Practice of Skills for Reading Comprehension in Large Classrooms by Using a Mobile Collaborative Support and Microblogging

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Abstract. Reading comprehension is essential for students, because it is a predictor of their academic or professional success, however, it is challenging for many students, even more if they are part of large classrooms. This paper presents a work which uses Design-Based Research with the purpose of combining theories, methods and techniques of the educational sciences to design a collaborative learning activity including peer evaluation to develop the skills of reading comprehension, oral and written communication. It also presents an application for iPads supporting teacher and students performing this activity. The most relevant contributions of the proposed design are two: (1) teachers can in real time automatically configure the members of the work teams using 3 different criteria: random, individual performance hitherto achieved by the student achieved in previous stages of the same activity, or the learning styles of each student prefers; and (2) the prior calibration of an evaluation rubric in order to ensure the quality of the application of the peer evaluation method in order to grade the answers students produce to an individual reading comprehension test. In addition, other methods and techniques are incorporated, such as: monitoring students' performance in real time; active learning based on peer instruction to support the strategy of reading comprehension implemented.

Keywords: Reading comprehension · Large classrooms · Collaborative learning

1 Introduction

Reading comprehension is an essential ability for students at any level, because it is a predictor of their future academic or professional success, [1]. However, reading comprehension is challenging for many students, who struggle in reading due to having difficulty with it [2]. Research suggests that the use of collaborative activities supported by appropriate technology [3, 4], can help to improve students' reading skill by

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supporting various of the activities involved in the required learning activities, such as delivering content, support students' practice, and introduce the level of participation, guidance and motivation needed in order to become successful in reading comprehension [2, 5, 6]. After all, most of today's students are digital natives; thus it would be natural for them to use technology as a tool to promote their engagement and achievement during reading comprehension.

On the other hand, large classrooms are a fact at any educational level, bringing disadvantages regarding attention, discipline, and learning [7]. In such situations, technological tools which allow collecting students' answers, (i.e. a classroom responder system) to problems or questions proposed by the teacher, are one of the most used technique to give interactive feedback by the teacher to their students, [8].

This paper presents a learning activity whose design requirements are based on validated learning methodologies which aims at improving Reading Comprehension skills of the students, supported by a technological tool named RedCoApp (described in detail in Sect. 3). The learning activity can be performed in large classrooms, using a method which collects the answers using technology which collects the answers of at least 60 students. The learning activity has been designed with the purpose of developing in students the skills of reading comprehension, oral and written communication, and teamwork. The RedCoApp application (described in Sect. 3) has been implemented with JavaScript, HTML5 and libraries that allow it to run in any browser of a desktop computer or mobile devices (iPad, SmartPhones) that are connected to the Internet.

The research method used was Design-Based Research [9], Which is characterized by being: (1) **Pragmatic**: the central objective corresponds to the design of effective learning activities based on learning theories. Design-based research refines both theory and practice. The value of theory is appraised by the extent to which principles inform and improve practice. (2) **Grounded**: Design is theory-driven and grounded in relevant research, theory and practice; conducted in real-world settings and the design process is embedded in, and studied through, design-based research. (3) **Interactive, iterative, and flexible**: designers are involved in the design processes and work together with participants. Processes are an iterative cycle of analysis, design, implementation, and redesign. (4) **Integrative**: Mixed research methods are used to maximize the credibility of ongoing research. Methods vary during different phases as new needs and issues emerge and the focus of the research evolves. And (5) **Contextual**: The research process, research findings, and changes from the initial plan are all documented. Research results are connected with the design process and the setting.

The difference between Design-Based Research and applied research in engineering or exact sciences areas is that in their "design", "experimentation" and "transformation" processes, there are overlaps and relationships between them, rather than conceive results of each process as products bound to their environment and previously established objectives. The Design-Based Research method relates experimentation and design through feedback cycles, in order to construct effective learning activities that the study of complex education systems require, [10].

