The Implementation of Deep Learning Methods in Education to Support Personalized Learning

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***Abstract*— A teacher's position will always exist in education, but due to artificial intelligence (AI) technology, that role and what it entails may alter. Because AI solutions in the field of education are still evolving, it is envisaged that AI will help cover the gap in needs in learning and teaching, allowing teachers to assist students wherever they wish to study, 24 hours a day, 7 days a week. One student is assigned to at least one teacher who truly understands the character, strengths, and weaknesses of the student in question, allowing him to deliver the finest therapy possible in the shortest amount of time and with the least amount of money. The goal of this research is to develop artificial intelligence that can become a learning partner for students (computers as teachers or digital teachers) in a practice-based learning system by implementing a fully connected neural network with group reduction, the results of this research yield 98 percent accuracy.**

Keywords—digital teacher, AI, education, deep learning

I. INTRODUCTION

Artificial Intelligence (AI), a term commonly found in science fiction, has gained widespread acceptance as it becomes more prevalent in our daily lives. Healthcare, transportation, retail, and finance are among the industries that are rapidly changing [1]. Another field with enormous potential for the application of AI technologies is education. Indeed, AI advancements in education have progressed from idealized laboratory scenarios to more complex real-world learning contexts.

Roll and Wylie summarize the impact of AI on education, particularly in terms of raising instructional effectiveness and efficiency, in their discussion of AI changes, particularly in applications in education, particularly teaching systems, which have been designed with the goal of solving numerous significant challenges in teacher guidance [2]. Other studies have highlighted the benefits of AI for learning and its impact on learning. For example, artificial intelligence has been used to promote academic honesty and integrity [3]. Another study [4]–[9] looked at how AI in the form of an expressive humanoid robot with dialogue and conversational skills can improve teaching quality by encouraging learners to engage with them because of their better abilities and human-like appearance.

According to Mikropoulos and Natsis, the development and use of AI, particularly its integration into online and web-based learning platforms, has resulted in improved teaching because AI has enabled the progress and use of greater pedagogical tools for these platforms [10]. The lack of traditional methods for teaching today's generation, as well as the complexity of the education system itself, can be addressed by AI. E-learning, in particular, makes massive amounts of data accessible, allowing AI to tackle the complexities of educational challenges and implement intelligent educational technology solutions.

The use of AI systems in education is becoming increasingly popular year after year. Since 2010, the number of papers published in the topics of "AI" and "Education" in Web of Science and Google Scholar has increased significantly as shown in Fig.1. It can be seen that papers published between 2015 and 2019 made up a significant portion of the total, accounting for 70% of all indexed newspapers. As technology advances in education, researchers are attempting to use advanced AI techniques, such as deep learning and data mining, to solve complex problems and personalized teaching methods to individual students.

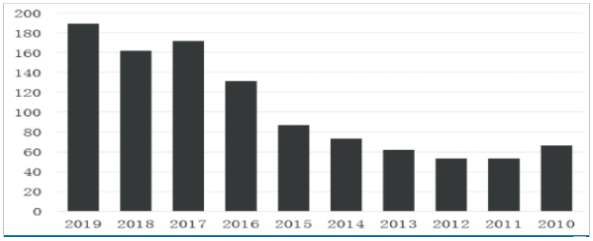


Fig. 1. Papers on Web of Science and Google Scholar in the last ten years with keywords “AI” and “Education”

As artificial intelligence (AI) solutions in education continue to evolve, it is hoped that AI will help fill gaps in learning and teaching needs, allowing educators to contribute more than ever before. With AI it can drive effectiveness, personalization, and simplify administrative tasks, giving educators more time and freedom to provide understanding and adaptability, human-specific abilities that machines would struggle with. The perspective of AI in education is to collaborate between teachers and AI to achieve the best results for students by leveraging the best attributes of both machines and teachers. Educational institutions must consider introducing and using such technology for students.

There will always be a teacher's role in education, but that role and what it implies may change as a result of AI. Assisting students in improving their learning and even serving as a substitute for in-person tutoring, AI can perform tasks such as grading and even serve as a substitute for in-person tutoring. However, AI can be applied to a variety of other forms of education as well. AI systems are equipped to provide insight, to serve as a forum for students to ask questions and seek knowledge, and even to take a teacher's position file for very basic course material. AI will transform the teacher's position into that of a facilitator.

