LSQUIZ: A COLLABORATIVE CLASSROOM RESPONSE SYSTEM TO SUPPORT ACTIVE LEARNING THROUGH UBIQUITOUS COMPUTING

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ABSTRACT

The constructivist theory indicates that knowledge is not something finished and complete. However, the individuals must construct it through the interaction with the physical and social environment. The Active Learning is a methodology designed to support the constructivism through the involvement of students in their learning process, allowing them to make analysis, synthesis and evaluations, therefore developing their thinking and reasoning abilities. The technology supports active learning through Classroom Response Systems (CRSs), which usually use clickers devices to allow students to submit answers to a questionnaire proposed by the teacher. However, these systems have some drawbacks, for example not considering the students' individualities, personal characteristics and needs. In this way, this study describes the creation of the LSQuiz, a CRS that implements a collaborative process that allows teachers to propose questions to students, who may choose to solve them individually or ask colleagues to help solve them. The LSQuiz applies concepts related to ubiquitous computing, such as context awareness and the analysis of the interactions among students to determine which student is the most suitable at a given moment to provide help. The system validation indicates wide acceptance by students, who consider the possibility of classroom collaboration an important element to support their learning process. The experiment indicates that adopting a CRS associated with ubiquitous computing features is a valid and effective way to promote active learning.

KEYWORDS

Active Learning; Collaborative Learning; Ubiquitous Computing

1. INTRODUCTION

There are several proposals and methodologies aimed to make the learning process more interesting and motivating for students. One of the most important contemporary pedagogical trends is the constructivism, which opposes to the traditional learning in which students passively absorb information. As Becker (1992) explains, constructivism has an idea that knowledge is not something finished, also being constituted by the interaction of the individual with the physical and social environment.

A form of practical application of constructivism in the educational environment is the Active Learning (Bonwell & Eison, 1991; Prince, 2004), characterized by the direct participation of students in their learning process (Morable, 2000). As stated by Chickering & Gamsom (1987), in an active learning environment students need more than just listen: they need to read, write, discuss, or be actively engaged in solving problems. In addition, students must perform analyzes, summaries and reviews to develop their thinking and reasoning abilities (Bonwel & Eison, 1991).

There are some methodologies created to support and promote Active Learning. For example, the Collaborative Learning (Collins & O'Brien, 2012), Cooperative Learning (Beck & Chizhik, 2013), Inquiry-Based Learning (Schneider, 2012), Problem-Based Learning (PBL) (Vosikanis et al., 2013; Holmgrem, 2013) and Peer Instruction (Mazur & Watkins, 2013; Zingaro & Porter, 2014).

It is increasingly common the use of technological devices to implement these techniques. For example, the Classroom Response Systems (CRS) allow feedback from students to the teacher, supporting the PBL and the Peer Instruction through the use of clickers, little devices that allow students to submit question's answers to the teacher. In these systems, the teacher can receive, analyse and compare a large number of answers, giving feedback to all participating students.

However, one problem of the CRSs is that they do not consider the students' individuality and specific needs, treating everyone the same way. Characteristics associated with the context, such as location, interactions' history with the teacher and classmates or even the freedom to participate (or not) in a collaborative process are not considered. In many aspects, the application of CRSs is closer to the traditional educational model than the constructivism, which it should support. Still, considering a technological point of view, the clickers have the disadvantage of being limited to a specific technology, not following the rise of new technological devices.

In previous work (Caceffo & Rocha, 2011; Caceffo & Rocha, 2012; Caceffo *et al*., 2013), we described the theoretical propose of a ubiquitous CRS, defined as Ubiquitous Classroom Response System (UCRS). The UCRS proposes the use of features associated with ubiquitous computing, such as context awareness and multiple device support, like smartphones and tablets, to create a smart collaborative process. This process allows teachers to submit questions to students, who may choose to solve them individually or ask colleagues to help solve them. In the latter case, the system considers factors such as the students' locations and their interaction history (affinity), thus determining which student is the most suitable to be invited to help his colleague. The teacher acts in this way as a tutor or mentor, having the ability to view a classroom map, intervening if necessary in the collaborative process.