The content of this article is organized as follows. Section 2 explains the relevant theories, methods and techniques used as design requirements for the reading comprehension activity. Specifically, they detail: (a) a learning support technology to be used in large classrooms (a Classroom Response System), (b) the advantages of using short messages, (c) real-time monitoring techniques by the teacher regarding the level of progress of the students, (d) learning theories and methods based on collaborative learning, (e) peer instruction and active learning, (f) techniques for configuring work team members, and (g) methods of peer evaluation among the students themselves. Section 3 details the design of the reading comprehension activity, along with the description of the RedCoApp support application. Finally, Sect. 4 describes the following stages of our work, and the most relevant contributions of the proposed design: (a) teachers can in real time automatically configure the members of the work teams using 3 different criteria: random, individual performance hitherto achieved by the student achieved in previous stages of the same activity and (b) the prior calibration of an evaluation rubric in order to ensure the quality of the application of the peer evaluation method in order to grade the answers students produce to an individual reading comprehension test, along with the description of the following stages.

2 Theories, Methods and Techniques to Support Learning

2.1 Classroom Response Systems in Large Classrooms

Nowadays, large classrooms are a fact at any educational level, bringing drawbacks regarding students' attention, discipline, and learning, [7]. Attempts to overcome common problems of lectures in large classes include introducing learning activities like recitation sections, case study teaching in labs, peer instructions, and the use of technology that allows to capture the students' answers. They are usually named Classroom Response Systems (CRS) [8]. Collecting students' answers introduce positives experiences by using interactive feedback systems that transform the traditionally passive classroom into an interactive experience, [8].

The popularity of CRS technologies has increased in large classrooms as a means to improve engagement and motivation, feedback to understanding, improve participation, to be a scaffold of collaborative learning [11, 12], and enhance learning [13]. It is a powerful and flexible tool for teaching, and has been used in a variety of subjects with students of almost any level of academic training, [11]. CRS change the student feelings of being disconnected in large classrooms [7], and changing the classroom traditional format of a lecture-style to let teachers provide feedback to the student and vice-versa as to how well a concept is understood.

According to [14], four different CRS-type technologies have been applied in large classrooms to improve classroom learning: (1) low-cost tools such as hands, flashcards, color cards, or whiteboards to give their responses; (2) instant response devices with numeric keypads, interconnected by hard-wired equipment; (3) wireless radio frequency or infrared devices; and (4) wireless interconnected systems that use desktop or mobile devices to collect students' answers. CRS can be used with many styles of questions, and new technologies allow other formats than multiple-choice questions, [15]. The only "rule" for question design is that each question's structure and content should reflect specific learning goals. Questions may have a single correct answer or be designed without any "right" answer in order to encourage debate and discussion. Furthermore, there are positive effects of CRS on student's high-level cognitive abilities: critical thinking, problem solving, metacognition, CRS can be applied for immediate feedback, interactive feedback, classroom monitoring, peer instruction, equal participation, and formative assessment, [16].

Based on what has been mentioned in this section, and considering that the number of students where the reading comprehension activity will be applied is large (at least 60 students), the RedCoApp application will be of the CRS type. We consider that a CRS adequately supports the implementation of the reading comprehension strategy (described in the next section) consisting of the execution of a sequence of stages. Each stage requires students to perform tasks that yield specific intermediate results. Each intermediate result will be collected and managed by RedCoApp, to be arranged as relevant information to be analyzed by the teacher, in a simple and easy to operate computational interface. The result of the analysis of the information will allow the teacher to make decisions such as: provide feedback to his students, set up work teams, or continue with the next stage.

2.2 Reading Comprehension

Students who use reading comprehension strategies (such as prediction, think-aloud, text structure, visual representation of text, key words selection, etc.), improve their understanding of the message read, identify the essential and relevant message of the text, and/or are able to express opinions [1]. The strategy of selecting 3 to 5 key words (KW) or main ideas of the text [6, 17] consists of following a series of elementary stages that the teacher should manage: (1) The teacher provides a texts to be read and establish the purpose (objective) of what is to be read, which is also known as the detonating factor; (2) students select the relevant KWs and justify them by means of brief comments corresponding to annotations providing justifications that support the achievement of the purpose of what is being read; (3) students make connections between KW; and (4) students examine and reflect on the KW and its associated brief comments in order to finally respond to the purpose established in the initial stage.

