CC–LR: providing interactive, challenging and attractive Collaborative Complex Learning Resources

S. Caballé,* N. Mora,* M. Feidakis,† D. Gañán,* J. Conesa,* T. Daradoumis*† & J. Prieto*
*Department of Computer Science, Multimedia and Telecommunication, Open University of Catalonia, Spain
†Department of Cultural Technology and Communication, School of Social Sciences, University of Aegean, Greece

Abstract
Many researchers argue that students must be meaningfully engaged in the learning resources for effective learning to occur. However, current online learners still report a problematic lack of attractive and challenging learning resources that engage them in the learning process. This endemic problem is even more evident in online collaborative learning approaches whose resources lack of authentic interactivity, user empowerment, social identity and challenge, thus having a negative effect on learners’ self-motivation and engagement. To overcome these and other limitations and deficiencies, in this paper, a new type of learning resource named Collaborative Complex Learning Resources (CC–LR) is presented based on the virtualization of collaborative learning with the aim of leveraging knowledge elicited during live sessions. During the CC–LR execution, the collaborative sessions are animated so learners can observe how avatars discuss and collaborate, how discussion threads grow and how knowledge is been constructed, refined and consolidated. In addition, complex aspects of the learning process can be incorporated in the CC–LRs during their creation, such as cognitive assessment and emotional awareness. The system produced from this research is tested to evaluate the CC-LR enriched with complex information and analyze its effects in the discussion process. The research reported in this paper was undertaken within the Seventh Framework Programme (FP7) European project called ‘Adaptive Learning via Intuitive/Interactive, Collaborative and Emotional systems’.

Keywords collaborative complex learning object, collaborative learning, discussion forum, learning engagement, virtual campus, virtualized collaborative sessions.

1. Introduction
Online collaborative learning is a mature research field in the educational domain oriented to improve teaching and learning with the help of modern information and communication technology (Dillenbourg, 1999; Koschmann, 1996). Collaborative learning is represented by a set of educational approaches involving joint intellectual effort by learners, or learners and teachers together. Collaborative learning activities vary widely, from the simple teacher’s presentation or instruction to the students’ exploration or application of the course material (Dillenbourg, 1999).

However, many researchers argue that students must be meaningfully engaged in the learning resources for effective learning to occur (Bandaranaike & Willison, 2010; Bomia et al., 1997; Nicol & Macfarlane-Dick,
This lack of engagement is quite obvious in collaborative learning activities and can be attributed to the lack of real interactivity, challenging collaborative tools, learner’s empowerment and authentic social interaction, among others (see also Schlechty, 1994).

To overcome these stated limitations of current collaborative learning systems, we have focused on a new type of learning object (LO) called Collaborative Complex Learning Object (CC–LO; Caballé, Gañán, Dunwell, Pierrí, & Daradoumis, 2012), which allows for the virtualization and registration of live collaborative sessions and is augmented by alternative learning paths, cognitive and emotional features, additional content, etc., during an authoring phase (i.e., an expert managing the learning object). The CC–LO can be interactive and animated (by movies or comic strips), empowering learners to observe how the collaborative knowledge is constructed, refined and consolidated. The registered CC–LOs are eventually packed and stored in LOs, in the form of Collaborative Complex Learning Resources (CC–LR) for further reuse, enriching live sessions of collaborative learning with balanced levels of interaction, challenge and empowerment (Caballé et al., 2012).

CC–LRs include innovative and complex features such as cognitive assessment (Mora et al., 2012) and emotional awareness (Feidakis et al., 2012) that enhance and improve the collaborative learning experience. Learners use the innovative CC–LRs to develop their collaborative abilities and competences through a sequential and integrated process, in which cognitive indicators, rules, and the use of the CC–LR are continuously evaluated. For this purpose, new forms of cognitive assessment are incorporated to empower the learning experience and improve the student awareness and engagement. In addition, the embodiment of emotion awareness provides the system with the ability to capture students’ affective state during the use of the learning resource. The latter is activating an affective agent that provides affective feedback to the users in the form of empathetic dialogue moves, based on fuzzy rules.

