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RETFAL: Real-Time Feedback System in Active Learning

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Abstract

There are numerous difficulties and challenges faced by teachers in getting real-time feedback from students during lectures in active learning. Three different educational technologies will be investigated in this paper regarding their efficiency and cost effectiveness: (1) Wireless Systems; (2) Tablet Systems; and (3) Audio-Visual Systems. To that end, we propose a new system called Real-Time Feedback in Active Learning system (RETFAL), which is a phone-based application with a view to assist educators in getting real-time feedback. The RETFAL system is implemented on the Android Studio platform using the Java programming language. We validate our RETFAL system using usability testing via an online survey and a face-to-face survey. Finally, we do a comparative study involving the RETFAL system and the LearnStar system in terms of effectiveness and performance. We find that our proposed RETFAL system performs better than the LearnStar system in terms of efficiency and cost-effectiveness with regard to real-time feedback. With RETFAL, we anticipate the performance of students can be improved with effective real-time feedback in active learning.

1. INTRODUCTION

Every semester, understanding some of the subjects undertaken in classrooms can be challenging for most university students. The lack of understanding during classrooms and university lectures can lead to many problems, which can affect the students' abilities to score high marks and cause failure of these students in exams. Although all learning online materials are available for the university students to enable them to do self-study with other course mates,

some subjects may be too difficult to understand and have many problems associated with them because of a lack of face-to-face teaching and learning.

Identifying the level of students' understanding during lectures and classrooms by getting real-time feedback can provide many advantages such as allowing teachers to give assistance to the students when it is needed, which can lead to improvement of their performance and assist them in the goal of achieving higher grades.

1.1.Educational technology in general

The traditional method of teaching which consists of lectures is no longer the best way to transfer information from teachers to students, which has led researchers to focus on the development of education. In addition, the number of students in lectures has seen a decline and one of the main reasons is students are mainly using a wireless network (Wi-Fi) to access information. Wi-Fi connection has been made available throughout most university campuses and students normally use it to access social networking sites such as Facebook or Amazon,(Preville, 2017).Using technology in classrooms is one of the best methods that has been used to develop education because it can encourage students to be more active in their classrooms. There are many technological applications to encourage students' participations in classrooms such as making quick quizzes, debates and peer instructions available online.

1.2.Educational technology in the classroom

Preparing university students and getting them ready to enter the job market after they graduate from university is the responsibility of educators. Therefore, educators should do their best to make the students' learning successful (Ranasinghe & Leisher, 2009). One of the approaches, which have been used in classrooms to improve the student performance, is technology. Using technology in classrooms such as computers, smart boards, and projectors can help educators. In addition, educators can help to improve student performance by using any type of technology to get real-time feedback, which will enable them to assist the students when it is needed. Moreover, the level of student satisfaction regarding the lectures can be increased by getting these real-time feedbacks, and the teachers are able to edit the contents of the lectures when required (Gligorić et al., 2012; Sneller, 2007).

1.3.What is the meaning of active learning and its benefits?

Allowing students to participate in different activities such as reading, writing and discussion in classrooms to improve their performance is a process that can be named as active learning. There are several benefits of active learning. Improving student performance in different subjects such as science, engineering, and mathematics is one of active learning process advantage (Freeman et al., 2014). By comparing the results of students who participate in active learning with the results of students in traditional learning classes, it was found that the average exam scores for students who participated in active learning was improved by 6% (Freeman et al., 2014). Some other advantages of active learning are the student's ability to remember information and develop skills such as critical thinking and problem solving (Prince, 2004;Fitch, 2004;Hattie & Timperley, 2007).

1.4.What is the meaning of real-time feedback and its effectiveness?