Students actively engage in classes in a teaching and learning environment, and using a method that helps students memorize what they learn is a crucial factor. Effective teaching techniques can boost learning quality. Students

learn best by doing and experiencing things for themselves. Science education programs must be student-centered and involve practical activities in order to be effective and efficient. Furthermore, when using a collaborative learning approach, students and teachers are in a constant state of interaction in the classroom. Each learner, however, has a unique way of learning. One example of a topic described by a teacher may be understood by students at once, or the subject might require more than two or three examples of the same issue to be comprehended. It is not uncommon for students to be absent from the previous class. Educators are not always able to present specific examples that are simple enough for every student in the class to comprehend.

Deep learning is a subset of AI, although it is central to AI. DL helps computers to improve their performance by leveraging their expertise and data [11]. The application of DL in the context of education is the topic of this work. The application categorization of AI from [12] still applies as part of AI. The following domains, in particular, see the most applications of DL technology in education: 1) adaptive testing and evaluation; 2) performance prediction; and 3) student retention. Pattern recognition enables DL programs to assess text assignments and identify students at danger of failing a course [13]–[15]. DL-based evaluation provides students and teachers with continuous feedback and recommends adaptable pathways to meet learning objectives [16]. DL can also identify performance of students, identify their strengths and weaknesses, and recommend strategy to enhance them through testing or practice [17], [18]. Finally, student retention is crucial for school enrollment management since it influences key criteria such as reputation, ranking, and financial performance. [19], [20] are two studies that used DL to identify students at risk for retention management.

The contributions of this research is developing artificial intelligence system that capable in serving as a teaching partner for students (computers as teachers) in an exercise-based learning system. Teachers are available to help students wherever they want to study, 24 hours a day, seven days a week. At least one student is handled by at least one teacher who truly understands the student's character, skills, and limitations so that the teacher is always able to deliver the finest treatment in order to develop student competencies in the shortest possible time and with the fewest resources, and the system can adjust to individual learning routines and deliver more challenging activities to help students learn faster. As a result, students can learn at their own pace at some point in the future.

II. LITERATURE REVIEW

A. Artificial Intelligence In Education

In education, artificial intelligence (AI) is utilized to improve distance learning, assist students, open virtual lessons, and much more. Modern education will be integrated with numerous innovations, such as voice semantic recognition, picture recognition, Augmented Reality/Virtual Reality, machine learning, brain neuroscience, quantum computing, blockchain, and so on, as artificial intelligence technology advances. Intelligent technologies, as a group, are being regularly and quickly implemented into the educational sector. Many artificial intelligence solutions are currently being used in academic contexts. [21] Intelligent tutor-assisted private teaching and learning, intelligent assistants such as educational robots, children's home partners, intelligent assessment, mining and intelligence education data analysis, learning and learning analytics, digital portraits, and so on are some examples of artificial intelligence educational technologies.

B. Virtual Teacher

Based on the advancement of artificial intelligence technology, several firms have started to supply online students with "virtual teachers" who use artificial intelligence to help students learn [22]. In London, there is a firm called "Whizz Education" [23], which is well-known for its flagship product, "Maths Whizz," which is an online tutoring software. The company has created an after-school study program that adheres to the school calendar. Students are free to ask questions at any time during the learning process. The virtual teacher will answer the students' questions step by step and adapt the answers based on their input until the students have mastered the subject learned.

C. Personalized Learning

Personalized learning refers to a variety of teaching methods and instructional strategies that can be tailored to each student's needs [24]. Different learners' learning preferences and specific interests are taken into consideration when designing their experiences. This artificial intelligence educational tool can adjust to individual learning routines and deliver more challenging activities to help students learn faster. As a result, students can learn at their own pace at some point in the future. The MOOC (Massive Open Online Course) Buddy teaching robot was invented and built by Holotescu to provide learners with customized and individualized educational content [25]. Bayne has also created Botty, a smart teacher's assistant that may support teachers in the classroom and improve efficiency. This instructional program will assist in a number of ways, including job auto-correction, online question answering, and intelligent assessment [26].

D. Adaptive Learning

Artificial intelligence is used in adaptive learning to systematically gather and evaluate teaching and learning data, define each student's learning styles and traits, and then automatically alter the teaching content, modes, and routines to meet their needs [27]. Teachers can use tools and content libraries on online platforms to design courses, and each part of the teaching process can add an element of interaction with students, so that students can master knowledge through completing several "tasks" in the course. Through this interaction, the system can collect student learning data at any time, track student progress, and find student learning barriers and difficulties, thereby providing real-time feedback and reinforcement.

III. METHODOLOGY

Deep learning technologies applied due to massive data being utilized to generate artificial intelligence. The big data is derived through the recording of the learning process based on previously existing/available practice questions, as well as the teachers as experts/experts in leading students to learn. Fig. 2 depicts how the suggested artificial intelligence operates.