In the current paper, we report on the development and experimentation with the CC–LR based on CC–LOs, extended with complex cognitive and emotional dimensions that eventually provide learners with balanced levels of challenge, interaction and empowerment during the collaborative learning experience, focusing specifically on the objectives of the Seventh Framework Programme (FP7) European project called ALICE.1

Specifically, in Section 2 we describe the scope and aims set for this research, alongside a concise discussion of the methodological background for the creation, management and execution of this new CC–LR, with specific support to cognitive assessment and emotional awareness. In Section 3, we present a research methodology that evaluates the nature of the innovative CC–LR and the benefits for learners through the development of a system prototype called virtualized collaborative session (VCS) that enables the embedding and execution of the new CC–LR. The prototype components are experimented and validated in Section 4 along with a discussion on the results achieved. In Section 5 we provide conclusions highlighting key concepts and outlining ongoing and future work.

2. Aims and background

CC–LO, was first presented and discussed in Caballé et al. (2012). This new concept was justified by setting up two research questions about what makes a LO (Wiley, 2001) collaborative and what makes a LO complex, which cannot be easily answered by current standard learning objects. The key differentiators from the standard LO include multiple levels of abstraction from pedagogic context, learners and representational medium (complexity), as well as intrinsic support for interaction across the object (collaboration).

To accommodate the concepts mentioned earlier with the model proposed by the authors (Caballé et al., 2012), a CC–LO was embedded into a VCS. A VCS is a registered collaboration session augmented by alternative flows, additional content, assessment, etc., during an authoring phase (subsequent to the registration phase). The VCS is interactive and animated (by movies or comic strips) and learners can observe how knowledge is constructed, refined and consolidated (see Figure 1).

In this paper, we extend our research towards the invention of an innovative learning resource based on the CC–LO approach. We propose the above-mentioned concept of CC–LR by integrating CC–LO into a complex learning material that is used, adapted and reused extensively in academic courses beyond the original collaboration. To this end, the CC–LOs can be
Figure 1  Screenshot of a Collaborative Complex Learning Object from the Virtualized Collaborative Session (VCS) Prototype Showing a Discussion that Evolves over Time, Produced by the VCS Performed in a Standard Web Forum
edited by the VCS to include complex aspects of the learning process, such as alternative paths, cognitive assessment and emotional awareness. The VCS containing the CC–LOs is eventually packed and stored as learning resources (CC–LR) for further reuse so that future learners can leverage the benefits from past sessions of live collaborative learning enriched with high quotes of interaction, challenge and empowerment.

In particular, two important extensions of the CC–LO approach were exploited when proposing the new CC–LR: cognitive assessment (Mora, Caballé, Daradoumis, & Gañán, 2012) and emotional awareness (Feidakis, Daradoumis, Caballé, & Conesa, 2012). For the purpose of our study, a dimensional methodology with respect to time was used by considering deferred and immediate time approach for both extensions. These extensions are reported next from the literature and in further sections they are developed and validated.

2.1. Cognitive assessment

Assessment is a systematic process for making inferences about the learning and development of students (Erwin, 1991; Swan, Shen, & Hiltz, 2006). In collaborative learning, assessment requires an even broader perspective about learning and the involved processes. It is necessary to encompass the asynchronous and synchronous interactions produced among group members as well as a formative evaluation of the group activity (Dillenbourg, 1999). These assessment methods have a significant effect in online collaborative learning processes because they engage learners through accountability and constructive feedback (Zumbach, Hillers, & Reimann, 2003). In this regard, the ground for the designing of enriched collaborative learning experiences is laid by the self-regulation of formative activities, the evaluation of contributions and the encouragement of participation behaviour, the knowledge building and the performance through selected assessment feedback (Caballé, Daradoumis, Xhafa, & Juan, 2011).

In addition, collaborative learning has an important social attitude (Bandura, 1977). Collaborative and social assessment aimed to detect problems in the interaction produced during the collaborative work sessions, such as content, collaboration, conversation, interpersonal interaction and performance support. As a result, collaborative and social aspects are developed in a sequential process that can be evaluated step by step to give useful feedback to partners. This assessment feedback meets the purpose of producing an enriched collaborative learning experience (Zumbach et al., 2003).

This section focuses on the cognitive assessment processes that are embedded into discussion activities with the aim of providing an enriched collaborative learning experience. Based on what has been mentioned earlier, two assessment models with respect to time dimension are proposed for the development of an assessment component that integrates cognitive information into the learning resources. More specifically (Mora et al., 2012):

- Deferred time assessment refers to the development of original collaborative interactions over time, by showing a variety of elements that contribute to the understanding of the nature of the collaborative interactions, such as the learners’ passivity, proactivity, reactivity, as well as the effectiveness and impact of their contributions to the overall goal of the collaborative learning activity (Caballé et al., 2011). As a result, the learner achieves a better understanding of the collaborative learning process while improving the overall social experience. For instance, by constantly showing cognitive assessment information about the live collaboration, the learner can develop reflective and experiential learning skills by analysis and application (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956).

