# A Multi-fold Assessment Framework for Virtualized Collaborative and Social Learning Scenarios

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# Acknowlegments

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# Abstract

Cognitive assessment in Computer-Supported Collaborative Learning (CSCL) requires assessment processes that achieve significant effect on CSCL and engage learners through accountability and constructive feedback. In order to design a coherent and efficient assessment system for CSCL it is necessary to design an enriched learning experience that predisposes the feedback and awareness in the group.

Current collaborative technical support involves online collaborative tools that allow for interacting and learning through socialization. For the sake of socialization, Social Learning (SL) theories play a fundamental role in this context by emphasizing observation and modelling of the behaviours, attitudes, and emotional reactions, in terms of continuous reciprocal interaction between cognitive, behavioural, and environmental influences.

These collaborative and social processes can be greatly enhanced by the latest educational, pedagogical and technological approaches, such as Collaborative Complex Learning Object (CC-LO), which virtualizes the knowledge elicited during the live collaborative sessions in order to alleviate the isolation of online learners whilst providing them with social identity, empowerment and effective interactivity. In addition, Social Networks play a major role in CSCL by locating people at the very centre of networks and exploiting the value of people's connections and relations. In this context, Learning Analytics and Social Network Analysis techniques provide a clear way of analyzing the underlying interactive behaviour and network structure to discover the collaborative knowledge hidden in large volumes of structured data.

The main goal of this research is to enhance and improve learning engagement and outcomes by means of the virtualization of CSCL and SL enriched with a complete e-assessment framework that evaluate and represent the quantity and quality of the collaborative and social interactions occurring during live CSCL activities. In particular, this thesis aims at showing evidences of the effects of incorporating cognitive and social assessment into an innovative educational and technological approach derived from CC-LO called Collaborative Complex Learning Resources (CC-LR) to support virtualized collaborative learning activities augemented with author information.

Overall, the thesis contributes to the CSCL assessment field with the application of popular data analysis techniques that are able to analyze and represent knowledge and social interaction during the live collaborative sessions. The interaction data extracted from social networking and collaborative learning is integrated into a general assessment framework to produce an efficient and personalized awareness and feedback about the collaborative activity and the social behavior of their participants. As a result, the thesis provides conceptual and methodological research approaches of e-assessment applications and tools to augment the CC-LR with effective assessment support.

From the results achieved, the proposed assessment framework incorporated in the CC-LR approach in the form of social and cognitive indicators becomes a reliable source of information at different level of learning assessment, such as individual and group performance and dynamics. Although levels of frustration appear, produced by strong expectations to learn faster and easier, high levels of satisfaction are reported with the use of the CC-LR extended with the assessment framework developed and integrated during the thesis.

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## Chapter 1: Introduction

## 1.1 Chapter overview

The main goal of this thesis is to enhance and improve learning engagement and outcomes by means of the virtualization of Computer-Supported Collaborative Learning (CSCL) and Social Learning (SL) enriched with a complete e-assessment framework that evaluate and represent the quantity and quality of the collaborative and social interactions occurring during live collaborative activities. In particular, this thesis aims at showing evidences of the effects of incorporating cognitive and social assessment into an innovative educational and technological approach called Collaborative Complex Learning Object (CC-LO) to support virtualized collaborative learning activities augemented with author information.

In this chapter we first go a step further by introducing the above concepts and issues that will play an important role in this area of research, such as collaborative and social learning scenarios, assessment models of collaborative and social learning, and new collaborative elements - the CC-LO as the virtualization of collaborative and social learnng, and their importance in this research area. Then, we motivate this thesis as the continuation of the research conducted previously in the context of an european project. Finally, the research goals, hypotheses and methodology are formulated to set up this thesis.

## 1.2 Collaborative and Social Learning

Computer-Supported Collaborative Learning (CSCL) (Dillenbourg, 1999) is one of the most important educational paradigms in the learning domain focused on how collaborative learning is supported by technology so as to enhance peer interaction and work in groups of learners, and how collaboration and technology facilitate the sharing and distributing of knowledge and expertise among learners (Lakkala,  et al., 2001).

Current technological support to collaborative learning involves the development of online collaborative tools that allow for interacting and learning through socialization. Social learning theories play a fundamental role in this context by emphasizing observation and modeling of the behaviors, attitudes, and emotional reactions, in terms of continuous reciprocal interaction between cognitive, behavioral and environmental influences (Bandura, 1977). Technological tools also provide learners with a wide range of social and interactive experiences though they need a holistic approach, which integrates all available social media in learning scenarios.

Therefore, collaborative and social learning scenarios must be effectively addressed, becoming a difficult task (Zyda 2005). Certain requirements are to be considered when constructing a social learning scenario using a CSCL model, such as the ability to observe the modeled behavior, recall this behavior and reproduce it. A further problem is the use of collaborative and social learning scenarios in the context of formal, informal and intentional learning experiences. It is necessary to define and differentiate the mentioned approaches to each of these areas.

A current mature research field deeply rooted in any form of collaborative learnning is that of assessment. Building a consistent assessment framework involves knowing how information

can be collected from collaborative and social learning activities and managing the extracted knowledge effectively. Driven by the users' interaction, a high amount of quantitative and qualitative information is expected to be managed. The knowledge extracted can be used for self regulation, monitoring and scaffolding the collaborative learning process (Daradoumis et al., 2006).

Furthermore, in collaborative learning assessment, it is especially interesting to consider the questions related to time, which brings about improvements in learning. Time factor is involved in all collaborative learning dimensions and processes, such as rhythm and speed of learning, contingent support for learning, automatic feedback, self regulation of study, duration of courses, chronology of competence achievement, ubiquity and distribution of teaching, learning support structures, learning resources, continuous evaluation, previous knowledge, synchronous and asynchronous time, and so on. Many of these aspects are directly related with collaborative learning assessment.

Finally, collaborative learning activities vary widely, but most of them are centered in students' exploration or application of the course material, not simply in the teacher's presentation or explication of it. However, many researchers argue that students must be meaningfully engaged in the learning resources for effective learning to occur.

## 1.2.1 Networking in e-Learning

The "network" concept is crucial today in many fields from the social sciences, communications, computer science, physics, to biology and ecosystems (Dorogovtsev and Mendes, 2003). Networks form complex systems, emerging in many forms in different application domains, and consisting of many aspects whose proper understanding requires the contribution from multiple disciplines. (Camarinha-Matos and Afsarmanesh, 2005). Network management and networking can thus be understood as intelligent because it must make an efficient and effective use of the available networks. Intelligent networking is a concept migrated from the management of physical networks (Caballé et al., 2011a).

Virtual networks are at the moment the last and more promising dimension (Camarinha Matos et al, 2005; Barabasi, 2003; Huang et al., 2010). Indeed, virtual networks are present daily in many life ambits, ways and forms. Every life ambit is a special place where different networks can be used, in a special proportion and form, to achieve the expected goals. Virtual networks are a part of the life of many people who share messages, experiences and multimedia materials in social networks, such as Facebook of Twitter. Moreover, collaborative networks have been adopted by many and varied entities and organizations (Camarinha-Matos and Afsarmanesh, 2005). Social networks are thus characterized by one to one connection versus a collective gathering virtually in one space to work on a single project or problem as is the case with collaborative networks (Fulkerson, 2009). Fulkerson proposes the following aspects that characterize and distinguish both types of networking:

- Social Networks: One to one, Social interaction centered, Achieving personal objectives, Individual enrichment, Results immeasurable.

- Collaborative Networks, Group to group, Objective and content centered, Achieving group objectives, Operational excellence, Results measurable.

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From this view, on the one hand, social networking is seen as producing intangible results, such as socialization, sharing ideas and knowledge. On the other hand, collaborative networking seeks tangible results, such as reports, diagrams, developments, and so on. However, there is not an evident frontier between both types of networks. For instance social networking tends to create a relation between individuals, but a group of people interested in some theme may interact with another group by using collaborative networks. In addition, the results of social networking are not measurable if we expect a tangible goal, but the relation can be measured by tools, such as social network analysis (SNA) (Romero and Ventura, 2013). Thus, sharing and distributing knowledge can be measured. In overall, these differences are found in general as nuances and both types of networks are eventually merged to form a general view of networking, especially for e-learning (Barabasi, 2003).

Particularizing this introduction to the e-learning field, it is possible to apply some features of both types of networking so as to consider a new kind of learning experience centred in virtual environments. Indeed, intelligent networking understood as the efficient and effective use of networks can provide the needed support and physical structure for e-learning. However, some relevant questions arise in this context: How intelligent networking can improve and make virtual learning more efficient? How to construct a special virtual environment where the collaborative and social networks works together to achieve the learning goals, minimizing the problems of the virtuality?  How the time factor is involved in the virtual learning processes?

In order to answer these questions certain competences for networking in the context of learning have to be considered. As for collaborative networking, Rosas et al., (2003) make a competence taxonomy centred in the organization competence. They show two levels of competence: soft and hard and define the organisation's soft competency as a general aptitude to perform an abstract behaviour (e.g. the ability to exchange knowledge), which is beneficial for the achievement of the outcomes and goals associated to the performance of a hard competency. The organisation's hard competency is defined as the capability to run activities, tasks or processes, which allow achieving concrete outcomes or goals.

In social networking for learning, it is not easy to find a competence taxonomy, many authors, as Boyanzis et al.,(1999) cite as crucial competences: listening, empathy, responding, problem solving, achieve goals through relations, leadership, helping and conflict management, as the main competences needed to develop a good social networking. These competences are directly related to social identity (sense of belonging to a social group). Promoting this social sense of belonging to a group because can become an important motivational factor.

Finally, effective networking requires competences in time by knowing how and when to select the appropriate learning goals and how to achieve them by means of planning the learning path. This competence is directly related to the time factor in e-learning and through the inner students' self assessment. Guash et al., (2010) describe this dimension by showing the results of a collaborative learning experience, which makes it clear the need to provide immediate just in time feedback to students during the online collaboration. Also, they point out that students must be able to improve their argumentative schema, rework the information, and produce new ideas. Time factor is found implicitly in all kind of networking replanning or reworking.

At this point, we can define intelligent networking for e-learning as an innovative and efficient manner to learn together principled in three levels:

- Goal(s) definition and planning, where collaborative networking contributes and it is necessary.

- Human relations and affective support, supplied by the social level of networking. (e.g., minimizing the isolation factor is crucial to have good results).

- The involving time factor that interrelates the two levels showed before.

There is also a general agreement on the limitations and deficiencies of the current technological support for networking, especially when addressed to e-learning. Many researchers (Dillenbourg, 1999; Goodsell, 1992; Stahl, 2006) argue that students must be meaningfully engaged in the learning tools for effective learning to occur. This lack of engagement is especially evident in collaborative networking tools 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 tools, which fail to stimulate learners, making the collaborative networking experience unattractive and discouraging progression; (iii) empowerment, as learner expect to be in control of their own collaborative learning experiences. Moreover, social networking tools for e-learning also do not consider the social identity of learners, thus becoming mostly isolated from their peers.

# 1.3 Cognitive and social e-assessment in CSCL

Assessment processes have a significant effect on collaborative learning because they engage learners through accountability and constructive feedback. Assessment is even more important in on-line collaborative learning environments because of the lack of real interactivity and of the feeling of social isolation of the learners. However, in order to design a coherent and efficient cognitive and social assessment system for CSCL, it is necessary to design an enriched learning experience that predisposes the feedback and awareness in the group (Mora et al., 2015). Cognitive assessment refers to the knowledge-based processes built during the collaboration while social assessment is based on the underlying interactive behaviour of the participants in the collaboration that build the network (Mora et al., 2016). To this end, a complex set of simultaneously applied assessment approaches, each reinforcing and/or complementing the other is the main tool to enhance collaborative knowledge and social interaction amongst group members.

In this context, modern technologies can alleviate these problems by implementing effective collaborative and networking techniques. Within the great variety of collaborative techniques in online education, inclass discussions are one of the most suitable mechanisms for supporting and assessing team work. Current Web-based discussion forum tools can support collaborative work effectively similarly to face-to-face collaboration and further as these tools can be used any time anywhere by students during inclass assignments. Participants of Web based discussion forums are only required to have a smart device, such as a cell phone, personal computer and tablet, with Internet connection (Huang et al., 2010).

The appropriate design of discussion-based activities in online forums enables the e-assessment process of the collaborative learning from the interactive behavior while improving student's engagement and reducing social isolation. Discussion participants can think about

the activity being performed, collaborate with each other through the exchange of ideas arising, propose new resolution mechanisms, and justify and refine their own contributions and thus acquire new knowledge.

In addition, social networks may play a major role in on-line collaborative learning by locating people at the very centre of networks and exploiting the value of people's connections and relations (Huang et al., 2010). This perspective is especially relevant in the emergent educational paradigms, which consider learners as central actors in their learning process. Moreover, social networks applications are characterized by a high degree of user-user and user-system interaction and hence generate a huge amount of information from networking. Therefore, the innovation of collaborative and networking systems combined with technological, social and pedagogical disciplines (Muijs, & Reynolds, 2010) described so far becomes a hot topic highly relevant for e-assessment of the learning process and for improving the overall online education experience.

## 1.3.1 CSCL Cognitive Analysis

A vast literature production and outstanding contributions have been published reporting on studies where the cognitive processes in CSCL have been exhaustively analyzed from the interactive behaviour during the collaboration (Daradoumis et al., 2006). In (Fahy, 2006) it was investigated whether CSCL in asynchronous discussion groups results in enhancing academic discourse and knowledge construction. Their research work showed that students in the discussion groups were fundamentally task oriented and that higher proportions of high phases of knowledge construction were observed. It was also evidenced by (Schellens, 2006) that students were able to construct their own understanding based on their interactions.

In addition, intensive and successful research from the interaction analysis field has been achieved over the last years to facilitate the management by computers of the large amounts of interaction data from online discussions. Current efforts (Gañan, 2013) aim to alleviate manual procedures while considering relevant aspects of the collaboration, such as how all participants are actually performing during the discussion and the dynamics of each participant with respect to the group. To this end, two levels of interaction analysis are considered, quantitative and qualitative level (Dillenbourg, 1999).

- Quantitative indicators measure the participants' performance and dynamics (e.g., number of contributions written and read by each participant) as relevant information to model the group functioning and task performance (Strijbos, 2006). To this end, efficient Learning Analytics (LA) are recently used to understand and measure the interactive behaviour underlying the participation (Romero & Ventura, 2013).

- Qualitative information has been also considered valuable to complete the labored task of interaction analysis and evaluation of contributions. (Dillenbourg, 1999), used a merging view of quantitative analysis within a qualitative methodology to build a model for the analysis of collaborative knowledge building in asynchronous discussion.

However, the mere consideration of the depth of discussion threads, the number of messages and he relation among messages do not guarantee by itself the quality of the discussion;

students' postings can be simply driven by socialization reasons and not directly linked to the development of the learning tasks (Dillenbourg, 1999).

## 1.3.2 Social Network Analysis

Social Network Analysis (SNA) provides a clear way of analyzing the network structure and discovering the collaborative knowledge hidden in large volumes of well structured data. SNA is a method of Educational Data Mining (EDM) whose goal is to understand and measure the relationships between entities in networked information (Romero, & Ventura, 2013). SNA views social relationships in terms of network theory consisting of nodes (representing individual actors within the network) and connections or links, which represent relationships between the individuals (Rabbany et al., 2011). In EDM, SNA can be used for mining in order to interpret and analyze the structure and relations in collaborative tasks and interactions within communication tools. (Rabbany et al., 2011; Romero & Ventura, 2013). To this end, the specialists performing the analysis must collect and process data through mining techniques (Romero, & Ventura, 2013 and do the required inference for filling up those indicators defined for measuring and evaluating the collaboration acts. In order to measure collaboration, SNA techniques include centrality indices, which are related with the position and relevance within a network (Marín et al., 2011), and measure how influential a person is within a social network.

SNA techniques are used in the context of CSCL and in particular the discussion forums to measure effective participation. First, log files of the e-learning course are used to extract the social network underneath the discussion threads. Second, appropriate social network measures for effective participation are selected, and, finally, the measures are reported (i.e. visualized) appropriately. The attributes of messages in a forum, such as time, task phase, sender and how the message is received (degree centrality, eigenvector, etc), as well as the content, reveal the nature of the social relationships (de Laat et al., 2007).

SNA is about the type of interactions produced within the learning network. SNA study patterns of relations, not just relations between pairs (Marín et al., 2011). Relations are measured in pairs of nodes, but the study of the effect and meaning of this relation requires broader patterns of ties within the network (Barnes, 1972). In Rabbany et al., (2011), the interaction patterns in the network were also analyzed in order to understand many aspects of the collaboration, such as how the discussion was developed over time, collaborative work sequences, planning issues, delays, etc. Therefore, SNA may help identify patterns of relationship between people who are part of a social network (de Laat et al., 2007), and the social environment can be mapped as patterns of relationships among interacting members (Wasserman et al., 2007).

Patterns in social networks can be identified and constructed using mainly two methodologies (Hernández-Leo et al., 2005): inductive pattern mining, seeking what is the pattern from a set of models, or deductive pattern mining, identifying the essence of generic models for solutions to recurrent problems that learning designers identified previously (Baggetun et al., 2004). Depending on the granularity or the detail level, prestructuring collaboration can be accomplished in a coarse grained process level and/or fine grained level of detailed learning actions.

# 1.4 Virtualization of Collaborative and Social Learning

Online collaborative learning is a mature research field in the educational domain dedicated to improve teaching and learning with the help of modern ICT (Dillenbourg, 1999). In this context, collaborative learning activities vary widely, but most of them are centered in students' exploration or application of the course material, not simply the teacher's presentation or explication of it. However, many researchers (Dillenbourg, 1999), (Goodsell et al., 1992), (Stahl, 2006) argue that students must be meaningfully engaged in the learning resources for effective learning to occur. This 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; (iii) empowerment, as learner expect to be in control of their own collaborative learning experiences.

To overcome these quoted limitations of current collaborative learning systems, this thesis focuses on defining a new type of Learning Object (LO) called Collaborative Complex Learning Object (CC-LO) embedded into a Virtualized Collaborative Session (VCS) (Caballé & Mora et al., 2011b). A VCS is a registered collaboration session augmented by alternative flows, additional content, 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. CC-LOs include also 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.

## 1.4.1 The Concept of Virtualization

An initial definition of LO was given by (Gerard, 1967) as self contained and reusable elements of learning. Furthermore, a number of other definitions have been put forward by researchers, such as (Rabbany. et al., 2011) who defines a LO as "any digital resource that can be reused to support learning", while (de Laat et al., 2007) emphasizes the need for LO to have learning goals and be reusable.

Following these principles, the notion of the CC-LO can be described as an extension of the LO paradigm by incorporating two main aspects (Fuentes et al., 2008): (i) collaboration in creation (several platforms exist for the collaborative creation of LOs by educators) and in use (where a collaborative learning object is capable of responding to and facilitating interaction by multiple simultaneous learners) and (ii) complexity at several levels of applicability (how widely an LO can be repurposed across technical domains), evaluability in pedagogic and technical terms, internal dynamicism to be able to adapt to context thus removing the need for

repurposing work, and composability to disassociate learning objectives from implementation issues. In practice, there are common attributes specific to CC-LOs:

- Self assessment by Q&A, alternative flows (non linear paths through CC-LOs), relevant assessment of each path, and well defined dependencies to other CC-LO.

- Animated and evolution over time allowing learners to observe how avatars discuss and collaborate and how knowledge is constructed, refined and consolidated.

- Instantiable and interactive by modifying some parameters and observing the effects and assessing the understanding.

## 1.4.2 Methodologies and Technologies for Virtualization

Technologists have made many attempts to provide better tools for content creation, management, and execution of LOs to educators, but the transition from the role of content creator to moderator, generates inherent resistance in the educator (Mosley, 2005). The LO are usually customized and adapted for learners needs while the educators adaptation needs are not considered.

Commonly, methods for creating LO include mining existing information to construct learning objects autonomously and participatory techniques (Singh et al., 2004), which 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, learners are not often the best LO creators and the resulting LOs require careful validation to ensure quality.

Recently, the management of learning objects has benefited from semantic technology, which supports both bottom-up processes such as support registration, management, and sharing methods. Also, creates high level elements such as courseware and e-learning tools autonomously, with remarkable benefits of ubiquity and interoperability, in line with tutors needs.

The execution of learning objects has previously been achieved through methods such as the SCORM Run Time Environment (Costagliola, 2006) allowing for user customization, adaptivity, high degree of dynamics and evolution of learning objects over time across a range of formats. 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.

Considering all these approaches, widespread usage of CC-LOs implies conformance to core SCORM standards and representation formats, with CC elements added as independent extensions. Incorporation into more sophisticated systems would require the CC-LO to be enabled with the information required to generate the high level tools required for collaboration, and support for complexity. As initial approach, existing methodologies for CC-LO can be 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.

- Learner centric: these methods advocate techniques such as participatory design to allow learners to be involved in the creation and management of CC-LOs.

# 1.5 Evaluation of Virtualized Assessment-based Collaborative and Social Learning Practices

A research oriented learning experience includes a formal and informal process of gaining, utilizing and systematically applying knowledge to an area of interest in order to make sense of the interrelationships between what one knows and what one learns (Denzin, & Lincoln, 1994; Bortz & Döring, 2006). With quantitative reasoning skills, one can integrate deductive logic aspects from multiple knowledge dimensions into program evaluation and research. There is a beginning, middle and an end to this cyclical process which allows for the adjustment of additional information. When approaching evaluation questions, within a particular context, it is important to keep in mind that a scientific, linear model is but one method of organizing information (Guba & Lincoln, 1989).

