A Gamified Virtual Learning Environment to Enhance Online Teaching and Learning Experience

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***Abstract*—Physical lecture delivery not only focuses on lecture material delivery but also on maintaining positive touch between lecturer and students and student to student. Online lectures are gaining popularity as a result of the Covid-19 pandemic situation. The majority of educational institutions have shifted to online delivery through the use of current video conferencing solutions. Due to the fact that video conferencing solutions are not designed for academic purposes, the learning-teaching process has become ineffective. Although humankind is naturally social and favors face-to-face conversation, online delivery is new to the majority of students and instructors. Current off-campus lecture delivery has created a barrier to students' attentiveness during the lecture and group studying. Also, the lecturer can not see the attentiveness of the students. A multi-user virtual learning environment that addresses the above-mentioned issues is introduced as the developed solution's primary deliverable. Apart from these problems, the research addresses the students' isolation during online lectures. Students attend online lectures from the comfort of their own homes and remain alone throughout the presentation. The physical separation of lecturers and students and between students and students causes students to feel isolated during lectures, which can have a detrimental effect on students' academic development and their social and psychological development. The suggested method would address the mentioned issue by the virtual group study environment.**

***Index Terms*—Online Learning, E-Learning, Gamification, Student Attention, Collaborative Learning, Group Study, Lecture note**

I. Introduction and Literature Review

Education is defined as the process of acquiring skills, value, information via experience. The morale and attitude of a person develop as a result of appropriate education, which includes information and discipline. As a result, education has risen to become one of the essential requirements for a person in today's society. Student academic life is divided into three stages: primary, secondary, and tertiary care. Missing one of these stages might have a negative impact on the students' future employment. They must complete these educational phases at some point in their careers.

A consequence of the Covid-19 pandemic was detrimental to both the local and international schooling industries. In particular, social distance has had an impact on nearly all sectors of society, with education being one of them [1]. According to the figures released by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) [2], Covid-19 has impacted 98.6% of learners globally, representing more than 200 nations. In order to address this issue, more than 90% of countries throughout the world have implemented e-learning programs. The summary of UNESCO data is depicted in Figure 1. The majority of educational institutions have been compelled to perform their academic activities online due to this situation. A form of teaching in which lessons or course material are delivered through electronic media, primarily the internet, is known as online learning or E-Learning [3].

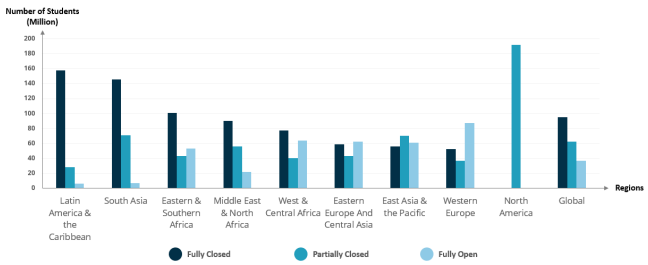

Fig. 1. Number of students (in million) impacted in countries due to School Closure.

A number of various systems for online learning have been developed by companies such as Microsoft, Google, Cisco, and Zoom, among others. Despite the fact that there are several platforms accessible, there is no assurance that students who participate in lectures on these platforms pay attention to the lecturer instead of a physical class where the teacher would have direct contact with the student. Because there are no commercial platforms available for online lecture delivery at this time, they are merely conferencing platforms in disguise. Moreover, due to a variety of factors such as a poor network connection or boredom, students are unable to take accurate notes, which might lead to difficulties when it comes time to take the tests themselves. A lack of connection between students and lecturers, as well as communication and social skills deficiencies have been recognized as the primary causes for this situation [4].

However, e-learning was an exciting topic even before the

Covid-19 pandemic situation, and it has been evolving since the beginning of the new millennium [5]. Though the world has been researching about e-learning for years, researchers have yet to implement it in a way that is useful for students. This could be identified as a number of reasons for not using [6], [7].