- Immediate time assessment considers the data generated or collected from human–human, human–resource or human–environment interaction and processed efficiently in real time, in order to obtain reliable results. To this end, we propose the development of a set of assessment rubrics that take diagnose inputs and return a diagnosis response. Diagnose inputs include interaction moves and information related with the personal user, the group, the resources or the environment. Diagnosis responses can be processed as human feedback or as interaction response of resources and environment. Finally, learners must be able to understand and manage the feedback supplied by the assessment system in order to have an enriched learning experience and a sense of deeply controlling their learning process (Zumbach et al., 2003).
Both types of cognitive assessment can be integrated into learning resources from evaluating special aspects of the learning produced by collaborative interactions. Deferred assessment, on the one hand, can be implemented by collecting, analysing and displaying in the learning resource the progress and performance of the individual or group activity from the original forum dialogues or collaborative learning material. On the other hand, immediate assessment can be implemented by using evaluation tests to assess the current progress and performance with the learning resource. Data coming from the interaction with the learning resource is also considered, such as the number of page visits and the time elapsed in every action or response. This information may be enriched with contextual information about the users’ profile and cognitive state, as well as other environmental data.

Finally, in order to ensure that the learning experience can be adapted and personalized from the cognitive perspective, the system also interacts with or collects contextual information from specific data models found in most of e-learning tools (Capuano et al., 2009), such as the learner model, the knowledge model, and the didactic model. As a result, a personalized cognitive response can be provided based on individual needs, preferences, interests, and so on.

### 2.2. Emotional awareness and affective feedback

Emotion has always been a major consideration and concern in learning and so far, a remarkable amount of research efforts (Hascher, 2010; Pekrun, Goetz, Frenzel, & Perry, 2011) examine students’ emotions (e.g., confusion, enjoyment, hope, excitement, anxiety, fear, boredom), in a variety of contexts (during exams, in the class, while studying, in leisure time). The role of emotions in learning and their realistic application in education has drawn attention to affective computing (Pekrun, 1992; Picard, 1997). More recently, Calvo and D’Mello (2010) provided evidence about the progress that has been attained in this field.

Today, Intelligent Tutoring Systems and online collaborative learning environments, are gradually enhanced with emotion awareness (detect and respond) capabilities (Afzal & Robinson, 2007; Arroyo et al., 2009). The automated detection of student’s emotions has exhibited promising results though it is still in its infancy (Calvo, 2009). Indeed, despite the advancement of the emerging e-learning technologies, we still lack in adequate empirically proven strategies to address the presence of emotions in learning (D’Mello, Craig, & Graesser, 2009; Hascher, 2010). There is still a need for more realistic, in-context studies to investigate successful affective sequences that propel students’ self-motivation and engagement. In addition, the availability of convenient and usable multimedia interfaces and tools to detect or report emotions is quite limited (Feidakis et al., 2012).

Based on the above, we have described the development of a component to measure emotions in e-learning systems, considering three time approaches: before the task, in parallel with the task, and after the task (Feidakis et al., 2012):

- **Before the task**: We are interested in the respondent’s mood and disposition before accomplishing a specific learning task. Positive mood fosters holistic, creative ways of thinking (Pekrun et al., 2011). On the other hand, negative mood create a pessimistic perceptual attitude, diverting the learner’s attention to aspects irrelevant to the task, activating intrusive thoughts that give priority to a concern for a well-being rather than for learning (Boekaerts, 1993). Groups and roles in subsequent collaborative tasks can be based on the prospective assessment of their affective state.

- **In parallel with the task**: The respondent’s affective state is monitored together with his/her learning performance. Physiological or behavioural methods can be applied to measure user’s emotions without interrupting the learning flow, although, sensors and cameras sometimes are considered obtrusive (Arroyo et al., 2009). Self-reporting is often invasive because it requires from the user to focus on the emotion reporting process, separately from his task. However, usable images and animations (non-verbal reporting) can provide brevity in user’s response and minimized disruption of associated task performance.