In this study we present the design, development and practical application of the LSQuiz, a software that implements the UCRS. The LSQuiz was developed as a Moodle plugin, supporting any device that has a html browser, thus including smartphones, tablets and notebooks.

Results indicate a wide acceptance for this model application inside the classroom. In addition, the combined application of a CRS with ubiquitous computing supports the Active Learning in a more efficient and transparent manner.

This paper is organized as following: section 2 presents the collaborative process definition and the LSQuiz features; section 3 presents the LSQuiz implementation; section 5 describes the experimental validation of the tool and; in section 6 is presented the conclusions and future works.

2. LSQUIZ COLLABORATIVE PROCESS

We defined a collaborative process that supports the interaction among teacher and students through the LSQuiz. The 12 steps that compose the collaborative process are:

1. Teacher creates a questionnaire and submits it to the students;
2. Students receive the questions on their own mobile devices;
3. Each student defines his location in a classroom map
4. Students start to solve the questionnaire;
5. At any moment, any student (defined as source student) can press a button and access the "help request" feature. This feature verifies, based on the location and affinity factor among students, which available student (defined as target student) is more suitable to help;
6. The target student receives a message, indicating the source's student name, photo, and location.
7. The target student can accept or not the invitation;
8. If the target student accepts the invitation, then he is oriented to move next to the source student's place;
9. Both students solve together the question;
10. The source student submits, on his device, the question's answer to the teacher;
11. Each student, using his device, qualifies the collaborative process as positive or negative.
12. The target student backs to his original location. Both students continue to answer the questionnaire.

There is more than one possible interaction path from the moment the source student press the "help request" button in step 5 until de moment that both students have qualified the collaborative process (step 11). For example, in step 7 the target student can accept or not the invitation, and in step 11 not necessarily both students will qualify the collaborative process at same time. Also, each student will visualize a different screen in each one of these steps. A State Machine, as described in section 2.1, organizes these different paths, interactions and visualizations.

In step 2, each student defines its location through a classroom map. This information supports the step 5, where the student's location is used as a context factor in order to help the LSQuiz to identify which student will be invited to help, and in steps 6 and 8, where the invitation is received and accepted (or not) by target student. Section 2.2 describes the classroom map feature.

The step 5 is also supported by the affinity factor, which is an empathy's measure among students. The affinity factor is calculated through the analysis of the proportion of accepted invitations (step 7) and the proportion of positive qualifications among students (step 11). The details about the affinity factor calculation are described in section 2.3.

Finally, section 2.4 describes the help request feature.

2.1 State Machine

A state machine, with five possible states, manages the LSQuiz collaborative process. The students may have two roles in the collaborative process: source and target. The student who asked for help is the source student, and the student invited to help is the target student. The LSQuiz adjusts its behaviour according to each student´s role and state, showing the following elements when necessary: classroom map, showing both students location; accept or reject help buttons, and qualification buttons (positive and negative) for the collaborative process. The latter two use as a template the Facebook's Like button to indicate the acceptance or positive qualification and a Dislike (upside down Like image) to indicate the help rejection and negative qualification.

Figure 1 shows the state diagram, describing the relations and transitions among states and the respective elements displayed regarding each student´s states and roles.

