

# Guru Gedara: Smart Mathematical e-learning Platform for Grade Five Students

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**Abstract**— This paper introduces a web-based educational support system developed aiming optimize mathematical knowledge of Grade 5 students. This application can be also used as a distance learning method for the lockdown situations occurred due to COVID-19 pandemic. Both primary class students and teachers face various difficulties, due to competitiveness of grade 5 scholarship examination. Consequently, emotion analysis which is a sub section in this system, uses sentiment analyzing to boosts the students' emotional state, while Automated MCQ generated sub section can be used to gain mathematical knowledge, by facing MCQ quizzes. Additionally, Smart Video-based Learning Environment sub section can be used to gain knowledge related to mathematics by searching relevant videos, besides the Voice-based Question Answering section can be used to get answers orally for the questions asked in voice format. However, some sections use IQ level of each student to provide better solutions. Above all, it can be used at home as an online service while identifying and solving student's weakness.

**Keywords**—Video base techniques, Question generation, Speech recognition, Sentiment analysis. Artificial Intelligent (AI), Natural Language Processing (NLP). natural language tool kit (nltk), Machine Learning (ML), Convolution Neural Network (CNN)

## I. INTRODUCTION

Sri Lankan parents are very keen on their children's education thus, they try to provide children with best education possible to brighten their future. This has resulted in creating a huge competitive environment at present in terms of child education. This is very much prominent in preparation of student for grade 5 scholarship examination [1]. Other than these parents are facing many other problems at present such as, financial issues, transport issues etc. especially with rural students. [2]. Moreover, students do not have similar interest for learning and due to diversity of the student they need diverse learning methods, where teachers find it hard to satisfy those requirements at the limited time given at the class room [3].

Therefore, this system has designed as one of the possible solutions to these issues which will provide students with an e-learning education where physical presence of both the student and the teacher are not required. We have specifically designed this to help improve knowledge on mathematics of grade 5 students, considering the fact that many Sri Lankan students are lacking the mathematics and science subject wise knowledge. According to an article published by Liyange (2014), even though the literacy rate of Sri Lanka is high [4], knowledge level of both math and science subjects are considerably low. Thus in this attempt we have tried to address this issue as well, by improving mathematics knowledge of students starting from the primary classes, where fundamentals of mathematics are taught.

This paper introduces, 4 main e-learning methods which encourage and support grade 5 students to full fill their mathematical related knowledge in an interesting manner using this system. It includes MCQ Generating and Student Training System with machine learning and Q learning such an e-learning method, which facilitates student to practice with auto generated mathematical MCQ based questions according to their current mathematical knowledge by passing levels gradually. The expected outcome of this function is to increase the capacity of the students thus they can face examinations with higher level of confidence. However, when considering the present-day student mind, it is a known fact that many children do not have strong mental ability to learn school subjects, especially mathematics [5]. Therefore, another interesting method named Tips and Tricks has been implemented as a solution for this issue, which boosts up the student mental status according to their hobbies or current preferences which are tracked at the registration process. Sentiment Analysis in Natural Language Understanding (NLP) approach has been used in this e-learning technique along with the voice-based mechanisms where pitch and loudness are used.

Besides, students are encouraged to a follow method named Search and Surf when they need to improve their knowledge in relation to grade 5 mathematics. Therefore, suitable video-based lessons which are existing on the internet will be provided to the students by tracking their current IQ level as that can be used to identify intelligence quotient score of the student while providing suitable learning environment as well [6]. Further, there is another inspiration provided by the system for students to improve their mathematical skills by providing the facility to ask voice-based questions from the system where answers are provided via in both voice and text. Moreover, system is also generating solving steps for each asked question since some of the students might be not good in understanding a question type and solving techniques [7]. Mechanisms such as Google Speech Recognition (GSR) and Custom Named Entity Recognition with Convolution Neural Network (CNN) sentence classification have been used to generate suitable answers.

The paper has arranged in to four sections as follows. (1) Literary review, (2) Methodology, (3) Results, and (4) Conclusions and Future Dimensions in order to provide better understanding about the functions which are mentioned above in this system. Literature review section explores the existing simulation systems which have similar context but different scope and methodologies compares to ours. It also reveals the gaps identified in those systems, which have been filled in this Guru Gedara Smart E-Learning Platform. Methodology section explains the methodologies which have been used to develop this system so far. Results section explains, how the system performs in the real world with the

accuracy level so far this system has gained. Finally, conclusion and future dimensions of the system is presented.

