

Real-time lecture's micro-quality assessment for diabetic students based on IoTs and cloud computing technologies

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ABSTRACT

Students with diabetes mellitus require more academic attention, intensive flow up, and a moderate temperature environment during classes. In this paper, the learning process for those students is improved by using the internet of things (IoT) and cloud computing technologies. The proposed system improves lecture quality using lecture micro quality which is based on lecture time segmentation. Therefore, the designed system provides each student with a microcontroller-based node to collect information about his understanding status in a real-time fashion. Based on this information, the system provides the lecturer with real-time statistical calculations about vital parameters such as the understanding status of each student, the level of the classroom's understanding ratio, and the total number of students who did not understand the topic which is being explained. The designed system is practically tested in a real classroom environment. The implemented system is practically tested in a real classroom environment and the obtained results showed up an improvement in lecture quality due to the real-time feedback which informed the lecturer to adapt the learning technique.

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1. INTRODUCTION

Diabetes mellitus is an irredeemable longtime disease and is one of the most challenging global health issues. The global dominance of diabetes mellitus is expected to reach 552 million people by 2030 [1]. This disease can cause serious body dysfunctions in organs, vision systems, and neurons which have a great impact on adults and children [2]. Since education is an essential ingredient for a cultivated society, diseases such as diabetes impede most students from education and impact their academic abilities. Authors previous works studied a sample of diabetic and non-diabetic students from various schools. Students academic grades were recorded in the written examination of various courses. These studies clearly illustrated that the students with diabetes achieved lower mean exam grades compared with their non-diabetic student classmates [3]–[5]. Therefore, students with diabetes mellitus require more academic attention and follow-up during lectures than normal students. Moreover, the classroom environment must be convenient for both students and the lecturer. Surrounding temperature is a factor that affects students with diabetes since diabetic individuals have lower sweating responses and less blood flow under the skin during heat exposure [6], [7]. This will impair students ability to concentrate and learn. In traditional classrooms which consist of diabetic students, most lecturers illustrate a topic disregarding the fluctuating level of students understanding ability. This teaching process has a great impact on the psychological situation of these students. However, technology can play a vital role in developing traditional classrooms [8]–[10]. Wu *et al.* [11] examined mobile

technology in classroom response systems (CRS) and its effectiveness in teaching techniques. The study also investigated students experience of CRS via mobile devices. Shen *et al.* [12] developed a smart classroom system to perform student attendance management and interactive function in real-time based on near-field communication. Tissenbaum and Slotta [13] investigated through a series of project designs, the infrastructure of a smart classroom including large projector displays, and their role to provide collaboration between students and teachers. The design also includes the application of intelligent software and real-time communication among students.

On the other hand, internet of things (IoTs) technology plays a vital role in improving the education environment to meet students' needs. IoT is a system that consists of hardware parts connected to a cloud platform via communication protocols. These systems are used to build a strong real-time interaction between students and teachers through instant communication, information management, and environmental information [14]–[18]. According to Chan *et al.* [19], a smart classroom based on IoT is presented. The system consists of two main objectives; an attendance system and energy-saving implementation. The autonomous attendance records attendance from students metric cards which can be viewed on the web. The energy-saving management implies turning off appliances in classrooms autonomously. IoT has also witnessed a rapid advance, especially in the health sector because sensor technology has vastly developed. Vital signs can be measured remotely and health monitoring is an essential application. Souri *et al.* [20] proposed a model to remotely monitor the health status of students. Using sensor technology, data is collected and analyzed through machine learning algorithms for detecting potential risks of physiological changes for students. Although these modern classrooms are equipped with illustration tools and sophisticated instruments, they lack real-time lecture quality measurement of healthy and non-healthy students. Lectures may contain various materials or topics that are difficult for non-healthy students to comprehend. That is, some topics require instant feedback from students during a lecture which helps the lecturer either to proceed to the next topic or re-clarify the topic at hand. However, many systems which are reported in the literature enable instant, real-time, and automatic feedback on lecture quality or student satisfaction [21]–[23]. Unfortunately, most of the reported systems produce the quality survey report at the end of the lecture which leads to making this information not beneficial to differentiate whether a lecture topic was understood by students or not. This problem is harder on diabetic students inside the classroom because of their low academic ability. Since classrooms are a combination of diabetic and non-diabetic students, lecturers are invited to assess their level of understanding via instant feedback during lectures using modern technology. In this paper, a type-1 diabetes mellitus student monitoring system based on IoT technology is designed and implemented. The system provides the lecturer with minute follow-up for diabetes students through real-time information about the understanding status of each one, the level of the classroom's understanding which reflects the overall quality of the lecture, and the total number of students who did not understand the topic that is being explained. The authors think this feedback information is very important for both diabetic students and lecturers to proceed with a certain topic in the lecture, re-clarify vital key points related to that topic, and or reconsider the teaching process. Also, the system may store the result of the students assessment to provide insight to the administration/management regarding the instructor's teaching approach. The main contributions of this manuscript are: i) visualize real-time feedback from each student which enable the lecturer to monitor the understanding status of the student during the lecture, especially diabetic students; ii) the designed system provides real-time calculations for lecture micro-quality during fixed time intervals periodically. This is essential for making some decisions related to the learning process strategy; iii) the designed system support scalability feature for future developments; and iv) the designed system can monitor some important environmental parameters such as the inside temperature of the classroom.