There is tremendous value in understanding the plural dimensions of both quantitative and qualitative approaches to evaluation methodologies (Wolcott, 1990; Guba & Lincoln, 1989) advocate the necessity of becoming familiar with all other methods in order to appropriately select the method that best fits your area of research and design. The context, purpose, and types of research questions asked will define the methodological foundation of a study. Keeping this caveat in mind will eliminate mismatched efforts and results that can only frustrate a beginning student in research (Trochim & Land, 1982; Patton, 1990; Miles & Huberman, 1994).

In order to correctly evaluate the computational models for the development of effective CSCL applications, evaluation should be considered as a process or a collection of processes to obtain and analyze significant information that support judgments of character on an object, a phenomenon, process or an event as an aid for an eventual decision on itself (Latorre et al.,1996). Evaluation in CSCL means to deal with many educational theories, each considering their own means and questions. This means that there is no a unique vision on how to deal with evaluation in CSCL. Literature shows different ways to successfully cope with evaluation, such as surveys, interviews, empirical experimentation, case studies and computer generated statistical measurements (Manson, 1992).

## 1.5.1 Trial Scenarios

Two different scenarios are considered to exhaustively pilot all features and functionalities of the developments of this thesis in different contexts of learning and by participants of each piloting site:

### Full e-learning for science teaching at university (UOC)

The Universitat Oberta de Catalunya (UOC) (www.uoc.edu) is an online university born in 1994 from the knowledge society and whose mission is to provide people with lifelong learning and education and education opportunities. The UOC develops the Virtual Campus as a network community where limitations of space and time are overcome. It also uses a student centred learning methodology based on the complete personalisation and guidance of the learner. Learners, lecturers and managers interact and cooperate in that network community to create, structure, share and disseminate knowledge. The aim is to help individuals meet their learning needs and provide them with full access to knowledge.

The UOC is a benchmark for quality in its academic work and research in e-learning based on Information and Communication Technologies (ICT). The UOC pioneers top quality distance education through the Internet since 1994. About 50,000 students and 3,700 lecturers and tutors are currently involved in more than 1,200 full on-line official courses from 60 official degrees and other postgraduate programs. This immense driving force serves to exploit e-Learning research and initiatives through its Virtual Campus by investigating, experimenting and using the resulting innovative adaptive environments able to contribute to the overcoming of the limitations of current e-learning systems and pedagogical models. The resulting environments will be interactive, challenging and context aware while enabling learners' and the public at large the demand of empowerment, social identity, and authentic learning experience.

Therefore, the UOC represents an ideal context for experimenting and evaluating the different approaches addressed in this thesis. Indeed, the needs for exhaustively evaluating the possibilities offered by the proposed assessment framework for enhancing and improving the learning experience are to be met by leveraging the real collaborative learning processes and dynamics found in the virtual classrooms of the UOC. This way, the impact and repercussions of using the virtualization approaches on the UOC's collaborative and social learning processes can be empirically reported by means of a set of surveys, user interviews, statistical measurements, and so on, involving in the evaluation process all the actors participating in the real learning experience at the UOC.

### Blended learning for engineering education at university (UCA)

The Cadiz University (http://www.uca.es/es/) is a relatively young university, since it was born in 1979 after split from the University of Seville. Cadiz university studies began in the eighteenth century. In 1748 the more prominent cultural institution that has had Cádiz, Royal College of Surgeons of the Navy is created. School of Engineering began his career in 1903 when higher level studies for the School of Arts and Industries are granted to Cadiz, although there was already an industrial school in the nineteenth century. In the Chapter Acts of the City of Cadiz 1852, we can read that on October opens in Cadiz the Industrial School of Commerce and Navigation, then under the sponsorship of the Provincial Council and the City Council, pending for later the establishment of industrial education as an essential to achieve success. The famous Vicente Rubio y Diaz, Industrial Engineer, honoured with a street in Cadiz, was first director of Columela Secondary Institute. He became professor of Applied Chemistry in

the existing Industrial School in early 1860, a chair he held until his death occurred in 1900; so he could not get to see his Elemental Industries and Fine Arts School and High School.

Engineers today are fundamental to the development and functionality of our society, deep and closely linked to knowledge and innovation. All these background has made the School of Engineering of Cadiz grown since to be the greater superior center in the university with more than 3300 students and 202 teachers in the University of Cadiz. The range of courses are a total of 6 engineering degree programs, three master's programs, one focused on research, and currently a doctoral program.

University of Cádiz has programs of innovative teaching that allow teachers to develop educational applications for classroom teaching as blended learning and distance learning. Besides there is a variety of research groups interested in the scope of teaching methods not face a variety of environments.

# 1.6 Thesis motivation

The motivation of this thesis starts from the research goals conducted in the FP7 European research project ALICE (2010-2012)[1]. The aim of the ALICE project was 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 was purposed to be interactive, challenging and context aware, whilst realising learners' demands of empowerment, social identity, and authentic learning experiences. The ALICE goals are expanded with the incorporation of the social dimension of learning.

With respect to the basic aspects of collaboration, the project pursued a broad set of objectives related to collaborative learning. ALICE studied 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, since collaborative learning approaches cannot be applied in every e-learning experience as they require a degree of presence, a new paradigm was required to reuse, in formal, informal or intentional learning contexts, the knowledge elicited during collaborative learning activities. Furthermore, this approach had to 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 was defined in the ALICE project 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

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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.

This thesis took the above CC-LO and the VCS approaches as starting point and incorporated an innovative and complete e-assessment framework in the scope of the virtualization of online collaborative and social learning. The research included conceptual, methodological, technological, and evaluation perspectives well in line with the corresponding perspectives of the project. This way, even though the thesis conducted an independent research line, this thesis' research work and outcomes were fed back to the project (ALICE D3.3.2, 2012) thus becoming an outstanding contribution to the ALICE project (Caballé & Mora et al., 2011c; Caballé & Mora et al., 2012b; Mora et al., 2012; Caballé & Mora, 2013; Mora et al., 2014a; Mora et al., 2014b; Caballé & Mora, 2014; Mora et al., 2015a; Mora et al., 2015b).

The ALICE project made it possible the study, development and use of CC-LO within virtual environments. These virtual environments offer to the isolated students an effective learning tool that provides many benefits from the collaborative work. From the real experiments and tools developed in ALICE, it was possible to develop the CC-LR approach and, in particular, all the real experiences shown in this research supported by this technological approach.

In order to tackle the mentioned topics and extend the research work, this thesis first provides an extensive study of the literature in Chapter 2. Chapter 3 presents the virtualization approaches of collaborative and social learning. These approaches are enriched with a complete e-assessment framework described in Chapter 4 forming the core and main contribution of this research. Chapter 5 shows the evaluation and validation of the approaches presented so far by several steps of experimentation in real contexts of learning. Finally, Chapter 6 concludes the thesis by summarizing the main findings and outlining ongoing and future work.

# 1.7 Thesis objectives and hypotheses

The main goal of this research is to enhance and improve learning engagement and performance and outcomes by means the CC-LO containing the virtualization of on-line collaborative and social learning enriched with a complete e-assessment framework approach that provides full support to the collaborative and networking interactions occurring during live collaborative learning activities

The goals and hypotheses formulated for this thesis' scenarios are related to the collaborative and networking assessment information incorporated. In particular, the usability and functionality of the software systems developed as for two main elements: (i) the provision of self evaluation and formative feedback for learners; (ii) the resources generated from forums and SNs in a multimedia attractive format; To this end, several experiments are run to pilot this scenario in a real learning context in support for a formal inclass assignment of learning based on a discussion. Next, the goals and hypotheses are formulated.

### 1.7.1 Objectives

O1. Provide methods and tools for assessment in collaborative learning: social and cognitive assessment and its application in the context of formal/informal learning

O2. Design and prototype Complex Collaborative Learning Resources (CC-LRs) as an extension of traditional Learning Objects, with special emphasis on aspects of cognitive and social assessment.

O3. Design a reference assessment framework for virtualized collaborative and networking scenarios from real online collaborative group experiences, using LA and SNA techniques and tools.

O4. Analyze and discover the social dynamics present in the virtual collaborative learning for knowledge sharing and production. This analysis will come, mainly, from real discussion forum experiences.

O5. Develop some case studies based on the assessment framework previously designed in the CC-LR context.

O6. Experiment with case studies in real situations and evaluate the expected learning improvements using the CC-LR approach extended with the cognitive and social assessment approach.

O7. Validate the experimental results obtained in order to improve the framework.

### 1.7.2 Hypotheses

H1. The use of cognitive and social indicators applied to CC-LRs allows users to acquire more knowledge from collaborative learning activities.

H2. The use of the CC-LR created from real collaborative activities enriched with LA and SNA techniques contributes to improve the virtual learning activities, increasing students' motivation and engagement.

H3. The levels of usability, emotional aspects and functionality of the CC-LR are satisfactory.

H4. CC-LRs are considered as a valuable educational resource by students.

# 1.8 Research Methodology

Provided that the main goal of the proposed thesis requires defining a new software models and systems, the most suitable research methodology applicable to achieve this objective is the 'D*esign Science Research Framework*' in the general design cycle, as explained in Hevner & Chatterjee (2010). This methodology defines five steps in an iterative fashion: Awareness, Suggestion, Development, Evaluation and Conclusion (see Figure 1.1, taken from Hevner & Chatterjee (2010, p. 27).
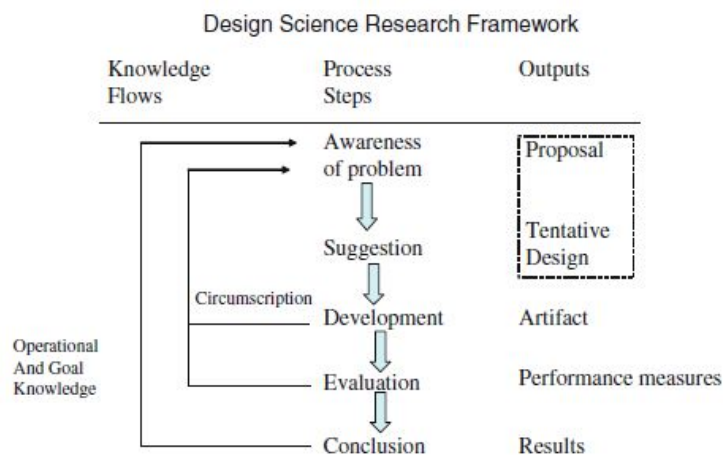
*Figure 1.1; Design Science Research Framework general design cycle.*

For the *Development* step we chose to follow the prototyping development methodology proposed in Carey (1990) while the method used for the evaluation and validation of the framework is based on the structure of the APA guidelines (American Psychological Association, 2009) to report empirical studies. The steps of this methodology are detailed below in Figure 1.2.

| Step | Description/Questions to be considered |
|---|---|
| **1. Research Goals and hypotheses** | What is the learning purpose/are the learning goals of the planned study? |
| | Which hypotheses can be derived from the goals? |
| **2. Method** **2.1 Participants** | Selection/Description of the participants: • How many learners and teachers are necessary/available? • More detailed description • Are there any constraints? • Selection criteria • Are the participants informed about the goal of the study? |
| **2.2 Apparatus and Stimuli** | How is the learning problem investigated in detail? |
| | What is measured? |
| | How is the learning outcome measured/quantified? |
| **2.3 Procedure** | Description of the procedure of the planned study: • Short summary of the main design, assignment of the subjects to the groups, … • The course of events during the study |
| **3. Evaluation Results** | What about the usability/functionality of the learning tool? |
| | What did the students like/not like regarding the learning tool? |
| | Were the students aware of the functions of the learning tool? |
| | What can be improved regarding the learning tool? |
| **4. Validation Results** | Results from the pedagogical and psychological perspective • Were the students motivated regarding the experiment? • Did the learning tool support their learning process? |
| **5. Conclusion** | What are the most important results with respect to the predefined goals? |

*Figure 1.2: Structure of the APA guidelines to report empirical studies (American Psychological Association, 2009).*

# A Multi-fold Assessment Framework for Virtualized Collaborative and Social Learning Scenarios

## Chapter 2: Literature review

# 2.1 Chapter overview

Collaborative learning has become a controversial research field that focuses on the change from traditional education, oriented to individual learning, to a new environment where the learner and a learning community are the principal actors of their own learning. Collaborative learning incorporates the learning community level and the learning consists in the evolution process of the learning community and the classroom must be reconceptualised as a knowledge-building community. A broad literature has been provided over the last two decades on collaborative learning building new learning theories and dimensions.

Main collaborative learning theories concern certain aspects, such as the definition of the collaborative situation, the interactions, the processes and effects as well as common dimensions, namely the collaboration scale (group size and time span), level of learning, and the depth of the collaboration. Computer-Supported Collaborative Learning (CSCL) is one of the most important educational paradigms in the collaborative learning domain focused on how collaborative learning is supported by technology so as to enhance peer interaction and work in groups, and how collaboration and technology facilitate sharing and distributing of knowledge and expertise among community members. To achieve these aims, CSCL has become a broad multidisciplinary area, where technology meets psychology, philosophy, and pedagogy. Instructional designers and software developers, educational psychologists, learning theorists, computer scientists, and even sociologists are interested in this area of research.

Current collaborative technical support involves online collaborative tools that allow for interacting and learning through socialization. For the sake of socialization, social learning theories play a fundamental role in this context by emphasizing observation and modelling of the behaviours, attitudes, and emotional reactions, in terms of continuous reciprocal interaction between cognitive, behavioural, an environmental influences. The social learning models are essential but there are more factors to consider, such as the different learner profiles: diverging, assimilating, converging, and accommodating. Translating these social learning concepts to CSCL implies introducing factors, such as self-efficacy, incentive and benefit in the system. For instance, the serious games are an interesting environment where to develop the collaborative and social learning and offer particularly compelling outcomes.

Technological tools also provide learners with a wide range of social and interactive experiences though they need a holistic approach, which integrates all available social media in learning scenarios. Scenario creation must reflect the learning requirements and also show its limitations in pedagogy. Therefore, the collaborative learning process must be arranged during the collaborative and social learning scenarios, becoming a difficult task. Certain requirements are to be considered when constructing a social learning scenario using a CSCL model, such as the ability to observe the modelled behaviour, recall this behaviour and reproduce it. Tools such as IMS Learning Design and scripts also help educators construct effective learning experiences though they lack to specify several characteristics of the use of tools that mediate collaboration. A further problem is the use of collaborative and social learning scenarios in the context of formal, informal and intentional learning experiences. It is necessary to define and differentiate the mentioned approaches to each of these areas.

Assessment of collaborative learning is a mature research field at present with a great impact on collaborative learning. Building a consistent assessment framework involves to know how knowledge can be extracted from collaborative and social learning activities. This knowledge can then be used for assessing and also for monitoring and scaffolding the collaborative learning process. Driven by the users' interaction, a high amount of quantitative and qualitative information can be managed from on-line collaboration. For example, students' posts in on-line forums are labelled with certain indicators that provide qualitative information about performance and behavioural aspects of the collaboration. Visualization techniques of this information have also a great impact on on-line social tools.

This chapter is organized in the following way: Section 2.2 gives a broad overview about basic theories of learning (Behaviorist, Constructivist and Cognitive). Section 2.3 focuses on collaborative learning from both theoretical and technological point of view. Section 2.4 describes the theoretical and technical models of social learning. Section 2.5 extends the issue of assessing collaborative and social learning by defining and describing different forms and types of assessment. Assessment is precisely described from the viewpoints of collaborative, cognitive and social theories, and e-assessment models and software of CSCL systems and online discussion tools are further exemplified. A specific subsection is dedicated for explaining how knowledge extraction from collaborative and social learning activities is important for providing feedback and monitoring services. The section concludes by examining the quality of assessment from a psychological viewpoint. Finally, the chapter summarizes the main ideas presented to back up and face the unique challenges presented in next chapters associated with using learning objects across advanced technological platforms and within pedagogic frameworks that reflect on the strengths of these technologies to enhance learning.

# 2.2 Theoretical foundations of learning

In this section we will provide a brief overview of the theoretical foundations of learning in general and of e-learning in particular (Berger, 2010).

## 2.2.1 Learning

Lefrancois (1994) defines learning as all behavioural changing because of personal experiences; variations in behaviour because of genetic or fake chemical reasons (e.g. changes in the course of drug or alcohol consumption) are excluded by this definition. When talking about learning theories there are three major ones: behaviourism, cognitivism and constructivism. It is very important to understand that there is no best learning theory. Every single one of those learning theories has its strengths and weaknesses but it depends on the learner and, of course, the things to learn to figure out what is best to use (Ebner & Holzinger, 2002).

Schumann (1996) gives a short description of these three learning theories:

- Behaviourism: Is based on visible changes in behaviour and therefore focusing on new behavioural patterns, which become automatic after repeating.
- Cognitivism: Contrary to the behaviourism it is not focused on behavioural changes but in the thought process behind, so it indicates what is happening inside the learners' mind.
- Constructivism: Focuses on preparing the learner to problem solving through individual experience (all learners construct their own perspective of the world) and schema.

In the 1970s was the first hype about the use of the term new media. At that time new media was an umbrella term for all procedures and technological devices that use new, and innovative technologies to extend the use of the old mass and storage media (like cable or satellite TV) (Hüther, 2005). Nowadays, the term is particularly used to describe the digital, computer based multimedia technology. Especially the wide use of computer for work, entertainment or teaching and learning device became an integral part of the new Information and Communication Technology (ICT). Hüther (2005) names the fundamental characteristics of new media as following: *Digitality*, *Networking*, *Globality*, *Mobility*, *Convergence*, and *Interactivity*.

The impact of the rapid use of ICT has caused learning and education systems to be more modern and global. Therefore, new and modern learning styles, settings and resources have been fostered to satisfy our society needs. These modern settings help people to improve their skills as well as their expertise to cope with the rapid changes in their societies (Dochy & McDowell, 1997). Consequently, teachers are no more considered to be knowledge carriers which they have to transfer to students' heads. Rather than they are considered to be trusted counsellors to their students encouraging them to use the knowledge and skills they have to understand. Nevertheless, the learning process has been changed from being repetitive to a new form of learning based on understanding, independency, learners' empowerment and skills improvement (Bransford et. al., 2000). Moreover, aspects related to the interconnections between the learning environments of Learner-centred environments, Knowledge-centred environments, Assessment-centred environments, and Community-entered environments have to be considered.

Bransford et al.,(2000) named five ways how new technologies can be used in learning and education:

- Development of new curricula based on real-world problems.
- To enhance learning more and better tools should be provided.
- Feedback, reflection and revision are important points of effective teaching and learning and therefore every institution of higher education should reach a good level to guarantee this.
- Organization of communities where students can communicate with other students as well as teachers, administrators or practicing scientists.
- Give teacher the opportunity for further development by using new technologies.

## 2.2.2 E-Learning

There are many different and broad definitions of e-Learning but one often used is by Micheal Kerres. In his opinion we are speaking about e-Learning for all the learning situations where digital media is used for presentation and distribution of learning contents or to support communication between people (Kerres, 2001). Stangl (2005) is more specific in his explanation. For his understanding e-Learning is a special kind of computer based learning where the learning systems and materials have following characteristics:

- Digital and online available.
- Distinguished by a high degree of multimedia.
- Have to support interactivity between learners, co-learners, system and teachers.

Furthermore he is writing that e-Learning is a learning strategy based on technology, especially on computers, which will take humans place in teaching. Learners should be self-organized

and independent in time and speed of learning. Although learning should become more efficient because of the lower long term costs and self-organization, Stangl (1997) points the problems referring to the high self-discipline needed by learners. Strokely (2003), for example, writes that e-Learning is also called online learning or online training and his definition is the following:

*"The delivery of a learning, training or education program by electronic means. E-learning involves the use of a computer or electronic device (e.g. a mobile phone) in some way to provide training, educational or learning material."*

Caused by the huge amount of different but very similar definitions, Ebner (2009) argues about what all of these definitions have in common. His opinion is that all of them use the word electronical or electronic in some variations. The first use of the term leads back to the time where computer based training was invented. Then the same term e-Learning has been used for web based training or learning management systems. Regarding to the varying definitions and different uses of the term it is very hard to draw the line. Over and above that, the rapid changing of the technology is another reason why e-Learning is so hard to define in just one way (Ebner, 2009).

Technology Enhanced Learning (TEL) in general is a broader field than e-Learning but there are better and unique definitions available. TEL means every form of teaching and learning where technology is used, not just computers or the internet. There is a long list of technology which includes of course the internet and computers as an integral part but also rudimentary electronic boards are meant when speaking about TEL. So it is obvious that e-Learning with its unclear borders is one possible part of technology enhanced learning and the main focus regarding this topic will be on e-Learning because of improving technologies like web applications or others (Dror, 2008; Ebner, 2009).

TEL is an interdisciplinary special field that is broadly influenced by following three subdivisions (Ebner, 2009):

- Pedagogic Science: for didactical design and the targeted use of technology in teaching and learning.
- Computer Science: information and communication technology as the main technology used.
- Human Computer Interaction and Usability Engineering.

As just described, TEL and e-Learning relate to teaching and learning through technology. But there is one important fact that has to keep in mind: Learning is an active process and has always been one. Every learner needs to know that there is technology which can support one in learning in different ways but there is still the need to learn. There is no teacher, no tutorial and also no e-Learning that can replace this part (Dichanz & Ernst, 2001).

Kleimann (2007) classifies e-Learning by three different levels of development: e-Learning 1.0, e-Learning 1.1 (or e-Learning 1.3 as often used (Karrer, 2007)), and e-Learning 2.0. The first generation of e-Learning (e-Learning 1.0) is the simplest form of online learning. Learners can download lecture notes from a homepage or CD-ROMs are provided. In the Mid-1990s e-Learning changed and based on new technologies more different learning scenarios have been used. WBTs (web based training), virtual laboratories, online seminars and e-Assessments are only some of them (Kleimann, 2007). But e-Learning 1.0 and 1.1 or 1.3 have a very important thing in common: The content of these two kinds of e-Learning comes from people who have some expertise in learning design and presentation. They all also have a lot of learner empathy which is the main contrary to e-Learning 2.0 (Thalheimer, 2008).