## II. LITERATURE REVIEW

In contrast, to the many other current existing E-Learning systems, Guru Gedara Smart E-Learning Platform has many ideal approaches. Thus, a comparison of the other existing systems are discussed in following paragraphs, to emphasize the importance and the usage of this system.

Therefore, when considering the achievements done for the learning section, such effort can be seen in the research conducted by Dongzong [8], where they have introduced a method which identifies the type of video required for a selected user. Therefore, they have used Named Entity Extraction, frame-based indexing, and Natural Language Processing for creating the e-learning content-based video environment to achieve this method. However, this method focuses mainly on high accuracy results. The system basically returns to the relevant video list and the user can select one and view more details with the other material attached to the video [8]. However, they have faced a problem in response time as query retrieving process takes long time to execute.

Chaiti Sen Gupta [9] and his team has developed an E-question paper generation system, which is another E-learning approach, has the similarity with our system where they have used AI to generate MCQ. Even though, this method was used to assess the comprehension level of the students, researchers have not considered about building a training mechanism to support students when they do mistakes, where our system has such approach in above stated function. However, these researchers have implemented question bank where relevant authorized instructor can add new questions and manage it. Henceforth, their system generates questions using the question bank, suitable enough to the student's level of understanding. However, even though they have categorized students understanding levels as high, medium, and low, they have not implemented mechanisms to improve students' understanding level. Notwithstanding, our system has mechanisms to solve those issues that are identified in this literature survey.

Corresponding to the above mentioned system function of ours, another research named "Detection and Analysis of Human Emotions through Voice and Speech Pattern Processing" conducted by Poorna Banerjee Dasgupta in India [10] also has emotion detection functionality like ours but with different approaches. According to their article, he has used some feature like pitch, SPL, timber, and time gaps in audio file for analyzing [10] purposes, with the support of the MATLAB and Wavepad software packages. Thereafter, values of each audio features have been used to obtain the average values for test values. Even though their system identifies the emotion category, they have not implemented a mechanism to provide solutions for identified negative emotions when our system does have. However, the functionality with similar approaches of our system to theirs, uses the audio as an input. Moreover, in our system uses K-nearest neighbor algorithm to analyze the rearranged audio file with the rated value set efficiently thereafter identifies sentiment based on the emotion and provides solution for negative sentiments.

An equivalent approach, related to the Voice-based Question Answering section can be seen in "Geovaqa voice

activated Geographical Question Answering System" [11], another question answering system which was designed for giving geographical directions in Spanish region. It also takes voice-based questions as inputs and provides text-based answers in return, as only output method, which differs from our system. Researchers have used several functionalities like Natural Language processing tools for generating answer, Geographical Knowledge Base, and the search engine Google to get snippets to get directions while processing the answer etc. In Contrast, the developed component of our system uses Convolutional Neural Network (CNN), and Custom Named Entity Recognition related mechanisms to generate answers. Furthermore, generated answers are provided via both audio and textual format. As our function needs to categorize asked questions, we have used CNN to categorize sentences according to defined categories.

## III. METHODOLOGY

Henceforth, description about the mechanisms used for implementing the whole system is addressed with the relevant technologies in this section. However, since this web based mathematical E- Learning system is consist of four main components, each of them are explained separately as below. Since our system is web-based application, Django has been used as the framework to implement attractive interfaces, with the support of Python and Mongo DB database for building backend as shown in figure 1.

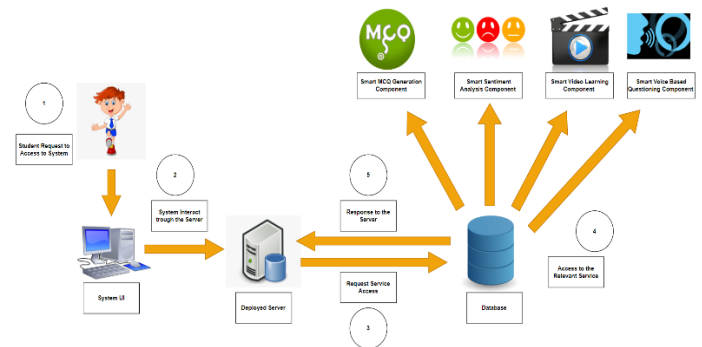


Fig 1: System diagram

### A. Identify student IQ level and preferable learning method

This sub part generates a series of IQ questions based on general math, and thereafter generates a score based on that set of questions as the initial step. Thereupon, this sub part generates a questionnaire to obtain information like students' preferability and IQ levels as shown in figure 2.