The rest of the paper is organized as follows: section 2 explains the proposed method for monitoring students. In section 3, the structure of the system is illustrated. In section 4, the obtained results from the designed system are plotted and discussed. Finally, section 5 contains the conclusion and future development.

2. PROPOSED METHOD

To build an efficient system that improves diabetic student learning achievements, the authors suggest measuring and visualizing the lecturer's quality periodically during the academic lecture. This process should improve the lecture's overall quality. To meet this goal, a lecture time interval is segmented into a series of smaller fixed time intervals called piece of lecture (PoL). Each individual PoL has its quality which is named (micro quality). Therefore, the final lecture quality can be found from (1):

$$\text{Total Lecture quality} = \frac{\sum (\text{Micro qualities})}{\text{Total number of PoL}} \quad (1)$$

On the other hand, PoL interval can be determined based on the lecture interval divided by the lecture quality factor according to (2):

$$\text{PoL (Sec)} = \frac{\text{Interval of Lecture (in sec)}}{Q_f} \quad (2)$$

Where Q_f is the quality factor (must be greater than zero).

The quality factor is an integer number that controls the required number of PoL intervals. If the lecture contains difficult topics, (Q_f) must be a large number to reduce the time of PoL and vice versa. Therefore, the success of lecturer in delivering information during each PoL will generate a successful and high-quality lecture. Based on this assumption, the proposed system must have multiple nodes and IoT cloud services. That is, one node is fixed in front of each student on the desk to report the real-time feedback signal that represents the students status of "understand" or "not understand". The generated signal will take a square shape as shown in Figure 1 in which the higher value is assigned for the "understand status" meanwhile the lower value reports "not-understand".

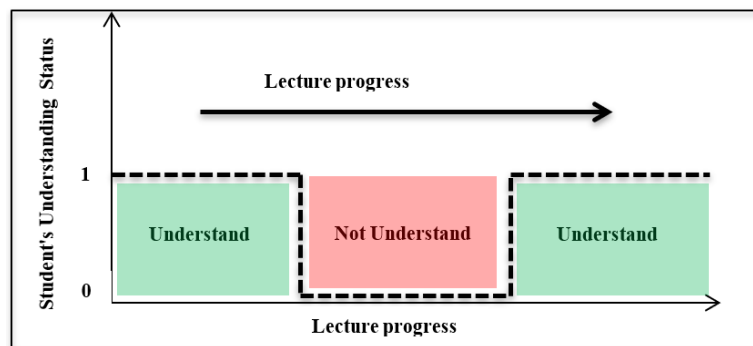


Figure 1. Signal generation for each students

All generated signals will be uploaded continuously to the IoTs cloud for real-time virtualization and analysis. Consequently, statistic calculations must be performed to extract some useful features from each signal or aggregated signals as shown in Figure 2. The measurement of these features helps lecturers to increase lecture quality by choosing the appropriate learning method for students to meet their understanding levels or it is possible to provide feedback to the administration or parents over web services.

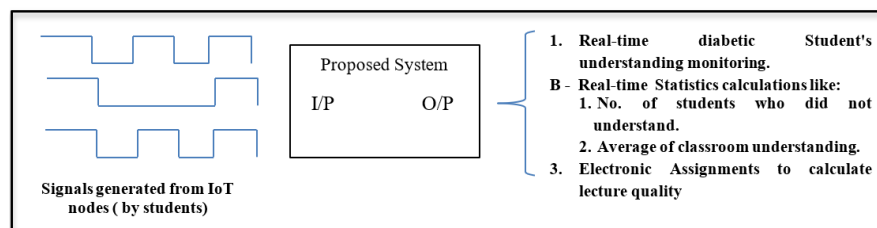


Figure 2. Proposed system operation

3. SYSTEM STRUCTURE

In this section, the proposed hardware, cloud connection, and node flowcharts are described. The main advantages of the design are increasing simplicity and scalability which supports different learning environments at the same time reducing manufacturing costs. However, the block diagram of the designed system is shown in Figure 3. The proposed system consists of many IoT nodes (students nodes). Each node is associated with two pushbuttons to extract the students understanding status as mentioned in the previous section. In addition, an ESP8266 development board is used as a microcontroller to collect and upload edge data [24], [25]. Traditionally, this board supports a wide range of IoT projects due to the integrated Wi-Fi connectivity, low power consumption, and low price. To simplify the designed topology, each node has its