Mode 1 involves students interacting with the teacher. Students are asked questions (by the teacher), and the teacher evaluates their answers/responses. The teacher selects the

next question that is appropriate for the learner based on the student's performance. All of the events involved are observed/documented by AI, and it learns about them. In mode 2, the AI takes on the role of instructor. AI handles the responsibilities of asking questions, evaluating responses, and selecting the next question. Fig.3 depicts the stages or work steps to be completed.

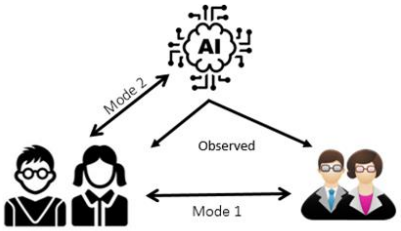


Fig. 2. Artificial Intelligence workflow

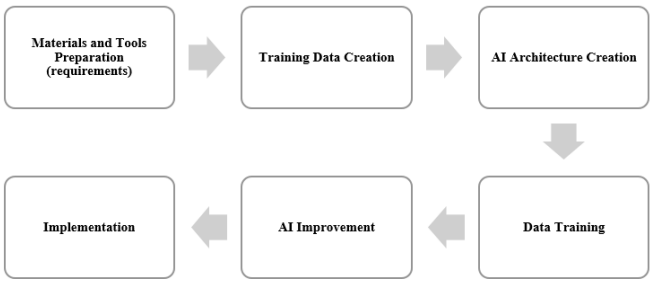


Fig. 3. Research work steps

Artificial Neural Network is classified as supervised deep learning methods. An artificial Neural Network is a component of a computing system that is supposed to examine and make decisions in the same way that the human brain does. ANN learns to recognize patterns based on inputs given to the input layer during its first training phase. The difference between ANN's output and the actual output is termed as an error during this phase.

The goal of backpropagation is to reduce error by altering the weight and bias of the interconnection. The difference between the desired and actual output creates the least error in the backpropagation process.

A fully connected network (Fig.4) is utilized as the model, which is one of the most basic types of artificial neural networks. In fully connected network each node is connected to all other nodes in adjacent layer of the network. Completely connected networks guarantee fast delivery of messages from any source node to any destination node (only one link has to be traversed). Though the training phase is long and requires a lot of computing resources, the testing phase is the opposite. We demonstrated this in our previous work with speech [28] and image [29] dataset. This kind of architecture was chosen in order to achieve a quick testing execution time and minimal hardware requirements. The architecture is made up of three layers: an input layer, a hidden layer, and an output layer. There is only one input layer with a total of 12 points (nodes). The number of points is proportional to the number of features in the training data. The number of hidden layers begins with one layer and will be increased if the model does not achieve good performance. This is done iteratively and incrementally until the performance goals are met. The number of points in the hidden layer is set to be equal to the number of points in the input layer, which is 12. The number of training data features is not compressed or expanded. Finally, there is only one output layer with ten nodes. The number of points is proportional to the number of labels in the training data.

Using the Grid Search technique, the hyperparameters were thoroughly examined. Batch size, epoch, optimizer, activation function, and learning rate are the parameters employed. The number of points in the hidden layer is fixed. During the training, k-fold validation with a value of k = 10 was employed for each combination (90 percent training data and 10 percent validation data). Different deep learning architectures/models are created with Teacher ID. Because for the same feature (row) data set, various teachers may supply different next question IDs.

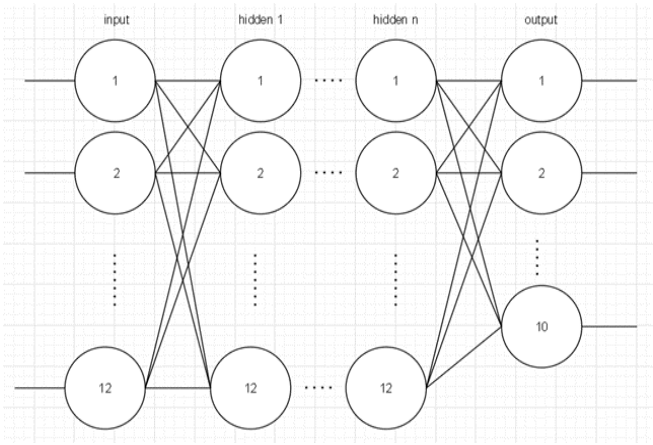


Fig. 4. System architecture

To increase model performance, the datasets are organized into categories (bins). Existing data in one group shares similarities or is close to one another. This reduces the number of classes or simplifies the classification process.