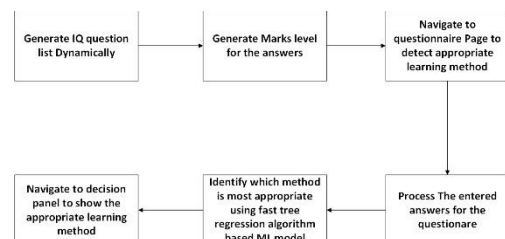


Fig 2: Overview process of understanding appropriate learning method

Thereafter, this sub system triggers fast tree regression algorithm to find out the best suitable method for the selected

student, which becomes suitable, according to the information provided by the system. However, the detailed explanation section is designed for weak students, for those who score low for IQ questions. Therefore, only the students those who score less than 80 point for target IQ level, can access the detailed explanations which are on video format. Moreover, it includes time spaces of important steps for solving mathematical problems, by highlighting to catch the subject matters easily. Likewise, for the students those who score points between 80 and 95, also have a facility where they can access to the examples-based learning method, since they are clever enough than the students who score low points.

Moreover, for the students those who score points greater than 95, can search and view lesson via Search Surf method, where resulted outputs will be displayed as a list on the relevant interface, since the relevant functions have been implemented integrating the Google Search API. Thereupon, system feedback form will be displayed to get some information like student satisfaction for the selected video lesson, regarding the playing video. However, the student response for that feedback forum, is a must since it is used to generate list of suggestions of solutions and videos considering the parts where student find as missing points in a video lesson. Afterwards, student history regarding the student engagement of playing and searching videos, are available for the respective parents. The whole process described so far is illustrated in the figure 3.

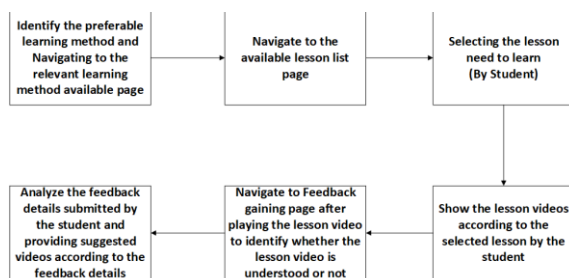


Fig 3: Overview process of suggestion video providing

Moreover, short notes will also be generated according to the key words tracked in the feedback filled by the student. However, in such case of not getting feedback form for a particular video, relevant function generates a short note including the whole lecture content, included in the relevant video.

### B. Student evaluation using questions

This section describes the mechanisms were used to build MCQ Generating and Student Training System with machine learning and Q learning, another sub part defined in this web-based approach. Hence, the developed methodology is used to teach mathematics for primary class students and has mechanism for generating 15 questions as exercises for each student, for those who needs more training trials for the completed math lessons. Therefore, as the initial step, student must log in to the relevant section of the web application to get facilities mentioned below. Thereafter, student can choose a preferred lesson to access the series of auto generated questions for that selected lesson. However,

student must select the number of hours studied at the beginning, in order to get the target marks.

The functionalities behind the above process, generates a series of questions randomly, covering all the sub-sections to get the idea of the student's current level comprehension. However, these questions are not stored or uploaded, but are generated automatically and randomly, by tracking the keys words defined in the database. Therefore, this subpart of the system, automatically generates the correct and incorrect answers, respectively. Moreover, target scores are given to motivate the student, by using regression tree algorithm with the two parameters, gender and studied hours. Further, this sub part of the system provides a specific amount of time to complete the given question, as shown in the figure 4.

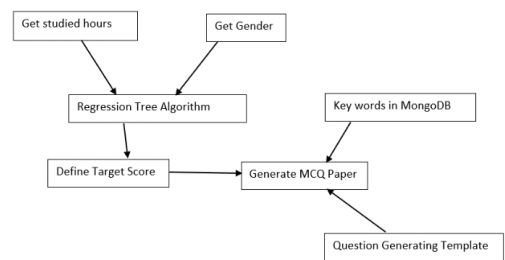


Fig 4: Workflow of question generating step 1

After the student completed all fifteen questions in a quiz, the student can review and involve in doing changes. Soon after the changes are made, the student can submit the answers by clicking the button. Henceforth, defined processes in this sub part then evaluates all the answers with the correct answers. Thereupon, data related to the student's performance are used to generate the next set of questions by using an AI-based algorithm called the q-learning model free algorithm.