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# 2.3 Collaborative learning

Dillenbourg (1999) defined collaborative learning as "a situation in which two or more people learn or attempt to learn something together". With this statement, he distinguishes three dimensions that define the space of what is encountered under the label 'collaborative learning': the *scale* of the collaborative situation (group size and time span), what is referred to as *'learning'* and what is referred to as *'collaboration'*:

- **The variety of scales:** Most empirical research on the effectiveness of collaborative learning was concerned with a small scale: of two to five subjects collaborating for one hour or so. At the opposite end of this scale, the label 'computer-supported collaborative learning' (CSCL) is often applied to situations in which a group of 40 subjects follows a course over one year.

- **The variety of meanings for "learning":** In the research literature on collaborative learning, there is a broad acceptance of what is put underneath the umbrella of 'learning'.

   - For some scholars, it includes more or less any collaborative activity within an educational context, such as studying course material or sharing course assignments. The term 'collaborative learners' would then be more appropriate.

   - In other studies, the activity is joint problem solving, and learning is expected to occur as a side-effect of problem solving, measured by the elicitation of new knowledge or by the improvement of problem solving performance. This understanding is also dominant in research on multi-agent learning.

   - Within some theories, collaborative learning is addressed from a developmental perspective, as a biological and/or cultural process which occurs over years.

   - This spectrum also includes learning from collaborative work, which refers to the lifelong acquisition of expertise within a professional community.

- **The variety of meanings for 'Collaboration':** The adjective collaborative concerns *four aspects* of learning:

   (1) A *situation* can be characterised as more or less collaborative (e.g. collaboration is more likely to occur between people with a similar status than between a boss and her employee, between a teacher and a pupil).
   (2) The *interactions* which do take place between the group members can be more or less collaborative (e.g. negotiation has a stronger collaborative flavour than giving instructions)
   (3) Some learning *mechanisms* are more intrinsically collaborative (e.g. grounding has a stronger collaborative flavour than induction), even if, at a very fine level of analysis, learning mechanisms must be similar to those triggered in individual learning.

The fourth element concerns the *effects* of collaborative learning, not because this element is used to define collaboration itself, but because the divergent views concerning how to measure the effects of collaborative learning participate in the terminological wilderness of this field.

## 2.3.1 Theories of collaborative learning

Diana Laurillard (2008a) has provided a theoretical framework for distinguishing instructionist, social, constructionist and collaborative learning. Pedagogical principles focus on different elements of the learning process, and have been characterized successively as:

(1) "instructionism," most prominent in the instructional theories of Gagné, Merrill, and their successors (Gagné, 1970, 1977, Merrill, 1994, Reigeluth, 1983); it influenced the use of the presentational and testing capabilities of the technology, given that the organisation of instruction is the main focus, and technology can be used to test predictable learning through multiple-choice questions, give right/wrong feedback, and select further presentation on that basis; Instructionism prioritizes the teacher's presentation, and their corrective responses to the learners' performance on the task, either in terms of what they present, or in terms of a new task (Laurilllard, 2008) (Figure 2.1).
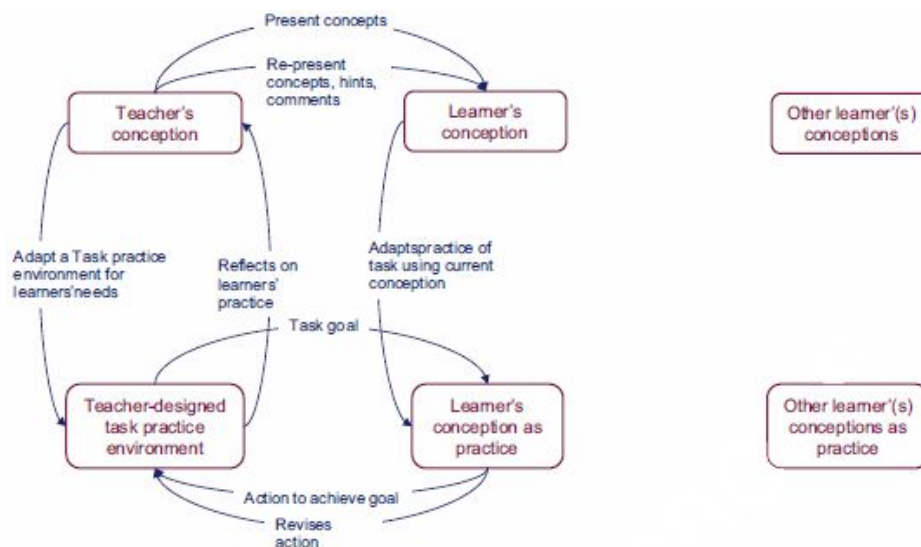


*Figure 2.1: Instructionism*

(2) "constructionism," deriving from Piaget (1977), but coined by Papert to emphasize the importance of construction of a model or object as an aspect of learning, making use of the programmable, simulation and modelling properties of technology (Papert 1991). Constructionism prioritizes the learner's activity in the practice environment, adapted by the teacher to their needs, where it provides intrinsic feedback on their action in relation to the task goal, enabling them to reflect on that internal relation in the light of their action adapted by their current understanding (Laurillard, 2008a).

*Figure 2.2: Constructionism*

(3) "socio-cultural learning," deriving from Vygotsky and focusing on the importance of discussion as an aspect of learning, making use of communications technologies (Vygotsky 1962, Wertsch 1985). Social learning prioritizes the learner's exchange of ideas with a peer or peers, where the teacher's role is to initiate the topic for discussion (Laurilllard, 2008).
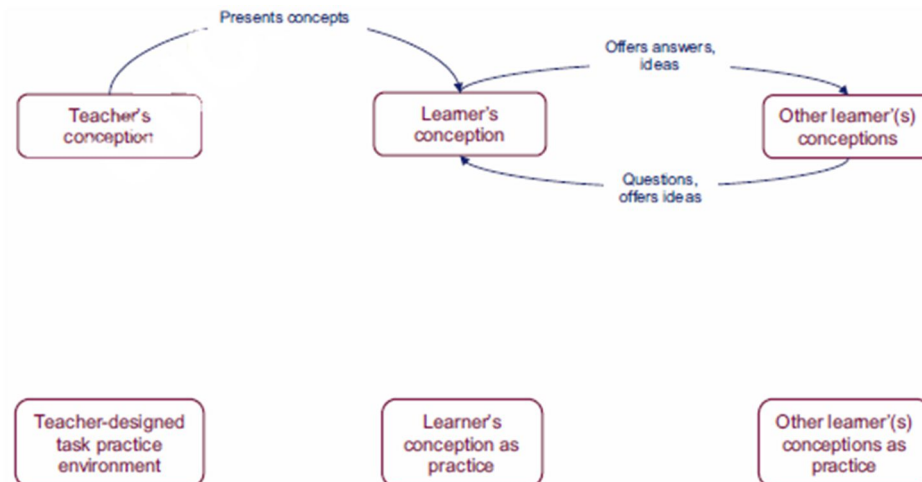


*Figure 2.3: Social learning*

(4) "Collaborative Learning," deriving from both Piaget and Vygotsky to combine the social and construction elements of the learning process, making use of integrated technologies capable of supporting both (Dillenbourg et al., 1996; Scardamalia & Bereiter 1994, 2006). Collaborative learning combines the pedagogies of constructionism and social learning to provide richer interactions between learners and their concepts and practice (Laurilllard, 2008).
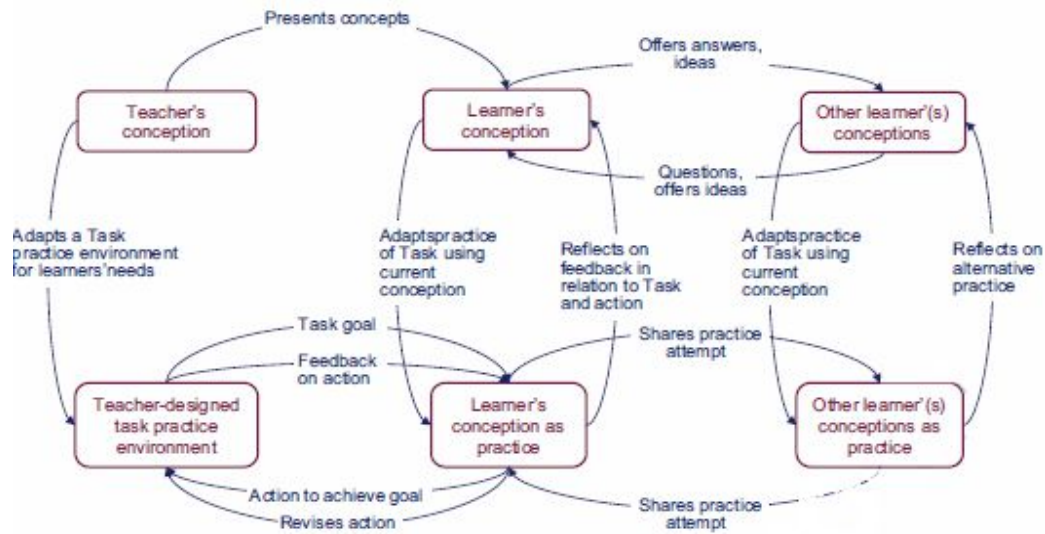
*Figure 2.4: Collaborative learning*

Collaborative learning combines constructionism with social learning—sometimes referred to as "social constructivism" (Vygotsky 1978; Wertsch 1985).

Because each approach focuses on a different aspect of the learning process as being critically important, they generate different conventional teaching methods, and, therefore, different uses of digital technologies. However, none denies the importance of the others.

According to Dillenbourg (1999), a theory of collaborative learning concern four items:

(1)    criteria for defining the situation (symmetry, degree of division of labour),
(2)    the interactions (e.g. symmetry, negotiability, ...),
(3)    processes (grounding, mutual modelling),
(4)    and effects.

The main theories cover the four aspects, while more local theoretical contributions (e.g. the self-explanation effect) cover a specific aspect. The key for understanding collaborative learning is in the relations between those four items.

### *Situated Learning (J. Lave)[2]*

Lave (1990) argues that learning as it normally occurs is a function of the activity, context and culture in which it occurs (i.e., it is situated). This contrasts with most classroom learning activities which involve knowledge which is abstract and out of context. Social interaction is a critical component of situated learning -- learners become involved in a "community of practice" which embodies certain beliefs and behaviours to be acquired. As beginners or newcomers move from the periphery of this community to its centre, they become more active and engaged within the culture and hence assume the role of expert or old-timer.

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[2] http://tip.psychology.org/lave.html

Furthermore, situated learning is usually unintentional rather than deliberate. These ideas are what Lave and Wenger (1990) call the process of "legitimate peripheral participation."

Other researchers have further developed the theory of situated learning. Brown, Collins and Duguid (1989) emphasize the idea of cognitive apprenticeship: "Cognitive apprenticeship supports learning in a domain by enabling students to acquire, develop and use cognitive tools in authentic domain activity. Learning, both outside and inside school, advances through collaborative social interaction and the social construction of knowledge." Brown et al.,also emphasize the need for a new epistemology for learning -- one that emphasizes active perception over concepts and representation. Finally, Suchman (1988) explores the situated learning framework in the context of artificial intelligence.

Situated learning has antecedents in the work of **Gibson** (theory of affordances) and **Vygotsky** (social learning).

**Scope/Application**:

Situated learning is a general theory of knowledge acquisition. It has been applied in the context of technology-based learning activities for schools that focus on problem-solving skills (Cognition & Technology Group at Vanderbilt, 1993). McLellan (1995) provides a collection of articles that describe various perspectives on the theory.

**Example:**

Lave and Wenger (1991) provide an analysis of situated learning in five different settings: Yucatec midwives, native tailors, navy quartermasters, meat cutters and alcoholics. In all cases, there was a gradual acquisition of knowledge and skills as novices learned from experts in the context of everyday activities.

**Principles**:

(1) Knowledge needs to be presented in an authentic context, i.e., settings and applications that would normally involve that knowledge.
(2) Learning requires social interaction and collaboration.

### *Social Development Theory (L. Vygotsky)*[3]

The major theme of Vygotsky's theoretical framework is that social interaction plays a fundamental role in the development of cognition. Vygotsky (1978) states: "Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (interpsychological) and then inside the child (intrapsychological). This applies equally to voluntary attention, to logical memory, and to the formation of concepts. All the higher functions originate as actual relationships between individuals."

A second aspect of Vygotsky's theory is the idea that the potential for cognitive development depends upon the "zone of proximal development" (ZPD): a level of development attained when children engage in social behaviour. Full development of the ZPD depends upon full

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[3] http://tip.psychology.org/vygotsky.html

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social interaction. The range of skill that can be developed with adult guidance or peer collaboration exceeds what can be attained alone.

Vygotsky's theory was an attempt to explain consciousness as the end product of socialization. For example, in the learning of language, our first utterances with peers or adults, are for the purpose of communication, but once mastered, they become internalized and allow "inner speech".

Vygotsky's theory is complementary to the work of Bandura on social learning and a key component of situated learning theory.

**Scope/Application:**

This is a general theory of cognitive development. Most of the original work was done in the context of language learning in children (Vygotsky, 1962), although later applications of the framework have been broader (Wertsch, 1985).

**Example:**

Vygotsky (1978) provides the example of pointing a finger. Initially, this behaviour begins as a meaningless grasping motion; however, as people react to the gesture, it becomes a movement that has meaning. In particular, the pointing gesture represents an interpersonal connection between individuals.

**Principles:**

    (1)    Cognitive development is limited to a certain range at any given age.
    (2)    Full cognitive development requires social interaction.

*Co-operative vs. Collaborative Learning (Stahl, 2000)*

Both cooperative and collaborative learning theories oppose the view that knowledge consists of facts told by teachers for students to repeat back. They may advocate a student-centred, constructivist approach in which students construct their own meaning using the ways in which they personally learn best. Social aspects of learning are considered theoretically important and the use of small group processes is emphasized in practice.

The difference may be defined in terms of the "unit of analysis." Cooperative learning still privileges the teacher as the orchestrator of the educational process and still looks to the assessment of individual student knowledge as the sign of learning. Collaborative learning – for instance in versions like Lave and Wenger (1991) – analyzes things at the level of the community. Here, the teacher is just another participant within the changing roles of the community, and learning consists of evolution of the group and the abilities of its members to participate within it. The classroom may be reconceptualised as a knowledge-building community (Scardamalia & Bereiter, 1996a) or a learning organization (Brown & Duguid, 1991), where the essential outcomes are measured at the group level not the individual. Thus, collaborative learning constitutes a distinct educational paradigm with a very different approach to defining and assessing learning.

Whereas cooperative learning is still measured by post-test evaluations of individual student learning based on teacher-defined goals, collaborative learning is concerned with evidence of

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social cognition (Crook, 1994, pp. 132f; Koschmann, 1996, p. 15). Social cognition may involve the creation of new socially-shared meanings, the increasingly skilled enactment of social practices by students, or the evolution of the learning community as such.

Given this distinction, one can see cooperative learning as a halfway stage to collaborative learning in the sense that the dissemination of the former provides an important basis for the implementation of the latter. Collaborative learning – whether supported by computer technology or not – must adopt many of the classroom practices of cooperative learning, such as its refined use of small group processes.

The differences between individual, cooperative and collaborative learning theories are illustrated in Figure 2.5.
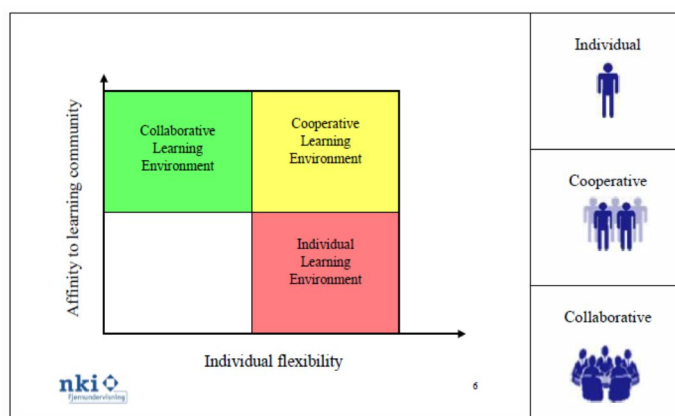


*Figure 2.5: Individual, cooperative and collaborative learning theories*

## 2.3.2 Methods and strategies of collaborative learning

Understanding and evaluating collaborative learning tools and methodologies is not a trivial task. During collaborative learning activities, factors such as students' prior knowledge, motivation, roles, language, behaviour, and group dynamics interact with each other in unpredictable ways, making it very difficult to measure and understand learning effects (Jermann, Soller, & Muehlenbrock, 2001).

The following sections describe a variety of commonly used collaborative learning structures (methods and strategies) [4,5]. These collaborative learning structures are frameworks and not specific activities. They provide a general structure that can be adapted to many situations, content, and disciplines. In fact there is a big variety of collaborative learning strategies. This section presents the most common ones. Some others (like Teambasket and TGroup) may be also added in a future version of the document:

(1) **Brainstorming:** Brainstorming is designed to generate a large number of ideas in a short period of time. For collaborative brainstorming, it is helpful to structure the activity as a roundtable/round-robin sharing of information. The roundtable structure is a method of brainstorming ideas (Osborne, 1963). Brainstorming generates a large number of ideas in

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[4] http://www.wcer.wisc.edu/archive/cl1/CL/doingcl/clstruc.htm

[5] http://www.texascollaborative.org/Collaborative_Learning_Module.htm

a short period of time. Explanations, evaluations, and questions are not permitted as the ideas are generated. To start, the instructor asks a question that has a large number of possible answers. Each group is given one piece of paper (or transparency). The paper is passed around the group and students write down their answers at the same time stating them out loud. This process continues until the students run out of possible solutions (Millis & Cottell, 1998). After the brainstorming, instructors give time for the team to review and clarify their ideas. If needed, the group can present the ideas generated to the rest of the class.

(2) **Case studies**: Clyde Freeman Herreid[6] describes case studies as educational stories used to teach students about their field, that are typically written as dilemmas that give a personal history of an individual, institution, or business faced with a problem that must be solved. Background information, charts, graphs, and tables may be integrated into the tale or appended. The teacher's goal is to help the students work through the facts and analyze of the problem and then consider possible solutions and consequences of the actions that might take.

(3) **Double-entry journal/ Paired annotations**: After students read and reflect on the assigned reading, they write their observations about the critical points and their responses to them in their journal. In class, they swap journals with another student who has also read and made comments on the reading. The pair (or group) discusses the key points of the reading and looks for areas of agreement and disagreement. Finally, the group "prepares a composite annotation that summarizes the article, chapter, or concept."

(4) **Dyadic Essays:** Developed by L. W. Sherman (1988), the dyadic essay confrontation (DEC) technique has students create an essay question on information previously covered in the course and compose the answer to the question as well. On a separate piece of paper, students write only the essay question.

(5) **Group reports:** Rather than just having each group reports its findings, it considers structuring the process as a poster session in which each group creates an outline or concept map. One person from the group serves as a spokesperson, explaining the poster as the rest of the group circulates to view the other groups' posters.

(6) **Guided Reciprocal Peer Questioning**: This approach provides students with a series of generic, open-ended questions designed to encourage synthesis, comparison/contrast, and extrapolation to other contexts within the context of a small-group discussion.

(7) **Jigsaw:** The jigsaw technique was first developed in the early 1970s by Elliot Aronson [7,8] and his students at the University of Texas and the University of California. Jigsaw divides a problem or issue into parts--as many parts as there are members of a group. Students who have been assigned the same piece of the puzzle join together temporarily as a focus

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[6] http://ublib.buffalo.edu/libraries/projects/cases/teaching/novel.html

[7] http://www.jigsaw.org/overview.htm

[8] http://www.wcer.wisc.edu/nise/cl1/CL/doingcl/jigsaw.htm.

group studying that piece. The jigsaw structure promotes positive interdependence and also provides a simple method to ensure individual accountability.

(8) **Learning Community**: A learning community is the "purposeful restructuring of the curriculum to link together courses so that students find greater coherence in what they are learning and increased interaction with faculty and fellow students" (Gabelnick, MacGregor, Matthews, & Smith, 1990).

(9) **Online collaboration**[9]: Sarah Haavind of The Concord Consortium describes the best kind of e-learning or web course as having many of the same qualities as "a well-run seminar."

(10) **Problem-Solving**[10]: Collaborative problem-solving usually requires more planning and more time. Instructors cannot take for granted that their students will have a readily available protocol for solving problems, and must often outline a process or provide a checklist of steps. The method by which groups are selected and roles assigned within those groups will need to be considered. The task or problem to be studied and the criteria for measuring the accomplishment of the task need to be clearly explained to the students. The National Institute for Science Education at the University of Wisconsin, Madison, offers problem-solving models including Structured Problem-Solving, Discovery Method, Think-Pair-Square, Drill-Review Pairs, and Thinking Aloud Pair Problem-Solving.

(11) **Send-a-problem**[11]: Send-A-Problem can be used as a way to get groups to discuss and review material, or potential solutions to problems related to content information. The process and one variation on it are described at this site:

(12) **Teamwork**: Often one of the motivations for using collaborative learning techniques is to prepare students for their experience in the workplace where they will, undoubtedly, be asked to work in teams at some point. Successful teamwork requires a set of skills including communication and organization. The College of Engineering at Bucknell University has developed an in-depth *Practical Guide to Teamwork* that covers everything you need to know to get started. Teamwork is highly recommended!