The information that is given by an agent, which depends on the level of his/her understanding or performance, is called feedback (Hattie & Timperley, 2007). Getting positive or negative

feedback from teachers is very important for students. Students would be interested to know their level of understanding by knowing their level of performance in classrooms, and exams. If their level of performance is high, that can encourage them and give them a sense of achievement to work harder and to be more effective in their learning (Jurs, & Spehte, 2020). Similarly, when the students get negative feedback from teachers, it is very important that they know their weaknesses in order to learn from their mistakes (Jurs, & Spehte, 2020). In addition, making students realize their weaknesses at real-time can motivate students and make them pay more attention in classrooms. In order to make feedback more effective, it should not take a long time between the work and the feedback because the longer the gap between students work and teachers' comments, the feedback becomes less effective (Jurs, & Spehte, 2020).

2. BACKGROUND

Recently, one of the topics that has been highlighted is real-time feedback in active learning. It has been discussed from different directions regarding the quality of lectures that depend on smart classroom in real-time feedback. There are three different systems in this section will be investigated as mentioned in the previous section: (1) Wireless Systems; (2) Tablet Systems and (3) Audio – Visual Systems which are a system that allows the capture of audio, video, slides, and handwritten annotation during a live lecture.

2.1. Wireless Systems

Transition of signals using different mediums such as microwaves and radios instead of cables is known as Wireless Systems. Wireless keypads is considered one of the most effective technologies, which has been used to get student answers at the universities and schools. It has been utilized in classrooms to determine the level of students' understanding instead of the traditional methods of asking questions to all students in the classrooms and getting only one or two answers, which is not an effective strategy to gauge the level of all students (Prince, 2004). In addition, getting real-time feedback from all students in the classrooms to know how well the materials were understood is the main reason for using wireless keypads System (Prince, 2004). This section will first display the system components and how it works. After that, it will provide some benefits of using wireless keypads in the classroom and finally display the weaknesses of Wireless Systems, by using an example system called LearnStar (Fitch, 2004).

In order to get real-time feedback in classrooms by using the LearnStar System, a number of devices should be provided in each classroom. One of the most important components that must be available to support the LearnStar system is providing the media capabilities such as cameras, keypads, teaching consoles, which are used to project computer videos, projectors and audio materials (Prince, 2004). The implementation of LearnStar system can be shown in a number of steps. First, the teacher will present the question for a few seconds on the class board to make students read the question, and then a number of choices will be displayed (Prince, 2004). After displaying the question and the choices, the countdown will begin by a clock timer that is set up by the teacher. Then, the student will select one of the choices that is believed to be correct. Finally, the result will be shown on the class board (Prince, 2004).

There are many advantages of using wireless keypads system in classrooms. First, it can allow teachers to get a real-time feedback immediately, which can help determine how well the students understood the material. The second advantage of using wireless keypads is that it can

increase the rate of students' participation in the classrooms (Prince, 2004). The third benefit is that it can allow more students to be more focused and active in classrooms (Prince, 2004). However, Wireless Systems have their own issues elaborated in the following sub-section.

2.1.1. Problems in Wireless Systems

There are a number of weaknesses any Wireless Systems can face:

- One of the Wireless System problems is the oscillation in the signal strength between a transmitter and a receiver, which has caused a problem called Path Loss (Willig et al., 2005).

- The second problem is when there is inability to send and receive the same channel by wireless transceivers (Willig et al., 2005).

- The third weakness of Wireless Systems is the Physical Layer Overheads.

- Channel Errors is the fourth problem of Wireless Systems, which will be explained in the following:

Using a wireless transmitter that propagates into multiple spatial directions transmit a group of waveforms at the same time. However, there are some problems caused by these waveforms such as scattering, diffraction, or reflections (Rappaport, 1996). These channel errors can affect waveform by making it use different paths and different time dispersion and send more than one copy to the receiver (Willig et al., 2005).

Wireless waveforms can also face another problem such as distortions to wireless waveforms, which can happen because of co-channel and adjacent interference (Rappaport, 1996).

Although LearnStar system, which depends on Wireless Systems, has many advantages in terms of getting real-time feedback in active learning and, of which it can likely further improve students' performance. Nevertheless, it can also cause many problems in terms of the prohibitive cost of the wireless keypads and the problems of Wireless Systems.

