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CC-LO: Embedding Interactivity, Challenge and Empowerment into Collaborative Learning Sessions

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Abstract: Despite their demonstrated potential through a range of early studies, on-line collaborative learning systems do not yet have the impact that many believe is possible. In particular, collaborative learning approaches cannot be readily applied to every e-learning experience, since they require a degree of presence and/or collaboration which may be difficult to achieve. In addition, collaborative learning systems often lack the challenging resources and tools required to fully support collaborations, making the experience unattractive to end-users and discouraging progression. Whilst the learner might expect to control the collaborative experience, often it is the collaborative experience that controls and limits the learner. As a result, collaborative learning resources can lack authentic interactivity, user empowerment and balanced levels of challenge, thus having a negative effect in learner motivation and engagement. To overcome these deficiencies, we propose a new paradigm named Collaborative Complex Learning Objects (CC-LO): a special type of Learning Object which aims to leverage the knowledge elicited during live sessions of collaborative learning, augmented with author-generated information, to produce interactive and attractive resources to be experienced and played by learners. During CC-LO execution, learners can observe how avatars discuss and collaborate, how discussion threads grow, and how knowledge is constructed, refined and consolidated. Furthermore, learners can interact with the CC-LO in order to modify some parameters observing the consequences and assessing their understanding. The research reported in this paper was undertaken within the European Framework 7 project ALICE (Adaptive Learning via Intuitive/Interactive, Collaborative and Emotional Systems).

Keywords: Collaborative Learning, Collaborative Complex Learning Objects, Virtualized Collaborative Sessions, On-line Discussions
Categories: K.3.1, L.1.2, L.3.0, L.3.6

1 Introduction

On-line collaborative learning is a mature research field in the educational domain dedicated to improving teaching and learning through the introduction of modern ICT [Dillenbourg, 1999]. Collaborative learning is represented by a set of educational approaches, involving joint intellectual effort by learners, or learners and teachers together [Goodsell, 1992]. Collaborative learning activities vary widely, though most of them are centred upon students' exploration or application of the course material, not simply the teacher's presentation or explication of it. However, many researchers [Dillenbourg, 1999; Goodsell, 1992; Stahl, 2006] argue that students must be meaningfully engaged in the learning resources for effective learning to occur. Such a lack of engagement is especially evident in collaborative learning content, and can be attributed to the lack of (i) real interactivity (in many cases the only interaction available is to click on the "next" button to obtain the next message in a discussion forum); (ii) challenging collaborative tools, which fail to stimulate learners, making the collaborative experience unattractive and discouraging progression; and (iii) empowerment, as learner expects to be in control of their own collaborative learning.

To overcome these and other related deficiencies, Learning Objects (LOs) have received much attention in recent years as technology that enables educational elements to be repackaged and reused far more readily than was previously the case [Littlejohn, 2003; Friesen, 2004; Polsani, 1997; Wiley, 2001]. In particular, the emergence of the Internet as a medium for educators, with its capacity to reach large audiences and bring together content from a wide range of sources, has been of significant interest. The initial definition of an LO is given [see Gerard, 1967] as self-contained and reusable elements of learning. More recently, the IEEE Learning Technology Standards Committee provided the following working definition: Learning Objects are defined as any entity, digital or non-digital, which can be used, reused or referenced during technology supported learning. Common themes from literature include:

- A need for a minimalistic approach to individual LOs. The greater a larger learning process (e.g. a training course) can be decomposed into individual LOs, and the more succinct these LOs and their constituent elements are, the greater their potential for repurposing.
- A focus on repurposability. The ultimate purpose of deconstructing a larger learning process into individual LOs is to facilitate straightforward repurposing of the individual elements to form part of other learning processes and pedagogic approaches [Polsani, 1997].
- Technical compatibility and format consideration. An increasing issue, as technology advances, is the transition towards new media for education, such as virtual worlds and collaborative online environments. As well as the pedagogic considerations that must be attached to this transition, technical consideration must also be afforded to how elements may transition from one collaborative online environment to another. This composability has long been a goal of virtual environment designers [Zyda, 2005], and the adoption of common formats for the representation of virtual content is increasingly enabling it to be moved seamlessly between game engines and virtual world platforms.

- Freedom in the definition of content. Content itself can be any form of media, as long as it is attached to an educational context [Kaldoudi, 2009], a definition which includes resources that have not been initially developed for educational purposes. Ultimately, content must be defined by the creator of an LO, not the end user: this is the nature of repurposement. Technological and pedagogic compatibility are not necessarily harmonious [Zyda, 2005] and the need is upon the designer of both the content and overarching system to ensure compromise is reached.

As the concept of the LO becomes well-defined and broadly accepted, an extension of this definition is needed to address the requirements of learners in collaborative scenarios, pedagogically designed with reference to the concepts of social and collaborative learning [Vygotsky, 1978; Bandura, 1979; Collazos, 2007]. 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). Hence, extending the LO paradigm we reach the notion of "Collaborative Complex Learning Object (CC-LO)" [Caballé, 2011] by asking two fundamental questions: what makes a learning object complex, and what enables a learning object to be collaborative?

