The Digital Tutor: A Concept, A Passion, A Reality

An Intelligent Solution to the World's Illiteracy Menace

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Abstract

Many world-class universities offer free K-12 online MOOCs, but only a few of the deserving students benefit from this platform of education. Studies show that only three to five percent of students enrolled in MOOCs complete their course. For children with less self-discipline as compared to adults, this success rate could be much lower. Moreover, the MOOCs are not structured coursework that would satisfy high school completion requirements. A possible solution to help eradicate illiteracy may use AI technology in teaching the masses. A Digital Tutor (DT) while applying adaptive learning methodology uses Lyrebird, an AI digital voice engine. Upon the student's login, the resident Digital Tutor loads the virtual classroom and the lesson on the computer. After teaching the lesson, the DT will assess mastery of the concept. In case of deficiency, it would repeat the lesson, or the student can pause/replay the instruction. At the backend, the DT uses a cloud-based AI-interface with the Lyrebird voice engine to deliver the lesson. When an internet connection is unavailable, the Digital Tutor steps down to DT-Lite and performs the tasks of teaching and assessment using lessons stored on the local storage. This innovative teaching methodology is expected to revolutionize the delivery of education to the underprivileged who do not have access to quality education and is likely an effort to eradicate illiteracy from the world.

Keywords: Cloud-Based, Intelligent Tutoring System, Digital Tutor, Adaptive Teaching/Learning,

Introduction:

The signatory nations of the Universal Declaration of Human Rights (UDHR) promised to prioritize basic human rights to their citizens (UN, 1948). Among those 30 articles of UDHR, article 26 promises that everyone has a right to education. Even though the global literacy rate has increased from 42% in 1960 to 86% in 2015, (OECD, 2015), a big percentage of the poor nations' population is still illiterate even after 71 years of the HDHR signing. Out of 775 million illiterates in the world, more than two-thirds of them are females (UNESCO, 2018). Kofi Annan, the former secretary-general of the United Nations once said;

Literacy is a bridge from misery to hope. It is a tool for daily life in modern society. Especially for girls and women, it is an agent of family health and nutrition. For everyone, everywhere, literacy is, along with education in general, a basic human right It is a bulwark against poverty and a building block of development. (Annan, 1997).

According to UNICEF, "Children and youth living in rural areas have little access to education or skills training programs, and overall the quality of education in rural areas is generally low due to poverty and limited investment resources." (Rolz, 2016, para 2).

A surface-level structural analysis of the world illiteracy indicates that the "problem" is known i.e. the illiteracy; the "need" is to educate the masses, and the "solution" is to take all

possible measures to educate them (Kenny & O'Donnell, 2015). This situation is more complex than it looks, the problem is not that straightforward, and the solution is not that effortless.

One Possible Solution:

For promising economic conditions, education offers the only route out of poverty, but this requires a dedicated and special intervention by the privileged (AIR, 2018). Educating more than three-fourths of a billion people is an overwhelming task (Fiske & Ladd, 2011). Despite substantial efforts of great world organizations like UNESCO, UNICEF, The Global Partnership for Education, and many others, proper education has not reached all people yet, especially most of the rural population is still deprived of basic education. Even with the opening of numerous education centers in sub-Saharan Africa, there are millions of school-age children who do not have access to proper education or education not available to them at all**.** So, what is the best possible way to reach those underprivileged and how could the masses be educated in less than a longer span over centuries? In its 2017 report on "Reimagining the Role of Technology in Education", the United States Department of Education states that technology could be used in transforming education and hence learning. It not only incorporates innovative measures in the delivery of knowledge but also builds unique relationships between students and educators (DOE, 2017). Students get motivated by these modern methods and easily adopt new learning experiences.

A possible solution would be incorporating Artificial Intelligence (AI) in education for the masses. An "Intelligent Tutoring System" (ITS) could offer the "Magic Wand", for eradicating illiteracy from the world (Gharehchopogh & Khalifelu, 2011). The research analyzes that even though there is an inadequate ratio of supply to demand, i.e. there are not enough resources available to educate the learning hungry world. Education is not a priority in many

cultures, societies, and nations, but with technology, we can change this belief (Bernard, 2008). Technology is transforming education, changing how, when and where students learn, and empowering them at every stage of their journey (Intel, n.d. para 1). Research finds that an ITS could be a good replacement for one-one-one adaptive tutoring (Sparks, 2019) and the incorporation of the digital tutor may offer a better alternative to unskilled teachers or when no teachers available.