(13) **Think-Pair-Share**: Was first proposed by Lyman (1981). This is a relatively low-risk and short collaborative learning structure, and is ideally suited for instructors and students who are new to collaborative learning. This is a quick collaborative learning activity in which the instructor asks an open-ended question and then allows students about a minute to think about it. Next, pairs of students discuss their ideas about the question or problem. Finally, the instructor solicits comments or other feedback such as a class vote regarding the question. For more details, see: http://www.wcer.wisc.edu/nise/cl1/cl/doingcl/thinkps.htm

(14) **Enhanced Problem Solving:** Many instructors wish to enhance the problem solving skills of their students. There is no agreed upon protocol to solve all problems but there are some general steps that are applicable in many situations (Woods, 1994; Millis & Cottell, 1998).

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[9] http://www.concord.org/newsletter/2002winter/online_courses.html

[10] http://www.wcer.wisc.edu/nise/cl1/cl/doingcl/prbsolv.htm

[11] http://www.gdrc.org/kmgmt/c-learn/methods.html#send

- Structured Problem Solving: Student groups are given a problem to solve within a specified time limit. A mini-lecture preceding the group problem solving may be appropriate depending on the specific activity.

- Discovery Method: This method is similar to the structured problem solving method except that student teams are asked to find the information they need to solve the problem on their own without the benefit of a mini-lecture. The instructor can structure a multi-layer discovery task. This way groups to ensure that groups that work faster than other groups can delve more deeply into the problem (Millis & Cottell, 1998).

- Send-a-Problem: This task involves several groups generating solutions to problems or analyzing possible solutions. A problem can be created by the instructor or by the students in an earlier class.

- Think-Pair-Square: Think-Pair-Square is similar to Think-Pair-Share. Students first discuss problem-solving strategies in pairs and then in groups of fours. Since problem solving strategies can be complicated, this structure may be more appropriate with experienced collaborative groups.

- Drill-Review Pairs: This structure is useful for courses that require drill and practice.

- Thinking Aloud Pair Problem Solving (TAPPS): This problem-solving collaborative structure was introduced by Lochhead and Whimbey (1987) as a means to encourage problem-solving skills by verbalizing to a listener one's problem-solving thoughts. The idea behind TAPPS is that presenting aloud the problem-solving process helps analytical reasoning skills. The dialogue associated with TAPPS helps build the contextual framework needed for comprehension (MacGregor, 1990). Similarly, TAPPS permits students to rehearse the concepts, relate them to existing frameworks, and produce a deeper understanding of the material (Slavin, 1995).

(15) **Guided Reciprocal Peer Questioning:** The instructor gives a mini-lecture in class and then provides a list of open-ended questions. Below is a selection of these adapted from King (1993) and Millis and Cottell (and references cited within, 1998). Included are questions that encourage synthesis, comparison and contrast, and extrapolation to other contexts.

(16) **Position papers/structured academic controversies**: The instructional use of intellectual conflict to promote higher achievement and increase the quality of problem solving, decision making, critical thinking, reasoning, interpersonal relationships, and psychological health and well-being. To engage in an academic controversy students must research and prepare a position, present and advocate their position, refute opposing positions and rebut attacks on their own position, reverse perspectives, and create a synthesis that everyone can agree to.

To start, the instructor selects a topic with two different viewpoints (e.g., "Nuclear energy should be used more/less in this country."). Students form groups and divide into two pairs. Each pair is assigned an advocacy position, and depending on available time, either receives supporting documentation or researches the topic. If the instructor wishes, student pairs from different groups with the same positions can compare ideas after becoming

familiar with their positions. The student pairs highlight the main arguments for their position and prepare a short presentation.

(17) **Writing to Learn:** Writing is an effective method to teach content as well as to test knowledge and can be combined with collaborative learning structures (e.g., peer editing). Writing aids critical thinking skills as well as lower levels of learning. Emig (1977) believes, "Writing represents a unique mode of learning - not merely valuable, not merely special, but unique." To learn we must place new knowledge into a cognitive framework. Writing provides the *process* needed to relate new knowledge to prior experience (synthesis). It also provides a means by which knowledge is symbolically transformed via language into icons. Finally, the written material, the *product* of this process, is concrete and visible and permits review, manipulation, and modification of knowledge as it is "learned" and put into a framework (Emig, 1977; Fulwiler, 1982; Tomlinson, 1990).

- Quickwrites

  - *Two-Five Minute Essays*: Students are asked to write in the last five minutes of class answers to the following: "What did you learn in class today?" and "What questions or concerns do you have?"

    In answering the first question, students often discover gaps in their knowledge, and these then appear in the second question. If instructors ask only the second question because of time pressures, students may not be able to formulate the more sophisticated questions. Students assemble into groups of four to share their responses and select the best one or two questions to submit to the entire class (Angelo & Cross, 1993; Young, 1997). Otherwise, students can submit their answers without first discussing them in a group.

  - *Other Short Writing Assignments:* Other assignments ask students to write the main ideas from the previous lecture, to tell what they already know about a certain topic before it is presented in class to explain a particular concept, to summarize the assigned reading, or to generate several questions they think may appear on the next exam. In each case, students are paired or grouped to discuss their ideas. When appropriate, student in pairs or groups can generate a new inclusive list or one that selects the five best ideas.

  - *Microthemes:* Microthemes are short writing assignments that usually can be written on a 5x8 inch index card. The goal is for students to invest substantial studying time prior to writing the microtheme; i.e., the microtheme leverages a lot of thinking, and later, to discuss their ideas with other students. Bean et al., (1982) classify microthemes into four categories. Though the categories themselves are not crucial to the science practioner, seeing these categories may clarify how to incorporate this writing technique into the course.

  - *Summary-writing:* Students are given a reading assignment and asked to summarize it. The student needs to understand the structure of the article and the main and secondary points of the article to successfully summarize it.

  - *Thesis-supported:* A statement that provides a clear choice between two opposing viewpoints is given to the students. The general structure of this

statement is: "This item does/does not cause this." The students are asked to take one viewpoint and provide supporting evidence for that perspective. This encourages students to take a focused stance on an issue, to gather information, and to summarize it in a coherent statement. (Note that one of the authors (Drenk YEAR) permits two page essays for this assignment.)

  o *Data-provided:* Students are given a series of related statements or data and are asked to draw a conclusion. This microtheme helps students arrange data in a logical order and generate a general statement from what they've induced from this information.

  o *Quandary-posing:* A conceptual question is asked and students compose a written response. An example: a cup filled with water to the brim contains a piece of ice some of which floats above the rim of the container. What happens to the water level as the ice melts? Will it remain the same, drop, or overflow? (Bean, Drenk, & Lee, 1982)

- Peer Editing: Peer editing pairs students as editors for each other's papers. There are many ways to structure this and much depends on the complexity of the assignment. For short papers editing pairs can review each other's drafts or "almost final" papers in class a few days before the final paper is due. For longer papers, the author needs to direct the editor's attention to a specific section or question. Peer editing can also be done outside of class, but face-to-face interaction is highly desirable.

- Dyadic Essay Confrontation: Students are given a reading assignment and asked to write a question that integrates this and earlier material. They respond by writing on a separate sheet of paper a one page "model" answer. Students are paired in the next class period, exchange questions, and write a one page response to the partner's question. The students exchange their one page model answers and their in-class writing. After reading their partner's in-class and model answers, the pair compares and contrasts the model and in-class answers.

(18) **Student Reports:** Having students give reports in front of the class is important but has drawbacks. In a class with as few as 30 students, if each group gave a short 10-minute presentation, this would consume considerable time. Also students spend most of their time in a passive listening role. Listed below are several more efficient methods of sharing group information.

## 2.3.3 Computer-Supported Collaborative Learning (CSCL)

How should one define computer-supported collaborative learning? In a nuts shell, CSCL is focused on how collaborative learning supported by technology can enhance peer interaction and work in groups, and how collaboration and technology facilitate sharing and distributing of knowledge and expertise among community members (Lakkala, Rahikainen, & Hakkarainen, 2001). Especially, in the field of computer-supported collaborative learning (CSCL), technology meets psychology, philosophy, and pedagogy. Instructional designers and software developers, educational psychologists, learning theorists, computer scientists, and even sociologists are interested in this area of research.

In fact, technology offers the kind of potentials for learning which are very different from those available in other contexts. Specifically, a wave of empirical research has revealed various promises and reported benefits of computer networks for collaboration (Lehtinen et al., 1999) such as: a) computer networks break down the physical and temporal barriers of schooling by removing time and space constraints, b) The delay of asynchronous communication allows time for reflection in interaction, c) Making thinking visible -by writing- should help students to reflect on their own and others' ideas and share their expertise, d) Shared discourse spaces and distributed interaction can challenge multiple perspectives and Zones of Proximal Development (ZPD) for students with varying knowledge and competencies, e) CSCL environments can also offer greater opportunities to share and solicit knowledge, and f) the database can function as a collective memory for a learning community, storing the history of knowledge construction processes for revisions and future use.

In 1996, Koschmann (1996) recognized CSCL as an emerging paradigm of educational technology. In fact, Koschmann (1996) has argued that the emergence of computer-supported collaborative learning research and development represents a Kuhnian paradigmatic shift in the history of instructional technology. According to Koschmann (1996), CSCL research is grounded on a very different concept of learning, pedagogy, research methodology, and research questions than its antecedents did. To this end, the short history of  CSCL shows, that there have been different interpretations and suggestions for the whole acronym as well as for latter "C" word (the first stands for 'computer') such as, collective (Pea, 1996), coordinated, co-operative, and collaborative (see Koschmann, 1994). Despite these different interpretations most researchers appear to use the aforementioned acronym –nowadays- as already suggested by Koschmann (1994, p. 220): "the best policy might be to simply use the acronym, allowing individual interpretation of what the letters might be". In general, even if the stress in CSCL research is on socially oriented theories of learning, there is still no unifying and established theoretical framework, no agreed objects of study, no methodological consensus, or agreement about the unit of analysis. Positively considered, this ambiguity can be seen as reflecting the richness or diversity of the field. Negatively interpreted, it seems that the field is proceeding along increasingly divergent lines.

However, despite the controversial interpretation of the theories, methods, and technology that underlie CSCL, researchers appear to agree on those mechanisms that could promote learning in this context. There exist two main theoretical perspectives for a mechanism promoting learning in a CSCL setting which trace back to the thinking of Piaget and Vygotsky. These approaches have been extensively reviewed in various studies (Dillenbourg, et. al., 1996; Hakkarainen, 1998; Littleton & Häkkinen, 1999; Palincsar, 1998; Salomon & Perkins, 1998). The first mechanism that is seen to promote learning in the context of CSCL is Piagetian socio-cognitive conflict. Children on different levels of cognitive development, or children on the same level of cognitive development with differing perspectives, can engage in social interaction that leads to a cognitive conflict. This "shock of our thought coming into contact with others" (Piaget, 1928, p. 204) may create a state of disequilibrium within participants, resulting to construction of new conceptual structures and understanding. The second well-known mechanism for promoting learning in the context of social interaction is based on the Vygotsky's ideas. There are two basic interpretations of Vygotsky's thought. The first view, assumes that because of engagement in collaborative activities, individuals can master

something they could not do before: the collaboration. People gain knowledge and practice some new competencies as a result of internalisation in collaborative learning. In other words, collaboration is interpreted as a facilitator of individual cognitive development. The other interpretation of Vygotsky's ideas emphasises that learning is more as a matter of participation in a social process of knowledge construction than an individual endeavour. Knowledge emerges through the network of interactions and is distributed and mediated among those (humans and tools) interacting (Cole & Wertsch, 1996).

Despite the fact that, some very intensive studies have had success in promoting high-quality learning supported with computer networks (Hakkarainen, 1998; Lamon et al., 1996; Scardamalia et al., 1994), on a large scale, there is no solid evidence that collaboration through networks leads to excellent learning results. In fact, some researchers reported that CSCL environments are mainly used for exchange of personal opinions, and for delivering surface knowledge and not for collaborative knowledge building (Stahl, 2002). It is also not clear if some of the results achieved in the CSCL studies would have been also achieved without any networked computer support. Among other constraints on the dominant research in CSCL is that there exists little research on how students participate in networked mediated collaboration, and on the consequences of different types of participation patterns, and how these are related to other aspects of CSCL, such as quality of students' discourse (Lipponen et al., 2002).

## 2.3.4 Models of CSCL

No generally accepted models are proposed by the literature. In fact, collaboration can be supported within different epistemological frameworks, instructional ideas, interaction models and computer applications. In the following section some models referred to (i) an epistemological infrastructure of CSCL, (ii) instructional frameworks where CSCL could be realized, and (iii) interaction models within CSCL are presented.

**Models of an epistemological infrastructure of CSCL**

Three models of innovative knowledge communities have been examined by Paavola, Lipponen & Hakkarainen (2002). These models focus on the "epistemological infrastructure" of CSCL: (a) the model of knowledge creation (Nonaka & Takeuchi 1995), (b) the model of expansive learning (Engestrφm, 1987), and (c) the model of knowledge building (Bereiter & Scardamalia 1993). The focus of Nonaka and Takeuchi's book is "on knowledge creation, not on knowledge per se". Engestrφm´s model concentrates on expansive, qualitative changes in activity systems while Bereiter's model is based on dynamic expertise and progressive problem solving where the goal always is to surpass previous achievements.

(a) *The model of knowledge creation*: The basis of this model is an epistemological distinction between two sorts of knowledge, i.e., tacit and explicit. Explicit knowledge means knowledge that is easy to articulate and express formally and in clear terms. Tacit knowledge, which is more important in innovation, means "personal knowledge embedded in individual experience and involves intangible factors such as personal belief, perspective, and the value system". The dynamics of this model comes from the interaction between tacit knowledge and explicit knowledge. A "knowledge spiral" is based on four alternative types of knowledge conversion,

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(i) from tacit to tacit knowledge (called socialization), (ii) from explicit to explicit knowledge (named combination), (iii) from tacit to explicit knowledge (called externalization) and (iv) from explicit to tacit knowledge (named internalization).

(b) *The model of expansive learning*: Engestrøm's model is rooted in the tradition of cultural-historical activity theory, which seeks to analyze and change practices of learning and working-life. He has studied innovative learning cycles in work teams using cultural- historical activity theory, and the theory of expansive learning as a framework for his analysis (Engestrøm, 1987). Engestrøm's model is based on a learning cycle consisting of the following seven stages in its ideal form (383-384; cf. Engestrøm 1987, 188-191, 321-336): (1) questioning and criticizing of some accepted practices by certain individuals; (2) analyzing the situation, (3) modelling of a new solution to the problematic situation, (4) examining how the new model works, (5) implementing the new model to practical action and applications, (6) reflecting on and evaluating the process, and (7) consolidating the new practice into some new form of practice. The model should be understood more as an ideal or heuristic for analyzing elements in the expansive learning cycle. Engestrom makes no claim that these steps universally follow one another in just the aforementioned particular order.

(c) *The model of knowledge building*: Bereiter's theory is a new way of understanding what is important in education based on the criticism of the folk theory of mind and knowledge. According to Bereiter the primary goal of members of an innovative expert community is not merely to learn something, but to solve problems, originate new thoughts, and advance communal knowledge. But in knowledge building knowledge work is seen as a collaborative achievement, where people develop, create, understand, and criticize various conceptual artefacts, not just "learn" something. Bereiter's theory diverges from the other two models in the sense that he emphasizes more strongly a conscious effort to advance knowledge and a commitment go beyond existing knowledge and understanding, an effort to solve knowledge problems through collaboration in innovative communities within a knowledge society.

**Instructional models within CSCL**

In this section three instructional models of CSCL are reported: (a) The ICT-rich learner-centred learning environment model (Danau, Verbruggen & Sligte, 1998), (b) The Didactical square (Kanselaar, De Jong, Andriessen & Goodyear, 2000), and (c) The progressive inquiry model.

### (a) The ICT-rich learner-centred learning environment model

In this model the learning environment is represented as a polyhedron (hexahedron) where the learner is in its' centre while in its edges are as components: the teacher, the peers, the learning tools, the learning materials, the information resources and the evaluation/monitoring procedures. The representation of the didactical polyhedron is characterised by a flexible networked structure in which ICT-tools and resources introduce new, and enrich all the old-fashioned components within the learning environment. New pedagogic and didactic arrangements, in addition to the ones merely based on the instructivistic paradigm can be implemented. Firstly, in addition to the physically present teacher, other teachers or experts at a distance contribute to learning. The teacher him/herself can be physically or virtually present, either via e-mail, Intranet, or groupware. Certain educational software can fulfil a teaching role.

Fellow pupils for collaboration and network-learning are introduced, not only within the classroom, but also around the world, via e-mail, web-based videoconferencing or groupware. Subject matter does not come in books alone, but in all kinds of digital media. ICT-mediated-(self) assessment tools broaden the monitoring and evaluation of learning, traditionally done by the teacher. Digital information resources complement the paper-based resources and a variety of new tools and media exist in addition to pen and paper.

### (b) The Didactical square

In this model the learning environment is represented as a square. In the heart of this square computer mediated communication (CMC) is situated implying social interaction by using media interactively. In the vertices of this square are represented: (a) the knowledge domain, (b) the media used, (c) the student and (d) other people (students and teachers). On the edges of the said square are represented: (a) multiple representations of the knowledge domain (connecting the vertex representing the knowledge domain with the vertex representing the media used), (b) technological mediation (connecting the vertex the represents the media used with the vertex representing the student), and (c) social mediation (connecting the vertex the represents the other people participated in the learning environment with the vertex representing the student). In this model CMC plays a central role to combine the advantages of social interaction (interpretative, meaning oriented) and electronic interaction (different representation forms – graphical, textual, dynamic – and automatic storage of the inter-actions). Because of storage of the interactions, a 'group memory' is also created, which is an advantage over oral communication. This CMC encompasses both the characteristics of the knowledge domain and the characteristics of the pupil.

### (c) The progressive inquiry model

Progressive inquiry is a synthesis of cognitive research and the interrogative model (Hintikka, 1982), and can act as a model of pedagogical implementation in the context of CSCL. Put brief, progressive inquiry is a sustained process of advancing and building of knowledge characteristic of scientific inquiry. It entails that new knowledge is not simply assimilated but constructed through solving problems of understanding. By imitating practices of scientific research communities, children can be guided to engage in extended processes of question- and explanation-driven inquiry. An essential aspect of this kind of inquiry is to engage collaboratively in improving of shared knowledge objects, i.e., hypotheses, theories, explanations, or interpretations (Scardamalia & Bereiter, 1996b). Through intensive collaboration and peer interaction, resources of the whole learning community may be used to facilitate advancement of inquiry. The flow of progressing scientific inquiry consisted of the following essential elements:

*1. Creating Context:* Creating a context for a study project is essential in order to: (a) anchor the problems being investigated to central conceptual principles of the domain of knowledge in question and of complex real-world problems solved by experts, and (b) help the students to understand that it is worthwhile and important to investigate the issues in question so that to be personally committed in the investigation process. To this end, some essential criteria for such a context formation are reported: (a) the topic of study has to be sufficiently complex and multifaceted, (b) the problem-area has to be central for the students' conceptual understanding of the aforementioned principles, and (c) challenging learning tasks that facilitate in-depth conceptual understanding are critical for both; students'

engagement and learning. It is essential that the teacher does not provide answers to the students directly.

2. *Setting up Research Questions:* An essential aspect of progressive inquiry is to set up questions or problems that guide the process of inquiry. Questions that could have a special value in this process should: (a) arise from students' own wonderment or their need to understand, (b) guide the inquiry process by constraining and directing the search for information, (c) activate a student's background knowledge, (d) relate what s/he already knows to new information (Hintikka, 1982; Scardamalia & Bereiter, 1992).

3. *Constructing Working Theories:* An important aspect of inquiry and a critical condition of developing conceptual understanding is generation of one's own conjectures, hypotheses, theories, or interpretations for the phenomena being investigated (Bruner, 1996; Lampert, 1995; Scardamalia & Bereiter, 1993). Engaging students with construction of their own explanations -even if initially mistaken- may guide them to see themselves as contributors to knowledge, as prospective scientists (Scardamalia & Bereiter, 1993). Each student comes to instructional situations with a large body of preconceptions that diverge from generally accepted scientific ones. By facilitating explication and externalisation of these preconceptions and taking them as the object of collaborative discussion -before obtaining scientific information- the differences between one's own conceptions and scientific conceptions become salient and accessible to the student. If scientific conceptions are assimilated without explicating one's own view, it is likely that potential differences or gaps of knowledge are not at all identified and misconceptions or wrong theories could be reproduced later on in the process of inquiry by the student.

4. *Critical evaluation of knowledge advancement:* Through evaluating whether and how well the working theories explain the chosen problems, the learning community seeks to assess strengths and the weaknesses of different explanations and identify contradictory explanations, gaps of knowledge, and limitations of the power of intuitive explanation. The evaluation helps the community to direct and regulate joint cognitive efforts toward searching new information that will help advance shared understanding.

5. *Searching New Scientific Information:* Considerable advancement of inquiry cannot be made without obtaining new information. By examining one's problem or intuitive theory with the help of new information, the student may become aware of his/her inadequate presuppositions or background assumptions. A comparison between ones' own intuitive and well-established scientific theories tends to make weaknesses and limitations of one's conceptions salient to the students facilitating conceptual progress. Monitoring progress of one's conceptual understanding facilitates also metacognitive awareness of the process of inquiry.