- Lesser attention to the lecture delivery.
- The lecturer cannot have an idea about the attentiveness of the students.
- Social isolation of the students.
- Lack of face-to-face communication.
- Lack of self-motivation of the students.

Therefore, most education institutes used traditional classroom-based teaching and learning process since it has no difficulties with the following concerns, and it is more effective and productive teaching and learning process. Moreover, as identified in survey data, it is validated that the students like on-campus lecture delivery more than online lecture delivery. Therefore, according to the findings of the research team's investigations, it has been identified what the pain points those students are experiencing and the user requirements that need to be addressed by the suggested solution. The following subsections show the review of current literature and the identified main user requirements.

A. Attention Detection

Remote education has been widely adopted due to the Covid-19 situation [8]. Because of this situation, the interaction between the student and the lecturer has been reduced [9]. Therefore, students attentiveness towards the lecture is less compared with the physical lecture. Currently, video conferencing tools such as Microsoft Teams and Zoom are used to conduct remote education. Still, none of these platforms can capture the attention of the student. Even though applications such as Face Reader exist [10], which could capture few emotions such as happy, sad, and angry, but this application cannot interpret the captured emotion to attention.

B. Simulated Student Behavior

Most students are unwilling to expose their faces and backgrounds to the public during online lectures. However, knowing how many students actively engage in the lecture and how many students understand the concept described would aid achieve the lecture's objective. Since the students' lack live reactions, conducting a lecture just in front of a camera would be challenging to the lecturers who used to conduct lectures in a physical classroom. Although current commercial applications provide face to face web camera option, that is not capable of observing all the students' live reactions and behaviours.

C. Collaborative Study

According to the research papers and materials that have been made accessible, studies have been conducted, and commercial solutions have been deployed to facilitate collaborative learning and improve the quality of collaborative learning. However, there is a fundamental problem with all of these solutions: they are ineffective in actual collaborative learning. These particular methods are focused on a small number of elements that can be beneficial in enhancing the efficiency of collaborative learning.

Researchers D. Coetzee, A. Fox, M. A. Hearst, and B. Hartmann conducted a study on "Chatrooms in MOOCs" [11] and "Initial experiences with small group discussions in MOOCs" [12] that focused solely on MOOCs (Massive Open Online Courses) and text-based discussion methods. On the other hand, these studies are more narrowly focused, and they have not taken into consideration other essential factors that contribute to the overall quality of collaborative learning.

In comparison, a number of commercial solutions have addressed certain additional aspects aimed at enhancing collaborative learning in a variety of ways. Cacoo [13], a commercial solution, focuses solely on collaborative content editing, which is a feature that is extremely important for distance learning. Although Cacoo tackles the challenge of shared material editing, it does not address the other elements that must be addressed in order to enable true collaborative learning. Other well-known and frequently used commercial systems do not have the capabilities that are designed for educational purposes. Instead, they provide capabilities that are meant for online meetings and conferences.

As a result, the suggested solution has been enhanced to include features and capabilities that solve aforementioned issues. In terms of collaborative learning, the developed solution is designed with more functionalities such as group text/voice chat, collaborative content editing, virtual group study room, and other features that can improve the quality of collaborative learning and increase the immersion of students in their studies when compared to other research and solutions that are currently available.

D. Lecture note generation

The transcript serves as a written record of what was taught to pupils by lectures on content presented up to a certain point in time. Students may miss crucial keywords or misinterpret ideas, regardless of how clear the lecture is, resulting in a reduced understanding of the subject and worse marks. Transcribing online lectures offers clarity for both the lecturers and the students who are attending the lectures. This also saves educators time by eliminating the need to answer semantical queries and concentrating on more essential main points [14].

The popular online conferencing platforms previously introduced few transcription options. The Microsoft Teams live transcription service provides text transcription of a live conference [15]. Sonix's Transcription app is also introduced to the Zoom platform, where users need to manually upload the audio/video file to get the transcription [16]. However, the major drawbacks in those apps are limited internet bandwidth availability and traffic problems, using provider APIs (Application Programming Interfaces) to capture data, which led to poor audio quality [14], [17]. Furthermore, many apps were not designed with e-learning in mind.