Delivering quality education to the disadvantaged students in rural Sub-Saharan Africa and Asian countries would be possible using a Digital Tutor (DT). The DT is a conceptual model and still under development. It integrates multiple existing and a few underdevelopment technologies to reach students in distant and remote areas. The technology is not limited to this mode of delivery only and could be used in corporate training, educating special needs students, elderly citizens and others. The article 26 of the Universal Declaration of Human Rights (UDHR, 1948) promises the right of education for all, but still, more than 750 million people have been deprived of this basic right (UNESCO, 2018). According to the Brookings Institute (2012) survey, out of 130 million schoolchildren, more than 37 million students are as much educated as their illiterate counterparts. Poverty, child labor, cultural influences, and ill-trained teachers can be blamed for this catastrophe. This paper evaluates the UDHR article-26 the right to education, analyzes its repercussions and recommends a possible solution to educate the masses.

Brookings Center for Universal Education Educational (BCUE) reports that one in three African children will reach adolescence lacking even the most basic literacy and numeracy skills (Watkins, 2013). The solution to the problem of illiteracy may lie in using technology, especially utilizing Artificial Intelligence (AI) in teaching the masses. This paper discusses the

incorporation of a Digital Tutor (DT) as an alternative to human tutors. The DT utilizes an intelligent tutoring system to offer adaptive learning & teaching (Phobun & Vicheanpanyain, 2010). When compared to no tutoring, the effect sizes of intelligent tutoring systems and adult human tutors are to be d = 0.76, and 0.79 (VanLehn, 2011).

The main components of a DT are:

- The Intelligent Tutoring System
- Adaptive Teaching/Learning
- Emotion Recognition
- Gaze Recognition
- Voice Recognition
- Pedagogical Agent
- Voice Cloning (for teaching)
- Learning Management & Assessment

The DT is a resident program installed on the student's computer. Upon s login, the DT loads the virtual classroom and that day's lesson plan on the computer. After teaching the lesson, the DT assesses mastery of the concept and challenges the student with higher difficulty problems. In case of any deficiency, it repeats the lesson, or the student can pause/replay the instruction. In the backend, the DT uses an intelligent tutoring system (ITS), and AI-based pedagogical agent, while incorporating adaptive teaching/learning techniques. When an internet

connection is unavailable, the DT performs its tasks using lessons stored on a local storage device. This could be termed as a lighter version of the DT.

Another possible use of a DT would be that it could be used in helping students with special needs, as student-based learning is more effective in those cases. And there is no doubt that technology is helpful in distance learning when reaching an institution is not an option for the student.

Literature review

The Intelligent Tutoring Systems:

The ITSs are AI-based tutoring systems, incorporate computers in tutoring but differ from their computer-based tutoring (CBT) antecedents. Rather than relying on delivering a lesson to a passive learner, the ITS tailors the concepts after evaluating pre-existing knowledge, student's learning style, and the advancements through the contents. ITSs are computer-based instructional systems that apply frameworks of instructional content and teaching strategies (Wenger 1987, Ohlsson 1987). These computer programs incorporate modalities of artificial intelligence to provide a symbolic tutor that identifies both content and teaching methodologies (Nwana, 1990). These systems dynamically adapt the content or style of instruction by making inferences about a student's mastery of topics or tasks (Murray, 1999). These are significantly helpful in providing instructions and feedback to learners in a customized manner that typically requires minimal human intervention.