connection to the internet (then to the cloud) via the network router directly. Figure 4 shows the operation flowchart of an individual node.

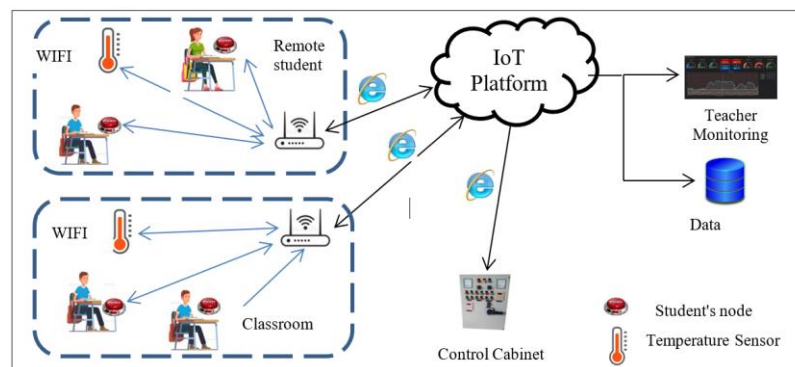


Figure 3. Proposed overall system for real time lecture quality monitoring

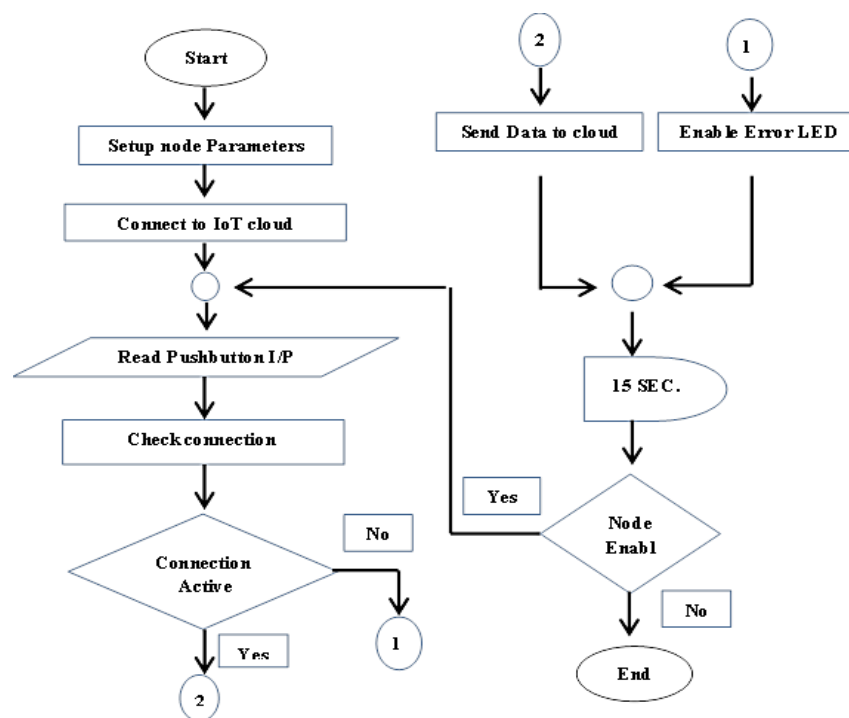


Figure 4. Students node operation flowchart

On the other hand, thingspeak cloud is used as an IoT platform to collect, analyze, visualize, and store uploaded data. Application programming interface (API) keys are used to write and read to/from the cloud's channels in real-time. Furthermore, real-time cloud computing analysis is used to calculate important statistical information during each PoL such as the average value of the classroom's understanding and the number of students who did not understand the topic. That is, "classroom's understanding value" reflects the value of lecture quality during the PoL (micro-quality). Meanwhile, the "number of students who did not understand the topic" helps the lecturer to monitor the total number of students which leads to decreasing the micro-quality value during the PoL. Eventually, all the collected and analyzed live data is shown to the lecturers to help them to adopt presentations or monitor the quality of the lecture at a time. Moreover, the designed system can monitor and control the temperature inside the classroom environment. Separated nodes named "environment node" and "control node" are built and connected to the cloud directly.