IV. RESULTS

Students learn by doing questions through the mobile application (or web version). Fig.5. shows the mobile application used to collect data.

Fig.5. shows four answer possibilities, namely A, B, C, and D, where students can select based on their knowledge/ability of the questions given. Points (orange color) represent the overall score that students have successfully achieved, i.e. the total value of right answers.

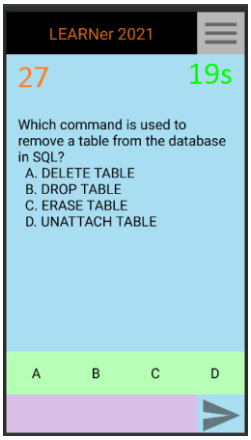


Fig. 5. Practice question user interface

The data recorded (green) indicates how much time is remained to answer to the presently displayed question. Each question has a different amount of time assigned to it (adjusted to the character and level of difficulty of the question). If the timer runs out, the student is declared to have failed to respond. A teacher can see the application screen on a student's mobile phone through other gadgets he employs (such as screen mirroring/sharing) while in learning mode. It could be a laptop or a smartphone. Teachers may see the activities in real time in this way. Based on these observations, the teacher can decide which questions to ask of another student.

Some of the most important aspects of this process in terms of the features of the produced artificial intelligence model are: 1) the correctness of the students' answers; and 2) the time it takes for students to answer. Another essential aspect is the arrangement of questions and a student's past results. Fig.6. shows the use case diagram of the system.

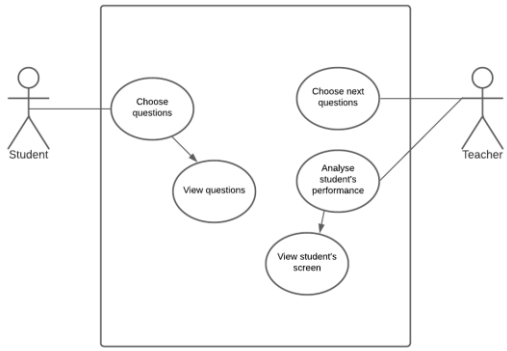
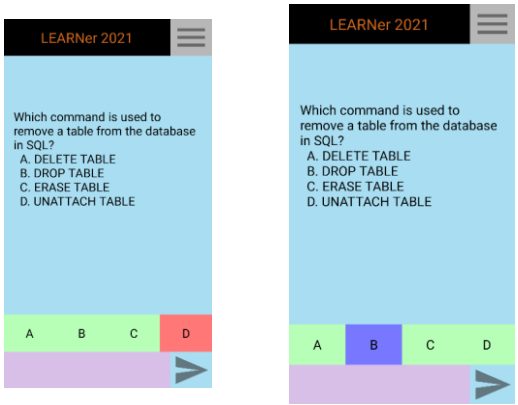


Fig. 6. Use Case Diagram

As shown in Fig.7(a), the red color indicates that the student's answer is incorrect. In this case, students can attempt over and over again until they get the correct answer (marked in blue as shown in Fig.7(b). This is useful for students when their study time is limited or they do not have time to search for references to get the correct answer. There is no information about scores or time in practice mode, so students are free to explore and spend more time as they see necessary.



(a) (b)

Fig. 7. Screen display when user choose wrong answer (a) and correct answer (b)

The application enables the teacher to select the best questions for students (those that are most relevant to be given at the most appropriate time) (Fig.8). The teacher chooses questions from a compiled collection. By scrolling up and down the screen until the relevant question displays, questions can be selected. The question is then selected by clicking on the question's contents.