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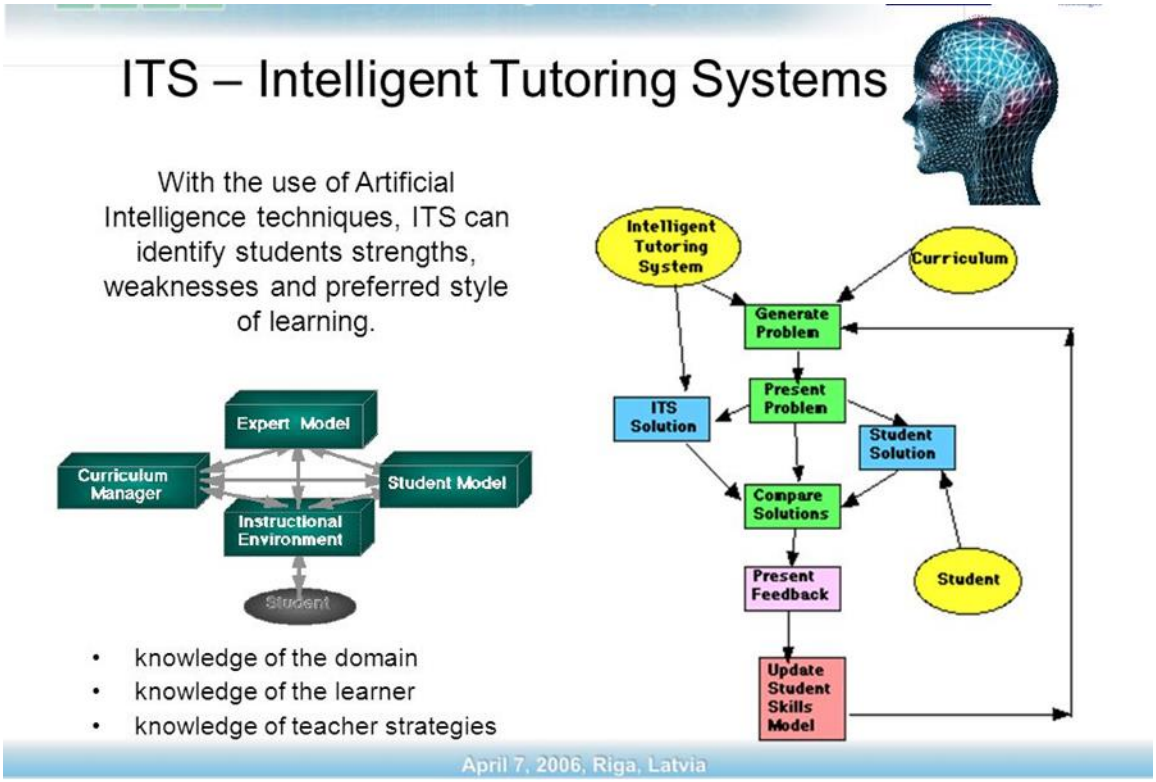
The design of the ITS has a direct influence on the efficacy and impact on the solution. In a typical ITS, pedagogical changes occur internally, based on the input from the user. The system gathers information about the user by observing the use of the application, and in particular by observing the browsing behavior of the user (Phobun & Vicheanpanya, 2010). The ITS then varies the content presented to the learner based on information stored in the system's learner model. All these changes and modifications happen within the ITS's multiple internal models, which are briefly described here.:

The effect sizes of an answer-based computer tutoring (Computer-based tutoring - CBT), an ITS and a human tutor are compared with no tutoring, show that a d = 0.3. d = 0.76, and d= 0.79 respectively (VanLEHN, 2011). This demonstrates that the ITS is as significant as a human tutor for the purpose of delivering knowledge.

Figure 1: The components of an ITS



Latvia, R. [2006]. Intelligent Tutoring System [Digital Image] Retrieved from https://slideplayer.com/slide/5985065/

The Expert/Domain Model:

It is the intellectual model or the expert model. This contains a knowledge base that accounts for all the possible steps for the concepts, problems, lessons, reasonings/solutions for problems, teaching methodologies. It also keeps a student's skill profile and interacts with the tutor model to compile the lesson plan. The logs of the student's interaction with the system are maintained in order to develop strategies for teaching. The student's learning style, prior knowledge on the subject, behavior patterns all help the Domain Model in developing a profile; "It can fulfill several roles; a source of expert knowledge, a standard for evaluating the student's performance or for detecting errors, etc." (Nkambou et al., 2010, p. 4).

The Student Model**:**

The student model collects information about student's learning progress. It also develops and maintains a profile of the learner, including his previous knowledge of the subject. A chosen set of attributes or characteristics related to the learning process is analyzed, stored and shared with the domain and the tutor models by defining relationships among skills, subskills, and prerequisite skills. The main task of the Student Model in an ITS is to develop a personalized adaptive lesson plan based on his profiles as developed earlier. This model helps the Domain Model in decision making while delivering the lesson to the student.