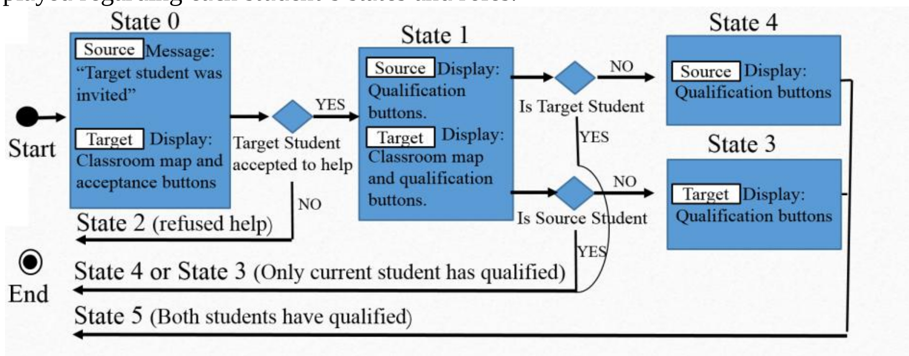

Figure 1. LSQuiz diagram states

The starting state is triggered when, in the step 5 of the collaborative process, the source student presses the help request button. The State 0 corresponds to when the target student receives an invitation to help the source student, as described in the step 6 of the collaborative process. This invitation contains a classroom map with the source student's location, name and photo. If the target student refuses to help, the collaborative process ends (end state). Moreover, if the target student accepts the invitation (collaborative process step 8), then the state machine moves to State 1. In this state the target student receives a message containing the source student's location, indicating that he should immediately go there to help the source student. Also, to both students are displayed qualifications buttons.

The states 3 and 4 relate to the situation when only one of the students have qualified the collaborative process. In this case, the student that have made the qualification is considered in the End State, being free to collaborate with other students as source or target student. However, the student that have not yet qualified is considered busy, not being able to make help requests or to be invited to help other students.

The State 5 corresponds to the situation when both students have qualified the collaborative process and can continue answering the questionnaire, as indicated in step 12 of the collaborative process.

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2.2 Classroom Map Feature

In the step 3 of the collaborative process, the system asks the students to report their approximate classroom location. The procedure is to move a box containing his or her name above the approximate location as shown in Figure 2a. The teacher can, at any time, view each student location trough a classroom full map, which shows the students names and their photos placed above their locations, as shown in Figure 2b.

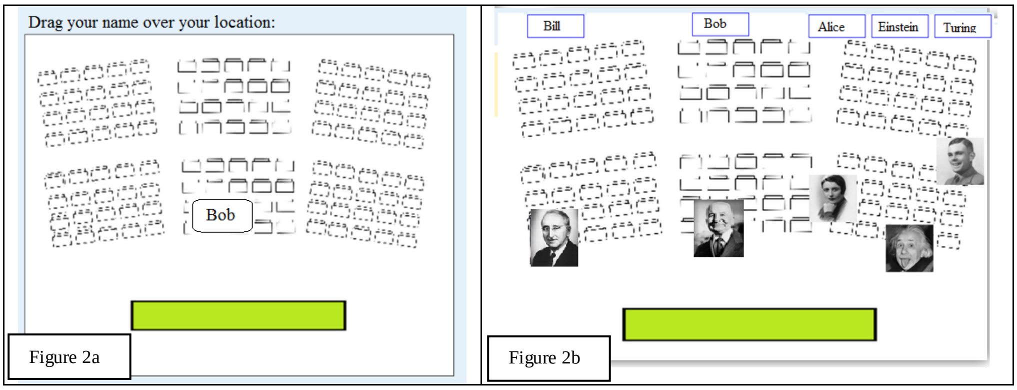

Figure 2. Students indicate their classroom location (Figure 2a) and; teacher's classroom map view (Figure 2b).

Still, the help request step (step 5) of the collaborative process uses the classroom map to indicate to the target student the source student's location. The student location feature also provides the information related to the distance between each one of the students. The LSQuiz uses these data to define which student should be invited to help the source student, as explained in section 2.4.

2.3 Affinity Factor

The Affinity Factor (AF) defines objectively the affinity degree (empathy) among students during the collaborative process. The AF, in conjunction with the students' location, determines which students should be invited to help, as described in section 2.4. The priority is to assign students with higher affinity to work together when possible.