6. *Engagement in Deepening Inquiry:* The process of inquiry advances through transforming the initial big and unspecified questions into subordinate and, frequently, more specific questions. The students try to solve the big question through using their existing knowledge and new information that provide answers to a series of subordinate questions. The dynamic nature of inquiry is, further, based on the fact that generation of intuitive explanations and obtaining of new scientific information make new research questions that could not have been foreseen in the beginning of inquiry, accessible to the students. By finding answers to subordinate questions, students approach gradually towards answering the big initial question.

7. *Shared expertise:* All aspects of inquiry, such as setting up research questions, searching for new scientific information, constructing of one's own working theories or assessing the explanations generated, should be shared with other inquirers. In order to explain one's view to his or her peers, an individual student has to commit his- or herself cognitively to some ideas, explicate his or her beliefs, as well as organize and reorganize his or her knowledge (Hatano & Inagaki, 1992). Through this kind of process, inadequacies of one's understanding tend to become more salient. Conceptual advancement is facilitated by cultivating each student's own expertise and guiding the students to reciprocally teach each other. Students engage in a self-regulated and collaborative inquiry being, as a group, responsible for the task. They are guided themselves to monitor progress of their distributed inquiry.

The model of progressive inquiry has been embedded in the Future Learning Environments (FLE) design. The environment provides each student with tools for building their own knowledge such as: (a) direct links to those of the other members of the study group, enabling all to share their process of inquiry (b) a shared space for working together for solving problems and developing ideas and thoughts (c) asking a user who is preparing a discussion message to categorize the message by choosing a category of inquiry scaffold (e.g., Problem, Working theory, Summary) corresponding to the progressive inquiry model (based on the practices of Scardamalia & Bereiter, 1993). These scaffolds are designed to encourage students to engage in expert-like processing of knowledge; they help to move beyond simple question-answer discussion and elicit practices of progressive inquiry (d) a module that encourages free flow of ideas and experimentation with different ways of representing knowledge, (e) tools for storing different versions of the object being developed: The users may take a version of the object and elaborate it further, and save it for the other users to be further develop, and (f) tools to make thinking visible by providing a graphic representation of development of a knowledge object (Brown, Collins, & Duquid, 1989).

Comparing to the metaphor of the traditional didactical triangle where the main interaction for the pupil is between the teacher and the pupil and between the content and the pupil (mostly by reading a book and doing tests on the content) in the aforementioned models the elements of pupil's interaction are increased and ICT became an integrated element in the learning environment. In the aforementioned models, collaboration is an important aspect of the learning process of the pupil, which is related to production of different learning outcomes than the ones could be produced within a traditional non collaborative and none technologically supported learning environment. The aforementioned models are also related to the constructivist idea that learning is a social process and practice in which personal interpretations are negotiated (Heeren, 1996). The use of ICT for these negotiations makes it possible to not only collaborate in the physical classroom but also with other pupils and experts, nationally and internationally.

**Interaction models within CSCL**

Crook (1994) has proposed four kinds of interaction in which computers play a part: 1) interactions at the computers, 2) interactions around computers, 3) interactions related to computer applications, and 4) interactions through computers.

The first three kinds proposed by Crook are face-to-face interaction situations where meanings are mediated through spoken language, faces, and gestures. In these situations, computers can act as a referential anchor, and mediate the coordination of attention and collaborative actions (Crook, 1994; Järvelä, Bonk, Lehtinen, & Lehti, 1999; Roschelle, 1992). By contrast, collaboration through networked learning environments is still mainly based on written language. Thus, interaction that takes place through computer networks lacks certain basic features of face-to-face collaboration: social cues such as faces, gestures and intonations of speech. It also lacks the rich referential field of the material world that is present in face-to-face interactions. The lack of referential anchors is quite pronounced in written communication. This means that explicating referential relations in a written message is important because, in written language, such explications of a message create context and grounding; in contrast these referents are usually known by participants or are easily checked in face-to-face discourse. Building a common ground is considered an essential part of coordinating collaborative activities and knowledge sharing (Dillenbourg & Traum, 1999; Koschmann, LeBaron, Goodwin, & Feltovich, 2001).

## 2.3.5 CSCL systems and tools

Over the past four decades researchers, educators, and corporate trainers from many varied disciplines have explored using computer systems in teaching and learning and several areas of research and practice have emerged (Sharda, Romano, Lucca, Weiser, Scheets, Chung, & Sleezer, 2004)..

**Computer-Supported Learning Systems** have traditionally been labelled Computer-Aided/Assisted Instruction (CAI) systems. These systems contributed significantly to the use of computers in education. However, they traditionally focused on individual learners working on a local computer to accomplish cognitive learning objectives. Distance Learning, at its most basic level, is an extension of CAI to enable remote students to access course content.

**Collaborative Systems** are often referred to by the all-encompassing term "GroupWare", that was coined by MIS researchers Paul and Trudy Johnson-Lenz Circa 1980. Collaborative systems can range from email to online discussion groups and Internet chat rooms to sophisticated **Group Decision Support Systems**. Most Group Support Systems (GSS) research for education has involved same-time, same-place classroom situations.

The intersection of computer-supported learning systems and collaborative systems includes systems that extend Distance Learning by integrating collaborative learning and information technology, which is commonly referred to **Computer-Supported Collaborative Learning (CSCL)**. Many MIS researchers have used Group Support Systems (GSS) in the classroom to enhance learning, while others in IS and related fields have developed Asynchronous Learning Networks (ALNs). Combinations of these two system types have enabled affective learning objectives related to interactive communication and teamwork to be achieved, in addition to more traditional cognitive learning objectives.

The field of CSCL can be contrasted with earlier approaches to using computers in education. Koschmann (1996) identified the following historical sequence of approaches:

(a) Computer Assisted Instruction (CAIs)

(b) Intelligent Tutoring Systems (ITSs)

(c) Logo as Latin (LOGO)

(d) Computer-Supported Collaborative Learning (CSCL).

**Collaborative Virtual Design Environments** (CVDEs) use Virtual Reality to view and review complete systems, assembly processes, and individual parts. CVDEs provide realistic 3D displays and enable rotational capability for complete 360-degree visualization as well as views from top, bottom, inside, and underneath objects.

**Categorization of technologies of cooperation:** The following categorizations of technologies of cooperation are proposed by the Institute for the Future[12].

**Environments for Collaborative Learning**

- Shared Computer Resources in Classrooms and Workplaces
- Online Collaborative Workspaces
- Web Conferencing Software with Collaboration Features
- Knowledge Collectives
- Collective Immersive Environments
- Collaborative Augmented Reality

**Networks for Collaborative Learning**

- Personal and FOAF Networks
- Group Forming Networks
- Social Mobile Networks
- Peer Sharing and Production Networks
- Community Computing Grids
- Self-Organizing Mesh Networks

**Tools for Collaborative Learning**

- Communications Tools
- Collaborative Process Tools
- Presence Tools
- Social Markup Tools - Annotation, Bookmarking, and Rating
- Project and Team Management Software
- Community Management Tools

## 2.3.6 Summary

The pedagogy of collaborative learning is an active and still controversial field, presenting a strong challenge to traditional education, oriented as it was toward the individual student. In particular, computer and Internet technologies have been inspiring new approaches to

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[12] http://www.iftf.org/node/763

supporting collaborative learning during the past decade (e. g., Crook, 1994; Koschmann, 1996; O'Malley, 1995; Sayed, 2014; Bowers, 2015; Wu, 2016). The field is now reaching the point where prototypes are establishing the viability of innovative ideas and the time has come for widespread dissemination. That is, we need to know how to conduct professional development of teachers for collaborative learning.

The aim of this section was to introduce and define general aspects of collaborative learning. In particular, we gave a definition of collaborative learning and described its theories and recent methods and strategies. Then, we focused on technological aspects of collaborative learning by presenting the different models, systems and tools of Computer-Supported Collaborative Learning (CSCL).

# 2.4 Social learning

Social learning theory focuses on the learning that occurs within a social context. It considers that people learn from one another, including such concepts as observational learning, imitation, and modelling. This theory has often been called a bridge between behaviourist and cognitive learning theories because it encompasses attention, memory, and motivation. Social learning theory is related to Vygotsky's Social Development Theory and Lave's Situated Learning, which also emphasize the importance of social learning. Among others, Albert Bandura is considered the leading proponent of this theory. His theory added a social element, arguing that people can learn new information and behaviours by watching other people. Known as observational learning (or modelling), this type of learning can be used to explain a wide variety of behaviours. The social learning theory has become perhaps the most influential theory of learning and development. While rooted in many of the basic concepts of traditional learning theory, Bandura believed that direct reinforcement could not account for all types of learning.

## 2.4.1 Bandura's Social Learning Theory[13]

The social learning theory of Bandura emphasizes the importance of observing and modelling the behaviours, attitudes, and emotional reactions of others. Bandura (1977) states: "Learning would be exceedingly laborious, not to mention hazardous, if people had to rely solely on the effects of their own actions to inform them what to do. Fortunately, most human behaviour is learned observationally through modelling: from observing others one forms an idea of how new behaviours are performed, and on later occasions this coded information serves as a guide for action".

Social learning theory explains human behaviour in terms of continuous reciprocal interaction between cognitive, behavioural, an environmental influences. The component processes underlying observational learning are:

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[13] http://tip.psychology.org/bandura.html

A Multi-fold Assessment Framework for Virtualized Collaborative and Social Learning Scenarios

(1) Attention, including modelled events (distinctiveness, affective valence, complexity, prevalence, functional value) and observer characteristics (sensory capacities, arousal level, perceptual set, past reinforcement),

(2) Retention, including symbolic coding, cognitive organization, symbolic rehearsal, motor rehearsal),

(3) Motor Reproduction, including physical capabilities, self-observation of reproduction, accuracy of feedback, and

(4) Motivation, including external, vicarious and self reinforcement.

Because it encompasses attention, memory and motivation, social learning theory spans both cognitive and behavioural frameworks. Bandura's theory improves upon the strictly behavioural interpretation of modelling provided by Miller and Dollard (1941).

**Scope/Application**:

Social learning theory has been applied extensively to the understanding of aggression (Bandura, 1977) and psychological disorders, particularly in the context of behaviour modification (Bandura, 1989). It is also the theoretical foundation for the technique of behaviour modeling which is widely used in training programs. In the 70's decade, Bandura focused his work on the concept of self-efficacy in a variety of contexts (e.g., Bandura, 1977).

**Example**:

The most common (and pervasive) examples of social learning situations are television commercials. Commercials suggest that drinking a certain beverage or using a particular hair shampoo will make us popular and win the admiration of attractive people. Depending upon the component processes involved (such as attention or motivation), we may model the behaviour shown in the commercial and buy the product being advertised.

**Principles:**

(1) The highest level of observational learning is achieved by first organizing and rehearsing the modelled behaviour symbolically and then enacting it overtly. Coding modelled behaviour into words, labels or images results in better retention than simply observing.

(2) Individuals are more likely to adopt a modelled behaviour if it results in outcomes they value.

(3) Individuals are more likely to adopt a modeled behavior if the model is similar to the observer and has admired status and the behavior has functional value.

Though an established field in its own right, only recently has social learning theory been applied to virtual worlds and serious games. The basic tenets of social learning are the need to evidence a chance in understanding amongst those involved, which goes beyond the individual and to wider societal units. Furthermore, this learning occurs through interactions between peers within a social network. The relevance to serious gaming is immediately apparent through parallels to the leisure industry which has increasingly sought to implement collaborative and social technologies such as Facebook, MySpace, and Twitter as both a marketing tool and platform for development and deployment. Collaboration can be defined as occurring at three distinct levels in virtual worlds – network, community, and team. Examples

such as TPLD's EduTeams[14] aim to use social collaboration within a gaming context as a means to develop team working skills amongst children. White also defines the higher community level as a potentially disparate group working towards a collective goal; whereas at a team based-level all individuals interact with one another, this is not necessarily the case in a community-based context. Finally, the network level considers the potential for collaboration between communities arising through contact between their individual members. These levels relate directly to web-based scenarios and the technologies required to implement them; MMORPG games such as World of Warcraft, for example, demand low-level team based collaboration to overcome simple objectives, but also feature high-level social constructs and web presences to facilitate community and network collaboration.

Irrespective of the context, modern theory derives in part from the work of Vygotsky (summarized in Vygotsky 1978, though written mostly in the period between 1925- 35, Rotter (1966), and Bandura (1977). Translating these concepts to virtual worlds, online environments, serious games, or other new media which facilitate social interaction demands that the basic tenets for effective behavioral change through social learning be applied:

- Self-efficacy: The learner must believe themselves to be capable of the required action

- Incentive: The learner perceives an reward for performing the action

- Benefit: The learner must value the immediate or long-term benefits of the action

Perceived self-efficacy is commonly cited as the most important factor in behavioral change through social mechanisms, since it is a pre-requisite for any action on the part of the learner. In road safety terms, and as mentioned in Chapter 1, we see the principal negative influencers here emerge as the child feeling motorists have ultimate control over their safety, or that the responsibility for their safety is in the hands of parents, teachers, or other adults. It is implicitly tied to self-regulation (Bandura 1977), as many programmes targeted at a behavioral change are ultimately seeking to persuade individuals to move from behavior controlled by an external administration of consequences to self-motivation and self-maintenance. Bandura argues that, as a rule, humans tend to hold ideological positions in spite of changes in situation and circumstance. Immediate actions and reactions are a result of judgments against a set of internally-held beliefs and values, and to adjust these immediate actions requires that these core beliefs are changed.

Grusec (1992) describes the specific case of children: young children tend towards observation and imitation of adults when creating their own principles and values for self-regulation. The specific case of a peer group has unique traits amongst children, since observation and imitation play less of a role. They are particularly important during adolescence as children transition away from dependence on parents (Siegler, 2006). This important shift away from reliance on adults and towards independence results in a proportional decrease in the influence adults have on the behavior of adolescents, as the peer group emerges as a key behavioral driver. Therefore, manipulation of behavior can often be more readily achieved

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[14] http://www.tpld.net/beta/store/view/Eduteams/

through a peer group in this age range than by a teacher or parent. Online environments have opened up a range of questions as the anonymity and identity of peer groups online can differ widely from the real world: research into teaching and learning in virtual worlds (e.g. Savin-Baden, 2007) has frequently reflected on how tutors and teachers are perceived differently by students, and how this can be capitalized upon.

It is this unique access that educators have to social communities for in online worlds and serious games that is particularly compelling. Social-constructivist elements in serious games are typically supported through additional resources common to electronic gaming as a whole, such as websites, and in particular web forums and discussion boards.

## 2.4.2 Models of Social Learning

The principal model of social learning, as put forward by Bandura (Bandura 1977), is one of observation and imitation. Bandura's theory largely centers upon the assumption that individuals are capable of learning through observation alone, and that indications of behavioral change are not necessarily required to confirm learning has occurred. This is at odds with the classical theory of behaviorism, which relies upon an implied link between learning and behavioral change (Skinner 1981). Incentive and reinforcement in social learning are hence key factors in motivation to learn, but not learning transfer itself. To create effective social learning Bandura notes several key requirements for social learning: that observation can occur, that the observer is capable of carrying out the action and that the observer perceives benefit in carrying out the action. Similarly, Vygotskyan theory (Vygotsky 1978) mirrors several aspects of social learning models: is bases itself in the notion that learners have a zone of proximal development (ZPD). This zone represents the capacity of the learner to develop their skills unaided, suggesting social interaction is critical in allowing learners to expand this zone. The theory emphasizes the need to scaffold transfer from learning made in an abstract fashion to real contexts, citing play as a key method for abstract learning and the requirement of the educator to support the learner in transferring these skills through problem solving or discussion. The educator is defined in broader terms of the "more knowledgeable other", complementing the notion of the ZPD. Indeed, this can take the form of a parent, sibling, peer, or tutor, and, in the case of technology enhanced learning, a virtual agent or artificial intelligence (Rebolledo-Mendez, Avramides et al.,2009).

To position learning technology in the role of this "more knowledgeable other" is no easy task. Effectively, the synthetic character must handle not the transfer of knowledge, but its synthesis and application. Moreover, in order to expand a learner's ZPD, it is necessary to *understand* ZPD, demonstrating the need for learning profiling and adaptation. A system which fails to do so is likely to frustrate learners by attempting to teach them concepts they consider as trivial, or induce disaffection or anxiety by presenting material too complex. The role of matching perceived difficulty to a learner's self-perception of their ability is noted in the works of Cziksentmihailyi on the "flow experience" (Cziksentmihalyi, 1997), Sustaining a flow experience requires the educator carefully match difficulty of task to the learner to ensure they avoid repeating exercises unnecessarily and are constantly challenged. Game-based learning can be effective in maintaining flow as simple game elements can create a low-level cognitive challenge in parallel to learning content, though it is essential to ensure cognitive overload

from game elements does not lead to instructional material being overlooked or ignored. As early evaluations of several serious games have shown, games which include high-load cognitive tasks in parallel to learning material can engender situations where the learner becomes wholly focused on beating the game to the exclusion of the educational content, an undesirable scenario (Binsubaih, Maddock et al.,2008).

In previous work by Mayes and de Freitas (2007), the authors analysed all e-learning and learning theory in terms of three categories: associative, cognitive and situative. The last category, situative, was the least populated by learning theories, and yet was clearly becoming a central driver in learning theory, particularly where children are moving from intrinsic to extrinsic motivational needs. The situative area of learning theory centers upon social interactions, especially what we have termed social interactive learning, and that is where learning is more focused upon social interactions, such as through dialogue or problem and challenge centered peer work.

Models of social learning having been derived from psychology and psychological models of social behaviors have a role to play in this understanding of learning as a whole, and social learning in this context means the same, that learning is mainly gained through social interactions. For example, observational learning (learning from imitation) occurs where individuals learn from watching and imitating. The best example of this approach to learning comes from the aforementioned work of the Russian Social Constructivist, Lev Vygotsky (1996). His work on the zone of proximal development (ZPDzpd) exemplifies a model of learning driven by social interactions. In this case child and adult, the child follows and imitates the adults' behavior, thereby learning from them and amending their own behavior to be aligned with that of the elder. Other related work comes from Wenger (1998) and his work around communities of practice, here he argued that learning is also social and that individuals benefit from social group learning, gradually moving from novice to expert through these sophisticated interactions.

In terms of serious game-design, social learning strategies have been employed to create environments where social aspects are provided by virtual characters, whose behavior is controlled via a 'levels of interaction' (LOI) system. This concept considers the needs of large-scale observation of crowds to perceive an authentic environment, but also the need to observe specific actions and interactions between virtual characters and be able to interact through dialogues. In Roma Nova serious game (Panzoli et al.,2010), the authors have developed an approach to learning whereby individuals have missions involving exploring a virtual environment, and through interactions with intelligent virtual agents they learn about citizenship and history in ancient Rome. The work builds upon social learning models such as the zone of proximal development, exploratory learning and situated learning.

Learning enviroments based on social learning networks are being studied and currently applicated (Morueta et al., 2016). We can cite the rise and promotion of MOOC environments based on dialogue discussion and collaborative construction of knowledge (Ma et al., 2015). The contributions made in these fields are the basis to develop the ongoing and future research direction of this thesis.

## 2.4.3 Social Learning systems and tools

Social learning systems and tools therefore are also built upon this theoretical basis. In the mentioned work of Roma Nova (Panzoli et al.,2010), a concept around distributed tutoring environments was developed that scaffold learning of the individual and leave scope for authoring team missions involving collaborative and peer learning and assessment. Based on this idea, in this thesis we envisage the serious game itself where the learning system will oin up quizzes and quests into a game that can interact with tutors and students to scaffold and exemplify particular aspects of formal and informal curricula.

The technological nature of a social learning environment can be wide ranging: for every bespoke solution targeted at a specific social learning activity, there are many collaborative technologies being used online by millions of individuals to interact, and inevitably learn, through socialization. These include established forms of communication such as web forums, chat rooms, and e-mail, through to more emergent media such as blogs, social networking sites, and virtual worlds. Entertainment games are also an increasing medium for large-scale socialization, with the online game World of Warcraft[15] having some seven million players. Hence, to consider only systems designed specifically with social learning in mind is to exclude a large proportion of the environments in which it occurs. In an attempt to consolidate this understanding, Wenger (Wenger et al.,2009) seek to identify common trends. They note distinctions between environments wherein learners learn *from* rather than *with* one another; in the former case, observation is key, in the latter case interaction. Therefore, whilst learning *from* one another is relatively simple to facilitate technologically, requiring only that the level of fidelity is matched to the activity being learnt, learning *with* one another requires technology be able to facilitate communication and interaction. Similarly, Wenger et al. (2009), note that learning can occur through formal as well as informal activities. In a practical technology-enhanced learning context, this can include learners interacting through supporting forums, or even in-person, particularly the case if IT use is taking place in a social environment. Hence, educators must take a holistic approach which integrates all available social media to maximally exploit the social dimension of education.

For the authors, the systems of learning in this context are the communities of practice as defined by Wenger in his work. The environment is the test bed for students to rehearse and practice key skills including social interactions. In another project by consortium partner COVUNI, an evaluation of the massively multiplayer online game *Code of Everand*, have used social network analysis to understand how children are playing the multi-player online game., Here we have found that social groups are emerging directly out of the game play, and that the nature of who you play with will alter the length of game play and the quality of outcomes. This early work has exciting implications for serious game design but also for learning design as a whole we argue, as the feedback coming from the game system and platform can allow for fast response. Feedback can be personalized and lead to shorter learning times and longer duration of memory of the learning. Future work will be evaluating these trends and will we envisage allow us to develop better metrics for learning design and deployment.

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[15] http://us.battle.net/wow/en/

More information in this Section can be further provided by referring to the paradigm of pedagogy 2.0 and integration between 2.0 and social learning and social software.

### 2.4.4 Summary

In this section, we provided a brief overview of the concept and idea of social learning. In particular, we first described the social learning theory of Bandura, focusing mainly on its principles. Then we briefly explained what models of social learning are and subsequently we introduced how social learning systems and tools may affect the development of the assessment framework as the main goal of this thesis.