If in addition, steps 2 to 4 mentioned above can be carried out collaboratively between 2 to 5 students. In this way the understanding of what they are reading is favored through conversations, exchange of various opinions or points of view, and discussion on the selected KWs and their comments, [1, 6]. Brief comments facilitate the exchange of information, discussion and convergence among students.

According to the above, the RedCoApp design that we propose (see Sect. 3), besides considering the implementation of a reading comprehension strategy based on the selection of KW, will use: (1) the advantages of the use of **short messages** (microblogging); (2) **real-time monitoring** to manage the follow-up of the elementary stages; And (3) the incorporation of activities of **collaborative learning** between 2 to 5 students who will work together in the selection process of the KW. Although students will work collaboratively in the process of identifying KW and its associated comments, each individual student will have to submit an answer regarding the purpose of the reading comprehension activity. By making each student responsible, the achievement of the detonating factor or purpose associated with reading can be measured individually.

In an educational context, **short messages** (microblogging, or tweets) can be used to express ideas, paraphrase or critique a concept, [18]. Short messages provide support for the collaborative work of the students, as they facilitate posing questions, share ideas and send answers. All this while practicing and learning by doing (**active learning**), that is in this case reading and writing, [19]. The educational activities that use short messages allow increased interactions, favor the discussion processes, and improve the commitment in the learning process of students, whether they are working through computer technologies in different places, or face to face, [20–22].

One of the main contributions of software applications as a scaffolding for learning activities is the real-time monitoring that the teacher can have on the level of progress and achievement of his students, allowing her to act as a catalyst to produce changes in the educational activity or in pedagogy [23]. For example, in [24] the teacher can review student responses, achievement levels, etc., and select one for the purpose of initiating a discussion involving the teacher and students. In this way, a computer application can implement immediate feedback to the teacher and the students, with the consequent contribution in the teaching-learning processes. Real-time monitoring is "the true heart of learning that allows students to converse with others on the basis of the dissonance revealed by the screens," [25] which is a shared zone where divergences and reconciliations occur, necessary for the processes of reformulation of ideas, [26].

Nowadays, university leaders are recognizing the need for **collaborative learning** inside of classroom, to bolster student success [27]. The goal of collaborative learning technique is to support learning for a specific educational objective through a coordinated and shared activity, by means of social interactions among the group members [28]. Research has shown that the proper design of collaborative learning tasks can improve motivation levels, facilitate communication and social interaction [29], support coordination and increase the level of students' learning achievement [12, 19], and facilitate face-to-face work supported by mobile devices [29–31]. Computational technology can help organize the information, do real-time monitoring, control and favor divergence and convergence processes, and support the coordination and communication of members of the collaborative work team [24, 28, 32]. On the other hand, **peer instruction** is an interactive and collaborative teaching technique that promotes classroom interaction to engage students and addresses difficult aspects of the material, [33, 34]. By providing opportunities for students to discuss concepts in class, peer instruction allows them to learn collaboratively from each other, [12]. It modifies the traditional lecture format to include questions designed to engage students and uncover difficulties with the material.

Active learning is any learning method that gets students actively involved; collaborative learning is one variety of active learning which structures students into groups with defined roles for each student and a task for the group to accomplish. Active and/or collaborative learning techniques involve the students in the class and increase retention of information following the class period. Individual active learning techniques are easier to apply and take less class time, while collaborative learning techniques require more advance planning and may take an entire class period, [35].

2.3 Choosing Members of Teamwork and Size of Team Works

According to [29, 36], technology can assist the configuration of working teams in order to apply various criteria with the aim of gaining more efficiency for achieving the proposed learning goals. In the literature we can find few examples of this when this has to be done by the teacher while the learning activity is taking place, and furthermore, it considers performance results from previous stages. Most common criteria used for forming work teams, in addition to random selection, are based on the selection of students by academic achievement (resulting from the assessment of the level of learning achieved for a specific educational objective) [37] and learning styles, [38]. Another criteria are based on social characteristics of the members; or group goals and a theory as an intelligent guidance that helps teachers to create theory-based CL scenarios, [39].