- **After the task**: Retrospective emotion measurement refers to the evaluation of the respondent’s affective state right after the task (i.e., after a quiz or test) or in deferred time. The latter is aiming at annotating past sessions (e.g., forums, chats etc.) with emotion information by exploiting observation (i.e., observe motor-behaviour signals in video files or images) or sentiment analysis & opinion mining techniques (classify posts based on their affective content).
In response to user’s emotional state detection, affective feedback design is aiming at sending appropriate affective or cognitive signals to the user, ensuring their emotional safety and their engagement or persistence in the learning process. Although few, there are remarkable studies evaluating computer mediated affective feedback strategies and their impact on users. Feedback methods include generation of dialogue moves (hints, prompts, assertions, and summaries), immersive simulations or serious games, facial expressions and speech modulations, images, imagery, cartoon avatars, caricatures or short video-audio clips. D’Mello et al. (2009) have proposed the use of agents to respond to student affect with either parallel-empathetic (exhibit an emotion similar to that of the target), reactive-empathetic (focus on the target’s affective state, in addition to his/her situation) or task-based (supplementary to empathetic strategies).

3. Research methodology

This section presents a methodological approach to validate the notion and nature of CC–LR aimed to enhance motivation and engagement during the learning process. To this end, we first identify the notion of the ‘VCS’ to support the creation, management and execution of CC–LR. Second, we describe the newly created editor tool to provide the CC–LR resources with complex information of the learning process, such as cognitive and emotional assessment (see Section 2). This approach is validated in Section 4.

3.1. Definition and purpose of the VCS system

An initial approach towards a VCS system is depicted in Figure 2 (see also Caballé et al., 2012, for further details). The VCS is made to be compatible and interoperable with broad collaborative sessions, such as chats and forums, in order to create general types of CC–LO (see Conesa, Caballé, Gañán, & Prieto, 2012, for further details). The VCS system processes data in standard format and creates a specific CC–LO named Storyboard Learning Object (SLO; Caballé et al., 2012), containing information about scenes, characters, and other artefacts used during the later visualization of this learning object (see Figure 2b). The viewer tool (SLO Player, see Figure 2a) enables students and moderators to watch the virtualized collaborative session in an interactive read-only way.

Next section presents the SLO Editor (see Figures 2a and 3), which is used to edit SLOs. This allows changing scenes order, adding or removing content, incorporating cognitive assessment and emotional information, defining workflow, etc.

This paper, takes the SLO approach one step forward by creating innovative CC–LRs that provide learners with complex aspects of the learning process as described in the next section.

3.2. CC–LR: provision of complex information of the learning process

Several types of scenes can be handled by the SLO Editor, such as Dialogue, Assessment, Emotional and Reference scenes (see Figure 3). Dialog scenes come from the conversion of the original text-based discussion into a SLO. In a Dialog scene the tool enables the CC–LR Editor in charge to fix the text of the original contribution, manage and assign avatars or pictures to each participant and deal with assessment information about the participants and the contributions, respectively (see Section 3.2.1). Eventually, SLOs are converted into CC–LRs and stored as regular learning resources for academic courses. The Editor’s role is played by the lecturer in charge of the course or by an expert in teaching material. Figure 3 shows a snapshot of the SLO Editor.

Being part of the process of creating CC–LRs, the SLO Editor enables Editors to create and manage different types of complex scenes. For the purpose of our research, we focus on two types: Assessment and Emotional scenes (see Figure 3). Both types of scenes deal with information in both deferred and immediate time (see Section 2 for the methodological background of this time dimensional approach).

3.2.1. Cognitive assessment

Deferred cognitive assessment of past sessions (see Section 2.1) can be added in the CC–LR by the editor tool (see Figure 4) as performance indicators of the original participants in terms of quantity, quality and passivity during the whole discussion. In the CC–LR, every avatar assumes representative icons (e.g., coloured hats, medals, etc.) that show selected performance indicators of the collaboration and make the deferred social interactions easier to understand. In addition, extra information about the contribution is
Figure 2 Upper Part (a): Architecture of the Virtualized Collaborative Session System and the Bottom Part (b): Storyboard Learning Object Structure
also provided in order to show the primitive type of interaction occurred (e.g., request or give information, clarify, explain, solve a problem, etc.). The ultimate purpose was to help learners during knowledge acquisition.