All students have an AF related to others, ranging in scale from 0 (lowest affinity) to 1 (highest affinity). At the beginning of each collaborative process, the Formula 1 is applied, updating the AF according to some context factors, like the proportion of accepted help invitations and the positive qualifications among students. Formula 1 uses a similar approach as proposed by Levis et al. (2008).

Fórmula 1. AF = 0.3HR + 0.7PQ

Where:

- HR = Proportion of help requests accepted
- PQ = Proportion of positive qualifications

In Formula 1, HR indicates the percentage of help requests accepted related to the total help requests among these students, and PQ indicates the percentage of positive qualifications related to the total of collaborative process qualifications among them.The weights are 30% for HR and 70% to PQ. PQ weight is higher in order to focus the collaborative process qualification, since the help request acceptance can be associated with factors not necessarily related to the students' affinity (*e.g.*, target student is busy with another task at the request time).

2.4 Help Request

At any time, any student that has difficulties in solving the questionnaire can press a button to request assistance from another student (step 5 of the collaborative process). After pressing the button, the LSQuiz automatically defines which student is the most suitable to be invited to help the source student through the following factors: students that are available, *i.e*, are not helping or being helped by anyone; students distances from the source student (defined by the classroom map functionality, as indicated in section 3.1) and the AF among students.

If there are students available to help, LSQuiz sorts the students according to their distance from the requesting (source) student. From the student with the shortest distance, the LSQuiz identifies the first student whose affinity is greater than the average affinity value calculated among all students available and the source student. Therefore, this student is invited to help the source student.

The target student receives an invitation message, displaying the classroom map with the source student location and identification, as showed by Figure 3:

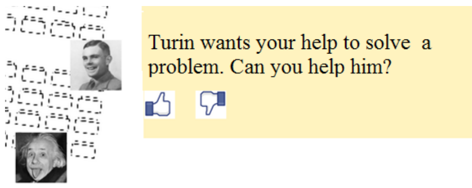

Figure 3. Invitation message displayed to target student.

If the target student not accepted the invitation, LSQuiz sends a message to the source student stating that his colleague is not available for help. However, if the target student accepted the invitation, the source student receives a message stating that he must wait for the target student help (see Figure 4a). In addition, the target student receives a message asking him to move to the source student location (see Figure 4b). For both students are also displayed qualification buttons for the collaborative process evaluation.

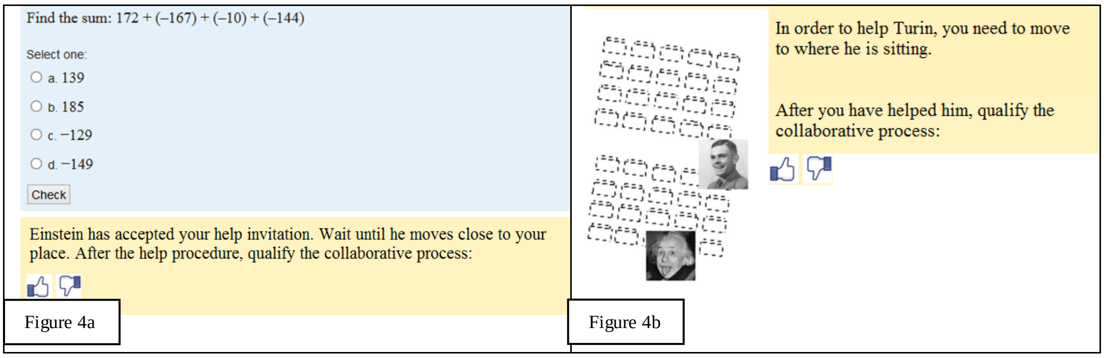

Figure 4. Invitation acceptance and collaborative process qualification steps

The data gathered in this step, related to the invitation acceptance and collaborative process qualification, are used to support the AF calculation, as described in section 2.3.