Configuring team works according to the student's **performance** is a well-known collaborative learning best practice. A sample of representative research suggests that task relevant, skill-homogeneous groups are good at narrowly defined analytical tasks, while heterogeneous groups perform better in extended synthetic tasks requiring learning, creativity and ideation, [32, 40]. According to [41], homogenous groups can be more motivating for students while heterogeneous ones can offer better learning opportunities. Liu et al. [36], say that the heterogeneity tends to achieve better learning levels in certain scenarios.

Learning styles are classifications of the different ways of learning that are more suitable to each student, whose use leads to an improved results. Using objects or learning elements that fit best with students' learning styles [42], Kolb developed a questionnaire to identify them that later Honey and Mumford modified it to be used with Spanish speaking students, [43]. Honey and Mumford classified learning styles in four groups: active, reflective, theoretical, and pragmatic. Since the learning objects that will be used in the reading comprehension activity will be the same, we consider that it will be more useful to bring together students who have heterogeneous learning styles. Regarding the size of groups, in [44] 2 to 3 members are recommended, in order to raise the levels of motivation among the members and avoid the formation of subgroups when the number of members is greater. According to [45], in a team of four members there will always be more simultaneous interaction than in a team of five or three. If the number of components of a computer is odd (3 or 5), it is more likely that one member will not interact with another at any point in time and will be out of activity.

2.4 Evaluation in Large Classrooms: Peer Evaluation

Another main problem with large classrooms, for both face-to-face and online scenarios is giving timely and systematic feedback to students or evaluation of their performance, because it takes a great amount of time and resources, [46]. One approach to solve the problem mentioned above is involving students as peer evaluators of their classmates in order to generate positive effects in the educational process, not only because it may help to overcome this problem by passing to the students most of the burden which traditionally has been taken by the teaching staff, but also because it has other positive effects on the learning process such as engagement, [47]. However, in order to be effective, peer evaluation should be positive correlated with that made by the teaching staff [48]. In other words, the peer student evaluation should be similar to those made by the teaching staff. For achieving this, we will introduce the previous calibration method, which consists in students practice the application of an evaluation rubric on sample examples before applying it to the work produced by their peers.

3 Design of the Reading Comprehension Activity: RedCoApp

This section describes the design of the collaborative activity supported by the RedCoApp application, which can be used under two roles: teacher (described in Sects. 3.1 to 3.3) and student (described in Sect. 3.4). The role of teacher allows access to specific functionalities which display real-time information that reflects the state of progress of the learning activity that students are performing at each stage (see Sect. 2, real-time monitoring). The information presented to the teacher will be shown by easy to understand graphic interfaces, such as comparative tables or matrices, bar charts, etc. (See Figs. 2 and 3). The teacher role allows to manage the learning activity of reading comprehension by activating in sequence each of the 6 stages that students must follow (see Sect. 3.4). These are: (1) The creation of activities on reading comprehension, and assigning them to students who will perform the tasks. (2) Real-time monitoring of the task progress, which will allow the execution in sequence of each stage of the task as they are completed; or identify at each stage the feedback that students need to receive in order to advance at each stage and advance to the next. And (3) the assignment of the student members that make up the work teams.

3.1 Reading Comprehension Task Creation – Teacher's Role

This stage consists of the creation of the Reading comprehension activity where the teacher performs following actions using the setup option (see Fig. 1): (a) inputs the name of the activity and specifies the detonating factor (DF) corresponding to the text students have to produce individually based on the Reading task; (b) uploads the documents students have to read; (c) identifies the relevant key words (KW) and its alternatives associated to the specified detonating factor in order to compare them with the ones identified by the students for measuring their achievement level; (d) assigns the students that will participate in the task (using the "Users" labelled button in Fig. 1); (e) specifies the rubric associated to the detonating factor (using the "Rubric" labelled button in Fig. 1) which students will use to evaluate the answers of their peers. The information required for each student is their names and preferred learning style previously identified based on the answers given to the questionnaire designed by Honey and Mumford [43], see Sect. 2.3.