4. RESULTS AND DISCUSSION

The proposed system is implemented and tested in a real education environment at the University of Babylon. Figures 5 and 6 show the implemented nodes of the system. In the experiment, five prototypes of identical nodes are built and programmed for five diabetic students. Moreover, Q_f value is selected to be 360 which gives 15 seconds according to (2). Based on these nodes, the designed system can virtualize each students understanding status instantly after each PoL time as shown in Figure 7.

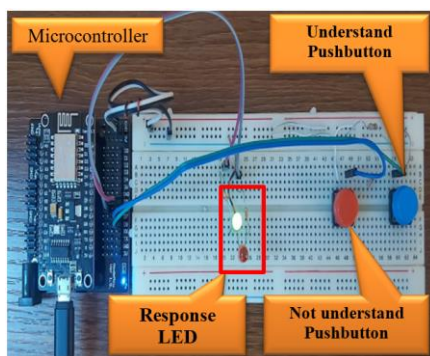


Figure 5. Student node

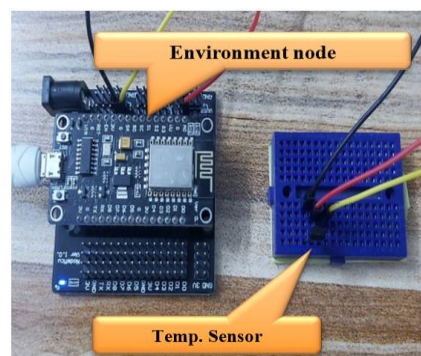


Figure 6. Environment IoT node to measure

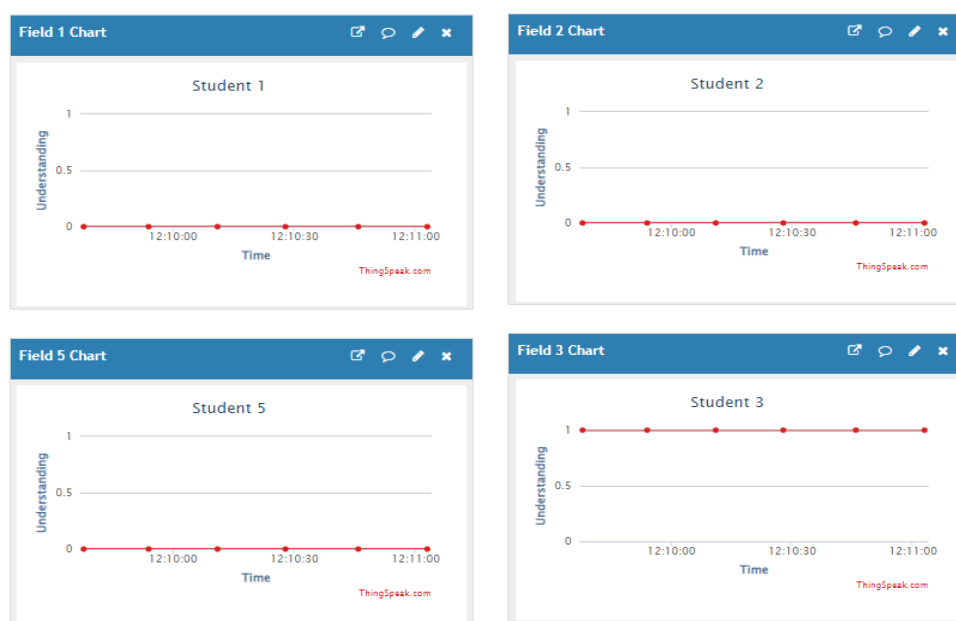


Figure 7. Real-time student understanding status: one represents understanding and zero represents misunderstanding

As mentioned in the previous sections, real-time feedback is important to make the lecturer modify the presentation strategy to meet student requirements. Moreover, the cloud computing services from thingspeak platform are used to calculate the real-time value of the classroom's understanding average and the total number of students who are not understanding as shown in Figures 8 and 9 respectively. These parameters are required to improve system scalability, make lecturers adapt presentations, and evaluate lecture quality momentarily. In relation to temperature monitoring, Figure 10 shows the level of classroom temperature during the experiment. To find the proposed system performance and impact on the understanding rate. The design system is used to aggregate students information in two cases. First, the students feedback is recorded to evaluate the average classroom's understanding ratio but without lecturer notification. While in the second, the information from students is shown to the lecturer in real-time. Figure 11 shows these results.