In order to define a CC-LO we consider first what makes a collaborative learning object. There are two principle ways in which collaboration occurs, collaboration in the formation of the object, and collaboration in its active use [Fuentes, 2008]:

- Collaboration in creation: Several platforms exist for the collaborative creation of LOs by educators. This can adopt a principle of segregated responsibility, whereby individuals are responsible for various elements of an object (e.g., independent designers for educational materials and assessment methods), or shared responsibility, whereby educators play a role in peer-reviewing and adapting content. [Boskic, 2003] describes the critical nature of this role, though discusses how it may extend to the perception of LO use and reuse in general, rather than best-practice for creation. [Vargo, 2003] address how such evaluation may be automated, concluding this remains most effective when implemented in a synergistic fashion with the educators.
- Collaboration in use: A collaborative learning object in this sense is capable of responding to and facilitating interaction by multiple simultaneous learners. It is hence a communication medium, through which learning objectives are achieved by the collaboration and social learning environment it forms [Collazos, 2007]. However, this simple notion brings with it a host of questions: the object must embed pedagogy and assessment to conform to the expectations of a standard LO [Wiley, 2001]. It must simultaneously accommodate multiple interactions and shared space, whilst also supporting the need for other groups of learners to approach it in different times and reuse it. [Farrell, 2004] describe the concept of dynamic creation of learning objects, in this case we see the emergence of a methodology whereby the learning object becomes analogous the object-orientation metaphor: it has a class (an overarching definition), and instances (multiple creations of that object with its different states in flux).

Of these two components, despite in inherent interdependence (a collaborative learning object allowed to evolve is effectively being recreated over time), the latter is of greatest interest and relevance to the social pedagogies [Bandura, 1979]. A true collaborative learning object in this sense is one which supports this collaboration between learners and the subsequent emergence of societal groups to create the shifts in social norms required for behavioural and attitudinal change.

The second consideration in defining a CC-LO is what makes a 'complex' learning object. The chief sources of may be defined with respect to pedagogy as well as the technical complex implications these pedagogic affordances imply, as follows:

- Applicability: A trait common to pedagogic as well as technical consideration is how widely an LO can be repurposed across technical domains. A CC-LO, under this definition, has the capacity to be deployed into an online collaborative environment as an encapsulation of learning activity, assessment, and integration. The learning activity could be through direct interaction with the learning object in a virtual incarnation (e.g., an object could be given physical form as a Virtual Scientific Experiment (VSE)). Further applicability to content rating systems is also a worthy consideration [Kumar, 2005].
- Evaluability: Following on from the need for content rating and assessment in order to provide adequate selection tool for educators, CC-LOs must support evaluability in pedagogic and technical terms [Ertl, 2010]. A key principle in the definition of any learning object is the implicit co-relationship between education and assessment, and a learning object must provide the interface to not only assess its users [Leal, 2011], but also to provide comparative evaluation for the purposes of repurposement selection. For a holistic view, this needs to come from the learner as well as the educator.
- Internal dynamicism: [Valderrama, 2005] describe the concept of creating learning objects which are themselves able to adapt to context. These 'intelligent' LOs are able to adapt to their content autonomously, removing the need for the end-user to undertake substantial repurposing work. We describe in [Section 2] the concept of a virtual collaborative session: in these sessions CC-LOs are instanced and evolved over time, but retain the capacity to reset to an initial state to allow their reuse with other groups of learners. Any form of adaptivity implies a core template and source exists, and our definition of a CC-LO here suggests a need for the ability to define CC-LOs in time-independent states (the core repurposable LO), and time-dependant states (following learner interaction and evolution). We refer to this as internal dynamicism, as the state of a CC-LO must adapt to collaborations, yet be supported by a core instance of the CC-LO from which these dynamic versions evolve.
- Composability. Virtual environments have long spoke of the need for content to be more easily composable [Macedonia, 1997]. Frequently, objects are created which are explicitly linked to a single learning environment through their singularity in technical implementation, and failure to dissociate learning objectives from implementation issues. A CC-LO in this sense must be defined in broader and platform-nonspecific terms.

In practice, these paradigms lead to common attributes specific to CC-LOs:

- Augmentation with author-generated information. This can take multiple forms:
  - Questions & answers: discursively-generated information can help evaluators assess indirectly the strengths and weaknesses of a CC-LO.
  - Alternative flows: internal dynamicism supports non-linear paths through CC-LOs.
  - Assessments: since flow is not linear, assessment must track the path of the learner through the CC-LO and provide relevant assessment.
  - Dependencies: applicability and composability are required to take the form of either interdependencies with other CC-LOs, dependencies on other simple LOs, or dependences upon the learning environment.
- They are animated and evolve over time. The forms of animation can be simple, such as movies or comic strips, allowing learners to observe how avatars discuss and collaborate and how knowledge is constructed, refined and consolidated. Alternatively, this animation can be a more sophisticated virtual simulation. In all cases, the animation should be composable.
- They are interactive. Learners can interact to modify some parameters, observing the consequences and assess their understanding. This implies they are instantiable – learners have their own instance of a CC-LO which can either be disposed of, or integrated into the initial CC-LO after a learning activity.