# 2.5 Assessment of Collaborative and Social Learning

In this section we will give a broad overview and definition of assessment of Computer-Supported Collaborative Learning. The main focus lies on introducing the basic ideas of assessment that will be picked up again later on in this review and will serve for assessing Collaborative Complex Learning Objects (see Chapter 3). Furthermore, in order to form a more complete view of this matter, other important related topics will be discussed, such as assessment of online discussion as well as the issue of knowledge extraction from collaborative and social learning activities. To meet the needs of this thesis we will discuss assessment with respect to educational settings only although some of the definitions and descriptions could also be generalized in order to cover other research areas.

### 2.5.1 Assessment of Computer-Supported Collaborative Learning

In the present knowledge society context (Corso et al., 2009, Lytras & Garcia, 2008, Lytras & Ordóñez de Pablos, 2007, Lytras et al., 2007, Lytras & Sicilia, 2005 and Stehr, 2007), interactive learning environments (ILEs) (Wang, Woo, & Zhao, 2008) have provided a huge improvement of distance learning development, mainly in the last ten years. A vast literature production and outstanding contributions have been published reporting on studies where the learning interaction process has been exhaustively analyzed (Chou, 2004, Fahy, 2006, Michinon & Michinon, 2005, Ordóñez de Pablos, 2005 and Perakyla, 2004). Interaction analysis is also a key issue in the field of collaborative learning to ensure full support to the on-line learning activity and specifically to provide assessment capabilities based on the information captured from the participants' actions during the collaborative process (Dillenbourg, 1999).

Collaborative Learning has been defined by Dillenbourg (1999) as "a situation in which two or more people learn or attempt to learn something together". Dillenbourg distinguishes three dimensions of collaborative learning: the scale of the collaborative situation (group size and time span), the level of learning, and the depth of collaboration. The emergence use of Information and Communication technologies (ICT) has fostered collaborative learning with various software and tools. Examples of those tools are e-mail, discussion forums, blogs, wikis, social networks, voice-over-IP (VOIP), and virtual words (Elliott, 2008; Crisp, 2007). Collaborative Learning enhanced by computers also referred as Computer-Supported Collaborative learning (CSCL) is an emerging science of learning where students are provided

computer-based social environments to discuss and collaborate; moreover they are encouraged to reflect on others' contributions in a way that may facilitate collaborative knowledge construction (Jonassen, 1994; Huang, 2002). Moreover, CSCL deals with issues that cover collaboration, learning processes, and the use of computer mediated communication (CMC). Nevertheless, CSCL aims to support and enhance student's collaboration and their team work in order to enhance their learning process (Kreijns et al., 2003, cited after Janssen et. al., 2007). Janssen et. al. (2007) discusses some problems that may rise during CSCL:

Lack of awareness: awareness concerns useful information that group members need on what others are doing, what others know about the current task, what group members will do next. According to (Romero-Salcedo et al., 2004) awareness is a problem of perception and information. Group awareness information may reduce group members' effort to coordinate among them, may increase their efficiency, and may reduce the chance for errors (Gutwin & Greenberg, 2004). Moreover, awareness information is important to monitor group mutual performance, as group members are collaboratively working on shared tasks they need to monitor whether other members are performing well (e.g., Who is doing what? Is group member's performance on a sufficient level?). Nevertheless, Conversational awareness information is important to have quality discussions. Another important type of awareness information is social awareness. Social awareness is required to regulate social aspects of the collaboration, enhance group coordination (e.g., who is available for discussion and communication? Who needs help? Is collaboration going fine or should changes be made?) (Kreijns et al, 2004a). Furthermore, social awareness may support group members to avoid the problem of free rider effect (Salomon & Globerson, 1989) by knowing who is doing what. Therefore, working in a CSCL environment requires group members to have not only task-related awareness information, but awareness information about social aspects as well. During collaboration, group members have to engage in different types of activities. These activities are related to task execution, regulation or socialization aspects of collaboration (Janssen, 2008). The collaborative group needs awareness information to know how to manage social aspects of collaboration (Kreijns, 2004b). The situational awareness deals with what happens around you in the environment and having a shared understanding of the information (Whitworth et al 2009). Situational awareness is expected to be an important determinant of team performance (Bolstad et al., 2006; Endsley, 1995).

Coordination problems: CSCL is a difficult task to students as they are required to perform a variety of group activities while working on a collaborative learning task. During collaboration group members have to maintain communication and coordination among them regarding the collaborative tasks. They have to exchange ideas, ask questions, enter in arguments, and direct their effort and progress towards the group product. This process is called production function of groups where students involve in social interactions in order to maintain group well-being and share social space for member-support (McGrath, 1991). As collaboration involves different types of group activities, coordination among group members is required. Erkens (2004) identified three types of activities that affect group coordination: (a) Activation of knowledge and skills: this includes the initial communication and knowledge sharing among group members to define tasks and provide member support. Sharing knowledge and skills

improvement are important activities for group's well-being. Moreover, they may foster collaboration with equal participation and contribution of group members so that each group member will have the opportunity to contribute to group production function, to engage in knowledge construction, and to utilize her/his skills during the production process (Barron, 2000). (b) Grounding: is another important activity that group members have to maintain. Group members have to have a common understanding of tasks and they have to ensure that they understand each other. In order to achieve grounding, the following strategies can be used: tuning, joint attention, focusing, and checking. (Janssen et. al., 2007) (c) Negotiation and coming to agreement: despite the common understanding in the grounding processes and knowledge sharing strategies, group members have to negotiate the problem state and to come to an agreement about possible solutions and next steps.

Communication Problems: research in CSCL has shown that communication problems mainly concern the communication media itself. Traditional CSCL communication media (e.g., e-mail or chat) lacks media richness. Media richness can be defined as "a medium's ability to facilitate communication and the establishment of shared meaning. Factors such as the immediacy of feedback or the ability of the medium to transmit multiple cues (e.g., facial expressions, gestures, or intonation of voice) influence its richness" (Janssen et. al., 2007). Low media richness may prevent group members from understanding group discussions which affects CSCL process with coordination problems and lack of quality discussions. Therefore, rich CSCL communication media- in terms of facial expressions, gestures, or intonation of voice - such as video conferencing has been used to foster the group communication. Communication problems lead to lack of quality discussions. When group members collaborate, they are often working on complex problems which require the input of all group members (Damon & Phelps, 1989). Ideally, group members engage in dialogued discussions looking for constructive approaches. There are four important aspects involved in the dialogued discussions (1) group members are critical of their own and the other group members' ideas, (2) criticism is accepted, (3) they offer explanations for their opinions, and (4) all group members participate in the interaction process (Janssen, 2008). If any of these aspects is not present, the dialogued discussions present communication problems.

Several solutions have been proposed in literature to solve the aforementioned problems, scripting, and specific roles for group members are some of these examples. Moreover, visualization aspects of textual and graphical visualizations have been recommended as a possible solution in order to support CSCL in both the collaborative learning process itself and the learning scaffolding (Janssen et al., 2007; Zumbach & Reimann, 2003; Reimann & Kay, 2010). Designing a suitable visualization highly depends on the following: what information it will visualize: CSCL related information can be either task-related (e.g., How many problems have been solved by the group?) or social-related (e.g., How many messages have been sent by each group member, or how much each group member have contributed to the CSCL product?) or both. Moreover, selecting information related to the aforementioned production function, member-support, and group well-being functions (McGrath, 1991; Zumbach & Reimann, 2003); why it is important to visualize those selected information; and finally how those information will be visualized: regarding this question possible visualization can be textual representations (e.g. tables or hints) or graphical representations (e.g. graphs and

charts) or a combination of both. However, visualizations have to be carefully selected and designed so that group members and easily perceive and interpret them correctly (Keller & Tergan, 2005). Furthermore, visualization aspects in CSCL can be used to scaffold task/social group activities in such a way to foster them to provide evidence for the assessment process (Reimann & Kay, 2010).

However, the literature shows that learning activities linked to assessment attracts more students and increase their motivation (Macdonald, 2003; Reimann & Kay, 2010). According to Reimann and Kay (2010) assessment has not been in the focus of research on computer-supported interaction analysis. Moreover, they argued that "Unfortunately, what students do in the course of their collaboration with peers does not relate to how they are assessed, and the outcomes of assessment rarely affect what they will do next" (Reimann & Kay, 2010, p. 184). Macdonald (2003) provides guidelines for the assessment of CSCL by which he highlights the importance of linking collaborative learning activities to assessment procedures. Although the use of computers in collaborative learning activities supports with logging and tracking individuals' interactions within the group work, the extraction of valid assessment evidences out of those log files is a challenging task. Therefore, Macdonald (2003) has distinguished between the assessment of collaborative learning process and the assessment of collaborative learning final product. Moreover, he argued that only the assessment of the CSCL final product should not be considered as a valid evidence for the collaborative learning. Rather than, a peer-review process has to be considered during the collaborative learning where student's performance can be assessed side-by-side with the final product.

According to (Reimann & Kay, 2010), assessing group work automatically is challenging; however it can be done when group artefact has formal semantics. For instance expert solutions can be used calculate the similarity between the concept's map extracted from the group artefact (e.g. wiki page) with a reference one extracted from a reference text. Moreover, the authors argued that "assessing group performance requires normative reference models of what constitutes "good teamwork", what processes characterize a good software team". For instance the relationship between the "Student Model" and the "Task Model" in the Evidence-centred Assessment Design (Mislevy, Steinberg, & Almond, 1999), where this relationship is maintained by an evidence model that determines which of the students interactions to register and how to use the registered interactions to update the student model. In order to make this feasible a detailed understanding and representation of the task model should be available. However, Reimann, Frerejean, & Thompson (2009) proposed an approach by which the student model can be updated based on a graphical model of team practices. The research discusses how transition diagrams can be used to formalize a graph of team decision making process automatically identified from the observations (even logs) and can be used as basis for formative and summative assessment.

Nevertheless, the literature of CSCL assessment shows that peer-assessment has been usually used to assess the collaborative learning processes. Examples of peer-assessment tools that can be used for group-work assessment are Web-SPA (Sung et al., 2005), and Self and Peer Assessment Resource Kit (SPARK). SPARK is an open-source assessment software designed to facilitate group work assessment (Freeman et al., 2002).

An interesting solution is to endow CSCL with a visualization environment (Janssen, 2008) capable of visualizing aspects of the collaborative process to mitigate the described problems of CSCL. Visualizations can increase the effectiveness of CSCL environments because they (a) make complex information easier to interpret thereby decreasing the cognitive demands placed on group members, (b) give feedback on import aspects of the collaborative process, (c) raise awareness, (d) facilitate coordination, and (e) provide a motivational incentive.

Recently, interesting studies, proposals and approaches about cognitive of learning assessment in virtual social networks have appeared. These approaches take into account behavioural patterns in online learning focused on discussion environments, such as forums or chats (Wu et al., 2016) as well as assessment of collaborative learning with innovative methods (Strijbos, 2015). These approaches will be considered in future steps of this thesis.

Next, we will show some insights from literature over the last two decades on using online forums and wikis for CSCL. Then, the following section will discuss some possible techniques of how information can be extracted from both the forum and the wiki logs and visualized to support teachers in scoring the student's performance.

## 2.5.2 Knowledge extraction from collaborative and social learning activities

In this subsection, we provide an overview of different methodologies to process the information collected from both collaborative and social activities in order to extract useful knowledge that allows all involved actors to understand better the learning outcomes as well as the learning process as a whole.

Similarly to the previous sections, two collaborative settings are provided in this section as case studies to analyze the extraction of knowledge for different purposes. First, a process of information management and extraction of knowledge is described for the purpose of providing group scaffolding (in the form of awareness, feedback and monitoring) from collaborative learning activities. Second, a process to extract knowledge for social purposes is presented by visualizing knowledge extracted from Wiki-based collaborative learning activities.

**Knowledge extraction in CSCL environments**

When developing CSCL environments that support online collaborative learning, several issues must be taken into account in order to ensure full support to the online learning activity. One such key issue is interaction data analysis, a core function for the support of coaching and evaluation in CSCL environments. It relies on information captured from the actions performed by participants during the collaborative process (Dillenbourg, 1999). In fact, a large amount of information data is generated from long-term collaborative interaction which includes complex issues of the collaborative work and learning process (e.g., group well-being (McGrath, 1991) as well as self, peer and group activity evaluation). Some of this information may be produced from specific data sources such as ad hoc questionnaires and, due to its high degree of informality, needs to be processed and analyzed manually. Consequently, the efficient embedding of all this information and of the extracted knowledge into CSCL

applications sets the basis for enhancing support, awareness and feedback (Zumbach et al., 2003) to achieve a successful learning process in collaborative environments.

Therefore, the success of CSCL applications depends to a great extent on the capability of such applications to embed information and knowledge of group activity and use it to achieve a more effective group monitoring. In the literature, however, questions related to the information and knowledge embedding have not been sufficiently investigated. An initial approach (Zumbach et al., 2003) considers the use of feedback in on-line learning and its effects on group activity in general. To this end, some types of information generated by the group activity are considered as relevant knowledge to be communicated to the group members for feedback purposes but the process of how to collect the information, analyze it and extract the desired knowledge is not provided.

On the one hand, CSCL applications are characterized by a high degree of user-to-user and user-to-system interaction and hence are generating a huge amount of quantitative information (log files) from both synchronous and asynchronous collaboration. Asynchronous collaboration generates quantitative information in the form of events as a result of the users' interaction with the system's resources and other users. Quantitative information generated from synchronous collaboration can be managed by applying a pre-structuring process where the users' interactions are labelled with certain indicators according to a rhetorical exchange structure (Daradoumis, 1997) that models the various types of interactions at different levels. All this information can be easily collected and automatically processed and analyzed by computers as a quantitative data source. The knowledge extracted by this process can then be used to facilitate a continuous monitoring of the learning activity, providing group members with appropriate support, as well as awareness about what is happening during collaboration. Furthermore, the constant and fast processing (Paniagua et al., 2005) of the quantitative data as well as their systematic analysis based on principled indicators that measure the type and the degree of group members' participation, may positively impact on participant's motivation, emotional state and problem-solving abilities and as a result enhance on-line collaborative learning (Zumbach et al., 2003).

On the other hand, qualitative information is collected from ad hoc questionnaires which are regularly filled out by group members, reporting human and behavioural aspects of collaboration as well as evaluating the collaborative learning experience. Participants qualify their own emotional and motivational state within the learning group as well as evaluate the participation and learning activities of their peers (Caballé et al., 2010a). The aim of this approach is to provide both a deeper understanding of collaboration and a more objective assessment of individual and group activity.

Indeed, it is crucial for group members to be aware of others' participation in the collaborative process as this may enhance the collaboration a great deal in terms of decision-making, group organization, social engagement, support, monitoring and so on (Dillenbourg, 1999; Daradoumis et al., 2006). Moreover, providing appropriate feedback about the collaborative activities may impact positively on the motivation, emotional state, and groups' well-being in on-line collaborative learning by means of a steady tracking of parameters related to group functioning, task performance and scaffolding (Daradoumis et al., 2006) and by giving a constant feedback of these parameters to the group. Note that in this context information refers

to quantitative and qualitative data generated by the learning group whereas knowledge refers to the result of the treatment of this information in terms of analysis techniques and interpretations that will be presented to the same group that generated it.

Therefore, participants in a collaborative learning experience may greatly enhance their abilities by increasing their knowledge about others in terms of cognitive processes and skills of the students and the group as a whole in solving problems, individual and group effectiveness regarding participation and interaction behavior, social support and help and so on. As a result, the success of CSCL applications depends to a great extent on the capability of such applications to embed information and knowledge of group activity and use it to achieve a more effective group monitoring as well as constantly provide group members with as much awareness and feedback as possible. Awareness (Gutwin et al., 1998) refers to the knowledge provided to participants about both what other participants are doing at the same time and what they did in the past, whereas feedback (Zumbach et al., 2003) goes one step further than awareness by providing exhaustive and elaborated information and knowledge of what is going on in the group over a long period of time. Furthermore, the persistent storage of the knowledge extracted as group memory (Conklin, 1992) is essential for both students and tutors since, on the one hand, it allows participants not to access only the latest documents and data, which are commonly stored for later retrieval, but also the context in which they were created, and, on the other hand, it allows tutors to track the collaborative learning process for several purposes such as scaffolding and assessment of the learning outcome.

In all cases, the provision of effective knowledge implies receiving knowledge simultaneously both synchronously and asynchronously since the current and history interaction data shown are continuously updated. Therefore, on the one hand, users should be aware of the current activity in the group (the contribution of other members, their location and availability, the users working on a shared document at the same time and so on) and should know what other co-participants are doing in real time (e.g. during a multi-user editor session, who is editing and what is being shown). In an asynchronous context, on the other hand, users must know the activities performed by receiving deferred information of who, when, how and where others' interactions have been performed, and also why these interactions have been performed, which implies receiving complex knowledge of the interaction history. However, the supply of efficient and transparent feedback to users in both synchronous and asynchronous modes is a significant challenge. Users are continuously interacting with the system (creating documents, reading others' contributions, etc.) thus generating a lot of events, which, once collected, they must be classified, processed, structured and analyzed (Caballé et al., 2010a). As a consequence of the complex knowledge provided to participants (e.g., constant and automatic learner's assessment according to quantitative and qualitative parameters of the interaction) there is a need for capturing all and each type of possible data that could result in a huge amount of information that is generated and gathered in data log files.

The ultimate aim is to extract relevant knowledge of the collaboration process from all possible sources. Note that in this context information refers to quantitative and qualitative data generated by the learning group whereas knowledge refers to the result of the treatment of this information through analysis techniques and interpretation. This knowledge will be fed back and presented to the learning group and its tutor for awareness and scaffolding purposes.

The management of both quantitative and qualitative information generated in both synchronous and asynchronous collaboration aims at achieving three main goals: (i) provide an analysis of the group's performance at three levels (Daradoumis et al., 2005), namely *collaborative learning outcome*, *group functioning* and *scaffolding*, by obtaining and classifying the necessary information gathered from the collaborative activity into these three essential categories; (ii), implement an effective way to collect, analyze and present this information given that the large amount of information generated during online group activity may need much time to be processed; (iii) embed the information and knowledge obtained into CSCL applications efficiently so as to facilitate both tutors to monitor the learning activity and group members to get as much and effective awareness and feedback as possible.

In order to achieve these goals, a conceptual model for data analysis and management should be considered that identifies and classifies the many kinds of indicators (variables) that describe collaboration and learning into the above-mentioned three high-level potential aspects of collaboration (Daradoumis et al., 2005). Then, a process is to be provided that, at a first step, collects and classifies both the event information generated asynchronously from the users' actions and the labelled dialogues from the synchronous collaboration according to these indicators. For efficiency purposes, this information may then be structured further in a way that facilitates its faster processing and analysis (Paniagua et al., 2005). The last stage of this process consists of interpreting the analysis outcomes and communicating the knowledge extracted to the group members for awareness and feedback purposes as well as to the tutors to track the collaborative learning process more effectively.

The development of a clear and well-structured conceptual model constitutes a principled manner for the design of a computational model that implements the process of embedding information and knowledge into a CSCL application. Indeed, an innovative and effective mechanism that structures and classifies the information into high-level collaborative processes is a must whereas it identifies potential mid- and low-level indicators that measure and evaluate each process. This mechanism contributes and facilitates the building of a portable, general and reusable collaborative learning ontology for the representation, learning and inference of knowledge about each collaborative process (Caballé et al, 2010). This allows the design of effective computational models (Caballé & Xhafa, 2010a) that reflects and describes task performance, individual and group behavior, interaction dynamics, members' relationships and group support as accurately as possible as well as facilitates the construction of CSCL applications endowed with enriched capabilities for providing more efficient knowledge management and scaffolding (awareness, feedback and group monitoring).

## A Case Study: Transforming Information into Knowledge for Group Scaffolding

Providing a process that aims at enhancing the effectiveness of the collaborative learning groups and practices is a difficult task. Main approaches propose the provision of relevant knowledge extracted from learners' interaction data for awareness, feedback and monitoring purposes (Caballé et al., 2010). Two difficult problems are to be faced: First, the problem of how to define an efficient process of embedding information and knowledge into a computer-mediated collaboration taking several essential steps into account. Second, how to give relevant and semantically grounded feedback to students and teachers on what is happening in a collaborative learning activity in order to allow them eventually to modify the on-going

activity. Given its magnitude, we focus on and discuss a solution to the first problem, while providing a brief description as how to deal with the second.

Next, we exemplify the previous ideas with describing the design of a specific process of three stages for an efficient management of information and knowledge in a collaborative learning environment that can serve for the development of applications in the context this thesis. The complete process is explained in Caballé et al., (2010). Then, following the process started in Section 2.5.1 by a dialogue model for modelling collaborative interaction data the collected and classified information s transformed into useful knowledge about what is happening during the collaboration within forums by means of analysis techniques. The whole process of information management and knowledge extraction can be seen as a particularization of the previous general process for CSCL into collaborative interaction data.