3. LSQUIZ IMPLEMENTATION

The LSQuiz was implemented as a Moodle[1] plugin. One difficulty encountered during the collaborative process implementation was the need to do a refresh in a specific screen region, thus keeping unchanged the rest of the screen contents. Thus, we adopted an approach based on AJAX technology, which allows the client to submit requests to the server and display the response data on specific and pre-determined screen area.

As described in the next section, this solution proved satisfactory to the LSQuiz, an academic prototype with relatively few users. In large-scale application systems, however, solutions that are more robust, like the Long Polling or WebSocket (Idol, 2013) should be considered.

[1] Moodle is an open-source LMS – Learning Management System. Available at: https://moodle.org/ Accessed: June 2014

4. VALIDATION EXPERIMENT

4.1 Methodology

In order to validate the LSQuiz application in real learning environment, an experiment was conducted with a group of college students (discipline laboratory of public policies). A small class, with 10 students was selected making more effective the initial application procedure and prototype analysis.

The methodology of this experiment followed the recommendation proposed by Rocha & Baranauskas (2003), being implemented in the following stages: preparation, introduction, testing, and final session. The experiment methodology is as follows:

- Preparation: In previous classes prior to the experiment, the teacher identified that most students bring to class some mobile device (e.g., smartphone, notebook or tablet) with internet access. Just in case, some devices were provided for ensuring back up if necessary. In addition, in order to prepare the experiment next steps, the students were registered in the Moodle system, including their profile photo.
- Introduction: After the initial presentations, the students were asked to access the Moodle to answer a questionnaire, composed by 5 questions related to the current discipline topic.
- Testing: In the questionnaire first question, students were oriented to locate themselves in the classroom map. Then they had the freedom to take the questionnaire at their pace, requesting help from colleagues if necessary. At any time, the teacher can access the classroom map and visualize all students' locations.
- Final Session: At this step, students and teacher received an evaluation form. The qualitative and quantitative data obtained from this form is discussed in the follow session 5.2.

4.2 Results

In general, the results show the collaborative model proposed by LSQuiz was widely accepted. Figure 5 indicates that students agreed on the following statements: "It was simple and practical inform the system my location in the classroom" (Figure 5a); and "The classroom map presented a correct representation of my position and my colleagues in the classroom." (Figure 5b).

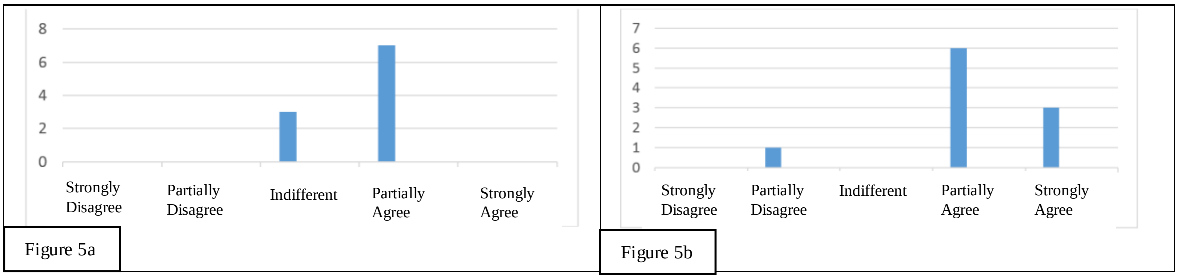

Figure 5. Students' opinion about the classroom map feature

However, the qualitative data analysis identified an issue related to the step where students should locate themselves in the LSQuiz. As one student stated: "The classroom arrangement and number of seats and rows was different in LSQuiz.". The problem is related to the fact that students tried to locate themselves accurately in the LSQuiz classroom map, which was not the original software objective. Thus, in future work is intended to decrease the classroom map accuracy, making it clear to students that they should inform the LSQuiz their approximate classroom location.

Regarding the collaborative process, qualitative analysis indicated that its use took place without major problems. Figure 6 indicates that students agreed on the following statements: "The move process to the colleague location was quiet." (Figure 6a); and "The collaborative process qualification, through the 'Like' and 'Dislike' buttons, was simple and clear to be held "(Figure 6b).