Immediate cognitive assessment is provided in the CC–LR by incorporating assessment scenes with evaluation tests in certain points of the storyboard in order to evaluate the acquisition of knowledge of the current learner after a certain amount of scenes con-
3.2.1. Cognitive awareness

The SLO Editor tool enables the incorporation of cognitive assessment (see Figure 5a). Upon the results of the test, different learning paths are triggered from a set of rules predefined by the Editor, such as to continue watching the storyboard or jump back to a previous scene with the purpose of revising the material from that point (Figure 5a). In case of failing the test repeatedly, the learner is lead to a special scene with content augmentation about the topic of the discussion (Figure 5b).

3.2.2. Emotional awareness

The SLO Editor tool enables the incorporation of the emotional state of the original participant as deferred emotions (see Section 2.2 and Figure 4 the emoticon added by the avatar’s name). The system is also able to suggest an emotional state based on the content of the original contribution and following a sentiment analysis approach (Conesa et al., 2012). Thus the Editor in charge of creating the CC–LR can either confirm the system’s suggestion or select a different emotional state.

Furthermore, the tool enables the incorporation of immediate emotion awareness (see Section 2.2) by means of emotional scenes that can inspect the emotional behaviour of the learner during the consumption of the CC–LR. The emotional information is collected by non-verbal mechanisms (see Figure 6a) and as a result, an affective feedback is provided by an agent triggering an empathetic response (Figure 6b). For instance, the agent can provide the learner with a relaxing situation (through music, pictures, etc) to correct a negative emotion.
Overall, the CC–LR provides a highly interactive, challenging and attractive learning resource while allowing the learners to take control of their learning experience and fostering social learning. Furthermore, the inclusion of complex aspects of the learning process helps learners to improve the acquisition of knowledge and enjoy of a more attractive learning experience. Finally, some steps of personalization are also added by designing different learning paths according to the academic background of learners. The CC–LR is able to interrogate the contextual systems about academic prerequisites of the learner (i.e., previous courses) and, for instance, send the learner to a special scene where additional learning material is provided related to the missing prerequisite knowledge.

4. Experimentation and validation

For experimentation and validation purposes, a prototype of the VCS with an embedded CC–LR was developed. Firstly, the data source of a live collaborative learning session was derived from the discussion forums of a learning management system called Intelligent Web Teacher (IWT) (Capuano et al., 2009), which are typically used to support in-class collaborative learning activities based on discussion. Then, we used the VCS prototype to generate an animated SLO from the IWT forums showing how people discussed and collaborated, how discussion threads grew and how knowledge was constructed, refined and consolidated (see Figure 2). This SLO was then stored for further reuse in the form of a CC–LR and augmented with cognitive and emotional information as explained in Section 3.2 (also see Figure 7). The ultimate goal was to evaluate the CC–LR enriched with authoring information and analyse its effects in the discussion process. The experimentation activities took place in the real learning context of the Open University of Catalonia (UOC).

4.1. Experimentation set-up and procedure

The sample of the experiment consisted of 44 undergraduate students enrolled in the course Organization Management and Computer Science Projects, which is part of the Engineering Computing degree at the UOC. Despite all 44 students participated in this experience, only 24 (54.5%) submitted the final questionnaire, the rest of the students (20) dropped out the discussion and the course for personal reasons. It is worth mentioning that the 45% dropout ratio found is considered normal at the end of the academic term. The group was supervised by a tutor who was in charge of the course.

The experimentation procedure was as follows. A formal in-class learning assignment was scheduled during the first 2 weeks of June 2012. The activity was individual and mandatory for all students and consisted of filling a test with questions on Software Project Management. Besides the usual didactical course materials, students of the experimental group were required to use a new material in the form of a video-discussion (CC–LR) to specifically support this activity called ‘Factors that lead a Computer Science project to failure’, which contained a discussion about project management. This material was enriched with emotional and cognitive information, which made the material highly interactive. The students could watch this interactive CC–LR material embedded in the VCS prototype through their online classroom of the UOC.

At the end of the assignment, students were required to fill out a questionnaire, which included: (1) test-based evaluation on the usability of the VCS system; (2) test-based evaluation on the emotional state; and (3) test-based evaluation of the CC–LR. For qualitative data analysis, we summarized the open answers in the questionnaires. For the quantitative analysis we employed basic descriptive statistics, such as mean (M), standard deviation (sd) and median (Md) to analyse the scores obtained in the questionnaire. We complemented this quantitative analysis by employing accepted statistical procedures (Alexander, Graybill & Boes, 1974), such as $\chi^2$, so as to compare the observed scores to the expected scores.