The Tutoring Model:

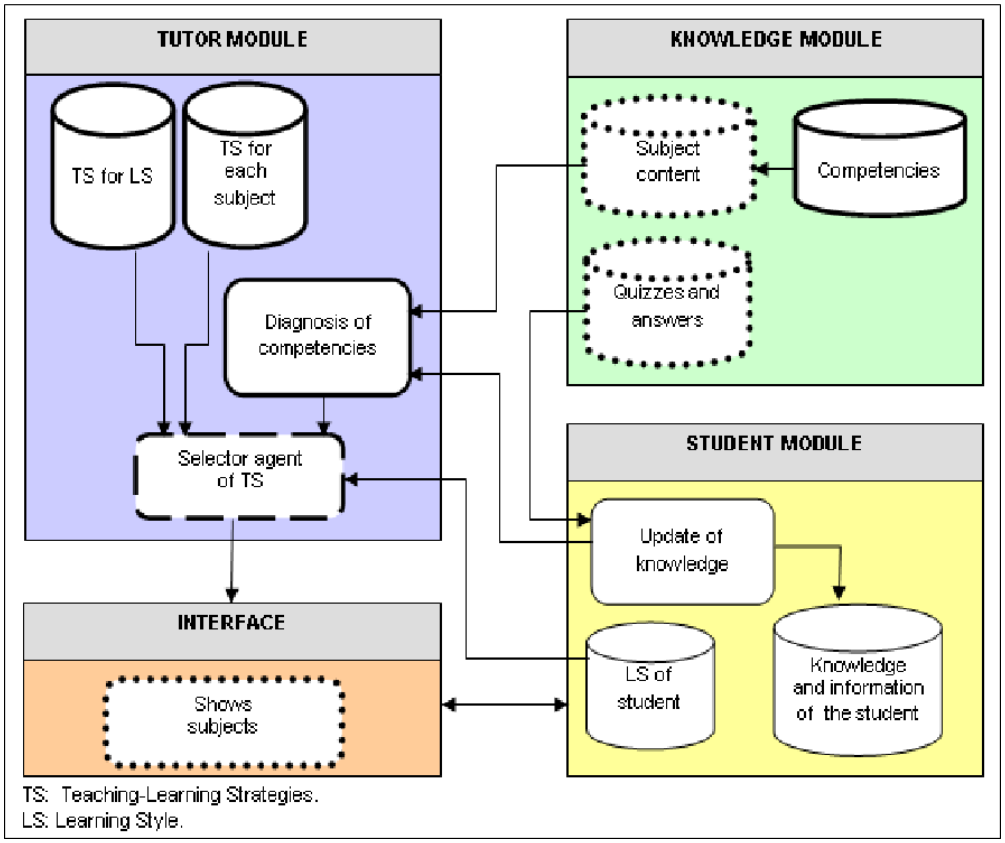
The tutor model receives student's data from the domain and student models and develops tutoring plans and modes of action to deliver lessons. The algorithm helps it to make the right choices in delivering the lesson to the student. It makes these decisions based on student logs, built by learner's cognitive responses to the lesson. The progressive feedback to the students helps them to reach proficiency with the predetermined standards. If the case of any deficiency, the tutor model revises the lesson with different strategies and examples, just like a human tutor.

The Interface Model:

For a general student, mostly not very technical, the graphical interface is the ITS. While providing the learning environment, it acts as a digital pedagogical agent that delivers the contents to the learner. The user interface integrates three types of information that are needed in carrying out a dialogue: knowledge about patterns of interpretation (to understand a speaker) and

action (to generate utterances) within dialogues; domain knowledge needed for communicating content; and knowledge needed for communicating intent" (Padayachee, 2002).

