

Smart Interactive Quiz Model For An Education System Based On Fog Computing Technology

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Abstract — In current years, the usage of Internet of Things (IoT) devices takes place in several things in our lives. Several learning organizations profit from using web platforms to enhance and develop their educational environments and attract learners. E-learning is gaining popularity worldwide, and the number of learners enrolled in online courses is so large. The Smart Interactive Quiz (SIQ) presents a new type of quiz modeling to gain the benefits of (IoT) devices in the learning field. The SIQ shows a drawing board that allows users to answer quizzes in different ways like writing or drawing instead of the usual answer type that depends on multiple choices. The development of SIQ achieves based on web technology to receive answers in a graphic view. The answers graphics view is formatted in Scalable Vector Graphics (SVG) represented as text format. The answers are corrected based on finding similarities with the correct answers saved before. Moreover, there is the emergence of the new fog computing technology to bring the services closer to the end-users and to handle the big data resulting from this type of quizzes, and fog computing was emerged to provide a suitable environment to achieve the target.

Finally, the paper uses a new methodology to construct new quizzes for the learning process and gives preliminary results.

Keywords — online quizzes, e-learning quizzes, assessments, quizzes, quizzes models.

I. INTRODUCTION

The usage of technology in the education field has become very popular, and the use of technology in education makes it easier for the learner to obtain what he wants from the information through the Internet. With (IoT) devices, it becomes an easy way to deal with learning environments [1-3].

With the advent of e-learning platforms, every learner has a profile specified for him. This profile can log in to the educational platform and obtain the educational materials from books, videos, audios, and other learning resources for academic courses. And it is preferred to make the learning resources available closer to the learners [4].

The instructors can create interactive quizzes and assessments on the educational platforms for each course, allowing the learner to take these assessments periodically [5]. The evaluation of the learners takes place according to performance during the study period [6]. For instance, MOOCs have been very popular and profoundly studied during the last years [7]. The creation of the quizzes is different from each other, as these quizzes can be in the form of multiple choices or in another way available to the learner to do it online.

As mentioned in Vygotsky in Kozulin et al. [8], they focus on interaction and perception that the instructor acts as a mediator between the student and his knowledge. This approach influenced the creation of conceptual maps for learners's themes. The maps assume the contents a student must learn and those that he probably already knows (from previous lectures).

This research introduces a new method of creating quizzes based on web technology in which students answer freely by providing a drawing board for the student to write the answer on it. This answer can be handwriting or a drawing of a schematic shape, or even a sketch diagram. The answer representation has two views. The first view is for the user in which he uses in the drawing. The second view is the source code of the student answer that takes text format. This text format is an Extensible Markup Language (XML) based vector image format for two-dimensional graphics with support for interactivity and animation called Scalable Vector Graphics (SVG) [9]. The answers are then encoded in base64 encoding format [10] to avoid distortion of data and saved.

The rest of the article is section 2 shows the related works, and section 3, describes the problem definition, section 4 explains the approach, and section 5, the presence of the results. Finally, section 6 conclusion of the research.

II. RELATED WORK

Fredj and Duce (2003) [11] show that in the higher-level diagram, description language that collects the structure and the semantics of a drawing generates accessible presentations in other formats such as text and graphics. Their project was called Graphical Structure Semantic Markup Languages (GraSSML) and created levels of decomposition: presentation, structure, and semantics.



Mong and Brailsford (2003) [12] experimented with the SVG format as a Web rendering technology. This allows a web drawing to be created using SVG instead of Hypertext Markup Language (HTML). Their findings were positive when converting both structured and unstructured Portable Document Formats into SVG.

Sergio Antonio Andrade Freitas, Rita De Cassia Silva, Tiago Franklin R. Lucena, Eduardo do N. Ribeiro, Victor Cotrim De Lima, Rodrigo M. S. Da Silva (2016) [13]. The authors introduced in their research the creation and development of smart quizzes (SQ) that are constructed especially for undergraduate students. The authors also state that the SQ consists of exercises concerning solids mechanics, which is a required course for engineering students. The construction of the SQ is based on multiple choices selection.

III. PROBLEM DEFINITION

In e-learning, questions are placed in the form of multiple-choice, and in some practical colleges, it is required to put questions so that they are answered by drawing, and this feature is not available in the current question system used in e-learning. Therefore, it asks that a model be made so that the teacher helps in developing a quiz and then gives the student the possibility of answering by drawing or handwriting. It gives the student better control over the answer to the question.

