading using Machine Learning Algorithm. *Journal of Physics: Conference Series.*

16. Samala, N., Katkam, B.S., Bellamkonda, R.S., and Rodriguez, R.V. (2020). Impact of AI and robotics in the tourism sector: a critical insight. *Journal of Tourism Futures.* https://doi.org/10.1108/JTF-07-2019-0065
17. Schleicher, A. (2015). *Schools for 21st-century students: Strong leaders, confident teachers, innovative approaches*. International summit on the teaching profession (). Paris: OECD Publishing.
18. Signorelli, C.M. (2018). Can Computers Become Conscious and Overcome Humans? Retrieved on 3rd June, 2021 from https://www.frontiersin.org/articles/10.3389/frobt.2018.00121/full
19. Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research, 104*, pp 333-339.
20. Uday, Y. (2019). Pedagogy, andragogy and heutagogy – continuum and comparison. *International Journal of Advanced Research, 7(8)*, 1229-1234.
21. Wang, E. (2020). Turnitin Tech Talk: Artificial Intelligence and Machine Learning at Turnitin. Retrieved on 3rd June, 2021 from https://www.turnitin.com/blog/artificial-intelligence-and-machine-learning-at-turnitin
22. World Bank. (2018). World Development Report 2018: Learning to realize education's promise. Washington, D.C.: World Bank.
23. World Bank. (2019). World Development Report 2019: The changing nature of work. Washington, D.C.: World Bank.
24. Yates, H., & Chamberlain, C. (2017). Machine Learning and Higher Education. EDUCAUSE Review.
25. Zerfass, A., Hagelstein, J., and Tench, R. (2020). Artificial intelligence in communication management: A cross-national study on adoption and knowledge, impact, challenges and risks. *Journal of Communication Management, 24(4)*, pp. 377-389. https://doi.org/10.1108/JCOM-10-2019-0137