Figure 2: Flow diagram of an Intelligent Tutoring System



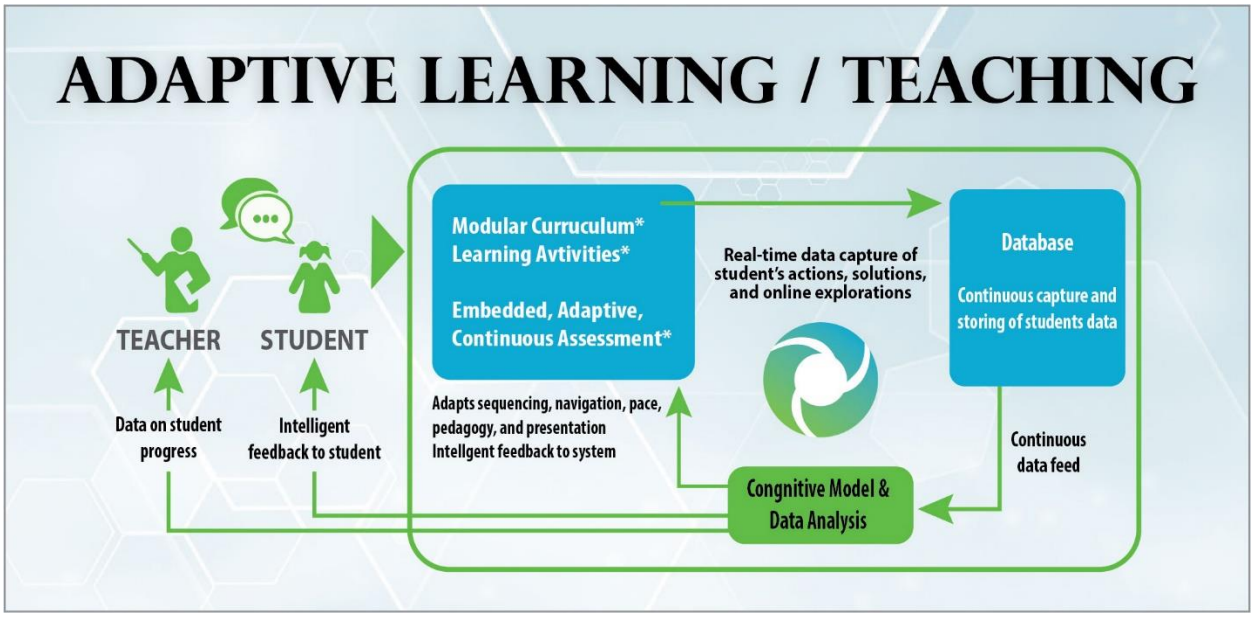
Morales-Rodríguez, Ramírez-Saldivar, Hernández-Ramírez, Sánchez-Solís, and Flores. [2012] *The Architecture of an ITS* [Digital Image] Retrieved from https://www.semanticscholar.org/paper/Architecture-for-an-Intelligent-Tutoring-System-Morales-Rodr%C3%ADguez-Ram%C3%ADrez-Saldivar/403c0f91fba1399e9b7a15c5fbea60ce5f28eabb

Adaptive Learning /Teaching:

The DT will use adaptive learning/teaching methodology to power the learning mechanism. The DT will also collaborate with the Domain Model of the ITS to customize lesson plans based on the unique needs and learning skills of the student. The algorithm takes into account, all the log files created by the Student Model, and stored in the Domain, goes through

the knowledge base that contains the syllabus, and if-then-else strategies, and delivers the lesson to the students (Ong & Ramachandran, 2008).

Figure 3: Adaptive Learning & Teaching



Lemke. C, [2013]. *Intelligent Adaptive Learning* [Digital Image] Retrieved from https://www.dreambox.com/adaptive-learning

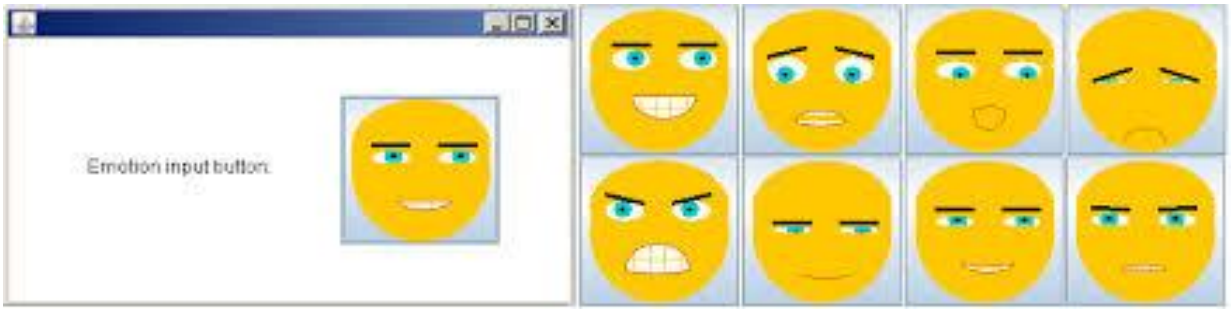
Emotions Recognition:

In a learning environment, emotions play an important role in the learning activity. If a learner is not in a state of learning due to fear, frustration, anxiety, and or depression, he or she can lead to boredom and non-clarity of the concept. The DT uses previous and current log files and self-assessment AffectButton Tool to measure the student's state of emotion. The AffectButton is a self-report tool that enables users to report upon their emotions, mood or attitude about things. It is a simple interactive button that presents a dynamically changing facial expression. (Broekens, 2014)

Behavior patterns like "Pleasure" (pleasant feelings towards lesson), "Arousal" (energy level of the learner), and "Dominance" (ability to cope with the new concept), are measured by

the AffectButton Tool using the computer's built-in webcam (Brookens, n.d.). The DT algorithm compares the learning effect size and recorded emotion recognition log files feeds them to the Domain Model, which delivers a tweaked lesson and for enhanced learning.

Figure 4: AffectButton Tool

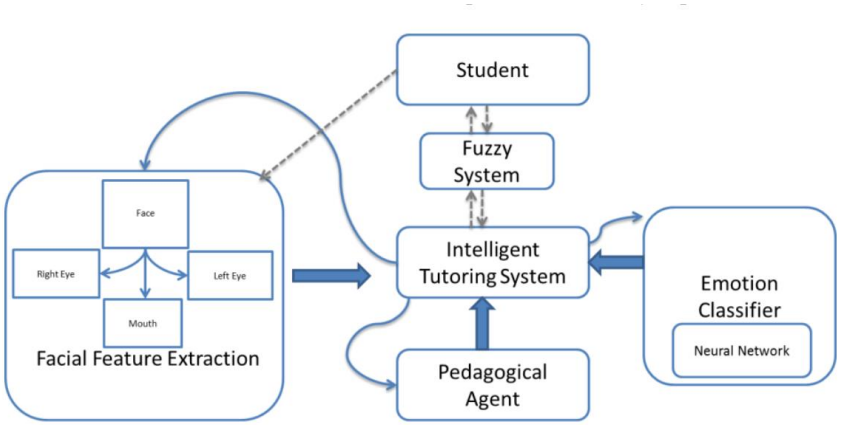


Brookens, J. [2014] The AffectButton Tool [Digital Image] Retrieved from http://ii.tudelft.nl/~joostb/files/Broekens%202014.pdf

Gaze Recognition:

The DT monitors student's boredom, disengagement or zoning out from the lesson using commercially available eye trackers. The motion of the eye based on the point of gaze is tracked by hardware or software (GazePoint, iMotion, Tobii). In case of any disengagement is found, the DT re-engages the student with a dialog. This technique promotes motivation and, hence learning occurs (D'Mello, Olney, Williams &_Hays, 2012)

Figure 5: The Gaze Recognition Process



Emotion recognition in an ITS by Gaze Recognition Cabada, R., Astrada, M, Hernandez, G., & Garcia, C. [2014].

Pedagogical Agent / Voice Recognition Cloning:

The DT acts as a pedagogical agent in order to interact with the student and ITS. Mabanza & de-Wet (2014) defined it as a virtual teacher that socially engages and interacts with the student in a human style. To interact and communicate, it uses a voice engine to generate a conversation with the learner. Text to Speech (TTS) and Speech to Text (STT) systems like PDF readers, audiobooks, and others have been in existence for a while. In all of these applications, the output voice is predetermined and is usually a low-quality computer-generated synthesized robotic voice. The DT will combine a new generation of ultra-realistic voice cloning tool developed by the Lyrebird Technologies (Lyrebird.ai), in its TTS application.

Implementation of voice cloning would make an ideal addition to the DT. A human-like pedagogical agent as the user interface would complement benefits to the student (Baylor & Kim, n.d.). Motivating students who have been deprived of education for a long time could prove to be an uphill battle. The assimilation of a national hero as the digital tutor would not only motivate the students but also promote a desire to learn. Using their beloved leader's voice would also be an inspiration affecting their learning and achievement since motivation directs behavior towards goals (Ormond, 2014). A good example would be mimicking the voice of famous African leader Nelson Mandela for African students.

The Technology Behind the Technology:

How actually this voice cloning technology works? Probably the same way we do as humans. The brain receives inputs in the form of verbal cues in variations of words, pitch, and tempo of the pronunciations, then absorbs, processes, filters, creates phonemes, and outputs them

into a speech. So is the case with the voice mimicking engine. It receives inputs, analyzes them, filters and digitizes for a vocal output. A brief description may explain the technology behind the cloning of a voice.