In order to accommodate these concepts, under the model proposed by this article a CC-LO is embedded into a Virtualized Collaborative Session (VCS) [Caballé, 2011]. 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 can be interactive and animated (by movies or comic strips) and learners can observe how knowledge is constructed, refined and consolidated. In this context, CC-LOs also include assessment, collaboration and communication features to enrich the learning experience provided by the VCS. The VCS containing the CC-LOs is eventually packed and stored as learning objects for further reuse so that individual learners can leverage the benefits from live sessions of collaborative learning enriched with high quotes of interaction, challenge and empowerment.

Focusing specifically on the objectives of the European Framework 7 project ALICE[1], in this article we uncover the notion and nature of this new CC-LO paradigm. To this end, [Section 2] provides a description of the scope and aims set for this research, alongside a concise discussion of the methodological background for the creation, management and execution of CC-LOs. [Section 3] presents a methodological approach with the aim of validating this definition of the notion and nature of a CC-LO through the development of a prototype VCS system which enables the embedding of CC-LOs. The prototype components are then technically tested by a proof of concept in [Section 4] along with a discussion on the results achieved. [Section 5] concludes the paper by highlighting the key concepts covered in this contribution and outlining ongoing and future work.

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[1] ALICE project web site: http://www.aliceproject.eu

2 Aims and Background

A key aim of this research was to review the main processes and concepts of the new paradigm of CC-LO, and advocate guidelines for the use of CC-LOs both within the ALICE project and by educators on a wider scale. In this section, we first describe the goals of the ALICE project related to this research work and then we present existing work that help understand and use the concepts related to the CC-LO.

2.1 The ALICE Project

The general objective of ALICE (Adaptive Learning via Intuitive/Interactive, Collaborative and Emotional Systems) is to build an innovative adaptive environment for e-learning combining personalization, collaboration and simulation aspects with an affective/emotional based approach, able to contribute towards overcoming the existing limitations of current e-learning systems and content. The proposed environment is to be interactive, challenging and context aware, whilst realising learners' demands of empowerment, social identity, and authentic learning experiences.

The ALICE starting point is an existing e-Learning platform, Intelligent Web Teacher (IWT) [Capuano, 2009] already developed to exploit experiences and know-how gained through several EC projects. IWT seeks to customize the learning experience through understanding of real learner needs and preferences, whilst ensuring extensibility and flexibility at content, pedagogic and service levels. With respect to the basic aspects of collaboration, the project pursues a broad set of objectives related to collaborative learning. ALICE studies in depth themes surrounding collaborative learning in situations where learners have to develop specific skills (e.g. communication, problem solving, decision making, etc.) and collaborative activities can increase learning efficacy. However, collaborative learning approaches cannot be applied in every e-learning experience as they require a degree of presence. Consequently, a paradigm is required to reuse, in formal, informal or intentional learning contexts, the knowledge elicited during collaborative learning activities. Furthermore, this approach must sustain the advantages achieved through such an approach after the closure of the live sessions, preserving aspects such as social interactions, conversational processes and the evolution of discussion threads.

In order to achieve the aforementioned goal, the paradigm of CC-LO is proposed and defined as special types of learning objects embedded into VCSs, obtained by registering live collaborative sessions executed in Web-based environments, and augmenting (during an authoring phase) the tracked data with author-generated information (questions & answers, alternative flows, assessments, dependencies, etc.) to define attractive interactive resources experienced by learners through several different experiences. During the CC-LO execution, a VCS is animated in such a way (using movie or comic strips metaphors) that learners can observe how avatars discuss and collaborate about one or more topics, how discussion threads grow, and how knowledge is constructed, refined and consolidated. Furthermore, learners can interact with the CC-LO in order to modify some parameters observing the consequences and assess their understanding.

2.2 Related Work

A range of methods for creating, managing, and executing learning objects exist and may be applied to the case of CC-LOs. Dynamic assembly of learning objects has gained increased focus as technological capacity to manage and deploy in real-time becomes increasingly viable [Farrell, 2004]. Therefore creation is not restricted to offline development and instructor-led pedagogic design. However, ensuring quality and a usable end-product remains a concern for automated construction techniques.

Particularly, if dynamicism extends to the learning session itself, inconsistencies in learner experience may potentially arise. Furthermore, management of LOs becomes an increasingly demanding task in the face of dynamicism, as LOs may evolve over time, invalidating attempts to index and categorize them effectively. This is particularly true of a collaborative LO, and hence the virtual collaborative session is defined in our research [see Section 3] as a means to control this evolution and afford dynamicism. In general terms, learning object-based systems have met with most success in subject areas such as information technology, in part because there is little established content for these topics, as well as constant evolution in the state-of-the-art, and in part due to the fact educators within these disciplines are more ready to engage with technology [Abernethy, 2005]. Reaching core areas such as literacy and numeracy is a more demanding task both due to the nature of the subject matter, and the experience of educators working within the area.