For Section 1 of the questionnaire (usability of the VCS player showing the CC–LR), we used the system usability scale (SUS) developed by Brooke (1996), which contains 10 items and a 5-point Likert scale to state the level of agreement or disagreement [it ranges from ‘I strongly disagree’ (1), ‘I disagree’ (2), ‘neither/nor’ (3) to ‘I agree’ (4), ‘I strongly agree’ (5)]. SUS is generally used after the respondent had an opportunity to use the system being evaluated.

To investigate the emotional state of the students using the new system (Section 2 of the questionnaire), we included the 12 items of the computer emotion scale (CES; Kay & Loverock, 2008). The CES is used...
Figure 7: A Storyboard Learning Object (SLO) from a Live Discussion Performed in the Forums of the Intelligent Web Teacher e-Learning System is Edited by the Virtualized Collaborative Session-SLO Editor to Create a Collaborative Complex Learning Resource, Which Contains Different Types of Scenes and Author Information, Such as Cognitive and Emotional Information of the Original Participant and Contributions.
to measure emotions related to learning new computer software. Research showed that the 12 items are describing four emotions:

- Happiness (‘When I used the tool, I felt satisfied/excited/curious.’);
- Sadness (‘When I used the tool, I felt disheartened/dispirited.’);
- Anxiety (‘When I used the tool, I felt anxious/insecure/helpless/nervous.’); and
- Anger (‘When I used the tool, I felt irritable/frustrated/angry’).

The answer categories in this section are ‘None of the time’, ‘Some of the time’, ‘Most of the time’ or ‘All of the time’.

### 4.2. Experimentation results and interpretation

This section shows the results collected from the aforementioned experiment where we evaluate student’s satisfaction with the educational tool considering the level of worthiness of the CC–LR as well as the usability and emotional aspects while using the tool.

#### 4.2.1. Usability assessment

To evaluate student’s satisfaction with the tool as regards efficient and user-friendly management, we collected data from students’ ratings and open comments on the usability/functionality/integration of the tool. SUS scores have a range of 0–100 with an average score of 68, obtained from 500 studies. A score above 68 would be considered above average and anything below 68 is below average. A score above 80.3 is considered an A (the top 10% of scores). Scoring the mean (68) awards a C and anything below 51 is an F (putting one at the bottom 15%).

After calculating the SUS score for each student \((n = 24)\), we obtained an average of 69.27, thus above the SUS mean. In particular, students of the experimental group thought they will use the CC–LR (video-discussion) often \((M = 3.36, \text{sd} = 1.09, \text{Md} = 3.5;\) see Figure 8). Students did not find the tool unnecessarily complex \((M = 2.18, \text{sd} = 0.96, \text{Md} = 2;\) see Figure 9). In addition, students stated that they did not need the support of a technical person so that they can use the video-discussion \((M = 1.68, \text{sd} = 1.00, \text{Md} = 1;\) Figure 10); they thought that most people would learn to use this system very quickly \((M = 4.22, \text{sd} = 0.58, \text{Md} = 4;\) see Figure 11), and they felt quite confident using the video-discussion \((M = 3.86, \text{sd} = 0.70, \text{Md} = 4;\) see Figure 12). Finally, students stated that the VCS functionality was well integrated \((M = 3.95, \text{sd} = 0.50, \text{Md} = 4)\) whereas video-discussion was found easy to use \((M = 3.13, \text{sd} = 1.23, \text{Md} = 3)\).

In sum, the usability of the video-discussion enriched with complex aspects, such as cognitive and emotional information, was judged satisfactory or very satisfactory in line with the general SUS score.
4.2.2. Emotional assessment

Regarding the students’ emotions of the experimental group during their work with the video-discussions, the results from a 4-point rating scale (n = 24) are as follows:

- Happiness ($M = 1.13$, $s_d = 0.67$, $M_d = 1$; Figure 13). This result shows that students were curious with the new type of scenes incorporated in the video-discussion (cognitive and emotional).
- Sadness ($M = 0.50$, $s_d = 0.78$, $M_d = 0$; Figure 14a), anxiety ($M = 0.45$, $s_d = 0.72$, $M_d = 0$; Figure 14b) and anger ($M = 0.54$, $s_d = 0.77$, $M_d = 0$; Figure 14c). These results are very good (being $M_d = 0$), which means that students did not experience these negative feelings.