II. Methodology

The developed solution has been offered for enhancing the e-learning experience, contains the following capabilities:

- Capturing students' attention levels and transferring the captured data to the lecturer or teacher using a gamified virtual classroom view and through a web front-end.
- Using a gamified virtual group study environment can facilitate collaborative learning when students are not all in the same physical place.
- Provide students with a summarized note of the lecture.

Since there are several aspects to consider in order to give the best possible solution implementing an enhanced E-learning platform is a challenging process to do successfully. Therefore, the feasibility study and user research were carried out as the very first job of the project.

A. User Research and Feasibility Study

Considering that implementing an enhanced E-learning system is a difficult task to complete successfully, the research team conducted a preliminary study to determine the feasibility of implementing such a solution and the requirements of the users. As previously mentioned, the research team used an efficient and effective research methodology in the first phase of the research to achieve success. Although face-to-face interviews and field studies are more effective user research methodologies, those approaches were unable to be used in global pandemic situations. Therefore, Two main methods were used to identify the user requirements.

- User Research Surveys.
- Studied the current literature of the domain.

In order to determine user needs, two user surveys were performed: a primary survey and a secondary survey. It was decided to conduct a secondary survey since several of the issues raised in the initial survey were not addressed. By completing the primary survey and reviewing the current literature, it was discovered that there are user requirements that the existing literature has not yet met. However, because the use of information technology could not correct all of the inadequacies, a secondary survey was carried out in order to determine which solutions were the most in need.

B. Identified Problems

Students and lecturers are subjected to a great deal of difficulty because there is no appropriate tool designed specifically for online lecture delivery. As a result, the lecturer/teacher cannot observe the students' real-time reactions and participation. For instructors who are used to delivering lectures in a classroom, delivering a lecture just in front of a camera would be a challenge.

An online survey was circulated among 396 Sri Lankan university and school students to get their thoughts on the online lecture delivery. When the results were analysed, it was discovered that students are bored and distracted the majority of the time during online lectures.

It is a well-known fact that students are bored and distracted during a lecture that lasts more than 1 hour. Apart from that, there may be some pause time or brief pauses throughout a regular lecture delivery. Students have the opportunity to engage with one another and discuss whatever they desire. It automatically becomes a stress-relief method [18]. The situation, on the other hand, is different in the case of online lecture delivery. Students have a feeling of alienation. 76% of students agreed that the online course delivery made them feel alienated during the breaks, and they also felt that it does so overall.

Furthermore, while students are attending on-campus lectures, they gather to work on group projects, which results in Collaborative learning, which is a learning technique that has a significant amount of beneficial influence on students [19]. However, there are currently no appropriate solutions in the form of conferencing technologies to assist in collaborative learning.

Figure 2 shows the High-Level System Architecture of the developed application. The system has two major components for students as well as for lecturers. The student's component consists of two sub-components. One sub-component is built using the Unity game engine for group studies, and the other sub-component helps capture and measure the attention level of the students during a lecture. The lecturer component consists of a virtual classroom where the lecturer can see the student's attention level and a lecture note generator. Furthermore, a web application front-end is provided to the lecturer to get a graphical representation of the attentiveness of the students. The following subsections show the ways how above-identified problems were addressed in this research study.

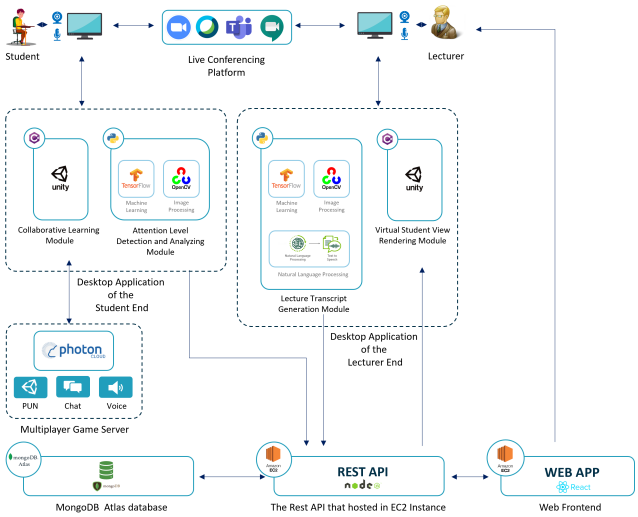

Fig. 2. High Level System Architecture

1) Attention Detector:

The attention detection module can measure the attention level of the student based on their facial emotions. This module

consists of two main components; The Deep learning model to capture the facial emotion of the student and the Background processing application to get data from the student's web camera. A dataset consisting of 28700 and 4000 facial emotion images were used as train and test data to train the deep learning model. The entire dataset was preprocessed before fitting it to the model. CNN (Convolutional Neural Network) was the type of neural network type used to develop the model. The trained model was embedded in the background process application, running at the student's device. This application accesses the web camera to get the input data for the emotion detection model. Since emotions might vary from time to time to get a more accurate value for it, the student's emotions are captured for a period, thereby selecting the emotion that has been predicted most is considered. The Overall attention level is calculated using the following equation.

$$\sum_{i=0}^{n} \frac{DE_i \times EW}{n}$$

Where :

- AI = Attention Index
- DE = Dominant Emotion
- EW = Emotion Weight
- OAI = Overall Attention Index
- n = Number of iterations

Emotion weights are finding in the research conduct by P Sharma et al.'s, 2019 [20]. Since this application requires the facial data of the student, edge computing architecture is used to process the facial emotions of the student into attention level. Edge computing helps process the data at the client-side rather than sending sensitive data to a cloud server vulnerable to attacks. Other than privacy, bandwidth consumption is also less.

2) Student Behavior Simulator:

The system provides a near real-time classroom view with the 3D model representing the students who attended the lecture. Live reactions and behaviors of the students are shown in the classroom view. The lecturer is provided with the ability to observe all students' attentiveness and overall attentiveness of the classroom. The lecturer can also talk to single or specific students separately while the lecture is going on. Furthermore, the lecturer is notified if most of the students are confused at a specific moment. All the collected data from Attention Detector is sent to a No-SQL database through a RESTful (Representational State Transfer) web service. The gamified classroom view is a separate desktop client application that runs on the lecturer end, and it consumes data via the API. Stored data uses the game engine to represent the students' behaviours in the lecturer end in near real-time.

3) Collaborative Study Room:

As another part of the developed solution, a collaborative study virtual learning environment is added. In "benefits of collaborative learning" [19] M. Laal and S. M. Ghodsi and In "gamification in education" [21], G. Kiryakova et al. have stated that the collaborative group study has a positive impact on students as well as on the lecturers/teachers who conduct the learning session. This collaborative study virtual learning environment is implemented using gamification techniques that increase immersion, motivation, and the engagement of students to the conducted lecture. In terms of gamification, gaming mechanisms are applied to the non-gaming environment to enhance the process enacted and the experience of those involved [22]. Furthermore, K. M. Kapp's "the gamification of learning and instruction: game-based methods and strategies for training and education" has stated that "gamification is the ideal process to creating engaging learning environments" [23].

In terms of the features and functionalities of this virtual learning environment, students do not need to use many tools to do their group activities. The same system can be used to do group studies. Nevertheless, if students do group studies with the existing solutions, they require other tools to do group activities which is a burden and unorganized circumstance to students. By using our solution, students can communicate with each other using text or voice chats. Also, they can do various group study-related tasks such as brainwriting, brainstorming, and mind mapping.

This collaborative study virtual learning environment has two intentions. The first one is to provide a way to do the in-class group activities during the online lecture delivery, which is challenging in other existing solutions. Since using the gamification techniques, students' engagement with the lecture is increased. Furthermore, the boredom and the isolation of the students during the lecture time is decreased. The other intention is to provide a solution for the students who try to do their group assignment discussions, project planning while they are in separated locations such as different boarding places or their own homes. Although they can use existing commercial conferencing tools for these discussions that do not provide optimum results since those platforms are not optimized for educational purposes.