Commonly, methods for creating learning objects have centered on mining existing information to construct learning objects autonomously [Rajendra, 2004]. The inherent appeal of this process is its ability to capitalize on the large volumes of semantic data present on the web and create educational material whilst requiring a minimum of involvement from educators. Some semantically-annotated sources [Auer, 2007], are particularly appealing sources of educational material. Validation of data from such a source remains a key concern, although these repositories are drawing increased attention as the veracity of peer-created data sources on the web is increasingly shown [Margaryan, 2007; Wang, 2010]. Participatory techniques have also been used for LO creation. These build upon the use of the creation process itself as a means for learning, instilling learners with increased engagement as a result of deeper engagement within the educational process [Abad, 2008]. However, the composability of these learning objects may prove a concern, as students are not best-placed to act as pedagogic designers thus requiring the resulting learning objects careful validation and development to ensure quality.

Early Learning Content Management Systems (LCMS) were closely integrated into existing e-Learning configurations as extensions or additions to content acquisition and control systems [Meinel, 2002]. More recently, the management of learning objects has benefited significantly from the application of semantic technology [Su, 2008]. Similarly, methods to extrapolate semantic relationships by direct and automated analysis of learning objects also exist, having been explored [Taibi, 2007]. This can be achieved through the use of content representation models, such as the Sharable Content Object Reference Model (SCORM), to enable the provision of a wide range of comparators. Peer-to-peer (P2P) approaches to learning object management have also been shown to have benefits in load distribution [Prakash, 2009], though bring with them the concerns common to peer-to-peer configurations around security and validity. Once adequately addressed through infrastructural design, a P2P management approach has strong long-term potential, and is of particular relevance to collaborative learning objects and CC-LOs since ownership must be carefully considered and assigned when deploying and devising learning objects for peer input and use.

An early review of repositories based on Learning Object Metadata (LOM) demonstrated significant advances in global standards for representation [Neven, 2002], and these have continued throughout the past decade. Yet the principal issue in the uptake of tools for LO creation and use remains in facilitating end-user involvement. Technologists have made many attempts to provide tools for content creation, management, and execution to educators [Mosley, 2005], however uptake remains limited. Fundamentally, though LO systems have the potential to make the teaching process less time-intensive in the development of course content, they transition the educator from the role of content creator to moderator, and hence generate some inherent resistance. Overcoming this requires that methods to better involve educators and allow their collaborative input are provided. Although LOM-based repositories offer strong potential to support independent learners working solely through e-Learning systems [Dinis, 2009; Leal, 2011], their use as a basis for tutor-led or collaborative activities requires much research [McGreal, 2006]. It is a consequence of this need that the notion of the CC-LO is explored within this paper.

The execution of learning objects has previously been achieved through methods such as the SCORM Run-Time Environment (RTE) [Costagliola, 2006]. The RTE defines a model by which LOs can be launched within a Learning Management System (LMS) and interchange data, allowing for user customization and adaptivity. The platform-independent nature of the system at the core allows for interfaces to be designed using server-side web scripting languages allowing for a high degree of dynamicism in the end-user interface and toolset. Evolution of learning objects over time is also supported across a range of formats, such as video learning objects [Fadde, 2009]. Overall, creating learning objects in an executable form represents a step-change in the context and autonomy in which they can be deployed, and reflects the transition of LOs from pedagogic material to semantic data constructs.

From the above approaches, methodologies for creating, managing, and executing CC-LOs can be largely grouped under three headings:

- Educator-centric: the educator assumes the role of author, moderator, and deployer of the CC-LO.
- Technology-centric: creation, management, and execution are handled by technology. Technology-centric case focuses on situations where an element of artificial intelligence or intelligent filtering is applied in lieu of a human expert.
- Learner-centric: these methods advocate techniques such as participatory design to allow learners to be involved in the creation and management of CC-LOs.

3 Research Methodology

This section presents a methodological approach to validate our definition of the notion and nature of CC-LOs by addressing the requirements of learners in collaborative scenarios, pedagogically designed with reference to the concept of collaborative learning. To this end, we first identify the notion of the "Virtualized Collaborative Session (VCS)" as an event in which CC-LOs are played and consumed by learners. Then, a newly created VCS system enabling the virtualization of collaborative sessions is presented to support the creation, management and execution of CC-LO. The realization of this system is reported from the requirements that conducted the development of a VCS prototype where CC-LOs are embedded. Finally, for validation purposes, a proof of concept of this approach is given that examines the embedding of a CC-LO into the VCS prototype, as well as the results of technical testing based on a set of indicators incorporated to measure and analyze user response.

3.1 Definition and Purpose of Virtualized Collaborative Sessions

Perhaps the best definition of a VCS can be achieved through analogy to a computer program. In this analogy, the learning objects exist as objects within the code, and the VCS is the overall execution of the program. As it runs, learning objects are created, evolve over time, and are subsequently disposed of. At termination, the evolved states of the learning objects are disposed of, and the VCS becomes ready to 'run' with new instances of CC-LOs from their initial templates, repeating the learning cycle to a new group of learners. This idea of the VCS is illustrated in [Fig. 1].