Meanwhile, this Q-Learning method identifies the current state of the student's knowledge by analyzing the provided answers, to find the path which is consisted of number of states that are used to describe weak points of a particular student. Therefore, each state is used to describe one weak point of the student. Hence with, new sets of 15 MCQs per paper, are generated according to the relevant weak point. Student can pass a state by getting 75% or above mark for a MCQ paper. This process continues until the student reaches the final state, where no more mistakes are done by the student. The following diagram show how the student's path is detected using Q-learning in figure 5.

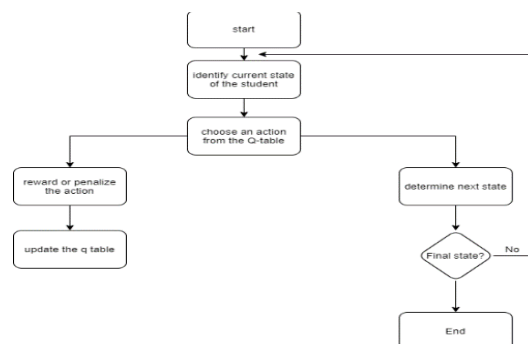


Fig 5: Workflow of q-learning algorithm working

### C. Sentiment analysis using audio

Uniquely, sentiment analysis sub part defined in the Guru Gedara Smart E-Learning Platform differs from other sub parts, since it involves with the student's emotional state to motivate him/her to engage in academic activities efficiently [12]. Hence, the methodologies used in this sub part are described as follows.

This sub section uses audio analysis methods to get the student information to identify the student's current emotional state. Initially, necessary information like hobbies, special preferences, tastes are tracked at the registration level and stores them accordingly in the database. This section asks necessary questions from the student orally and record the student's voice as the answer for that question. Thereafter, recorded audio goes to the analyzing process. According to this component, it uses two main characteristics such as pitch and loudness to identify emotions. Moreover, remarkably pitch and loudness in the audio files are different from male to female. Therefore, mean value of Mel Frequency Cepstral Coefficients (MFCC) in audio file, is use to identify the gender. This coefficient values are found by using the speech module in python. Thereafter, knn algorithm is used to predict the nearest mean coefficient values which are used in predicting the gender, from the stored audio file of the student. Thereafter, these audio files are sent to find the pitch and loudness analysis according to the gender. Correspondingly, pitch and loudness values are used in determining the emotional state, by using these two audio features in k-nearest neighbor (knn) algorithm in a two separate processes as pitch find and find loudness methods. However, these two audio features have a relationship, where values of these are increased, if a value of one of these feature increases.

Therefore, it is also has been considered in this process. Soon after the identifying the emotional state, sentiment analyzer method in nltk is used to predict the sentiment, which has been converted to textual format. However, just before the prediction stage in, earlier predicted emotions in textual format use in sentiment analyzer, must be cleaned, since it could consist of noise like unwanted characters. Therefore, in such case of recognition of a negative sentiment of the student, relevant functionality provides list of suggestions to boot the student mentality to positive state, where he/she can involve in academic activities more efficiently as shown in figure 6. Furthermore, if the mood of the student identified as a positive sentiment, relevant functionality motivates student to continue the academic activities, currently the student involves in. However, those suggestions are generated according to the previously tracked student preferences, at the registration stage.

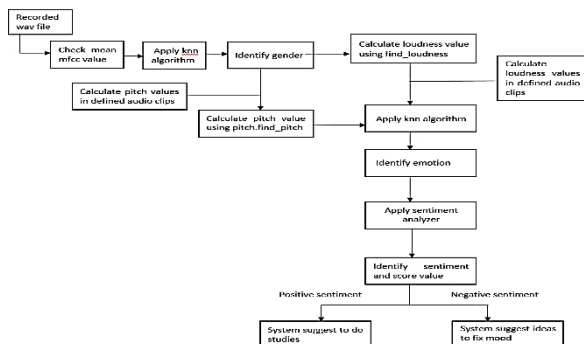


Fig 6: Sentiment analyze using nlp and audio

### D. Voice-based approaches.

Voice-based Question Answering, the last sub part of this system, encourages the student to ask mathematics related voice-based questions, where voice-based and text-based answers are provided in return. This approach is more beneficial as it does not require typing skills or knowledge about handling keyboard as it only encourages student to ask questions verbally [13]. Therefore, either students or adults who does not know how to operate a computer will not find any difficulties when handling this Voice-based Question Answering approach. Since, the voice is taken as the main and only input method, it is converted to machine understandable format. Therefore, the voice-based question is recorded in the initial stage, and thereafter in the middle process it is converted into an array, which is then converted into the text. However, microphone is not needed to record the voice. The main mechanism, in this scenario is Voice to Text (VTT) under Speech Recognition.