Let's review the working of the Lyrebird.ai by taking the example of D. Vraghavan (2018) work on deep neural networks for cloning human voice. Using an input sample sentence; Have a good day. This sentence can be broken down into four steps by the voice engine of the Lyrebird:

1. Converting Graphemes (Text) into Phonemes (Phonetic):

English language with all the grandeur is a very difficult language. Words like "Do", "To", "So", Go", may spell in a similar pattern but sound quite differently. At the same time, the words like "Wait, Gate, Eight", totally spelled differently but sound alike. In the Deep Voice engine, the first layer input of the words uses CMU (Carnegie Mellon University) pronunciation dictionary to process the corresponding Phonemes in the TTS pipeline, e.g.:

Wait – W EYI T, Gate – G EYI T, Eight – EYI T, etc.

"Have a good day" would be somewhat: HH AE1 V . AH0 . G UHI D . D EYI .

2. Duration of Phonemes:

The word "unequal" and "fun", the phoneme for the letter "u" is said for a fractionally longer time in the case of "unequal" compared to it in the word fun. When processed the duration of the word "Have" looks somewhat like this:

[HH (0.1s), AE1 (0.05s), V (0.05s), AH0 (0.05s), …]

3. Fundamental Frequency (F0) Prediction:

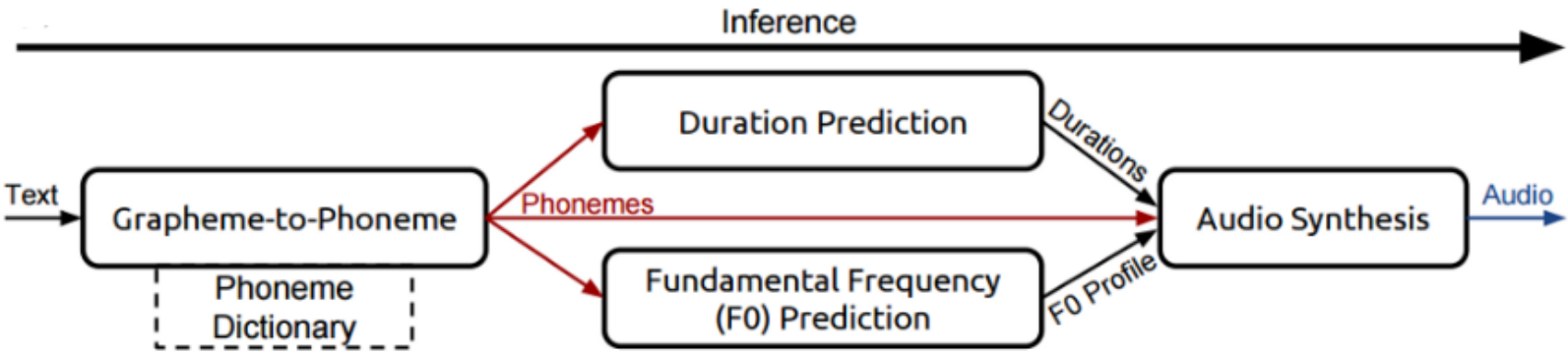
Using the computerized spectrometer application, the fundamental frequency of a phoneme is preserved in the TTS pipeline. It would look somewhat like

[HH (180Hz), AE1 (184Hz), V (182Hz), ….]

4. Audio Synthesis:

The phonemes of the word's grapheme, the duration of phonemes, and the frequency prediction (F0) are used to generate an output voice. Since each one of us has a unique pronunciation frequency, the voice engine learns it, and reproduce it in seconds.

Figure 6: The STT / TTS Interface



TTS Inference [online image] retrieved from https://medium.com/voice-recognition-is-an-important-feature-that-we-use-extensively-on-a-daily-basis-be-it-for-50cf366e47a6

A sample of Lyrebird voice cloning is enclosed herewith for review: Please click the play button to hear politicians discussing Lyrebird.ai.