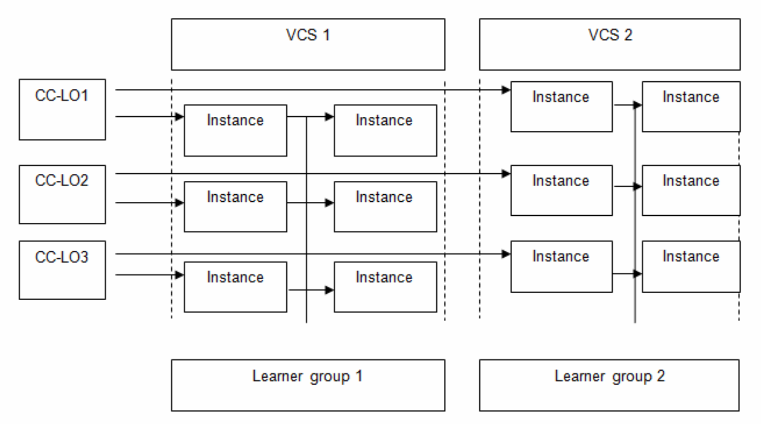

Figure 1: Execution of CC-LO instances within VCS programs

From this view, we capitalize on the instantiability of CC-LOs to facilitate multiple collaborative sessions in which CC-LOs evolve but remain reusable and reinstantiable for a second learner group. There are some notable considerations and benefits from this time-evolution, such as that the CC-LO can encapsulate the learning requirements on both pedagogic and technical levels, whilst retaining repurposability and reusability. Furthermore, as the VCS itself is not constrained to a single technical platform, compatibility with different platforms, such as forums and chats, can be facilitated through a driver interface (i.e., converter) to the CC-LO which, through middleware, converts it into the technical format required for representation within a given online collaborative environment.

3.2 Realization of the VCS System

Based on the above requirements, it becomes possible to propose some key guidelines for realizing a VCS system [Fig. 2]. The main feature of a VCS system is to be compatible with different kinds of chat messaging, forums or more general collaborative sessions to create CC-LOs. For this purpose, the input of VCS system is a file containing the collaborative session data in a common format called Collaborative Session Markup Language (CSML) based on XML. The CSML specifies an ontology named Collaborative Session Conceptual Schema (CS^2) that allows for modeling and representing knowledge about Web-based collaborative sessions [Conesa, 2011].

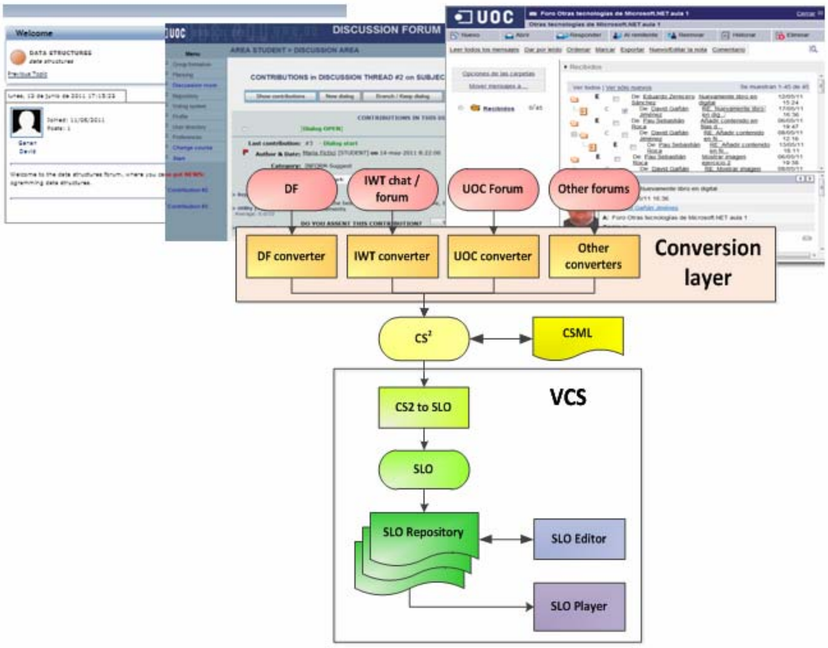

Figure 2: Architecture of the VCS system. The system is compatible with multiple forums and chats by specific converters

A first approach to a VCS system is depicted in [Fig. 2]. The process of conversion between the source of collaborative session data and CSML is done by a specific converter, which is different for each kind of source (i.e., the data model of a forum). Then, the VCS system processes data in CSML format and creates a complex learning object named Storyboard Learning Object (SLO), containing information about scenes, characters, and other artifacts used during the later visualization of this learning object. The SLO is editable by the use of a tool (SLO Editor), which allows for changing scene order, adding or removing content, adding assessment scenes, defining workflow, etc. Finally, the viewer tool (SLO Player) enables students and moderators to see the virtualized collaborative session in an interactive but read-only way. While the edition capabilities are still under development, the current status of our VCS prototype fully supports the viewer tool [Caballé, 2011].

Overall, the VCS transforms a live discussion forum into an animated storyboard and produces an event in which SLOs are played and consumed by learners, sessions evolve ("animate") over time, and the ultimate end-user interactions with SLOs are handled. As a result, the VCS becomes an attractive learning resource so that learners become more motivated and engaged in the collaborative activities [Fig. 3].