The figure revealed that the designed system improves each students understanding level. That is, the designed system successfully notified the lecturer to change his/her learning method during the lecture. Therefore, the overall quality of the lecture and student satisfaction increased as shown in Figure 11. Unfortunately, the proposed system has some delay due to the policy of IoT cloud which makes lecture walk slower than normal. Finally, a comparison with most related works reported in the literature is made in Table 1 to demonstrate the contribution and system advantages.

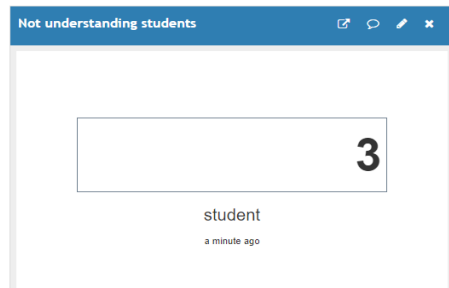


Figure 8. Real-time indicator represents the number of students that misunderstand during PoL

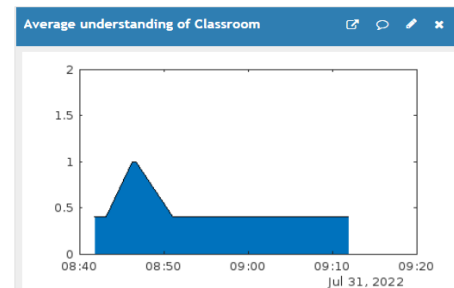


Figure 9. Real-time chart represents the average number of classroom understanding which reflects lecture quality over time

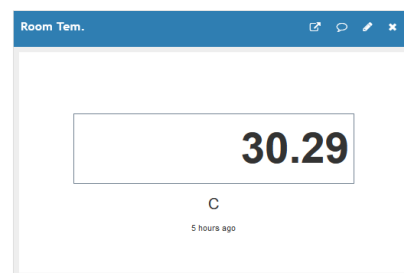
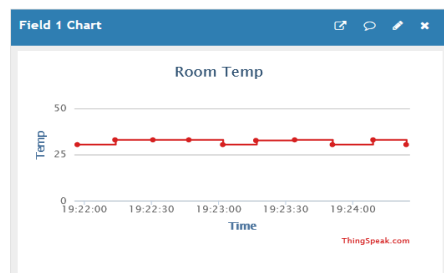


Figure 10. Results of the classroom's environment temperature

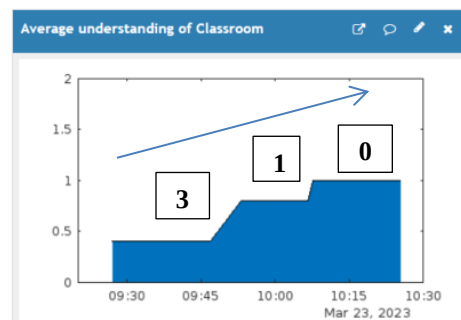


Figure 11. Improvement in lecture quality after applying the proposed system (the numbers inside the box represents the student who did not understand the topic)

Table 1. Comparison between the proposed system and most related reported work in the literature

Work	System output	Structure complexity*	Scalability property	Implementation
[11]	Mobile-based CRS technology evaluation	Medium	N/A	No
[21]	Students satisfaction with the lecture	Very complex	N/A	No
[13]	Quality of lecture	Complex	N/A	No
[23]	Improve the quality of the educational	Very complex	N/A	Yes
This work	Students understanding momentarily during the lecture	Simple	Yes	Yes

Complexity range: very complex, complex, medium, simple

5. CONCLUSION

According to the literature, students with diabetes mellitus require more academic attention and follow-up than normal students during lectures. Therefore, a new IoT-based and cloud computing system is built into this work to increase lecture quality for diabetic students. The idea is based on assumption that the academic lecture interval can be segmented into a series of smaller fixed time intervals called PoL. Each PoL has its quality which is named (micro quality). Therefore, the final lecture quality represents the summation of these micro qualities during lecture time. That is, after each PoL, the designed system produces information about several important parameters related to those students such as individual student understating status, an average ratio of classroom understanding, and the number of students who did not understand. All these parameters can be read by the lecturer in real-time so that he/she can adapt the presentation process to increase lecture quality and student satisfaction. IoTs technology is used to aggregate data from students while cloud computing from thingspeak is used to process uploaded data. Moreover, classroom environment temperature is measured to provide a comfortable class. The obtained results were good and encouraging which accurately improved lecture quality. In addition, the system can be scalable to any number of students attending a face-to-face classroom or a remote one. Also, artificial intelligence algorithms can be added as future work to increase system efficiency.

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