Each task may have 2 or 3 associated documents with a length of a half page which are related according to the instructions given for the Reading task. The corresponding detonating factor will require from each participating student to identify and mark three keyword for each document ordered by relevance and write a small text justifying their selection.

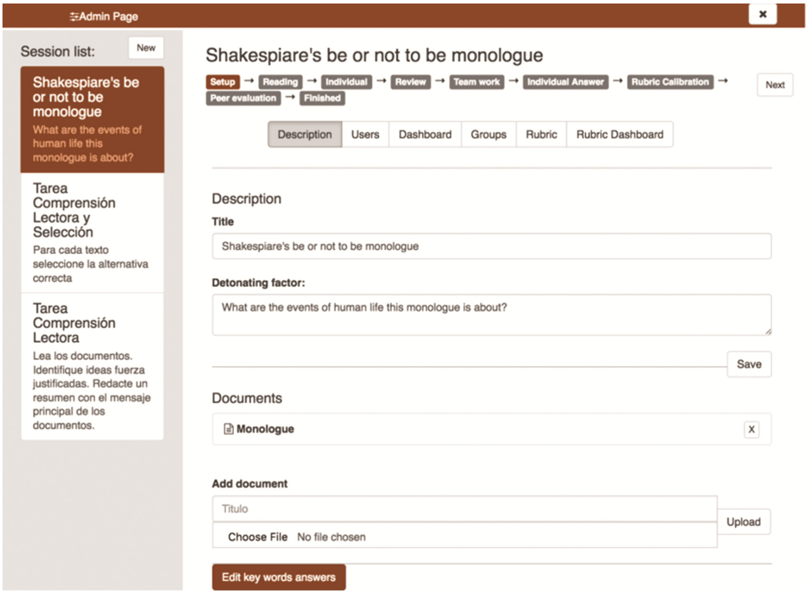

Fig. 1. View of the RedCoApp application's interface for the teacher role to upload documents to read (in the example, Shakespeare's Monologue), specify the detonating factor (what are the events of human life this text is about?). On the left there are three activities of reading comprehension.

The KW specified by the teacher can then be compared with those produced by the students thus generating relevant information about their performance. This information is presented in a simple, clear visual way when the teacher presses the "Dashboard" button in her application's interface. (see Fig. 2). This information can be used by the teacher in order to decide about: (a) going to the next stage; (b) provide feedback to the students in order to better accomplish the task; (c) assign members to working groups for the next working stages.

The evaluation rubric consists of 2 to 5 criteria for 4 levels of achievement, each of them described in detail and specified by the teacher. In addition, the weighting of each criterion should be specified and a final comment will be made to the proposed rubric. Before requesting the students to perform a peer evaluation of their responses, a calibration process will be performed for the rubric. For this, the teacher introduces three possible answers, which will be used as examples. After completing the specification and determination of the data and instructions necessary for each task, the teacher can start the learning activity (using the "Reading" button of Fig. 2) at the beginning of the class, and to continue with the following stages.

3.2 Real Time Monitoring of the Task Development – Teacher's Role

As already said, using the RedCoApp application the teacher has access to relevant information during the learning activity in order to: (1) Identify the state of progress of