4) Lecture note generator:

To allow the finest e-learning to be used, it is necessary to meet all students' needs. It is difficult for students to take notes when attending online courses, especially students with disabilities in writing. Thus, providing a meticulously structured and streamlined transcription that incorporates relevant graphic representations can aid these students. An instructor demonstration is recorded and transcribed in real-time from the client-side via the lecture note generating module. Then, it compiles everything and provides a summarized lecture note. Additionally, visual components that the lecturer shares

in their presentation is captured. In other words, the visual components, along with a summarization of the transcription, are organized together. Since the lecture notes are thoroughly processed, they are sent out as PDF-formatted (Portable Document Format) files to students.

III. Results and Discussion

A. Survey Results

A questionnaire was initially circulated among university and school students to get their feedback on online education and its effectiveness. A total of 396 responses were received from university undergraduates and school students. Following pain points were identified as main user requirements, and it was decided that providing a virtual learning environment will reduce these pain points as much as possible. Among them, 84% of students said they feel bored during online lectures, and 89% responded that they do not feel comfortable turning on the web camera and appearing to others in the classroom. Figure 3 depicts the summary of the main findings of the survey.

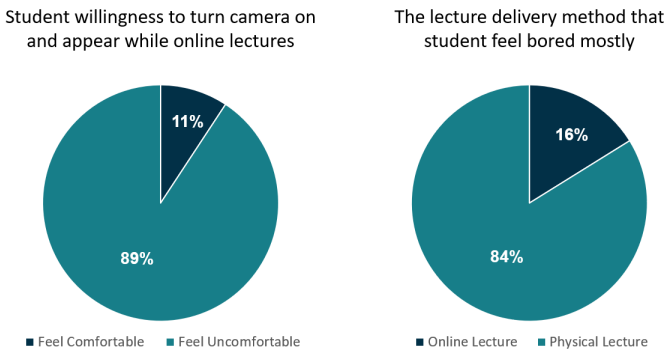

Fig. 3. A summary of the main findings of the survey

B. Attentiveness Test Results

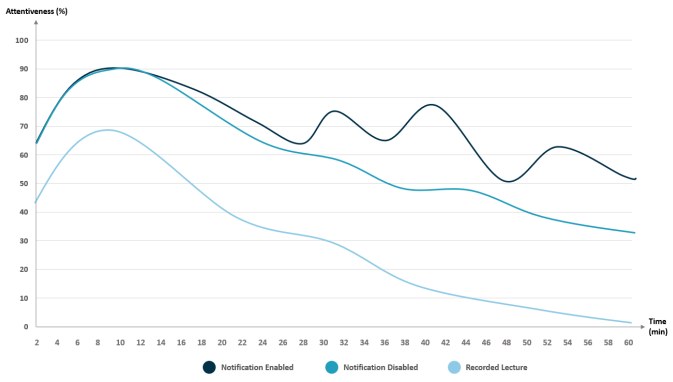

Fig. 4. A comparison of attentiveness in different lecture types

Figure 4 was generated after having a lecture with two groups of 15 students, each without any irrelevant discussions. A live lecture was conducted with attention warning notifications for the first student group, whereas the other group had a lecture without warning notifications. Moreover, the same 30 students participated in watching a recorded lecture. Figure 4 depicts the attention level measurements of those three circumstances. When attention warning notifications are enabled, and if students attention is also declining, a warning notification will be sent from the system to the student.

According to Figure 4, when the notifications of the system were disabled, the graph depicted that the student's attentiveness gradually increased during the first 10minutes. Nevertheless, after that, a gradual decrease in attention level was observed throughout the lecture. Furthermore, Figure 4 illustrates that initially, the student group's attentiveness to having notifications enabled also showed an upward movement. However, the student group having disabled notification showed a decline in attentiveness continuously, but in the student group with notifications enabled, the overall attentiveness increased after a slight decrease. Apart from live lectures, recorded lecturers too show an initial upward momentum in attention level during the first few minutes. However, then it has a drastic decline in attention when compared with live lecturers.