Video 1: Politicians discussing Lyrebird Technology

Politicians discussing Lyrebird [Online Video] Available at https://youtu.be/e43SUEfCeU0

Conceptual Model of Digital Tutor Front End:

The Teacher:

The DT functions as follows:

- Digital Tutor: is a resident program in a laptop or chrome-book computer
- Students logs in – DT loads up
- Virtual classroom displayed on the screen.
- DT - Checks the date and loads that day's lesson based on the data fed by the Tutor Model of ITS.
- The syllabus is already developed as per Governmental Education Standards.
- The pedagogical agent teaches the lesson by incorporating cloned digitized voices, animation, slideshows, videos, and other multimedia means.
- Assessment is carried out during and after the lesson to check the concept mastery (Table 1)
- In the case of mastery, the difficulty level could be raised to challenge the student
- If any deficiency is found, DT repeats the concept with different examples and checks if the understanding of the lesson is accomplished.
- The student can pause, replay and or advance the lesson.
- DT uses the Lyrebird Technology Voice Engine to teach.

If the internet is not available:

- DT is a resident program on the computer.

- The syllabus is prepared in advance and installed in the computer storage or USB drive.
- Tests and assessments are recorded, saved in a protected location on the drive and uploaded to the education server manually.

Discussion:

The ITS may not have been adopted fully by the education community in the advanced world (Ferster, 2017), but it can prove to be very effective in the developing world (Nye, 2015). Educators and policymakers cannot deny the influence of this novel teaching methodology, its interactive knowledge delivery, and its role as a teacher, facilitator, and mentor in the field of education. Enhanced learning occurs through collaborative communication, discovery-based research and students remain motivated throughout the lesson (Eskadari & Soleimani, 2016). The use of symbolic tutors allows for adaptation to assist students in developing mastery of tasks and topics. This approach to personalized learning provides benefits to students using learner models contained within the system.

The Ethics Behind the Technology:

The ethical aspects of misusing these tools will always be there, new rules and regulations must be implemented. Policymakers are aware of the AI integration in our lives, but they must be more vigilant in placing laws to stop its improper use (Scharre & Horowitz, 2018). At the same time, there are companies working diligently to develop a multi-factor solution for advanced voice authentication. Passport by Pindrop, a cyber-security developer is working on the Deep Voice engine to passively identify the authenticity of callers based on their device, behavior, and various voice factors. Pindrop's Deep Voice biometric engine – a system which

accesses top-of-the-line neural network technology for speaker recognition, to help companies separate suspected fraudsters from authentic callers solely by analyzing voice patterns **(**Balasubramaniyan, 2018).

Lyrebird.ai Disclaimer:

Lyrebird.ai addressed the issue of unauthorized use of voice cloning by posting a disclaimer:

> As pioneers of this technology, we believe that we have the responsibility of guiding its path to developers and the general public. We have worked hard to create principles that accurately reflect the values we espouse as technologists. We have sought the insights of machine learning researchers, our investors, ethics professors, and many others.
>
> Imagine that we had decided not to release this technology at all. Others would develop it and who knows if their intentions would be as sincere as ours: they could, for example, only sell the technology to a specific company or an ill-intentioned organization. By contrast, we are making the technology available to anyone and we are introducing it incrementally so that society can adapt to it, leverage its positive aspects for good while preventing potentially negative applications. (Lyrebird.ai, 2019, p.1).

Conclusion:

The problem of illiteracy has plagued the world's poorest nation like an epidemic. Multiple efforts by different organizations had derived mixed results but the delinquency in this basic human right is far from a viable solution. Political, financial and environmental restrictions bar human efforts to eradicate illiteracy completely from the world. The digital tutor may offer a possible solution for educating the masses. Moreover, in a traditional educational setting,

providing a tutor for each student may be ideal, but certainly is not reasonable in terms of financial and other circumstantial constraints. An ITS can provide students with experiences similar to those provided by a tutor, but at a fraction of the cost. The World would have to rise with its might, help the poor and work diligently to eradicate illiteracy from the world.

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Fig. 3. Lemke. C, [2013]. *Intelligent Adaptive Learning* [Digital Image] Retrieved from https://www.dreambox.com/adaptive-learning

Fig. 4. Broekens, J. [2014] The AffectButton Tool [Digital Image] Retrieved from http://ii.tudelft.nl/~joostb/files/Broekens%202014.pdf

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Fig. 6. TTS Inference [online image] retrieved from https://medium.com/voice-recognition-is-an-important-feature-that-we-use-extensively-on-a-daily-basis-be-it-for-50cf366e47a6

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