In sum, students felt more often happiness than sadness, anxiety or anger when studying with the new learning material (CC–LR). The most noticeable result regards Happiness, attributing the highest value to it, while the values of Sadness, Anxiety and Anger emotions were very low, almost inappreciable ($M_d = 0$), being the Anxiety emotion the lowest one. Overall, we consider it as a good result taking into account that students faced a complex type of learning material that was new for them and they had to learn its functionality and how to use it for their learning benefit. Finally, this result is in line with the results concerning usability that were presented earlier.

4.2.3. The CC–LR as a valuable resource

In this section we evaluate the level of worthiness of the CC–LR enriched with complex information and supported by the VCS as an educational tool. To this end, we collected quantitative and qualitative data of the questionnaire that included seven open questions addressed to students. The rating scales for the majority of the quantitative questions were based on the usual 0–10-point scale. The rating scale went from the lowest (0) to the highest (10) considering a ‘good’ assessment from 5 to 10 and a ‘bad’ assessment from 0.0 to 4.9, being the ‘good’ assessment the expected scores for each question ($n = 24$, degrees of freedom = 1 and $p < 0.05$ for the calculated $\chi^2$).

To evaluate the video-discussion (CC–LR) material, the following questions were asked to all students (each question required to assess the CC–LR from the question’s view in the scale 0–10):

1. What did you like and what you did not like from the video-discussions.
2. Compare the video-discussions with traditional teaching material and tools (books, web pages, forums, blogs, etc) and indicate pros and cons of the video-discussions.
3. Do you think the video-discussions have helped you acquire more knowledge about the discussion topics in comparison to the text-based forums?
4. Express your opinion about the video-discussions in terms of efficiency and performance.
5. Let us know your opinion about the potential of video-discussions to observe how people discuss and collaborate, and how knowledge is constructed.
6. Do you think that both performance indicators on each character and test questions integrated in the video-discussion allowed you to understand the contents of the video and acquire more knowledge?
7. Indicate whether the consideration of both characters’ emotional states and your own emotional state in the video-discussion has had any impact on your learning experience?

After calculating the 0–10 scale for all the seven questions and participants (n = 24) we obtained a general mean score of 6.28 (sd = 1.31 and Md = 6.5) and $\chi^2(1) = 4.46, p < 0.05$. These results are in line with the previous usability and emotions results, both confirming the value of CC–LR as an educational resource.

In particular, for Question 1, students liked the CC–LR enriched with author information ($M = 6.40$, sd = 1.44, Md = 6.75) and $\chi^2(1) = 12.76, p < 0.001$. On the one hand, some students found the CC–LR quite impressive and original, and considered this as an innovation with respect to the current technology at UOC. Als, they felt that the CC–LR simulated a ‘real’ discussion, that is, it was close to a real discussion with the presence of the discussants. On the other hand, others found the interface not very pleasant, including the ‘robotic’ voice, and suggested to embed different voices for each character. However some students had no problem to understand the VCS text-to-voice engine, which was implemented thanks to the VCS Editor, and the opportunity to correct the syntax of the original posts, which in turn improved the conversion text-to-voice. Finally, some students indicated the benefits of the CC–LR for disable people.

Question 2 aimed to compare CC–LR with traditional teaching material and tools. It achieved good scores [$M = 6.33$, sd = 2.32, Md = 7.00 and $\chi^2(1) = 7.85, p < 0.01$]. In general, students found this resource more attractive and pleasant to study rather than the traditional material (e.g., teaching books and text-based forums and blogs). With CC–LR, some students felt like studying in a collaborative fashion and because characters were based on real students they had the impression to form part of the collaborative activity registered in the video. In addition, others found that sharing experiences in an only-read way in a video-discussion represents a different way of individual study and not ‘just yet another forum’. Some of them missed a human moderator in the video-discussion.

Question 3 aimed at exploring whether CC–LR has helped students acquire more knowledge on the topic. It achieved marks that were slightly above the average ($M = 5.92$, sd = 2.34, Md = 6.50) with $\chi^2(1) = 7.85, p < 0.01$). Some students mentioned that observation of the different characters’ points of view helped them understand the main topics in the video better as well as speed up understanding. However, they thought that this material should ‘complement’ the official material rather than replace it, while others mentioned that the material helped them reflect and reason upon their ideas since the special video format made it easy for
them to be introduced into the topic. Finally, some students found the potential of the video-discussions ‘huge’ since it is more didactic and comfortable to learn through video being with people sharing opinions rather than reading a teaching book.