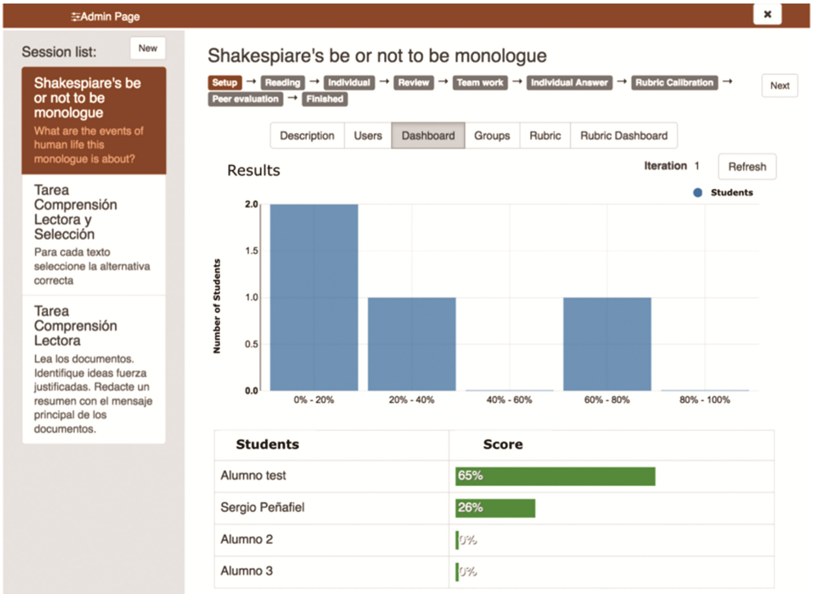

Fig. 2. View of the teacher's interface, showing a bar diagram with students' performance, based on comparing keywords chosen by the students and those proposed by the teacher.

the students in each of the stages of the learning activity. For example, the teacher can know how many students have chosen the correct keywords (see the bar diagrams of Fig. 2), or how many work teams have already completed the selection of the keywords (using the "Dashboard" button during the "Team work" stage). Figure 1 shows all steps in the upper part of the interface. This information will be used to decide whether to move to the next stage or wait for a significant number of students to complete the current activity stage; (2) identify the level of achievement of students in each stage according to keywords correctly chosen by the students. For example, if at the individual keyword selection stage, there less than 1/3 of the students have successfully completed the task the teacher may proceed to intervene the class, offering feedback to explain the detonating factor, how to identify relevant keywords, explain the context of the texts, etc.

3.3 Configuring Work Teams – Teacher's Role

Using the application, the teacher determines the configuration of the work teams, each one composed of 2 to 4 students (see Sect. 2.3), or 3 in case the total number of students is odd. Three criteria can be applied: (1) randomly; (2) based on performance (correct selection of keywords during the "Individual" stage); and (3) based on the learning style of each student. For the last two criteria, the teacher can also choose to group those students who had similar or different performance or learning styles (see Fig. 3).

Fig. 3. Interfaces used by the teacher for the selection of the team members of a working group. The top view generated a random proposal; The bottom one is generated based on performance, with heterogeneous criterion: students with a good performance with others who did not perform well.

3.4 Stages in the Learning Activity – Student's Role

This section describes the 8 stages students should take with RedCoApp to accomplish the reading comprehension learning activity. The 8 stages are performed in 2 regular classes of 90 min (stages 1 to 5 in the first class). RedCoApp was developed to be used on iPads that will be provided to at least 60 students in a classroom. Stages 3 and 4 correspond to collaborative activities (see Sect. 2.2). Stages 2 to 7 correspond to active learning activities (students are developing and applying reading comprehension strategies to develop this activity, see Sect. 2.2). Stage 4 corresponds to activities of the peer instruction type (allows students to learn collaboratively from each other, see Sect. 2.2).

Stage 1: Read instructions and texts ("Reading" stage of Fig. 1); time: 10 min. And Stage 2: Start performing the task individually ("Individual" stage of Fig. 1); time: 20 min. By entering the application and logging using a personal account, each student receives the activities assigned by the teacher on their respective iPads. At this stage, each student will read the instructions, the detonating factors, the documents, and generate a keywords ranking individually. To choose a keyword, the student selects 1 to 3 words from the document, and write a short comment that justifies this selection. The student can at any time modify or eliminate an already specified keyword, as well as the associated comment. During this stage, the student can change the order of the keywords ranking. At the end of this stage, each student must identify between 6 and 9 keywords (3 for each of the 2 or 3 documents) ranked by relevance, justified by short messages.

Stage 3. Re-elaborate the task individually ("Review" stage of Fig. 1); time: 20 min. Anonymously, and individually, each student accesses the keywords and comments proposed by the other members of his team, with whom they will work in a non-anonymous way in the next stage. On the basis of these keywords, the student re-elaborates its initial keywords ranking proposal of ranking. Its original proposal remains accessible. It is expected that the processing will generate between 6 and 9 new KW.