2.2.Audio–Visual Systems

Several different systems aim to get real-time feedback in active learning to improve students' performance. Audio-Visual Systems is one of the systems, which has been used to get real-time feedback in active learning. There are a number of components that must be available to take advantage of this system such as handwritten annotation, the capture of audio, video, slides, and the capture of audio during any lecture (Gligorić et al., 2012). Moreover, measuring the level of satisfaction of the students during lectures is one of the system's aims, which can be done by analyzing facial movement, the person's tone of voice, or getting gestures by utilizing the wearable device (Gligorić et al., 2012). A set of tools must be available to achieve the goal of this system, which is getting real time feedback. These tools are a motion detection tool, a tool of sound recording and a tool of scene capturing.

In order to take advantage of Audio-Visual Systems, you must first use a capture device using different tools such as Microphone, Camera, PIR Sensor and Sound sensor to enable the capture of audio, video, slides, and handwritten annotation during a live lecture (Gligorić et al., 2012). Knowing the performance level of students in lectures and providing help to the students when required is the purpose of using Audio-Visual Systems.

Although Audio-Visual Systems aim to get real time feedback to help students improve their performance, it also has some disadvantages as described in the following.

One of Audio–Visual System disadvantages is when students feel that they are being monitored; they will not behave normally (Gligorić et al., 2012). Some behaviours can be used to measure the level of student satisfaction such as doodling, fidgeting and looking around (Verner& Dickinson, 1967). However, feedbacks will not be accurate when the students know that some devices have been used to monitor their actions such as the motion detection tool. Therefore, they will not behave normally.

The second disadvantage of using Audio-Visual Systems in active learning is that using the scene capture tool in classroom will be affected by surrounding sounds such as opening of doors and these effects will make the real-time feedback inaccurate, which will be given, as a chart (Gligorić et al., 2012). Making the sound capture tool captures students 'voice only without the other sounds is one of the biggest problems that Audio-Visual Systems can face because students' attendance times vary from student to student and the times of students leaving the lectures are different. All these sounds will make the real-time feedback inaccurate. In addition, students will be affected when the lecture is tedious or uninteresting and this will make them behave abnormally like moving the table or issuing some sounds (Hattie & Timperley, 2007).

2.3.Tablet Systems

One of the most effective systems, which has been used in active learning classrooms to get real time feedback, is Tablet Systems. There are many uses of the Tablet Systems and getting real-time feedback in classrooms is considered as one of the most important uses. This section will (1) first discuss the benefit of using Tablet Systems in classrooms; (2) provide some different ideas based on DyKnow System (Sneller, 2007) which has been used to get real-time feedback in lectures; and finally (3) present some Tablet Systems disadvantages in active learning.

2.3.1. Benefits of using Tablet Systems in classroom

The first benefit of using Tablet Systems in classrooms is it allows teachers to re-display their materials, which had been explained on the white board (Mock, 2004; Freeman et al., 2014). Tablet Systems allow teachers to save a copy of all their work and re-display it when needed. The second benefit of Tablet Systems in classrooms is they enable teachers and students to use different colour pens to take notes easily. Additionally, it allows them to also save their work by using digital ink, which they can review at any time (Mock, 2004; Koile & Singer, 2008; Koile & Singer, 2008). Using assorted colours to take notes during the lectures makes notes more attractive and organized. The third benefit of Tablet Systems is that the cleanliness level of the classroom will be higher, and the classrooms will be ready for later usage.

2.3.2. Disadvantages of using Tablet Systems in active learning classroom

Despite the benefit of using Tablet Systems in classrooms, there are also some disadvantages as described in the following:

One of the problems that Tablet Systems can face is Tablet PC should not be placed in portrait mode and must be placed in landscape mode when the Tablet PC is used by the students in the classrooms (Mock,, 2004).The level of students’ concentration in the classrooms may drop

when they feel uncomfortable using the Tablet .The second problem is that, there are a number of Tablet PC models that have some problems with display angles(Mock,, 2004).The third problem of Tablet Systems in classrooms is the high cost of the system and its accessories (Mock,, 2004). Buying a Tablet PC for every student to use in class is very costly. This may make some schools and universities not interested in implementing this system. The use of the tablet pen is the fourth problem of Tablet PC, which can sometimes make right-clicking difficult (Mock, 2004).