The process in generating the answer have approaches as described in the next phrase. Initially the converted text needed to be categorized as in examples 1,2 and must be filtered according to its mathematical and important terms as shown in examples 3. Meanwhile, predictions and decisions must be taken as English language has lots of homophones. Finally, correct answer should be generated.

Example 1:

Text: What is the answer to 167 multiply by 6?

Category: Multi\_2

Example 2:

Text: What is the answer to 167 multiply by 6?

Category: Multi\_1

Example 3:

What is the answer to 167 multiply by 6?

Filtered text =167, multiply,6

Thus, to categorize the questions according to their mathematical forms, a sentence classification model has been trained under supervised learning by using CNN and LSTM deep neural networks, with the possible user questions related to the grade 5 mathematics as labels. Therefore, it is used in predicting the question category of the student question, as the initial process in answer generating mechanisms. Thereafter, categorized text is sent through another function which finds the important terms in the text. Relevant function uses a trained model of custom named entity recognition. Then, this function recognizes the important terms in the user question, which are further used in other functionalities like generating answers and providing question solving steps to the student.

Hence with, correct answer is generated according to identified category. However, the answer is given through both voice and text format, since the student might need the pronouncing way of the answer, way of writing the answer, and as well as the solving steps. Therefore, text and voice-

based answer is provided to the user at the same time. Thus, generated answer is converted to voice by using Text to Voice concept (TTV) and provided through the speakers in the machine, and displays on the screen at the same time. Process goes as the figure 7.

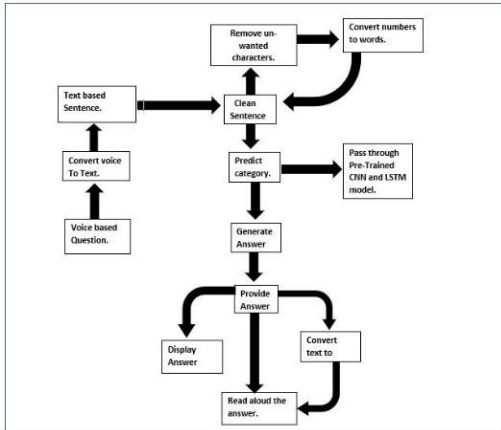


Fig 7: voice-based technique workflow

IV. RESULTS

However, the success of any invention relies on the positive reviews sent by the target community after using the relevant invention. Therefore, reviews sent by the potential sample users about the appropriateness and user friendliness of the system are important for every invention. Correspondingly, such attempt was done by the research team by letting a sample of primary class students use and interact with our Guru Gedara Smart Mathematical E-Learning Platform. The research team received positive reviews about the system, from randomly selected forty students, following the testing. The feedback results are shown in figure 8.

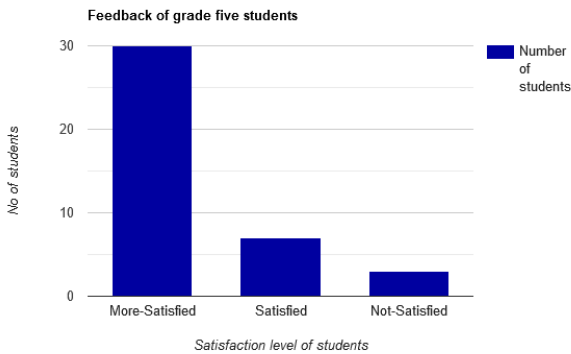


Fig 8: Feedback from group of forty students

In the smart video learning component named Search and Surf, students must answer the IQ tests and questionnaires provided, to identify the most appropriate learning method for the relevant student as mentioned in the section A. Then the defined ML builder function shows the selected appropriate learning method with to the compared results of the questionnaire. ML model predicts the appropriate learning method with 88.25% of accuracy up to the current development phase. Below figure 9 shows the ML model accuracy rate with R squared value.