IV. THE PROPOSED SMART INTERACTIVE MODEL

In this research, The SIQ will be offered as a new quiz model, and this model allows the instructor to create a quiz that accepts graphical answers from the students. The SIQ allows the instructor to set questions and put model answers to them in the form of images, where the SIQ then corrects the students' answers by comparing them with the model answers previously stored in a smart way. The following steps demonstrate the model sequence:

- The instructor put the questions with model answers and set the quiz.
- The student takes the quiz and starts answering by drawing on the board.
- The drawing is represented as images on the front end and in the back-end as text.
- The answers are converted to base64 and then saved in the database for later display.
- The SIQ starts to auto-correction by comparing the student answer with the model answer and setting a grade.

The SIQ provides the student with a drawing board to answer the question, and this drawing board uses the Scalable Vector Graphics (SVG) language, which is a suitable way to represent images on web pages. The web interface of the browser has two views. The first view displays the graphics, and the second view shows the back-end source code. The next section demonstrates the SVG format.

A. Scalable Vector Graphics (SVG)[14]

The SVG is an Extensible Markup Language (XML)-based vector image format for two-dimensional graphics with support for interactivity and animation.

As such, it's a text-based, open web standard for describing images that can be rendered cleanly at any size and are designed specifically to work well with other web standards, including CSS, DOM, JavaScript, and SMIL. SVG is, essentially, to graphics what HTML is to text. The SVG images and their related behaviors are defined in XML text files, which can be searched, indexed, scripted, and compressed.

Compared to classic bitmapped image formats such as JPEG or PNG, SVG-format vector images can be rendered at any size without loss of quality and can be easily localized by updating the text within them without needing a graphical editor to do so.

B. Quiz preparation view

Each course in the learning system is supported with a question editor. The question editor is equipped with an editor that allows the instructor to enter pictures and shapes, format writing, and add colors. And the editor provides the possibility to add model answers for the auto-correction of the question.

Different types of questions could be applied for the courses, like multiple choices, which is the most used type. In some cases, the instructor needs to add a question that requires a graphical or drawing answer from the student. In this case, the SIQ provides a drawing board to do so.

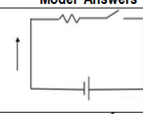
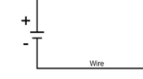
Question Head	Model Answers	Grade	Action
Draw a basic electrical circuit diagram.		10	Edit Delete
Draw a simple electrical circuit.		5	Edit Delete

Figure 1: Shows the questions in the question bank

Figure 1 shows a list of the questions, and the instructor can manage the question content. When the instructor sets the quiz, the questions are selected randomly from the list and displayed to the students at the quiz start time. And the student can answer the quiz online when it starts.

C. Student Answer view

The SIQ offers a new type of receiving students' answers. It allows the student to use the IoT device to answer by displaying a drawing board, and the student puts his answer by drawing or writing using a pen designated for the IoT device.

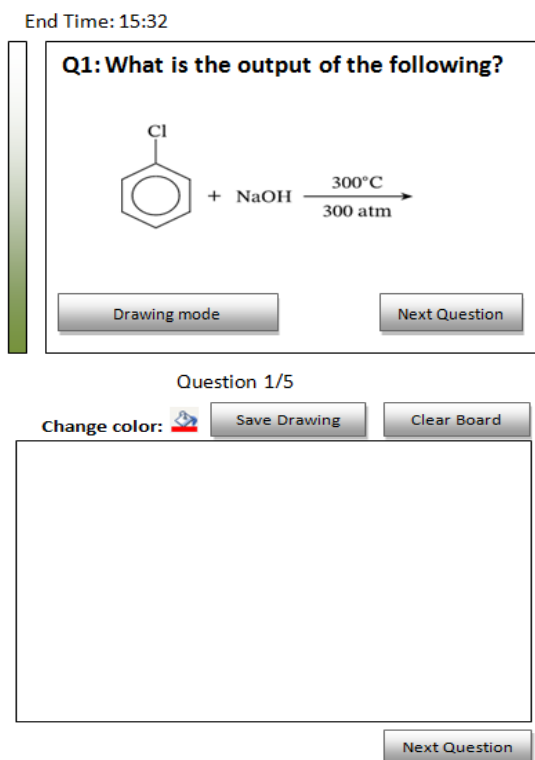


Figure 2: a) Shows the student question view – b) Answer panel

In figure 2-a, the question set by the instructor is shown to the student. Figure 2-b shows the drawing board for students to do the answer.