3. Proposed RETFAL system architecture

As mentioned in the previous sections, effective real-time feedback is a crucial component of active learning. As can be seen from Section 2, currently there has been a lack of real-time feedback systems for active learning. To that end, this paper proposes a real-time feedback system involving mobile phone application that has not been dealt with in detail, to the best of our knowledge.

The main purpose of our proposed system, Real-Time Feedback System in Active Learning (RETFAL), is to enable teachers to identify the level of students' understanding during lectures and classrooms by getting real-time feedback and providing their assistance when it is needed, which can allow more students' participation in classrooms and improve their performance, in an efficient and cost-effective manner. In this paper, we present the RETFAL system overview and functions.

3.1.RETFAL system overview

The RETFAL system is a mobile application with a view of developing an efficient and effective level of feedback in active learning education. The RETFAL system aims to measure the level of students' understanding in classrooms by allowing teachers to create a new quiz any time on their phones and then, write one question or more and set up multiple-choice answers. RETFAL can be accessed by using two kinds of devices such as Android and iOS. The RETFAL application would be supported by providing a Wi-Fi network in each classroom at the schools and universities to allow students and teachers to use the application features. The following diagram (Figure 1) shows the system block diagram, followed by the description of each component and the system audience.

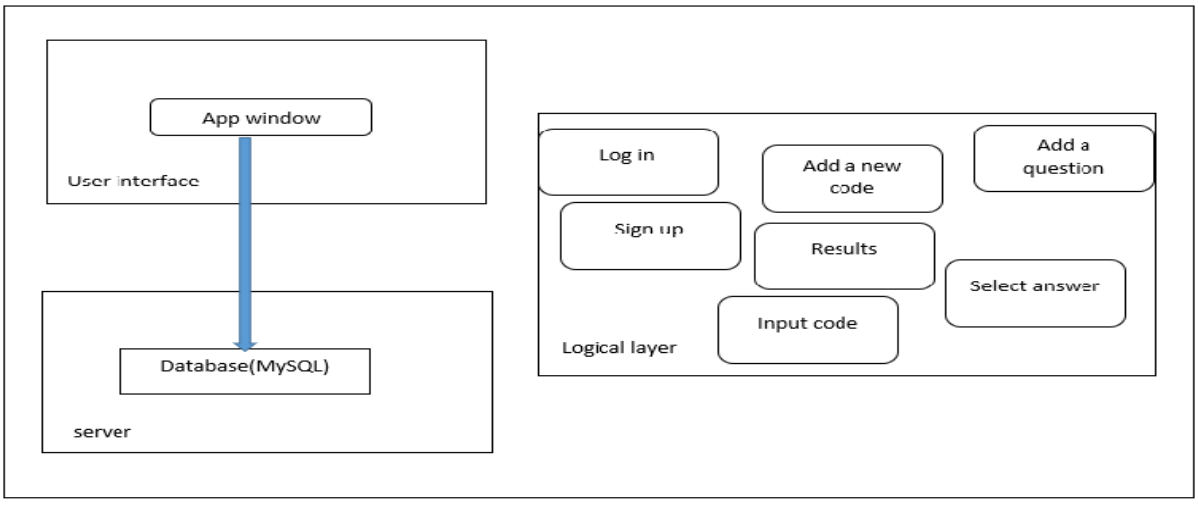

Figure 1 RETFAL system block diagram

3.1.1. RETFAL components

Log in: The function of this button is to enter user information to the system. It generally asks the user to enter his user name and his password.

Sign up: Sign up button is allowing the user to create a new account by asking him to enter his email and set up a password so that the user can use them when he wants to benefit from the application any time.

Add a new code: The function of this button is to allow teachers to create a new quiz file and give it a name and get a special code for it.

Add a new question: The function of this button is to allow teachers to create a new question and set up some choices in addition to identifying the correct answer for this question.

Input code: Here is where students can enter the special code given by the teacher to allow the students to join the quiz.