Stage 4. Re-elaborate the task collaboratively ("Team Work" stage of Fig. 1); time: 25 min. The application shows each student the names of the members of his/her work team. Each student can see the ranked list of keywords and their feedback of the other members of their work team. Trough face-to-face interaction they must re-elaborate a proposal for a new keywords ranking, based on those developed in stages 1 and 2. They can identify new keywords and their respective comments/justifications together, which will be used in the next stage.

Stage 5. Answering to the detonating factor individually ("Individual Answer" stage of Fig. 1); time: 15 min. Each student answers individually and in written form to the detonating factor, based on the documents read, the ranking and comments/justifications of the keywords. The written document should refer to the keywords identified, and their comments/justifications.

Stage 6. Rubric Calibration ("Rubric Calibration" state of Fig. 1); time: 40 min. Around three texts are evaluated with a specific rubric, for which students must: (a) read the text to be evaluated, and their detonating factor; (b) apply the rubric individually (the text can be shown whenever the students want it), along with writing the general comment; (c) analyze the results contrasting their own answers with the correct one issued by the teacher. The teacher will be able to analyze statistical data (mean, frequency distribution, etc.) in order to be sure that students are correctly "calibrating" their assessment skills, and can therefore activate the next stage. Calibration is a stage that we foresee that needs special attention, because text examples for each learning task depending on students' prior achievements should be carefully chosen and commented by the teacher.

Stage 7. Peer evaluation ("Peer evaluation" stage of Fig. 1); time: 30 min. At this stage, students evaluate the responses of two other students anonymously and based on the evaluation rubric proposed by the teacher. Each student receives 2 answers to evaluate, which requires: (a) to read the text to be evaluated and its detonating factor; (b) apply the evaluation rubric, together with the writing of a general commentary associated with its evaluation.

Stage 8. Analysis of the results and closure of the activity ("Finished" stage of Fig. 1); time: approximately 20 min. In this stage the teacher analyses the students' performance in front of the students presenting some data. The data are: general performance comparing the answers of the students with the "correct" ones introduced by the teacher, frequency distribution of the results associated with the detonating factor, the best answers of the students, example of "interesting" answers, etc. It is expected that at this stage the teacher will close the activity, provide feedback and assessment to the students.

4 Conclusions and Next Steps

Following the Design-Based Research method, this section describes in general the experiences that led to the design proposal explained in Sect. 3. The design was developed during 4 months by a team of experts from different areas, such as educators, psychologists, computer scientists, and teachers. Coordination meetings were held together for 4 h per week, along with at least 4 h on average of individual work that each expert invested to explore, analyze and propose educational theories, methods and techniques, and their possible combinations to specify an educational activity. The decision about which would be the most appropriate reading comprehension strategy to be used in large classrooms was most essential outcome to design a collaborative reading comprehension activity and its RedCoApp support tool, which used several benefits and advantages that were identified in the literature on related applications.

From our experience and having reviewed the literature, we consider that the most relevant contributions of the design of the presented activity to support reading comprehension and RedCoApp, are following two aspects, which are not present in other approaches: (1) the teacher can configure in groups in real time based on 3 criteria: random, individual performance achieved by students during previous stages of the activity, or the learning styles of each student (see Sect. 3.3); and (2) the prior calibration of an evaluation rubric in order to ensure the quality of the peer evaluation application to individual reading comprehension responses that are asked of each student (see description of stages 5 and 6 of the learning activity and Sect. 3.4).

It is also important to highlight other aspects of the design, which have been used in other applications already but not in the context of reading comprehension: (1) Classroom Response System as a method for solving problems that arise in large classrooms; (2) monitoring of students' performance in real time; and (3) active collaborative learning and peer evaluation.

The following steps of this research work envisage the implementation in large classrooms and using it with real students, in order to implement the experimental process associated with the aforementioned design contributions. Results are expected to feedback the design processes, and introduce improvements in learning activity and the RedCoApp application.

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