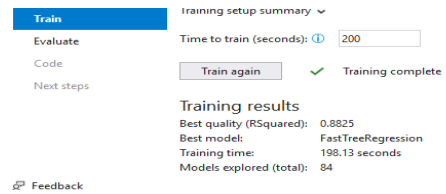


Fig 9: ML model accuracy rate with r squared value

When consider the automated question generating section, it is supposed to generate the target score for the test to motivate the student. Therefore, this target score is predicted by using the student’s study hours and the gender by using regression tree algorithm for analysis. Based on the results of the prediction, it shows 71% of for getting accurate results when testing the machine learning model as shown in figure 10.

r squared value.....  
 0.7153342516063266  
 r squared value as percentage 71%  
 Mean Absolute Error: 2.026051151511092

Fig 10: Accuracy of target score prediction model

Below figure 11 illustrates the Q table of identifying weak areas of the student to generate questions and guide students.

Trained Q matrix:

[ [ 0., 79.91344028, 63.93075222, 63.93075222, 63.93075222
63.93075222, 63.93075222, 0. ]
[ 63.93075222, 0., 63.93075222, 63.93075222, 63.8108161
63.85144487, 63.61719463, 99.89180035]
[ 63.93075222, 79.91344028, 0., 0., 0.
0., 0., 0., ]
[ 63.93075222, 79.91344028, 0., 0., 0.
0., 0., 0., ]
[ 63.93075222, 79.91344028, 0., 0., 0.

Fig 11: Trained Q matrix

According to the marking chart depicted in the fig 12, it proves that the students’ success in improving the knowledge for 1<sup>st</sup> lesson defined for mathematics during 5 attempts.

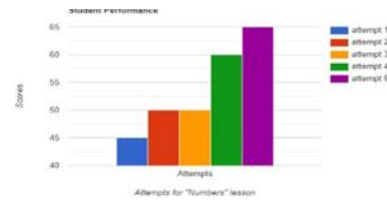


Fig 12: Student performance based on the attempts of first lesson.

A such effort with the correctly identified emotional category when applying the audio analysis, is illustrated in the figure 13. According to the figure, relevant section has identified the student’s current emotional state as positive which was a correct identification.

```
{'1': 'neutral', '2': 'calm', '3': 'happy', '4': 'sad', '5': 'angry', '6': 'fearful', '7': 'disgust', '8': 'surprised'}
[(2.0, 19)] 3.0
happy
```

Fig 13: Current emotion state using audio

Moreover, students' scoring values for relevant emotional state within a week shown in figure 14, clarifies that the relevant function works properly.

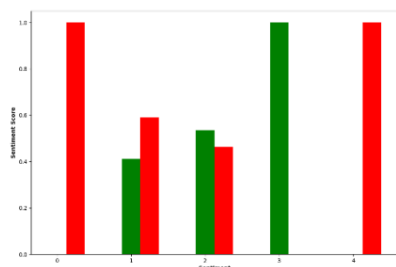


Fig 14: Variation of sentiment within a week

Besides, when considering the Voice-based Question Answering approach, it also works under the accuracy level of 85% percent. Since it has to depend on the voice-based input which might consist of homophones as well as mispronunciations of the user, it affects 15% of drawback for the overall process. However, capturing voice, converting voice to text, and text to voice functionalities have higher accuracy levels when the user has proper internet connections. Therefore, overall sub section works as expected when the above-mentioned drawbacks do not appear.

#### V. CONCLUSION AND FUTURE WORK

The main objective of conducting this research is to create a successful, attractive learning environment and progressive process for the parents concerned to improve their children's learning motivation and ability to get high marks in grade 5 examination. Therefore, the members of this research team have developed a web-based application which is able to fulfill the students' desires of being a talented student, by providing learning motivation, identifying the appropriate learning method, and letting the students to change their negative emotions to positive emotions. Moreover, students are encouraged to improve their knowledge, by facing system generated MCQ based quizzes, and also by asking mathematic related questions from this web application, which provides the correct answers via both audio and text format in return. Since, this web application has been developed targeting grade 5 students, who sit for the grade 5 scholarship examination, inventers plan to promote it among parents and grade 5 students by introducing it to schools as the main approach.

Moreover, inventers plan to introduce this web-based approach as a mobile application to provide best experiences, where students do not need a desktop or laptop to use the application. Therefore, past paper and model paper section with essay type questions, extracting features in audio file to identify the mental state of the student, generating time table to make the students more capable in managing time efficiently, and implementing chat bot feature in the question answering system to connect with the students in more user-friendly way likewise, extra functionalities have been considered as the future work related to the research to optimize the service supply to the students. Apart from that, it is expected to make available this system to users to use this in their native languages in future.

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