*Three Stages in Providing Information and Knowledge*

To manage and provide adequate information and knowledge in a collaborative learning environment, we propose three separate, necessary steps: collection of information, analysis and presentation. The entire process fails if any one of these steps is omitted. Figure 2.6 shows how the quantitative information generated in the form of events (aggregated in log files) is structured and classified during the first step. This information is then analyzed in order to extract the desired knowledge. The final step is to provide users with the essential awareness and feedback from the obtained knowledge. Each of the three stages is explained in turn.
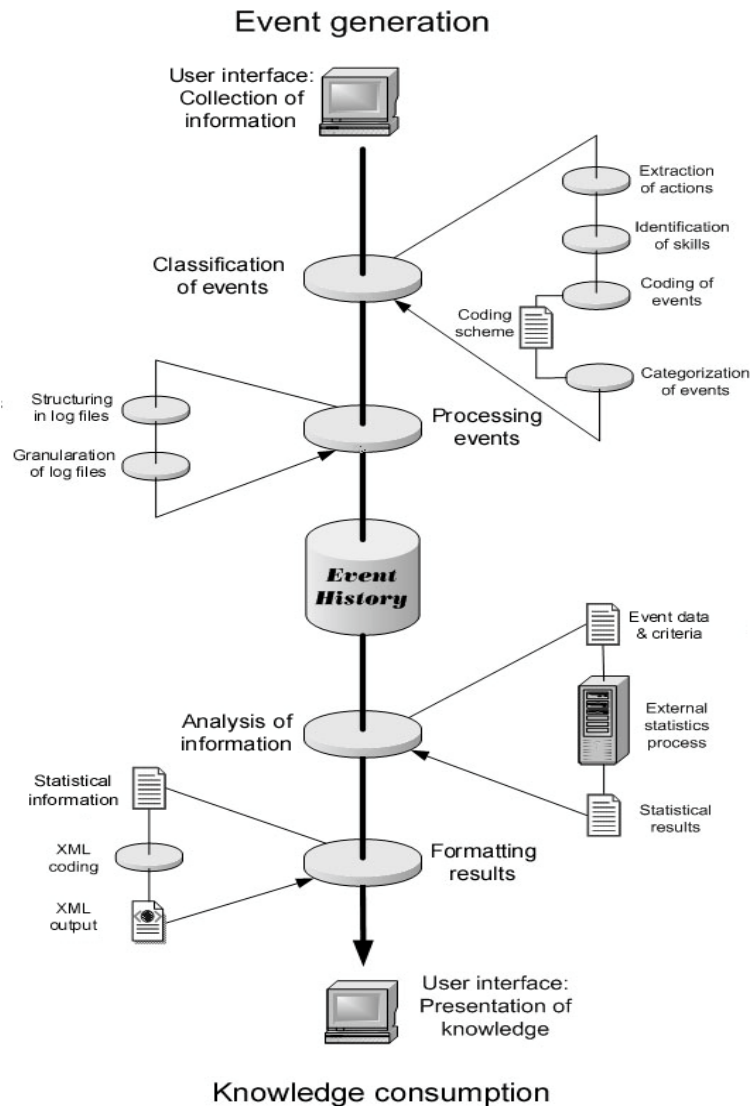
*Figure 2.6: Three Stages in Providing Information and Knowledge (Caballé et al., 2010)*

**Collection of Information.** Three types of data sources are distinguished where we can extract and collect information about group activity: (i) asynchronous interaction in the form of users' events, (ii) synchronous conversations logs, and (iii) self, peer and group evaluation reports about task performance, group functioning, scaffolding and groups' well-being function. On the one hand, a very important issue while monitoring group activity is the collection and storage of a large amount of quantitative information generated by the high degree of interaction among group participants during both synchronous and asynchronous collaboration. Though the computer has many advantages in terms of storage capacity and data processing, the need to convert the information generated in a workspace into an appropriate computational format represents a major drawback. On the other hand, qualitative information (such as group well-being) comes in the form of structured and textual questionnaires. The latter must be explicitly provided by the students and is difficult for computers to collect and analyze due to its high degree of informality, so it is manually processed and interpreted.

A Multi-fold Assessment Framework for Virtualized Collaborative and Social Learning Scenarios

On the one hand, in asynchronous environments, the information comes from group members' interaction with the other members and system's objects in the form of events. As shown in the previous section, classification of the event information is achieved by distinguishing several high-, mid- and low-level indicators of effective collaboration. Based on this, we further categorize and specify users' particular actions according to the following criteria:

- Who is doing something? (i.e. the originator of the event).
- When did s/he do it? (i.e. timestamp).
- Where does s/he do it? (i.e. the location of the affected resource).
- What is s/he doing? (i.e. the action type and the object involved).
- Why did s/he do it? (i.e. student intentions and motivation which are captured by the indicators associated with each action; for example, a user performs the action "create document" or "edit document" in order to generate new information or re-fine existing information in the shared workspace).

The aim is to provide the means to classify the user actions during asynchronous group activity in an adequate manner. To this end, a classification process is needed in which the event information collected from the log files is handled in sequential steps consisting of extraction, identification, coding, and categorization. In particular, first, the specific action performed is extracted by a user on a resource (e.g. file document, debate, etc.). Second, this action is interpreted according to the type of event that was involved in (this information should be provided implicitly by the system according to the context where the action was triggered or explicitly by the user who triggered it). This provides the basic information that is used for the identification of the real intentions or skills shown by the user (e.g. creating a contribution during a debate can be interpreted as either revision or reinforcement of the information depending on whether the contribution was created in the context of a reply or as an observation). Subsequently, the user event is codified taking into account both the user action and the event type. Doing so, we associate a unique code to the user skill identified in the context of the action. Finally, the user event is categorized into one of the group activity indicators mentioned the in previous section (i.e., task performance, group functioning, and scaffolding).

On the other hand, information from on-line synchronous collaboration is characterized by the spontaneous interactions of their participants. Dealing with this information is a difficult task due to the informality of the participants' contributions, so free dialogue is usually treated by a manual or controlled semi-automated manner. In order to incorporate this kind of information in an automated quantitative process of analysis, this information should be structured in some way so that it can be collected and processed by computers. To this end, before carrying out a contribution, participants are urged to label their dialogue moves according to certain indicators that show the intention of their contributions. This labeled information is then classified according to the three categories of the model (i.e., task performance, group functioning, and scaffolding), forming a data source which can be processed and analyzed in a similar way as the asynchronous information (following the processing and analysis steps in Figure 2.6).

*Data Analysis and Extraction of Knowledge.* In the last years, in collaborative learning applications the generation of information has experienced a dramatic increase as a consequence of high-throughput technologies. As a result of this explosion, the extraction of knowledge from interaction data has become a critical factor for the support of collaborative learning. In particular, effective information processing has be-come an essential element of the performance capability of CSCL applications within knowledge-intensive environments. Furthermore, the central role that knowledge plays in individual achievement and group performance creates the need to obtain high quality knowledge.

The second stage of information and knowledge management consists in processing all the information previously collected and classified according to the indicators mentioned before by means of analysis techniques. There is a fair deal of research focused on the analysis of online group interaction. The result of this analysis produced knowledge that provides meta-cognition about the state and evolution of interaction, which in turn enhances awareness about the efficiency of group activity, group behavior and the individual attitudes of its members in shared work-spaces.

Knowledge extraction is based on criteria related to the three mentioned socio-cognitive functions that operate simultaneously during group interaction, namely collaborative learning outcome, group functioning and scaffolding and their associated indicators. At the same time group's well-being (McGrath, 1991) is taken as a global function into account. For instance, as regards the collaborative learning outcome, it is possible to extract knowledge about members' activities (e.g. showing each group member's absolute and relative amount of contributions) or the status of shared resources. Knowledge acquired by ill-functioning situations, such as lack of participation, missing or insufficient contributions, etc., allows to explore the communication and interaction flow among group members and thus to reveal incorrect group functioning, or lack of social support and help concerning individual members in specific situations. Finally, knowledge extracted about group well-being facilitates the identification of members' motivational and emotional state as well as comparative studies of effective and ineffective groups.

The definition of a variety of indicators at several levels of description allows us to determine the granularity of information to be transmitted to the interested parties. In other words, based on a model of desired interaction (establishing a comparison of the current and desired state of interaction), the analysis approach detects and highlights the indicators which were not satisfied and need to be corrected by redirecting group and individual attitudes. These indicators reveal those aspects of the collaborative learning activity (task performance, group functioning, or scaffolding) that present problems and need to be corrected adequately. Thus, they set up rules and filters in order to extract and summarize only that information which refers to the malfunctioning aspect. The summarized information, transformed into useful knowledge, is communicated to the group members who use it to improve the performance of the problematic aspect.

On the one hand, this approach enables group members to become aware of their own progress and that of their peers in performing a learning exercise, as well as of the extent to which other members are participating in the collaborative process as this influences their decision making (Dillenbourg, 1999). On the other hand, our approach provides tutors with

information about students' problem-solving behavior, group processing and performance analysis (Kiesler & Sproull, 1987) for assessment and guiding purposes (Ellis et al., 1991). Knowledge presentation to the interested parties is briefly presented below and constitutes the last stage of the process of embedding information and knowledge into CSCL applications.

*Presentation of the Acquired Knowledge.* As a consequence of the knowledge acquired during the previous stage, a CSCL application must be capable of providing adequate information to the participants in appropriate formats. Moreover, these for-mats could vary from case to case depending on the participants' needs.

In this stage of the process, the problem consists in identifying the roles and needs of each learner and the tutor in every moment and being able to decide what information is required to provide, in which granularity and how to present it. For example, the knowledge obtained from the interaction analysis should be tailored in a different way depending on whether it is provided as a support for self-regulation or peer assessment and has to be adapted to the role the learner plays at a particular moment. In that way, scaffolding information would be different for a learner playing a coordinator role from one that plays a software designer role. To this end, we distinguish different levels that we consider necessary and which dictate how the acquired knowledge is to be presented, namely awareness, feedback, assessment and scaffolding (or guiding) levels.

To sum up, a conceptual model has been discussed that defines a process for transforming information generated from group activity into knowledge in an efficient manner for individual and group awareness, feedback and monitoring. We now turn to discuss the implementation of this approach into a computational model that constitutes a generic platform which can be eventually used for the systematic construction of CSCL applications with enriched capabilities for knowledge management and group scaffolding.

*Interaction visualization during the CSCL.* The problems outlined in Section 6.2 can be related with the small fraction of information really available during the collaborative task (Jannsen 2008). Visualizations can enhance and drive personal and group work information in real time or in typical differed time presents in online forum discussions. The answer can be what information is necessary show and how to show the information. It is essential that group members could be identified from each other without any doubt. Personal identification allows us to interact and collaborate through our personal peculiarities and skills. This personal identification can be realized from a picture or personal avatar. It is not a bad idea to use a real photograph, because synthetics avatars can propitiate creation of synthetic personalities (McKenna & Waraich, 2000). Another personal identification can be done using different colours or colour combinations. (Gutwin & Greenberg, 2002). The colour can be used in task development diagrams or collaborative tasks information.

It is interesting to collect motivation rates through a direct question for every group member (Jannsen 2008). These data can be aggregated and visualized in a line graph, showing the development of each group member's motivation over time. Group members can use this information to track whether someone is, for example, dominating the collaboration, or if the motivation of a group member is dropping below a critical value. Furthermore, the environment gives feedback about the way group members have approached the problem.

*Knowledge extraction from collaborative interaction data*

There is a fair deal of research focused on the analysis of online group interaction. A detailed description of an integrated approach we will follow to analyze the collaborative learning interaction in this context can be found in (Daradoumis, Martínez, & Xhafa 2004). As a consequence of this analysis, knowledge is generated providing meta-cognition about the state and evolution of interaction, which enhances awareness about the efficiency of group activity, group behavior and the individual attitudes of its members in shared workspaces.

Knowledge extraction is based on criteria related to the three socio-cognitive functions that operate simultaneously during group interaction, namely production function, group well-being and member support (McGrath 1991) and their associated indicators. In that sense, as regards the production function, we can extract knowledge by constantly observing the members' activities (e.g. showing each group member's absolute and relative amount of posts) or the status of shared resources. In addition, we can obtain knowledge that is relevant to individual and group well-being by exploring the communication and interaction flow among group members (such as members' motivational and emotional state, comparative studies of effective and ineffective groups and so on). Finally, knowledge can be acquired by ill-functioning situations, such as missing or insufficient posts, lack of participation, etc., which can reveal the need for helping individual members by providing them specific scaffolding where and when this is necessary (i.e. member support).

The definition of a variety of indicators at several levels of description allows us to determine the granularity of information to be transmitted to the interested parties. In other words, based on a model of desired interaction (establishing a comparison of the current and desired state of interaction), the analysis approach detects and highlights the indicators which were not satisfied and need to be corrected by redirecting group and individual attitudes. These indicators reveal those aspects of the collaborative learning activity (task performance, group functioning, or scaffolding) that present problems and need to be corrected adequately. Thus, they set up rules and filters in order to extract and summarize only that information which refers to the malfunctioning aspect. The summarized information is finally transformed into useful knowledge that is communicated to and acquired by the group members who use it to improve the performance of the problematic aspect.

This approach enables group members to become aware of the progress of their peers in performing the learning exercise both at individual and group level, as well as of the extent to which other members are participating in the collaborative process as this influences their decision making (Dillenbourg 1999) Moreover, the approach provides tutors with information about students' problem-solving behavior, group processing (Kiesler and Sproull 1987) and performance analysis (Daradoumis and Xhafa 2003) for assessment and guiding purposes (Ellis et al 1991).

Based on all the previous assumptions, forum posts are recorded as exchange moves, which are later on analyzed and presented as knowledge to participants either in real time (to guide directly students during the learning activity) or after the task is over (in order to understand the collaborative process). Finally, relevant feedback is provided to the discussants and tutors based on the data collected and the following methodology that identifies and measures relevant dimensions of the discussion process (see next Table):

| Activity | | Number of contributions | ANY |
|---|---|---|---|
| | *Proactivity* | Active participation<br>No replied contribution | INFORM<br>REQUEST<br>PROBLEM STAT. |
| | *Reactivity* | Active participation<br>Replied contribution | ANY − Greetings<br>Encouragement<br>Motivation |
| | *Support* | Participation to motivate<br>and encourage | Encouragement<br>Motivation |
| Passivity | | Passive participation | |
| | *Pending to read* | Number of contrib.<br>pending to read | ANY − Greetings<br>Encouragement<br>Motivation |
| | *Pending to evaluate* | Number of contrib.<br>pending to evaluate | ANY − Greetings<br>Encouragement<br>Motivation |
| Impact | | Impact of a contrib. on<br>the discussion process | |
| | *Positive* | Reply+REQUEST<br>Reply+PROBLEM-SOL | INFORM<br>PROBLEM-ASSEN/<br>PROBLEM-EXTEN |
| | *Negative* | Reply+INFORM<br>Reply+PROBLEM-SOL | REQUEST<br>REQUEST/INFORM |
| Effectiveness | | Participant consents a<br>contribution | |
| | *Positive* | Assientment YES | INFORM/PROBLEM |
| | *Negative* | Assientment NO | INFORM/PROBLEM |
| Assessment | | Quality content<br>assessment | |
| | *Tutor assessment* | Tutor assessment | ANY − Greetings<br>Encouragement<br>Motivation |
| | *Peer assessment* | Peer assessment | ANY − Greetings<br>Encouragement<br>Motivation |

*Table 2.1 Relevant dimensions of the discussion process (Caballé et al.,2011)*

- **Participation** behaviour indicators are distinguished into proactive, reactive and supportive (or assentive). Participants are proactive when they take the initiative to open a new exchange of the type give-information, or raise-an-issue. Participants are reactive when they reply to moves such as elicit-information, set-up-an issue/problem, or provide-solution. Participants are supportive if they give their assent to previous contributions. In that case, a supporting value is defined which is assigned a default numerical value 1, which means that the move fully supports and recognizes the value, contribution and effectiveness of a previous move it refers to. If several supporting moves refer to a particular move M, it implies a broader consensus about the impact of M, which increases M's impact value to 1.

- **Passive** behaviour is considered for those participants who just read others' contributions, as well as the ones who also evaluate the usefulness of these contributions. Passivity becomes an essential indicator for the discussion process' dynamics as it identifies certain important profiles of the participant, such as arrogance (participant who just contributes but does not read the contributions of others) and also

promotes reactive attitudes and social grounding skills (Daradoumis, Martínez and Xhafa 2006) by engaging the participant in the collaborative process.

- The **impact** value means an initial (default) numerical value between 0 and 1, which is modified (increased or decreased) according to the impact (number of reactions received) that the move M has on the dialogue and on the achievement of the current discourse goal and task. If the reaction is positive (the move M is being assented), then M receives a positive one (+1) point. If the reaction is negative (M is not assented) then it receives a negative 0.5 points. The points received by a reaction move depends on the type of learning action underlying the move and take on the default value of the move's impact value. The final value is obtained by the mean value of all moves involved in move M.

- The **effectiveness** value of a move is calculated by the mean value of the number of assent moves received. An assent move M is identified and recorded after a participant receives M and consents it. Note that only give-information and raise-an-issue exchange acts can be assented. A negative assent requires a reply move on M to provide further information to reason why M has not been assented, which generates another move in the current discourse.

Tutor and peer assessment indicators are to evaluate both the quality of the contribution's content by the lecturer monitoring the discussion process and the usefulness of the contribution by the student participating in the discussion. Both indicators are on the scale 0-10 so as to be accurate in providing mean values of them.

**Presentation of the knowledge acquired.** Here the problem consists in identifying the roles and needs of each learner and the tutor in every moment and being able to decide what information is required to be provided, in which granularity and how to present it. For example, the knowledge obtained from the interaction analysis should be tailored in such a way that the support provided for self-regulation or peer assessment is adapted to the role the learner plays at a particular moment. In that way, scaffolding information would be different for a learner playing a coordinator role from one that plays a software designer role. Moreover, the format used to present the information could vary from case to case.

Consequently, we proceed to define three general levels that dictate how the acquired knowledge is to be presented, that is, at what format and detail level:

- **Awareness level.** At this level, we need to inform participants about what is going on in their shared workspace, providing information about their own actions or the actions of their peers, or presenting a view of the group interaction, behaviour and performance (Gutwin 1998). To this end we display plane indicator values that show the state and specific aspect of the collaborative learning interaction and processes that take place. The information presented to the learner can support him/her at a meta-cognitive level.

- **Assessment level.** At this level, we need to provide data and elements to assess the collaborative activity, so the indicators used are associated with specific weights that measure the significance of each indicator in the assessment process. As in the previous case, the information provided acts at a meta-cognitive level, giving the actors the possibility to evaluate their own actions and behaviour as well as the performance of their

peers and the group as a whole.

- **Scaffolding** (or Guiding) level. Supporting participants during collaborative activities has become a main concern of current research (Zumbach et al 2003; Soller 2001; Lund 2004). At this level, we need to produce information aiming at guiding, orienting and sup-porting students in their activity. This information is determined by the unsatisfied indicators and helps students to diagnose problematic situations and self-estimate the appropriateness of their participation in a collaborative activity as well as to counsel their peers whenever insufficient collaboration is detected

**Knowledge extraction in Social Learning: Visualizing Knowledge Extracted from Collaborative Learning Activities**

In this section we will discuss some insights from research of how visualizations aspects can be utilized to present extracted knowledge from CSCL activities. Visualizations are considered as tools for knowledge management, by which extracted knowledge out of group members' interactions within the collaborative learning activities can be organized and presented in such a way group members can interpret correctly (Keller & Tergan, 2005; Hirsch et. al., 2009). Visualizations can be used to present extracted knowledge out of task-related aspects, social-related interactions or both. Furthermore, they can be used to foster CSCL solving problems such as, lack of awareness (e.g. social awareness, group awareness, and task awareness), coordination problems (e.g. production function, group well-being, member support, knowledge and skill sharing, grounding, and decisions). Therefore the following examples will demonstrate some selected visualizations that have been presented to avoid the above mentioned CSCL problems:

The work of Zumbach and his research group (Zumbach & Reimann, 2003) discusses how knowledge extracted from social and task-related aspects of the collaborative process can be visualized in such a way to provide feedback to the online collaborators. The CSCL environment tracks and logs group members' interactions, analyzes these interactions, and feeds it back using a combination of textual and graph visualizations as in Figure 2.7. The aim of this research is to investigate how the knowledge extracted from the interactions of small problem-based learning groups can be supported by means of visual feedback and used to scaffold group's function and well-being. However, they have analyzed firstly, parameters of interaction namely participation behaviour, learners' motivation, and problem-solving capabilities by which they have investigated group coordination and enhanced group well-being. Secondly, they have tracked and analyzed interactions related to the task of problem solving design and provided feedback in form of problem-solving protocols. Furthermore, at regular intervals each group member had to rate his motivation using pre-defined forms. These data were aggregated over time and visualized using line graph showing all group members motivation. Nevertheless, group members' contributions were recorded by the CSCL environment and visualized as pie chart.
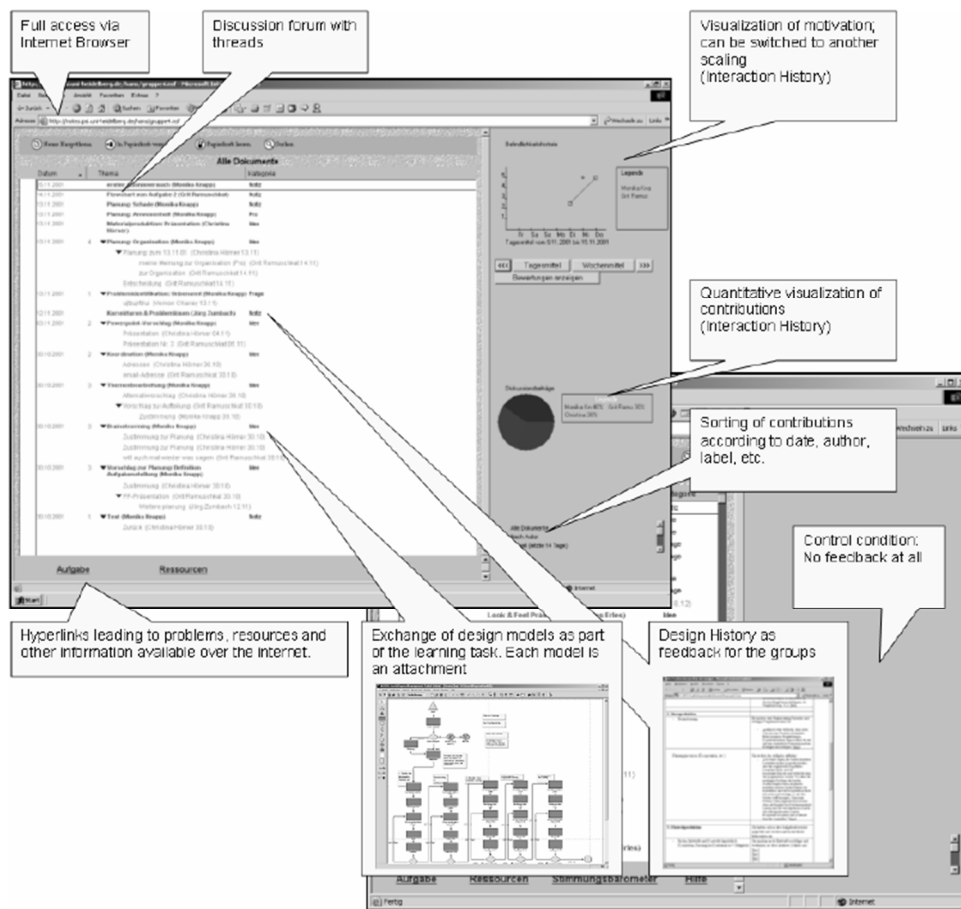
*Figure 2.7: Asynchronous collaboration platform with feedback mechanisms (Zumbach & Reimann, 2003).*