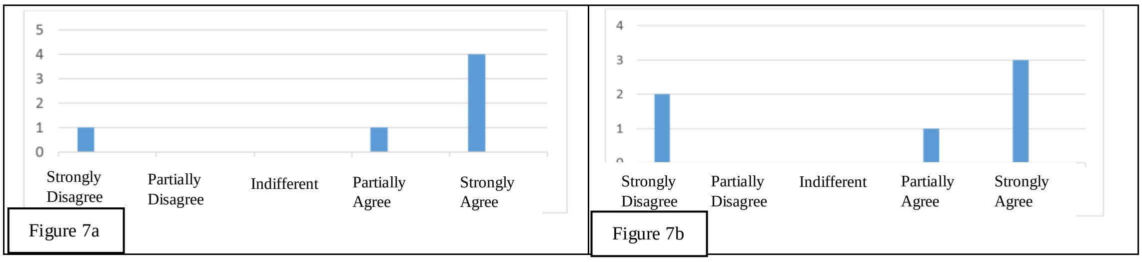

Figure 6. Students' evaluation the help (Figure 7a) and qualification (Figure 7b) procedure

Still, all of the respondents stated to be positive the opportunity to request assistance to colleagues to help solve an activity. However, the qualitative data analysis identified a situation where a particular student, after refusing to help his colleague, was again selected by the LSQuiz to help the same student.

We identified that this is related to the LSQuiz algorithm, which in the AF calculation (see section 2.3) considers most important collaborative process qualification than the acceptance or not of the help request. In order to minimize this problem, LSQuiz future versions will consider: a) a clause that inhibits a student who did not accept help a colleague to be chosen again, in the same class, to be invited to help the same student and b) a change in the AF calculation, leaving both factors (acceptance and qualification percentages) with the same weight of 50%.

5. CONCLUSION AND FUTURE WORK

The LSQuiz implementation and evaluation indicate the importance of the model focused on students' autonomy, where students can interact and collaborate with their peers according to their will. The collaboration is supported by context factors, like the students's location and affinity. This approach aims to support the student's individuality and specific needs, as each student can at any moment ask for help or accept or not accept an invitation.

Technology is a crucial factor to support this approach since the automation of the collaborative process would not be possible without the use of mobile devices. Regarding the experiment, teacher and students approved the use of the LSQuiz prototype, stating its effectiveness in the teaching and learning process.

According to students, the classroom has become more dynamic and interesting through the communication and collaboration process proposed by the LSQuiz while the teacher related an increased participation and motivation of students. These reports support the main LSQuiz goal, which is to create an Active Learning environment where students have an active participation in their learning process.

Teacher and students also related as a project risk factor the classroom size and the number of students. According to them, the experiment happened in a small room with few students, thus favoring the mobility and communication among them. They concluded that, in other condition, the LSQuiz application could not be so positive. Thus, based on user's opinions and following the spiral prototyping methodology (Rocha & Baranauskas, 2003), we are planning the next experiment in a large class, involving more students.

Concerning the classroom map, students related some difficulty in identifying their exact location in the system. Ideally, following ubiquitous computing concepts, the determination of student's location should be an automated process, without the user's interference. However, this approach is not possible today due the technological constraints related to the current mobile devices. LSQuiz future versions will have a classroom map with lower accuracy, making clear that students should use their approximate classroom location.

Also, the experiment related on this paper describes the outcomes from just a single session. The results conceptually validated the LSQuiz proposal the application. In future studies we intend to apply this system for one semester, which will allow us to analyse the impacts of this methodology in the teaching and learning environment for a longer period.

Still, future work involves the students' classification according to their learning styles, following the Felder & Silverman model (1988). We expect that providing customized content for each student, according to his preferred learning style, is an effective way to individualize the learning process, thus increasing motivation and promoting the active learning in a more effective way.

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