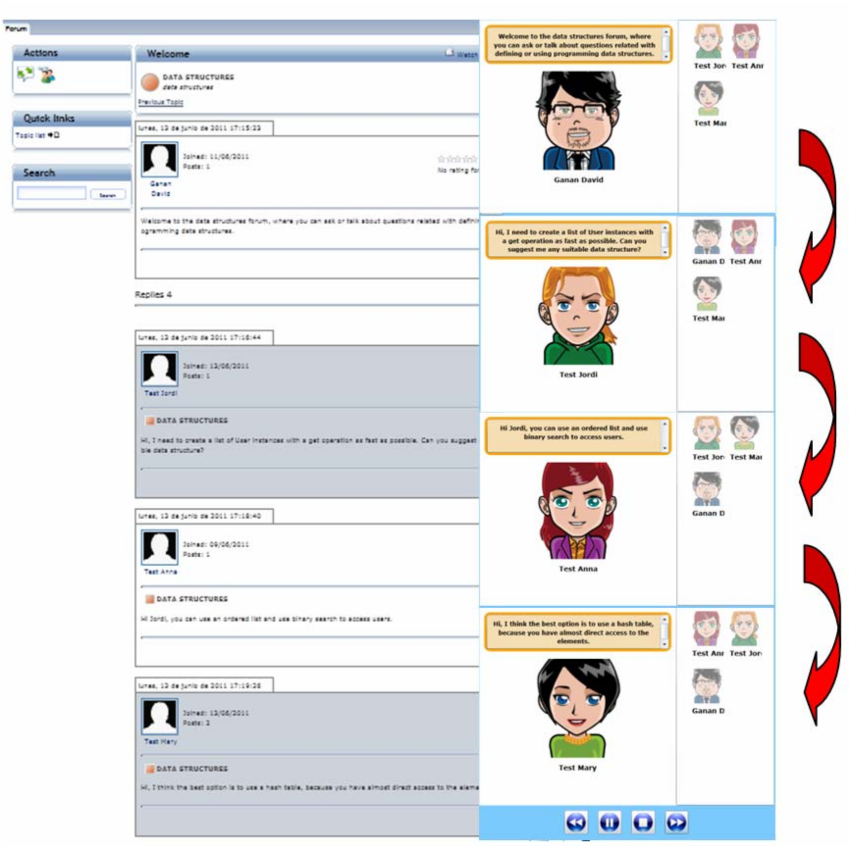

Figure 3: Sequence of snapshots of a CC-LO evolving over time after the virtualization of a live collaborative session. Four contributions of the text-based discussion are converted by the VCS prototype into an animated storyboard (SLO) supported by a text-to-voice engine

The extracted knowledge need to be represented by using typical standards of Semantic Web, such as: RDF, RDFS, OWL and SKOS [see, Fahad, 2011]. Simple Knowledge Organization System (SKOS)[2] is a family of formal languages designed for representation of thesauri, classification schemes and taxonomies.

2 http://www.w3.org/2004/02/skos/

In the SKOS ontology each individual is a Concept [Fig. 4]. A Concept can have a label (skos:prefLabel) and one or more synonyms (skos:altLabel). Hierarchical relationships between concepts can be expressed through the properties skos:narrower (that links a concept to a more specific one) and skos:broader (that links a concept to a more generic one), while a simple correlation is expressed through skos:related .

A sequence of mapping steps transforms the fuzzy lattice, into a semantic technologies compliant representation. [see, Granitzer, 2011].

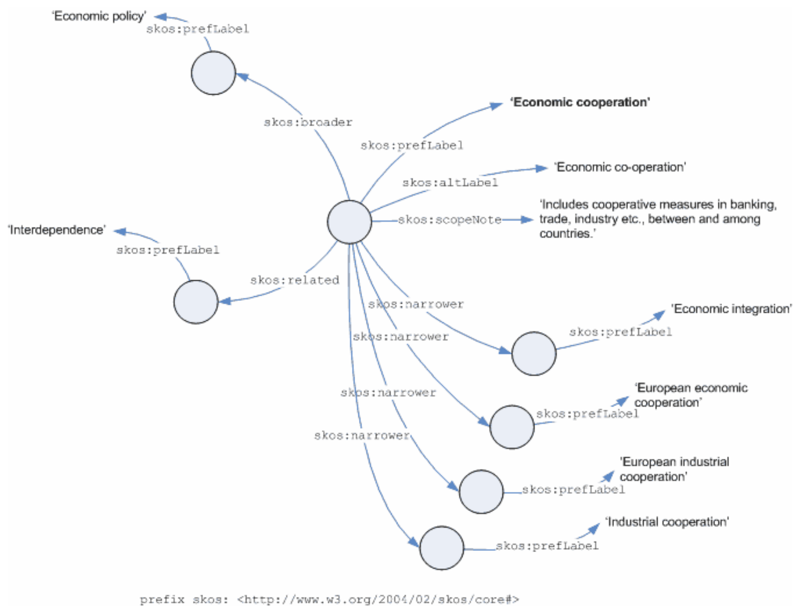

Figure 4: Example of use of SKOS

4 Experimentation and Validation

For experimentation and validation purposes, a proof of concept of the VCS prototype with an embedded CC-LO/SLO was developed [Fig. 3]. Firstly, the data source of a live collaborative learning session was derived from the IWT forums [Section 2.1], which are typically used to support in-class collaborative learning activities based on discussion. Then, following the process of modeling and representing forum data mentioned in [Section 3.2], a specific converter was built to turn the data model of the IWT forums into CSML representation [see, Conesa, 2011 and Fig. 2]. From the CSML representation, the VCS prototype generated an animated SLO showing how people discussed and collaborated, how discussion threads grew and how knowledge was constructed, refined and consolidated.