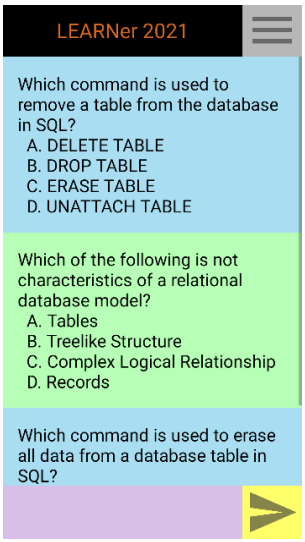
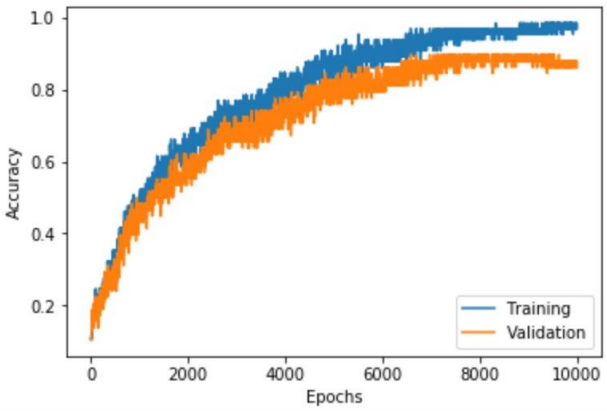
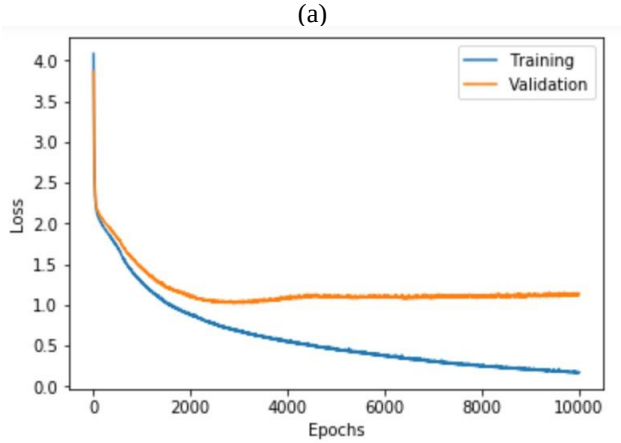


Fig. 8. The user interface for teacher in choosing/selecting questions

Aaccuracy results for training and loss validation are shown in Fig.9. From the figure it can be seen that the validation loss continues to drop for both training (0.1684) and validation (1.1346) after 2000 epochs, and that the validation value then increased even as the training value continued to fall. Starting at 7000 epochs, the training accuracy reached its maximum (98.46 percent) and could not be increased further. The same is true for the validation accuracy of 87.93 percent, which begins at the same time and never increases.



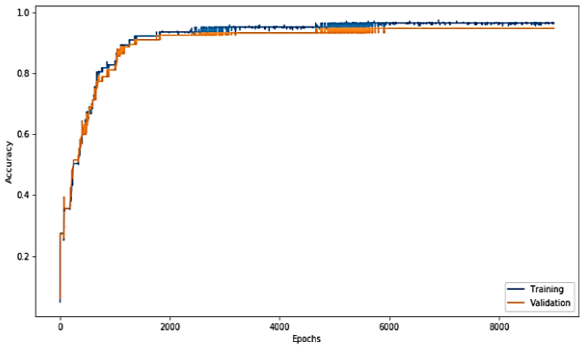
(a)



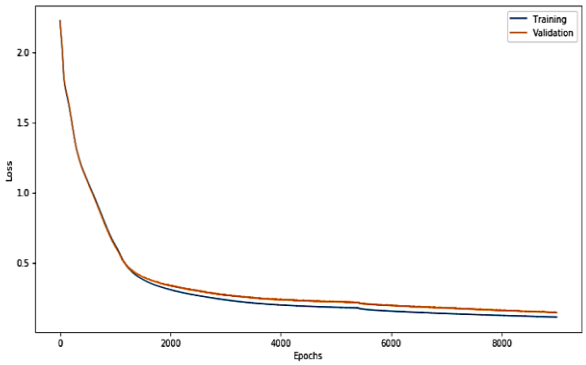
(b)

Fig. 9. (a) Accuracy and (b) plot loss training data and validation without group reduction for a model trained over 140 epochs

As shown in Fig.10., compared with the performance of the model trained without group reduction (Fig.9), there is an improvement in loss. Aside from the more similar training (blue) and validation (orange) graphs, the nominal value obtained was also lower, falling from 0.1684 (training) to 0.03150 and from 1.1346 (validation) to 0.0355.



(a)



(b)

Fig. 10. Accuracy (a) and loss (b) training result and validation with group reduction

V. Conclusion

This study was successful in establishing an artificial neural network in order to create an artificial intelligence application capable of serving as a learning partner for students (computers as instructors or digital teachers) in an exercise-based learning system. Tests have been conducted, and it is known from the test results that the accuracy rate is 98 percent. Based on the experimental results, the teacher's position can be properly replaced by an artificial intelligence system. This study also found a considerable improvement, particularly in validation accuracy, when compared to the performance of the model trained without group reduction. The accuracy achieved has increased from 98.46 percent (training) to 98.69 percent (validation) and from 87.93 percent to 98.48 percent (training).

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