The previous pedagogical result is also confirmed by Question 5 that seeks the potential of the VCS and CC–LR systems to observe how knowledge is built ($M = 6.54$, $sd = 1.93$, $Md = 7$ and $X^2(1) = 10.08$, $p < 0.01$). Most students mentioned that they were able to observe the knowledge construction process in a ‘natural’ and ‘progressive’ way. Some students found that CC–LR provides ‘simulation’ by giving them the possibility to build knowledge from real life. This was especially appreciated and was mentioned that it fostered exploration of new forms of representation. The test scenes that were found in strategic points of the video (see also Question 6) were mentioned to ease the process of knowledge construction by fostering knowledge retention and consolidation.

Question 4 is related to the efficiency of CC–LR. It obtained good results ($M = 6.92$, $sd = 2.41$, $Md = 7.0$) with $X^2(1) = 10.08$, $p < 0.01$. In line with the control group, almost all students indicated that this resource was very easy, intuitive and fast to use, while it showed efficiency and high performance. Only a few students reported problems with installing the application in Linux platforms.

Question 6 reported very positive results about the incorporation of cognitive aspects and obtained a mean score as high as 6.94 ($sd = 1.12$, $Md = 7.0$) and $X^2(1) = 12.76$, $p < 0.001$, being the highest score of all questions. In general, students found the chance for self-evaluation by several test scenes in certain points in the video very didactic. They reported better consolidation of the concepts and ideas (i.e., knowledge retention). Also, examination of the performance indicators identified by the avatars demonstrated knowledge reliability of the character. Finally, most students expressed their wish to have more test scenes to reflect, self-assess and check their knowledge. Only a very few students found that the test scenes broke the rhythm of the video reproduction.

The last Question 7 concerned emotional awareness and scored low ($M = 4.94$, $sd = 1.99$, $Md = 5.0$), being the lowest score of all the questions and the only one under average, though the Median was on average (5.0). Moreover, $X^2(1) = 2.17$, $p > 0.10$, which is not statistically significant in the number of students who scored $\geq 5$. Indeed, many students mentioned that the emotional assessment was not useful to understand the concepts better and they did not even understand the purpose of this feature. However, some students mentioned that they found interesting to know the emotional state of the character (i.e., participant) in the video when ‘talking’, since the character transmitted confidence, cordiality and other positive feelings that cheered them up, though other students mentioned that they could understand the contribution without knowing the emotional state of the character. A few students indicated that the feature that asked them to select their own emotional state even ‘bothered’ them and interfered with the progress of the video, while others indicated that this helped them keep concentrated on the work.

5. Conclusions and future directions of research

This paper presents a research work aimed at providing online collaborative learning with authentic interactivity, challenging tools and user empowerment, with the ultimate aim to influence learner motivation and engagement. To this end, a new type of learning resource called CC–LR has been proposed that registers live collaborative sessions and produces an animated storyboard so that learners can observe how people discuss and collaborate, and how knowledge is constructed. The development of an editor tool in the VCS system was also reported to augment the CC–LRs with author-generated information, thus showing the provision of complex aspects of the learning process, such as cognitive assessment and emotional awareness.

The notion and nature of the CC–LR was finally validated by experimenting with a prototype of the VCS system that embeds a CC–LR. Validation activities were carried out in a real context of learning. In general students liked the CC–LR and found this new type of learning resource easy to use, interesting and useful, since it contributed to better content understanding, knowledge retention and construction.

Ongoing work includes further evaluation of the CC–LR approach in a massive scale in our real learning context of the UOC. Intensive experimentation and validation activities will be conducted in several online courses and in different academic programmes and disciplines in order to provide attractive and challenging learning resources to support our pedagogical model.
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Notes

1 ALICE project web site: http://www.aliceproject.eu
3 The UOC is located in Barcelona, Spain. The UOC offers distance education through the Internet since 1994. Currently, about 60,000 students and 3500 lecturers and tutors participate in some of the 3000 online official courses available from 43 official degrees and other PhD and post-graduate programmes. The UOC is found at http://www.uoc.edu
4 Because of the particular profile of the UOC students (students are about 30 years old on average and 95% with a job) the dropout ratio at UOC at the end of the course is 50% on average being about 20% in the first third.

References