The design of the experiment consisted of three user assessments of the prototype with the aim to evaluate the proof of concept. The first at the Open University of Catalonia (Site A), the second at Coventry University Serious Games Institute (Site

B), and the third at the company Modelli Matematici e Applicazioni (Site C).

On all sites, a group of three types of testers were formed to provide three different evaluation perspectives, namely pedagogical, technical and usability. Thus, from the pedagogical perspective, domain experts (i.e., researcher and teacher in e-learning) were chosen; from the technical perspective, skilled technicians (i.e. developers with experience in e-learning systems) were selected; finally, novice users (i.e., students with experience in e-learning systems) performed testing on the VCS prototype to provide a usability perspective. Hence, each pilot site prepared a group of three testers, each of each type. Finally, the testing was run in each pilot site and by each tester by using different data input and running several executions of the prototype. The aim was to validate the concept of CC-LO by the next four indicators of interest asked to the VCS testers at the end of each test:

1. Build automatically an effective draft storyboard (CC-LO/SLO) from a threaded discussion coming from a forum. Score on scale 0-5 and open comments.
2. The VCS prototype allows non-expert users to build a CC-LO/SLO (i.e., in a friendly way and efficiently). Score on scale 0-5.
3. Create, edit, manage, store and playback the generated storyboard. Score on scale 0-5 and open comments.
4. The VCS prototype allows users to observe how knowledge is constructed. Score on scale 0-5 and open comments

		Indicators of interest				
	Testers	**#1**	**#2**	**#3**	**#4**	**Total (M)**
Site A	# Expert	4	4	2	2	3.0
	# Technician	5	4	4	3	4.0
	# Novice	5	4	4	2	3.8
Site B	# Expert	5	3	3	2	3.3
	# Technician	5	4	4	2	3.8
	# Novice	5	5	3	1	3.5
Site C	# Expert	5	5	4	3	4.3
	# Technician	5	4	3	4	4.0
	# Novice	5	3	4	4	4.0
	Total M(SD)	4.9(0.3)	4.0(0.7)	3.4(0.7)	2.6(1.0)	**3.7(0.4)**

Table 1: Mean (M) and Standard Deviation (SD) statistics in the 0-5 scale

4.1 Quantitative and Qualitative Results

This section presents a brief discussion on the data collected from the aforementioned subjective assessment performed at both sites on the VCS prototype.

[Tab. 1] shows, on the one hand, some basic statistics of the quantitative marks on the scale 0-5 scored by all testers for each of the four indicators of interest considered. Each tester performed 5 executions in a row before providing the scores.

On the other hand, [Tab. 2] shows an extract of qualitative results from those indicators with open comments provided by the testers after the test in questionnaires.

Indicators of interest with open comments	**Testers' open comments (type of the tester: E: Expert; T: Technician; N: Novice)**
Build automatically an effective draft storyboard from a threaded discussion coming from a forum.	"I could watch the storyboard very easily, it was exciting!" (N, Site A) "The automatically created SLO follows the same structure as the threaded discussion" (T, Site A) "To test fully [the system] would need to be compatible with all our existing forum content" (E, Site B) "Why can't I see people's real faces?" (N, Site B) "It looks very nice to build a story from a forum in this way." (N, Site C) "The draft SLO should be larger to be tested appropriately" (E, Site A)
Create, edit, manage, store and playback the generated storyboard.	"I could control the storyboard with the play, pause, stop, back and forward controls and playback the discussion many times." (N, Site A) "...felt like features for editing were lacking, but playback and storage worked fine" (E, Site B) "To test fully [the system] would need to be compatible with all our existing forum content" (E, Site B) "For complicated stuff... [it] might be better if I could advance the discussion pressing a key rather than keep pausing" (N, Site B) "The storyboard player could be more clear" (N, Site C) "Yes, it was possible to observe some knowledge building but it still misses the editor tool to remove some scenes that cause noise" (E, Site A) "The player only gives a sequential view of the knowledge" (T, Site A)
VCS prototype allows users to observe how knowledge is constructed.	"It is interesting and easier to follow a discussion though I could not observe knowledge construction" (N, Site A) "...would be great on a mobile device" (T, Site B) "Why would I store it instead of just making it again every time?" (N, Site B) "The management of the created SLO is not immediate to understand and the Playback should be improved" (T, Site C) "It was interesting to me to see how a discussion progressed but the built knowledge is not quantifiable." (E, Site C)

Table 2: Excerpt of the questionnaires on the 3 commented indicators #1, #3 and #4

4.2 Discussion

At site A, from the quantitative results, we can see that whilst the total score is promising, it is limited as the VCS prototype currently offers the player tool only. In particular, indicators #3 and #4 were scored low by the expert tester [see Tab. 1]. According to this tester's comments [see Tab. 2], since the prototype could not still offer all its potential regarding the edition of the storyboard, this in turn limited the improvement of the storyboard-based discussion. Novice's quantitative scores were also low for indicator #4. According to his comments, he reported a failure to observe a noticeable improvement of knowledge building from the text-based discussion. Finally, the technician tester scored the prototype well, and commented positively on the automatic transformation of the threaded discussion into a SLO, considering also the lack of edition capabilities of the SLO, which is currently a work-in-progress.