Result: The result will be shown at the end of the quiz, giving the number of correct answers, the number of incorrect answers and the rate of correct answers for each student.

3.1.2. RETFAL system audience:

The audience of our system are:

- User (student): This includes specific students in classrooms. Basic phone knowledge is required to make users able to download the application and interact with it.

- Admin (teacher): This refers to the teacher who will use the system. They are expected to have a basic understanding of the application and its features.

3.2.RETFAL functions

The main functions of RETFAL system are given below:

- Allow teachers to set up a question at any time during the lectures.

- Provide real time feedback to the teacher by giving:

- The number of students who answered the question.

- The number of correct answers

- The number of incorrect answers.

- Provide real time feedback to each student by giving them:

- The number of his/her correct answers

- The number of his/her incorrect answers

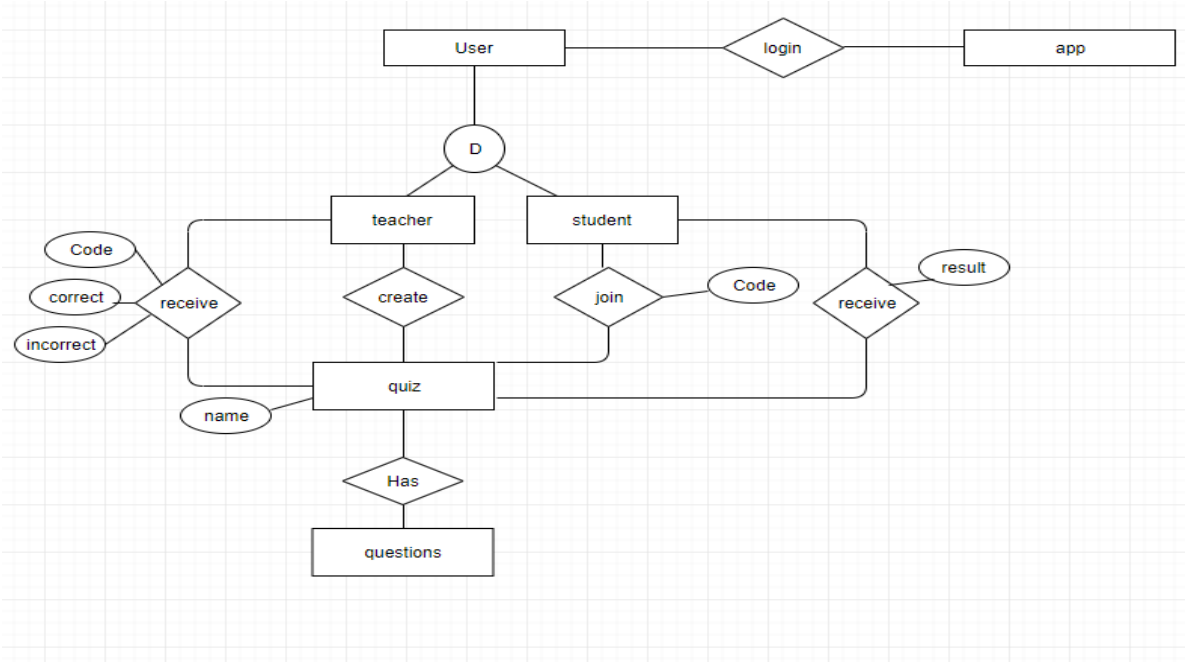

Figure 2 RETFAL entity-relationship diagram

Figure 2 shows an entity-relationship diagram. First, starting from the top of the diagram is the user. The user can be one of two choices (Teacher or Student). Only the teacher can create the quiz and each quiz can have one question or more. Each quiz will have a code to allow students to join the quiz. Students can join any quiz by using a code that will be given by their teachers. Finally, teachers can receive the students' quiz results as well as students will also be able to view their results.