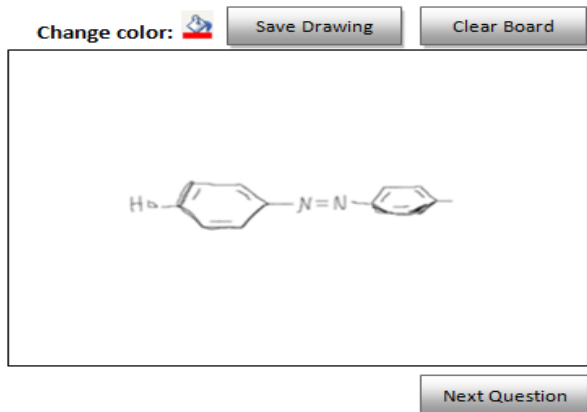


Figure 3: The student answer from IoT device

In figure 3, the student answers that are represented in the SVG format have two views. The first view is the web view, which shows it as an image, and the back-end view is represented as text. According to the model, the back-end is encoded to base64 encode then saved in the smart correction method.

D. Smart quiz correction

The question correction was done automatically according to model answers of the question in which finding the percent of similarity between the student answer and the model answers. The image similarity

technique is better than comparison because it is more accurate to set the grade. So, the correction of the student answer is done according to the following algorithm:

Algorithm 1: Question correction algorithm

```
function check_answer(exam_id, user_id):
    Input: user_id, exam_id.
    userAnswers = getAnswers(user_id);
    ModelAnswers = getModels(question_id);
    Results = [];
    TotalScore = 0;
    for(int i=0; i < userAnswers.length; i++):
        for(int j=0; j < ModelAnswers.length; j++):
            percent = similar_img(user_img,
            ModelAnswers[j]); // get similarity percent
            Results[question_id] = percent;
        // set grade in array
        TotalScore += percent;
    endfor
    endfor
    print("Your score: " + TotalScore);
Output: the record of corrected answers saved in the
database.
end function
```

Several programming languages could be used to measure the similarity percent between the student answers and the model answer, like MatLab, Python, and PHP [15].

The similarity between images was measured according to finding contours in both source and target images. Contours are defined as the line joining all the points along the boundary of an image with the same intensity [16]. Contours come in handy in shape analysis, finding the object's size of interest, and object detection. The algorithm used in auto-correction is shown below:

Algorithm 2: image similarity percentage between two images with finding contours:

```
Input(img1, img2)
function similar_img(img1, img2):
    File1 = read(img1);
    File2 = read(img2);
    // convert images to gray scale for simple comparison
    Imgtogray1 = getGray(File1);
    Imgtogray2 = getGray(File2);
    // get the main contours on the images
    contours1 = findcontours(Imgtogray1);
    contours2 = findcontours(Imgtogray2);
    // get the difference between the contours
    percent = abs(contours1 - contours2);
    return percent;
end function
Output: percent_of_similarity;
```

First, the student answer is converted from SVG to PNG format. And then finding contours take place. Then the same thing is done on the model answer images and then find contours on them. After that, a comparison between the student answer contours and the model answer contours according to figure 4.

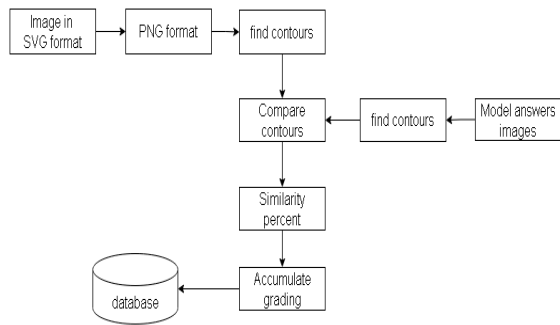


Figure 4: Correcting student answers using image similarity technique

The data flow in the SIQ starting from the student answer screen and ending at the database need to be explained in which the student answer is received in SVG format. The data analysis could be done for this model.

E. Data analysis

The SVG format is like XML language. So, the answers data are encoded to the base64-encoded format, which saves data without any loss of its contents. The Base64 is an encoding and decoding technique used to convert binary data to an American Standard for Information Interchange (ASCII) text format, and vice versa. It transfers data over a medium that only supports ASCII formats, such as email messages on Multipurpose Internet Mail Extension (MIME) and Extensible Markup Language (XML) data.