At Site B, an open group discussion was held between expert, technician and novice, moderated by the researcher, following all other data collection activities. Tension between novice and technical expert was evident for several aspects of the system: the novice feeling the system "lacked clarity of description", whilst the technician disagreed, suggesting the system was "completely clear". One aspect here might be that the creation of the SLO is fully automated, and therefore a novice user is unaware of this underlying functionality, instead experiencing only the high-level playback of the VCS. Therefore, in the testing at Site B, the novice failed to engage with this aspect of the system instead focusing on visual aspects (e.g. "Why can't I see people's real faces?"), and failing to appreciate the benefits of creating the SLO ("Why would I store it…"). Results for indicator #4 reinforce this finding, with expert and technician feeling the process was too transparent, and the novice failing to observe the relationship between use of the tool and knowledge creation. This presents something of a paradox: on the one hand, much investment in SLO creation emphasizes the need to make the process as simple as possible for the novice user, however, in this case the degree of abstraction is so great supplemental materials or explanation may be required for novices to understand this component of the system.

At site C, experimentation highlighted that further work remains to be done. In particular, the story management, and absence of an edit phase, suggested that although the system has a good potential it may be still improved. For example, participants suggested it could be useful if the avatars have different voices at least between male and female, allowing more access to users with vision impairments as well as enhancing immersion for general users. Site C reported that major efforts must be done in order to give more emphasis on indicator #4 to observe how the knowledge related to a specific topic is constructed. Expert users noted that the knowledge extracted by the storyboard is not quantifiable. Hence, at this stage the prototype seemed to be more interesting from the technological rather than methodological point of view.

However, it should be noted, from the data collected from novice users at all sites, the potential of the VCS player tool is evident, providing a step forward through the provision of an attractive resource which motivated and engaged the tester in discussion. The technician and novice at Site B also suggested the system would have particular potential for mobile devices, as the visual representation of the discussion fits well to a small screen and would be particularly beneficial due to the difficulties of reading large volumes of web-forum text on such a device.

In summary, the results of the tests reported here are not conclusive due to their exploratory nature. A recurring theme is the difficulty in balancing ease-of-use and transparency against the need to provide the user with an understanding of the underlying process and its value. Future work, therefore, will address not only the increased incorporation of key features and functionality based on the findings of this study, but also explore how better to convey the underlying process and principles to novices, supporting them in developing their understanding of the use and application of CC-LOs. This is fundamental to applying the main processes and concepts of the new paradigm of the CC-LO, as well as providing guidelines for their use by educators on a wide scale.

Previous related studies [Caballé, 2011b] investigated in a conceptual framework for modeling interactions from live collaborative activities. The results showed an improvement of the collaborative learning process in terms fostering student participation and enhancing individual performance. The current approach differs from previous initiatives by considering virtualized instead of live collaboration as the grounds for the study. Virtualization provides further benefits towards the learner's engagement, such as reusability of the knowledge elicited during the collaboration, more real interaction, and empowerment of the collaborative experience from attractive and challenging learning resources. This may provide a significant step forward in the development of current e-learning systems and applications.

5 Conclusions and Ongoing Work

This paper has detailed research work undertaken within the European Framework 7 project ALICE, a project devoted to providing on-line 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 LO called CC-LO has been introduced, embedded into a VCS system that registers live collaborative sessions and produces an animated storyboard (SLO) such that learners can observe how people discuss and collaborate, and how knowledge is constructed. The development of this VCS prototype has been reported from a methodological research view. The notion and nature of the CC-LO is finally validated by running extensive tests on a proof of concept of the VCS system that embeds a CC-LO. These validation activities were carried out following the same methodological procedures in several international sites with different perspectives and expectations towards the research presented in this paper. Ongoing work includes the evaluation of the VCS prototype in the real context of learning of the Open University of Catalonia. Intensive experimentation and validation activities will be conducted in on-line courses in order to provide attractive and challenging CC-LOs to support the collaborative learning activities, in particular in-class discussions. Moreover, current work within the ALICE project is the development of an editor tool to augment the VCS system with author-generated information. For instance, e-assessment scenes will be added to the VCS, such as tests (with optional jumps to storyboard scenes) as well as supporting videos, to be connected with scene parts according to the dialogue timeline. As a result, tutors will be provided with edition capabilities of the SLOs, such as cutting scenes, modifying involved characters, selecting emotional states, dialogues and connected concepts.

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