3.3.RETFAL implementation

Android Studio is the main software used to implement the RETFAL system. The implementation depends on Gradle which an advanced build-in toolkit is used to follow up the build process (Pachube, n.d.; Google, 2015) . Android Studio helps in implementing the RETFAL system in the following nine steps:

- Step 1: Creating user interface
- Step 2: Creating a user account
- Step 3: Logging into the system
- Step 4: Creating new quiz and getting a code
- Step 5: Writing questions and saving them in a database.
- Step 6: Using teacher code to log in to the quiz
- Step 7: Enabling students to select an answer

- Step 8: Showing student results
- Step 9: Showing class results

4. Usability testing of RETFAL

In order to analyse the system architecture and validate the readiness of the RETFAL system, we apply usability testing. The usability testing consists of several tests with the following aims in mind:

- To find out problems with design and consistency.
- To check if the application is meeting its requirements.
- To check if the application caters for its users.
- To determine if the system has any error.

4.1. Usability testing methods

We conducted two groups of usability testing – online survey and face-to-face survey. Most people who participated in the online survey are unfamiliar with La Trobe University. They were selected randomly at the La Trobe University Agora venue on the testing day. These participants had different abilities to use phone applications and come from different nationalities, age groups, and specialization.

4.1.1. Online survey method

A short explanation was given to online participants, after that, the participants used the application to do different scenarios to test the application functionality and to test the design of the application. Finally, the participants were asked to provide feedback by filling out an online feedback form.

The metrics for the usability here is defined as follows: “Participants will be asked to do different scenarios using the RETFAL app. For each scenario, the RETFAL app will be evaluated based on (1) how successfully the participants achieve the proposed goal, (2) the participants’ speed to achieve the goal, and (3) the accuracy of the RETFAL app's outcome”.

Online survey Usability testing Feedback

#	Usability Feedback	Strongly	Disagree	Neutrality	Agree	Strongly Agree
1	The Feedback application is easy to use:	1	2	3	4	5
2	The buttons were well organized and easy to understand.	1	2	3	4	5
3	Understanding the function of each button was very easy	1	2	3	4	5
4	The app could have been better at showing results to the teacher	1	2	3	4	5
5	Moving between the pages efficiently.	1	2	3	4	5

#	Usability Feedback	Strongly	Disagree	Neutrality	Agree	Strongly Agree
6	Are there Problems on the colour scheme?	1	2	3	4	5

Conclusion of the online survey

Based on the feedback from the independent users, we deduce that:

- the real-time feedback of the RETFAL application is impressive,
- user friendliness of the RETFAL application buttons is good,
- the function of each button can be easily understood,
- the design of showing results to the teacher is positive,
- the efficiency of moving between pages of the RETFAL app is high, and
- the colour scheme of the RETFAL system is acceptable.

4.1.2. Face-to-face survey method

A brief introduction was given to participants, and after that the participants completed three different scenarios which cover some of the main functions of RETFAL, as shown below.

Scenario 1: Teacher creates a new quiz.

Teacher should use the RETFAL app successfully to navigate and to create a new code:

Step 1: Create a teacher account.

Step 2: Login to the application.

Step 3: Press add new code to add a quiz and give it a name.

Scenario 2: Student joins the quiz.

Students want to participate and check their understanding.

By giving them a code of 5 numbers and asking them to join the quiz and answer the questions:

Step 1: Create a student account.

Step 2: Login to the application.

Step 3: Enter the given code.

Step 4: Select the right answer.

After that, student results will be shown on their phones screens.

Scenario 3: Teacher checks students' results.

Teacher opens the application and get the students' results:

Step 1: Login to the application.

Step 2: Press on show attend student.

After that, the participants' results will be shown as a table, which include the total number of correct answers, the total number of incorrect answers, and total number of students who had joined the quiz. Finally, the participants are asked to provide feedback verbally or filling a feedback form.

Finally, the face-to-face participants are asked to provide feedback by filling an online feedback form. The metrics for the usability here is defined as follows: "Participants will be asked to do different scenarios using the RETFAL application. For each scenario, the RETFAL app will be evaluated based on (1) how successfully the participants achieve the proposed goal, (2) the participants' speed to achieve the goal, and (3) the accuracy of the RETFAL app's outcome".