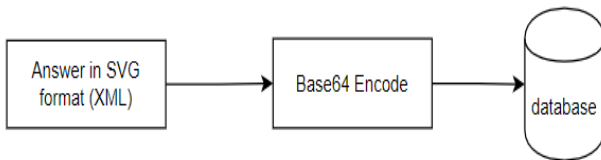


Figure 5: Data analysis for student answer

The instructor can see the student's answer by decoding the saved data back again to its view and could be previewed it on the web and revise the grading for the question.

F. Emerging fog computing for better performance

The SIQ data is an image representation in the format of SVG language. These data are so large may cause latency in learning environments. So that, fog computing technology was emerged to enhance the performance and decrease the latency [17].

In this article, an experiment was conducted on a fog platform and a cloud platform. The response time for this experiment was measured to choose the best platform to apply the SIQ.

V. RESULTS

The results were obtained by applying a simulation algorithm to collect the response time and throughputs from the learning platform. The experiment was conducted on a sample of 1500 students, and they took the quiz on

both platforms. The platforms used in the experiment are based on:

- Cloud computing technology [17].
- Fog computing technology [17].

After collecting the data and refining the results, data received from users is ranged from 1000KB to 5000KB, which is represented as follow:

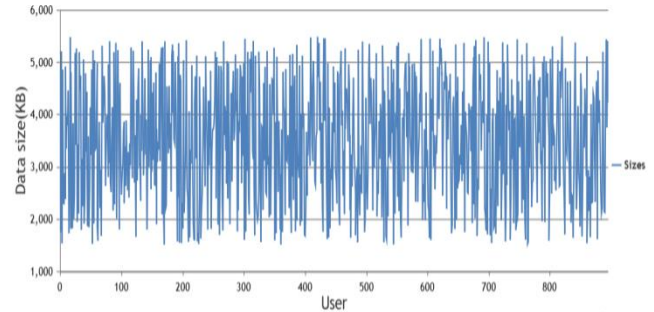


Figure 1: Data received during experiment

A. Results from using cloud model only

The experiment was conducted on the cloud platform by loading the quiz page to the students and measuring the response time. Then the response time was measured again when saving the student's answer to the questions. The results are as follow:

Table 1: Loading exam page and saving student answers statistics on cloud model

Description	On loading exam	On saving answers
Total requests	1500 requests	1500 requests
Total response time	1227.109 Seconds	1799.16 Seconds
Max response time	11.85 Seconds	12.015 Seconds
Min response time	0.672 Seconds	0.900 Seconds
Average response time	0.818 Seconds	1.2 Seconds
Standard Dev.	0.466	0.535

For the cloud platform, the response time and throughput are plotted in the figures below:

Table 2: Response time and throughputs on cloud model

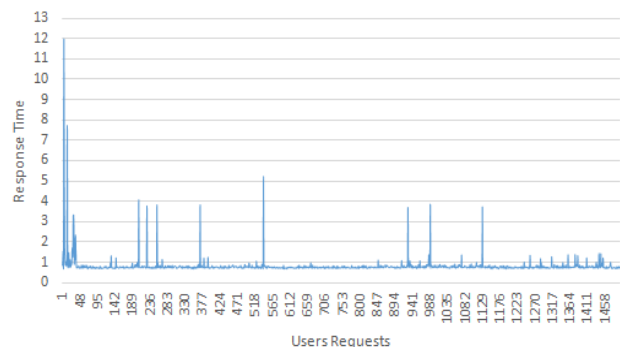


Figure 2: Response time for loading exam page

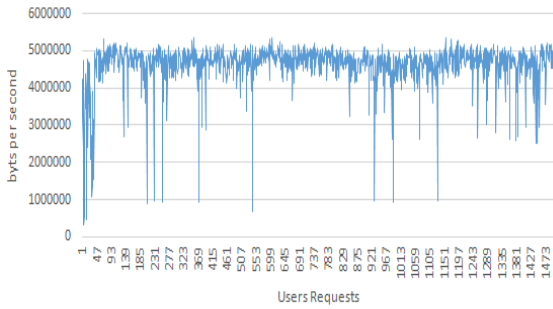


Figure 3: Throughputs for loading exam time

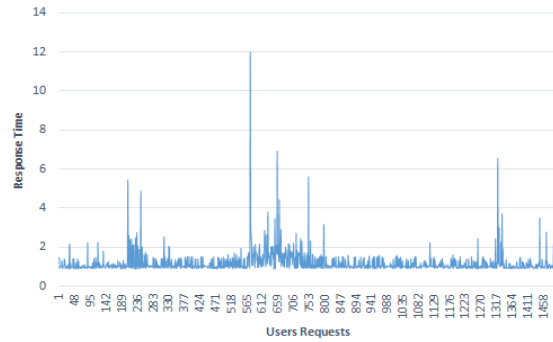


Figure 4: Response time for saving student answer

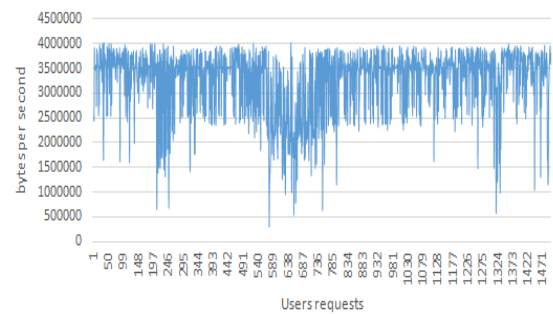


Figure 5: Throughputs for saving student answer

B. Results from using fog platform

In this experiment, three fog nodes are used as an example for using fog computing technology which is decentralized, and users connected to it according to their geo-locations. The number of users split out over the three fog nodes based on their locations. So, that the loading time improved, and the performance became better. The results of loading the exam page are as follow:

Table 3: Loading exam page statistics on fog nodes

Description	Loading exam Fog 1	Loading exam Fog 2	Loading exam Fog 3
Total requests	357	683	460
Total response time	13.96	52.62	23.20
Max response time	0.101	0.240	0.189
Min response time	0.004	0.004	0.004
Average response time	0.039	0.077	0.050
Standard Dev.	0.022	0.048	0.028

The results of saving the student answers are as follow:

Table 4: Saving student answers statistics on fog nodes:

Description	Saving answers Fog 3	Saving answers Fog 2	Saving answers Fog 1
Total requests	460	683	357
Total response time	24.07	52.98	14.58
Max response time	0.316	0.450	0.198
Min response time	0.006	0.008	0.006
Average response time	0.052	0.077	0.040
Standard Dev.	0.031	0.046	0.024

The fog nodes response time and throughputs are illustrated in the figures below:

- Results on fog node1:

Table 5: Response time and throughputs on fog node 1:

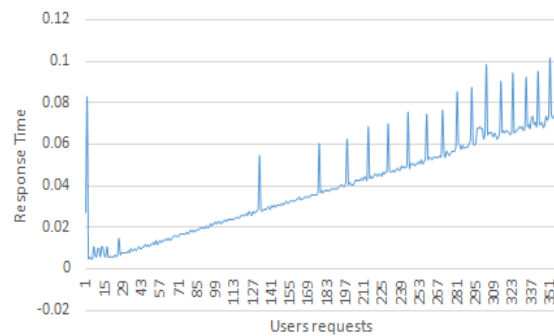


Figure 6: Response time for loading exam page

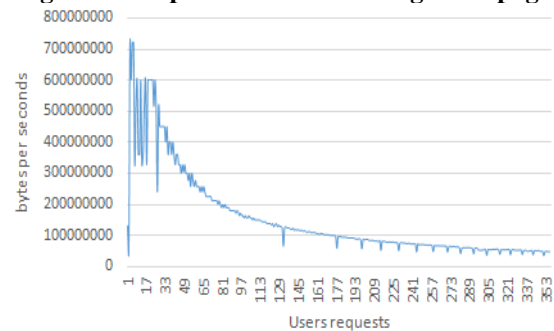


Figure 7: Throughputs for loading exam time

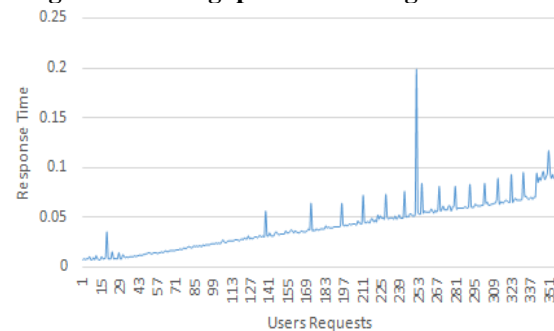


Figure 8: Response time for saving student answer

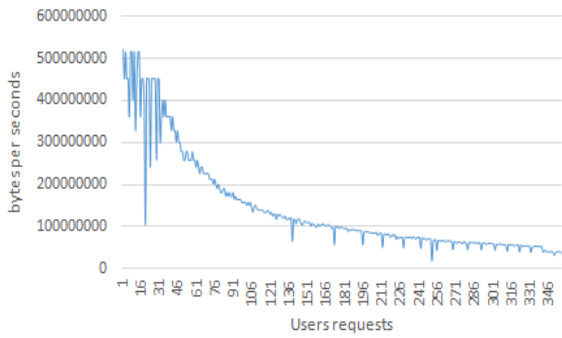


Figure 9: Throughputs for saving student answer

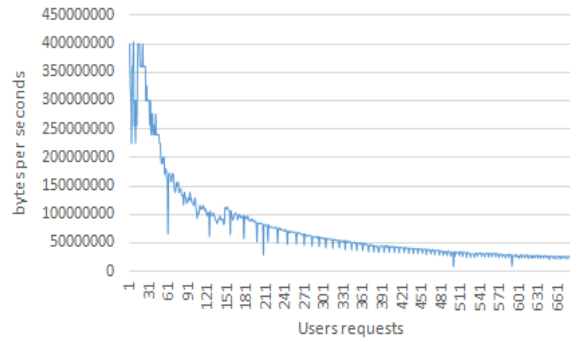


Figure 13: Throughputs for saving student answer

- Results on fog node2:

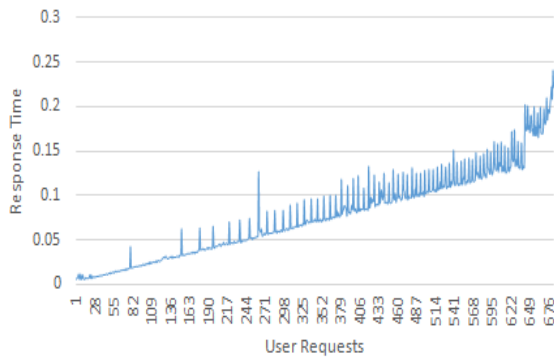


Figure 10: Response time for loading exam page

- Results on fog node3:

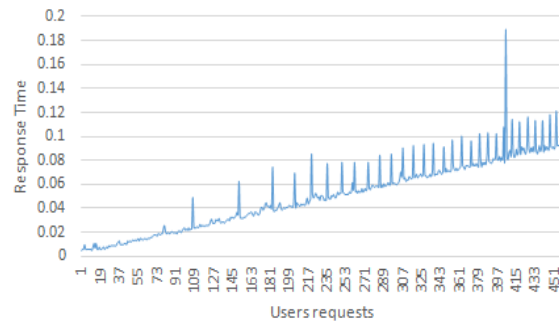


Figure 14: Response time for loading exam page

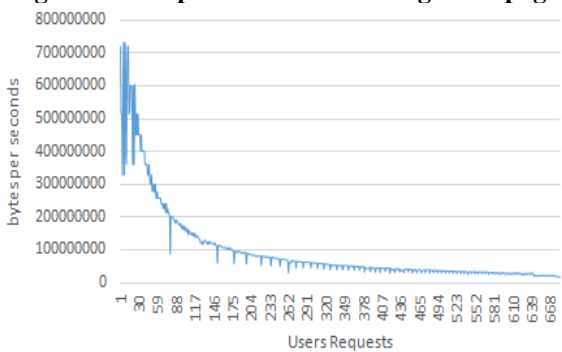


Figure 11: Throughputs for loading exam time

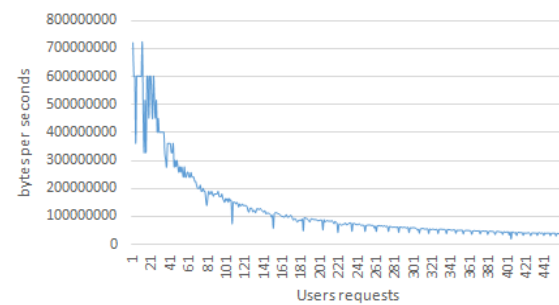


Figure 15: Throughputs for loading exam time

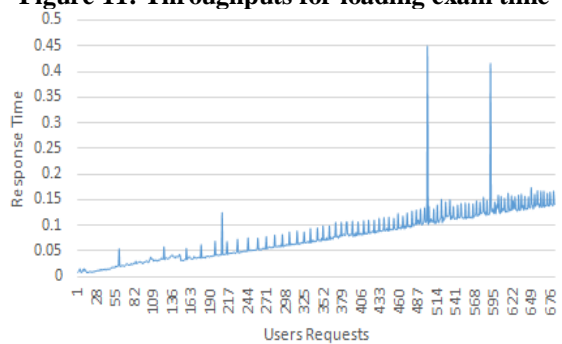


Figure 12: Response time for saving student answer

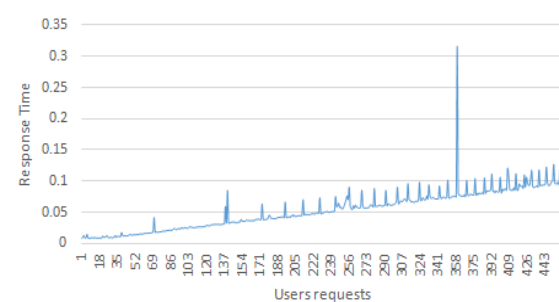


Figure 16: Response time for saving student answer

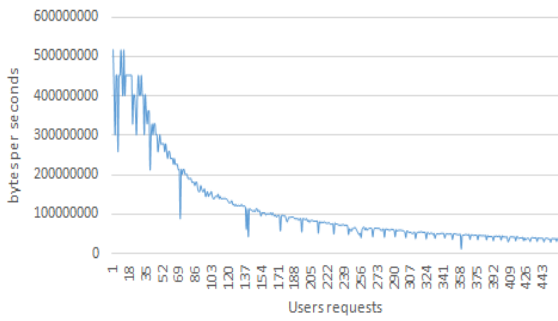


Figure 17: Throughputs for saving student answer

- Results of cloud platform v.s fog platform:

When comparing the data resulting from the experiment conducted on the fog platform and the cloud platform, it was found that the fog platform is better in performance than the cloud platform. As the requests are divided into batches based on the students' geographical locations, this improves the performance of the learning system, unlike what happens in the cloud platform, which receives all requests at once, as shown in figure 23. And the data are transferred later on from the fog layer to the cloud layer.

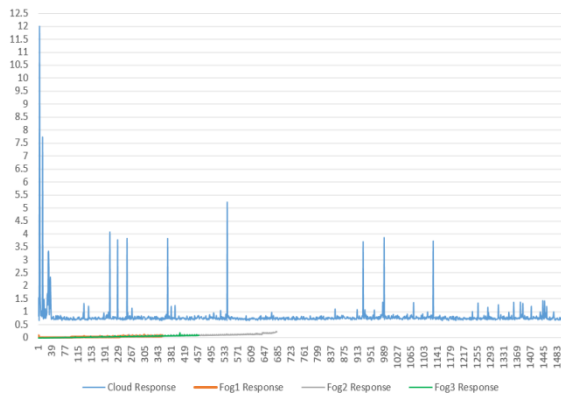


Figure 18: Cloud platform versus Fog platform

The response time comparison, the response time average, and the standard deviation is figured out for both platforms as follow:

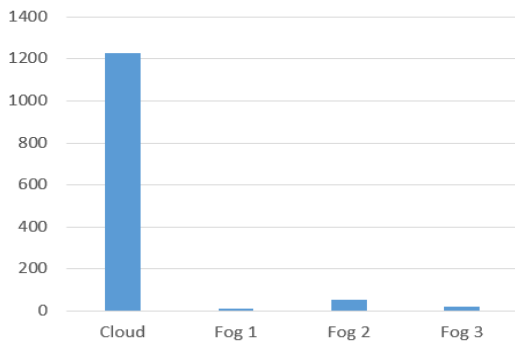


Figure 19: Response time comparison

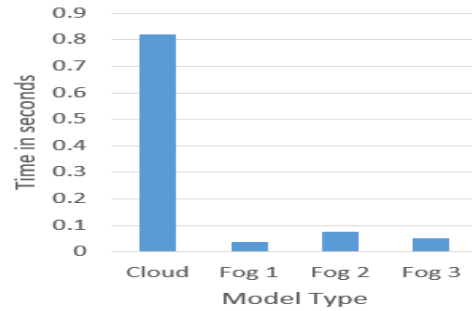


Figure 20: Response time average

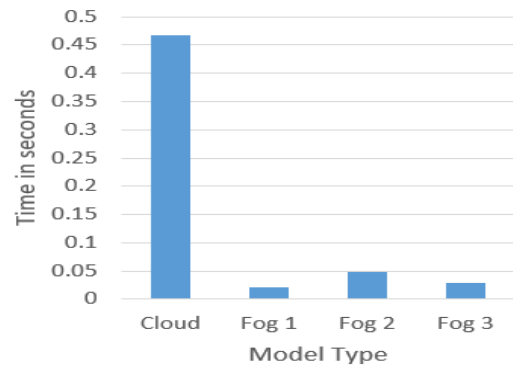


Figure 21: Standard deviation

A. Results of smart correction:

In this section, the auto-correction of student answers takes place. The correction is done according to image similarity matching between the student answer and a model answer. Let's take a question from the experiment done before from the quiz.

In figure 27, a sample of questions showed to the student, and the student can draw the answer in the box below the question. As explained before, the front end will be the graph panel, while the back end will be the code representation for the answer.

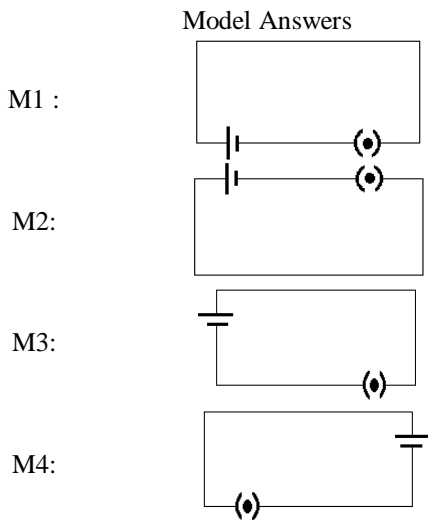
Q1: Draw a schematic diagram of a circuit consisting of a battery and a plug key, all connected in series.



Figure 22: A sample of questions

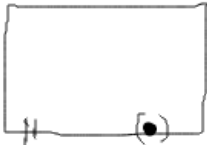
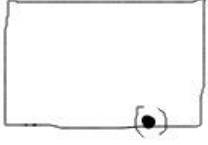
The model answers saved before are as follow:

Table 6: Model answers for a question:



The student answer is saved in SVG format. So, first, it is converted to an image, then image similarity matching with the model answers. the students' answers shown in the figure below is an example:

Table 7: Students Answers

Answer 1	Answer 2
	
Figure 1 23: Student Answer 1	Figure 1 24: Student Answer 2

After applying the matching algorithm. The results of the matching are as follow:

Table 8: Similarity results with model answers

Answers	M1	M2	M3	M4	Best score
Answer1	0.0012	1.79	1.797	1.797	0.001
Answer2	1.7976	3.98	3.059	1.348	1.348

From table 8, the lower the result value, the more similar the answer to the model answer. In which it is corrected automatically, and the grade is set.

In this research, image similarity is used because it is more accurate than comparing the two images. After the correction, the results are saved for the student to review.

Finally, it is good to let the student answer by drawing instead of selecting a value from a list of choices. The SIQ offers a new technique that could be developed and improved in future work, hopped this research to be a good start.

V. CONCLUSION

Different types of quizzes could be done in distance learning environments. The famous type of question is the multiple choices. This encourages to development of a new type of quizzes that could help in practical faculties like Engineering Architecture, Chemistry department ... etc.

A new type of quiz was presented in this research, providing a drawing board for the student to answer the questions. Therefore, the student can do answer in various ways like drawing or answering by handwriting. Then the answer is saved and displayed to the instructor in the form of a Scalable Vector Graphics (SVG).

The SIQ do a smart correction for the student answers according to an algorithm using finding contours for student answer and the model answers saved for the question.

As shown in the results section, the data collected from users are too large in some cases. So, using the fog platform rather than the cloud platform. The fog platform is faster than the cloud platform in processing the data that comes from the users.

The preliminary results for this research show that the SIQ applied in the quizzes can be a good educational tool. It can help both students and instructors and give the student ability to express the answers instead of using multiple choices.

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