It is a known fact that the optimum attention level duration of a student is about 45-50 minutes. This could clearly be observed in Figure 4. All three trend lines in the graph show there is some decline in attention level after 50 minutes. However, there is an upward movement with notification enabled trend lines due to warning notifications, which helps the students improve their attention level. Effect of notifications to improve attentiveness could be observed throughout the class duration, i.e. when there is a slight drop in class attentiveness, warning notifications have helped to push up the overall attentiveness.

C. Model Accuracy

The CNN used to predict the students' emotions show an accuracy of 60% with 70 epochs. Figure 5 illustrates that training accuracy and validation accuracy are almost identical, which means the accuracy of test data is similar to the accuracy of the training data. Figure 6 shows the training and validation loss of the CNN. Training and validation loss gradually decreases with the number of epochs and tends to achieve a stable trend, resulting in neither over-fitting nor under-fitting.

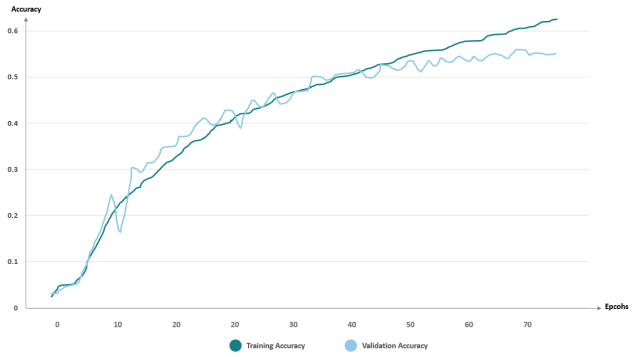

Fig. 5. Training Accuracy vs. Validation Accuracy

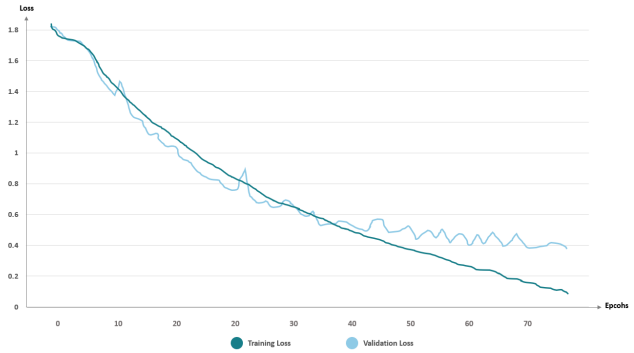

Fig. 6. Training Loss vs. Validation Loss

IV. Conclusion and Future Work

The developed solution is intended to assist students and lecturers who cannot participate in the physical learning-teaching process, primarily due to the global pandemic. Through the use of this solution, the relationship between students and lecturers/teachers is strengthened. Furthermore, this solution attempts to improve distance education by providing attention level monitoring and indicating, enabling the collaborative learning experience, and providing a proper lecture transcript, among other features. With that primary concern addressed, this solution fills in the gaps that have been identified in the current state of affairs in the education sector.

According to the system's designers, the primary advantage is that the lecturer or teacher can adequately understand the students' attention levels, both from an individual student perspective and a whole-classroom perspective. Furthermore, providing a proper lecture note is beneficial for regular students and students who have physical difficulties writing. The collaborative virtual learning environment facilitates the conduct of group studies, which is critical in the educational setting. Students can complete their group studies using this system even if they are not in the exact physical location as one another.

Currently, the machine learning model determines students' levels of attention by observing their facial expressions during class. However, it can be suggested that a new feature can be introduced to capture the drowsiness. It is more beneficial when attempting to determine the level of attention of the students. When determining the level of attention required, the input from the camera is critical. This calculation can therefore benefit from improving the quality of the camera's image input. If the issues that have not been addressed are addressed, the system is more effective than the current solution.

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