Feedback from testers

While a participant is doing the scenarios, we (as testers) observe and offer help if needed. Everything was recorded on an observer form.

The scenarios were completed by all participants with some assistance. We found that most of the participants had no errors when pressing buttons and were fast to make choices at the end of doing the scenarios.

Conclusion of the face-to-face survey

Based on the feedback from the independent users and the testers, we deduce that:

- most students are familiar with the Android platform, and
- most students are able to use different phone applications, including the RETFAL app,
- most of the participants' responses are positive in terms of design and ease of use, and
- the functionality of the RETFAL application is rated highly and so are the application buttons.

5. Comparative study: RETFAL Versus LearnStar

To evaluate our proposed RETFAL system in terms of costs, a comparative study was carried out.

5.1. Experimental setup

The experimental setup for the comparative study of the feedback applications (RETFAL and LearnStar (Fitch, 2004)) involves the following three elements:

- Students
- Materials and procedures
- Presentation format.

5.1.1. RETFAL system participants

The study included 20 students. Nine of them were older than 26 years old and eleven of these participants were between 18-25. Only 11 students have phones with Android system. They consisted of different age groups, different abilities to use phone applications and different backgrounds. The study was conducted in a small lecture hall used by Shaqra University. The room has Wi-Fi to support feedback application which is very important to provide internet service for all the students.

5.1.2. Materials and procedures of RETFAL System

As indicated before, RETFAL system allows the teacher to write one or more questions at any time and to set up multiple-choice answers. The results will be shown on the teacher's phone screen which will include the number of students who answered the questions, the number of correct answers, and the number of incorrect answers.

5.1.3. Presentation format of RETFAL System

1. Only the teacher can set up a quiz and get a code of 5 numbers for each quiz. These quizzes can include one question or more.
2. The teacher will ask the students to go to the quiz by using the same code and give an answer.
3. After that, the question and the answer will appear on the students' phones.
4. Students' results will be displayed on their phone screens.
5. Finally, the number of the correct and incorrect answers will be displayed on the teacher's phone screen.

5.2. Cost evaluation: RETFAL versus LearnStar

As mentioned in Section 2 Background, the LearnStar system allows students to answer questions by using individual keypads and then these keypads will transmit the results to a receiver that is connected with a computer (Prince, 2004). In the following, our proposed RETFAL system is compared to LearnStar System in terms of materials and procedures, and the cost.

5.2.1. Materials and procedures RETFAL System versus LearnStar

Feedback application depends on mobile phones which allow the teacher to create a new quiz any time with his/her phone and then, to write one or more questions and set up multiple-choice answers. The results will be shown on the teacher's phone screen which will include the number of students who answered the question, the number of correct answers and, the number of incorrect answers. On the other hand, the LearnStar system depends on keypads to write questions and provide multiple-choice answers (Prince, 2004). Student's answers will be recorded immediately. After that, these keypads will transmit the results to a receiver that is connected with a computer and then the results will display on the screen (Prince, 2004).

5.2.2. The cost of using the RETFAL system and the LearnStar system in classrooms

The RETFAL system aims to take advantage of the availability of smart phones used by all students to get real-time feedback in classrooms, which is very useful and can reduce the high cost of devices. By using our proposed RETFAL system, there will be no extra cost to get real-time feedback. One the other hand, The LearnStar system depends on keypads to get real-time feedback in classrooms which means there is a need to provide a keypad for each student, and this may reduce the capacity of universities to benefit from the LearnStar system.

6. CONCLUSION AND FUTURE WORK

While RETFAL system reaches its goals, there are still many ways to extend and improve the system. One of the most important strategies to make more students benefit from our system and to achieve the goal of the system concerning real-time feedback in active learning, we plan to extend our RETFAL system from the Android platform to the iOS platform, connected to the same backend database. Future work also includes improving the system functionality by enabling a teacher to select diagrams and photos from his/her phone when he/she writes a new question. Allowing teachers to select diagrams and photos from their phones is likely to provide a great help to the teachers because there are subjects that make use of diagrams and codes to deliver effective learning outcomes.

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