In the work of Trentin (2009), the author tested an approach for co-writing where the students used online discussion forum for co-planning and structuring the content for the co-writing phase. Moreover, they used online discussion forum for peer-review where they were required to peer-review their peers contributions and writings. 3D graphic projections had been used to visualize both the interaction among participants and among the links between the hypertext pages. Figure 2.8 demonstrates the distribution of forum contributions during collaborative planning of the document's structure. Figure 2.9 demonstrates a 3D graphic projection for group member's contribution to the peer review. Figure 2.10 shows the group member's contribution to the reticularity of the final hypertext. In this Figure, the numbered points correspond to the page clusters developed by each individual student where the lines refer to the connection between any page of cluster "A" and any other page of cluster "B". The bold lines correspond to a reciprocal link (outward–inward). Moreover, network analysis techniques had been used to represent the reticular relationships among those interactions. According to Trentin (2009) the use of 3D projections and the network analysis for the visualizing the reticular relationships among interactions has facilitated the evaluation of the level of group collaboration.
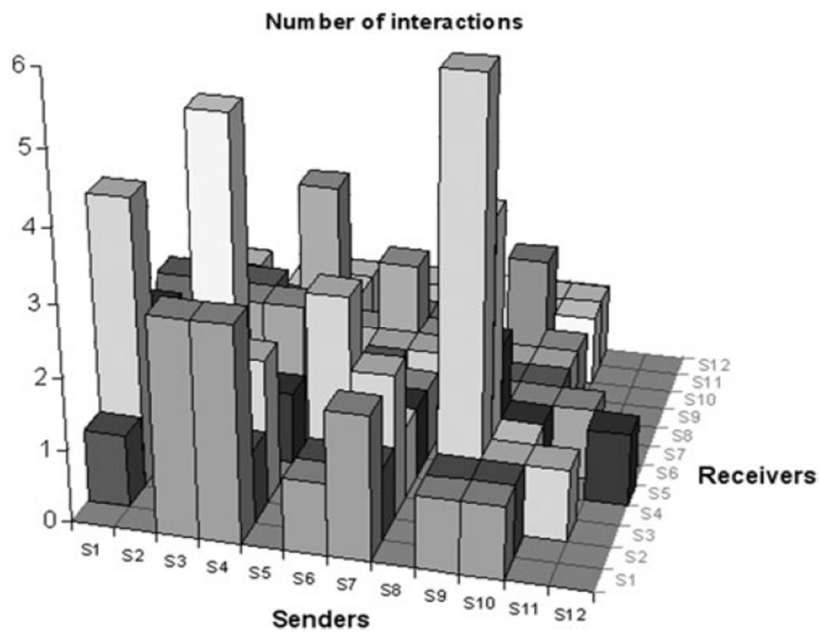
*Figure 2.8: Projection of the forum interactions (Trentin, 2009).*
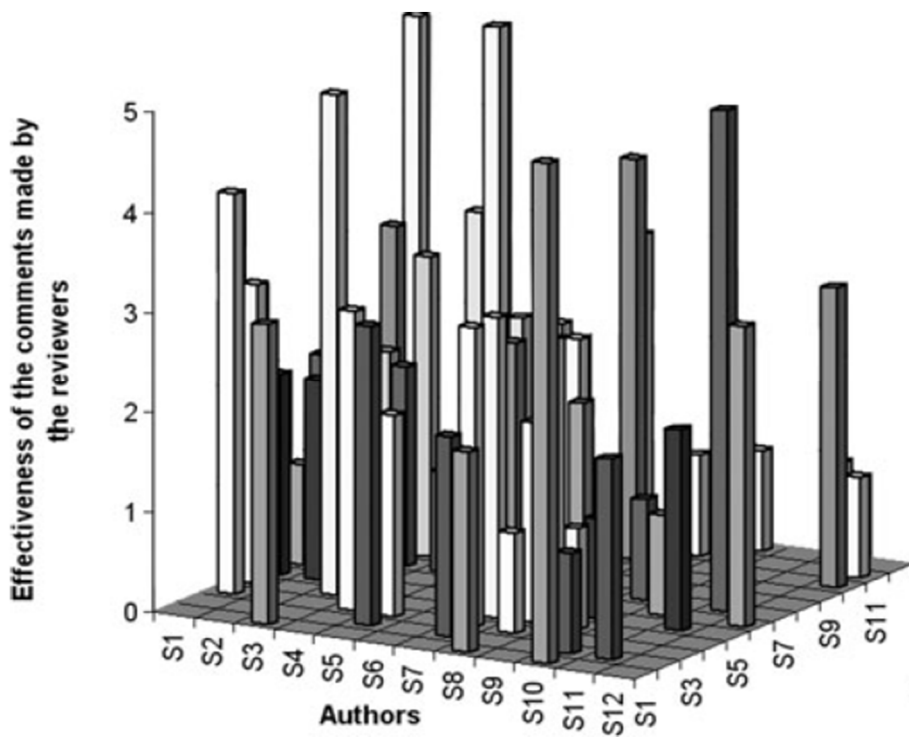


*Figure 2.9: 3D graphic projection for group member's contribution to the peer review (Trentin, 2009).*

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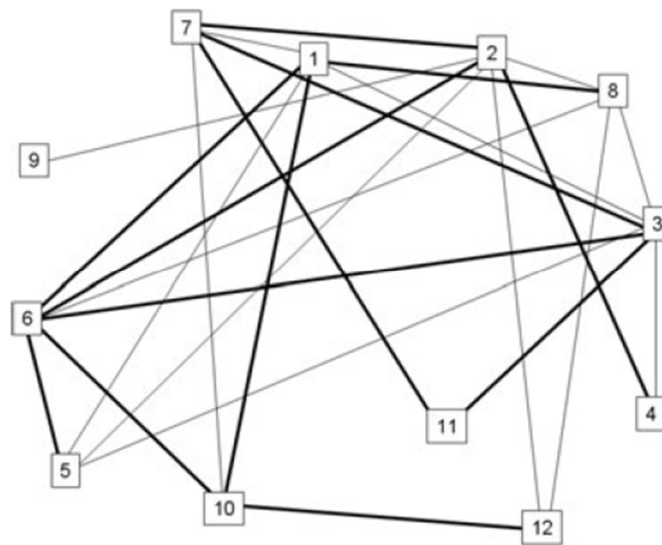
*Figure 2.10: Connection network between page clusters of the hypertext (Trentin, 2009)*

Another example can be found in (Khandaker & Soh, 2010). In this work the authors implemented what they called ClassroomWiki – an intelligent agent-based Wiki tool to assess the students' contributions toward their groups- and used it to assess students' contributions in group-based work for a wiki-writing assignment. As part of this wiki they implemented a tracking and modelling module (TAM) by which they track all the interactions and activities within the CalssroomWiki. Moreover, they provided a visualization of student activity counts over time by which teachers can assess group-members contributions and detect free-riding, scaffold group coordination and production function, see Figure 2.11.



*Figure 2.11: Detailed student's activity plan on ClassroomWiki (Khandaker & Soh, 2010).*

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The work of (Larusson & Alterman, 2009) to visualize students' activities in a wiki-mediated co-blogging exercise is another example. Students as part of their participation may take three kinds of actions: blogging, commenting, and reading. In this research the authors developed visualizations to demonstrate student activity as: level and balance of participation; conversation locator, as well as interactions in a form of networked graph. Figure 2.12, demonstrates the students' level of participation based on the main actions (blogging, commenting, and reading). By default all actions weigh the same. Students (circles) are placed on the axis from left (high level of participation) to right (lowest level of participation). Each circle has a blue colour indicative of the average length (word count) of his/her blog posts. The darker the colour the longer the blog posts. The circle size represents the attention that the particular student attracts. The larger the circle the more frequently are his/her blog posts read.
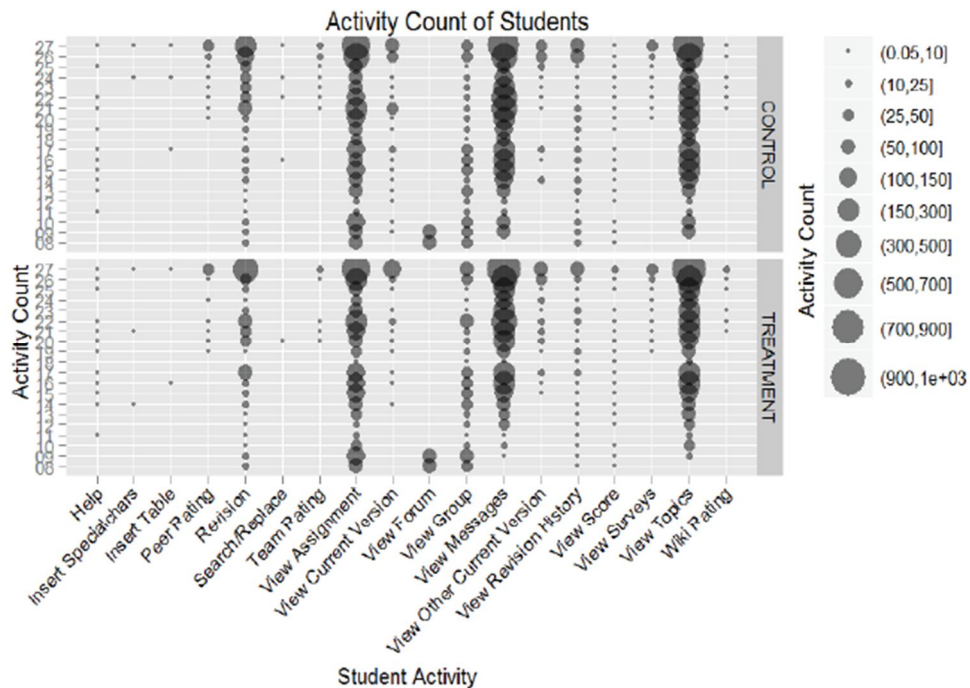


Figure 2.12 Students' level of participation (Larusson & Alterman, 2009).

Social networks diagrams have been developed to visualize information regarding who contributes to the wiki-page (Reimann & Kay, 2010). The authors used what they call Interaction Network (based on Social Network Analysis) to show the relationships and flows between entities. The network is modelled as a graph, with each node representing a team member, always shown in the same, fixed position. Lines between these nodes indicate interaction between these team members. We define interaction to occur when two people modify the same wiki page. The width of the edge is proportional to the number of interactions between them. For a given resource, the number of interactions is calculated as $n = min (n1, n2)$ where $n1$ and $n2$ are the number of times user1 and user2 modified the resource. As depicted in Figure 2.13 the Interaction Network based on for the wiki shows that every member of the team interacts with every other one, including the tutor.
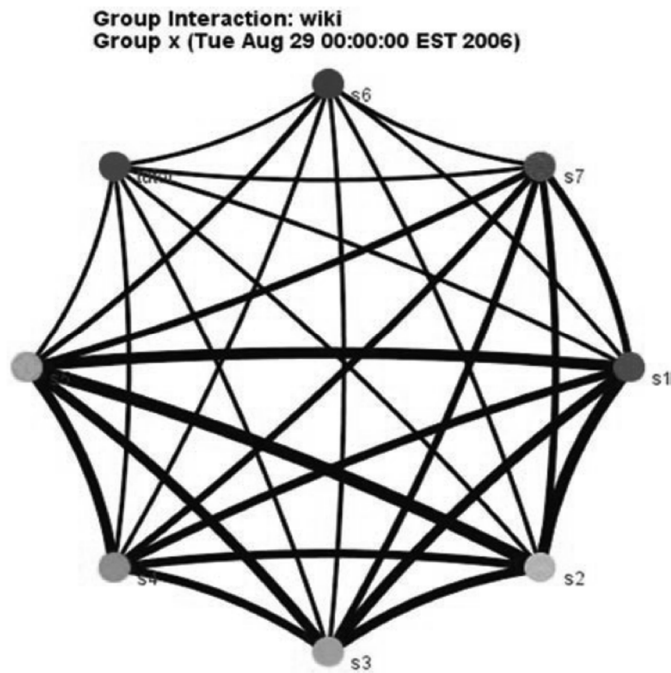
*Figure 2.13: Interaction network based on wiki entries (Reimann & Kay, 2010).*

Finally, recent literature indicate that social learning will become more and more represented in online learning as a teaching innovation in (Perozzi et al., 2014). These proposals are to be considered in ongoing and future directions of research.

## 2.6 Summary of the chapter

This chapter provides and extensive overview and background of the main research areas involved in this thesis. Main pedagogical paradigms, including collaborative, cognitive and social theories are widely reviewed for the purpose to serve as a solid base for the research reported in the next chapters. The chapter also explores the methods and tools that are used for assessing more formal computer-supported collaborative learning, such as online discussions. In this case, specific assessment strategies are presented and discussed. Then, it discusses on how knowledge can be extracted from collaborative and social learning activities and how it can be used for assessing as well as monitoring and scaffolding collaborative learning. Finally, the chapter ends by examining another important issue: how assessment can be performed and presented in social collaborative learning situations, such as Wiki-based Collaborative Learning.

# A Multi-fold Assessment Framework for Virtualized Collaborative and Social Learning Scenarios

## Chapter 3: Virtualization of Online Collaborative Learning

# 3.1 Chapter overview

Virtualization can have significant impact on the efficacy of collaborative learning (Kahai, Carroll et al.,2007). In particular, it has the potential to allow for aspects such as cultural cohesion to be fostered through the methods in which virtual worlds can facilitate embodiment whilst preserving anonymity (Miller, 2010). As such virtualization impacts learner identity, it has pedagogic as well as technical implications; a principal consideration in the context of this research is how to effectively incorporate pedagogic, as well as technical elements into learning objects. This and all approaches and ideas described in previous chapter (see Chapter 2: Literature Review) lead to new needs and expectations for collaborative learning.

In this chapter, we identify the unique challenges associated with using learning objects across advanced technological platforms and within pedagogic frameworks that reflect on the strengths of these technologies to enhance learning. To this end, collaboration and complexity are key aspects firmly considered as extension from the traditional learning objects (LO) to exploit the notion of Collaborative Complex Learning Objects (CC-LO). Therefore, in order to understand and use the CC-LO notion we propose an extension from the traditional LO containing multiple levels of abstraction from pedagogic context, learners, and representational medium (complexity) and the intrinsic support for interaction (collaboration). Examples of CC-LO will be provided which address the requirements of learners in collaborative scenarios, pedagogically designed with reference to the concepts of social and collaborative learning emerging from the social learning. As consequence of this, it was described the notion of Virtualised Collaborative Session as an event in which CC-LO can be created, applied and consumed by learners, how these sessions evolve over time, and how the ultimate end-user interactions with CC-LO can be handled. Finally, it is shown how CC-LO might be created through either the extension of existing tools, or developing specific authoring tools.

To this end, in this chapter, we first discuss the notion and nature of a 'collaborative complex learning object' (CC-LO). The concept of a learning object (LO) is well-defined, as we discuss in Section 3.2, and we extend this to define the concept of a CC-LO and its key differentiators from a standard learning object in Section 3.3. Principally, these include multiple levels of abstraction from pedagogic context, learners, and representational medium (complexity), and intrinsic support for interaction across the object (collaboration). We are hence able to identify the use of objects which would fall under this definition in a range of contexts, through the state of the art case-studies in Section 3.4. In Section 3.5 we turn our attention to defining examples of CC-LOs which address the requirements of learners in collaborative scenarios, pedagogically designed with reference to the concepts of social and collaborative learning emerging from the theories of Vygotsky and Banduras cited in previous chapters. We identify the concept of the "Virtualised Collaborative Session" as an event in which CC-LOs are applied and consumed by learners, how these sessions evolve ("animate") over time, and how the ultimate end-user interactions with CC-LOs are handled. In Section 3.6, we address how CC-LOs might be created through either the extension of existing tools, or creation of proprietary tools which seek to allow for their formation (either through bespoke creation or repurposing of existing LOs / CC-LOs). Often, it is not the content itself which requires creation, rather the CC-LO must be formed by appropriately recognising the pedagogic relationship between existing technical and conceptual components and consolidating them into the CC-LO.

Focusing specifically on the objectives of the thesis, Section 3.7 shows how the registered CC-LOs are eventually packed and stored as learning objects for further reuse as regular learning resources so that individual learners can leverage the benefits from live sessions of collaborative learning enriched with high quotes of interaction, challenge and empowerment. In particular, CC-LOs in the form of **'collaborative complex learning resources' (CC-LR)** include cognitive assessment as innovative and complex feature that greatly enriches the collaborative learning experience. Hence, learners use the innovative CC-LRs to develop their collaborative abilities and competences through a sequential and integrated process where interaction moves determinate the next learning step in the process according to cognitive indicators and rules, and the use of the CC-LR is continuously evaluated.

Finally, in Section 3.8, we summarise the chapter with a review of the processes and concepts covered, and advocate guidelines for the use of CC-LRs both within the ALICE project and by educators on a wider scale.

# 3.2 From LO/CLO to CC-LO: Standards for Collaborative Complex Leaning Objects

The definition of 'learning objects' (LOs) has received much attention in recent years as technology enables educational elements to be repackaged and reused far more readily than was the case several decades ago. 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 by 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. Furthermore, a number of other definitions have been put forward by researchers (e.g. Friesen, 2004; e.g. Polsani, 1997; Wiley, 2001) in the field. For example, Wiley (2001) defines leaning objects as "any digital resource that can be reused to support learning", while, Polsani (1997) emphasises the need for LO to have learning goals and be reusable. Common themes from much of the 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). Therefore, the decomposition of any material into isolated LOs must be conducted with careful consideration of how the item may be ultimately reused. The adoption of standards for LO definition is one component of a technological solution to this problem: by constrating how educators may create a learning object, a technical system may encourage and enforce best-practice in their formation.

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- 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 (a key driver of our definition of the CC-LO), technical consideration must also be afforded to how elements may transition from one virtual world 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 (or associated resources) can be "anything as long as it is attached to an educational context" (Kaldoudi, Balasubramaniam & Bamidis, 2009, p. 6), and includes resources that have not been necessarily developed for educational purposes. This more general definition fits well with the serious games content since serious games might have been developed with certain learning objectives, but might not have been accompanied by the necessary assessment, expected outcomes etc. or may have been used in strictly informal or non-educational contexts initially. Ultimately, content must be defined by the creator of an LO, not the end user: this is the nature of repurposement. Hence, the systems we define for creation later in this Chapter must consider that constraints in creation limit the value of the object. 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.

Ultimately, as technologies such as virtual worlds present new potential for educators, they also bring new challenges. In the next section, we go on to describe the notion of the CC-LO as an extension of the LO paradigm. To do so, we ask two fundamental questions: what makes a learning object complex, and what enables a learning object to be collaborative? In doing so we identify that whilst the definition of a CC-LO may be new, the concept is reflected in a wide range of systems and studies which have looked at the challenges of repurposing LOs, particularly in virtual worlds.

# 3.3 Definition and Purpose of CC-LO

The purpose of the CC-LO definition put forth by this section is to identify the unique challenges associated with using learning objects across advanced technological platforms and within pedagogic frameworks that reflect on the strengths of these technologies to enhance learning. Social learning has clear applications in virtual worlds, and the large-scale communities they are capable of forming (Dickey, 2005, Dede, 1996). In effect, these principles can allow educators to overcome some of the drawbacks of virtual worlds, such as the layer of abstraction between real and virtual they induce (Dunwell & de Freitas, 2010). A common objective of learning through virtual worlds and serious games is to induce a behavioural change, and social collaborative learning provides an ideal vehicle to overcome some of the common barriers to such change, for example subjective norms (Elliott, Armitage et al.,2007), and personal identity   (Terry, Hogg et al.,1999).

Noting this, 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 et al., 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 et al., (2003) address how such evaluation may be autonomised, though conclude 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. Extending this concept to a virtual world, the learning object in itself may not encompass the communication medium, though it must be compatible with it. For example, a virtual 'toy' created in Second Life could be repurposed to allow a learner to use it to gain a better understanding of physics through collaborative play. In effect, a virtual object becomes a learning object. 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, Lieburd, and Thomas (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 defined earlier in the report (e.g. Bandura 1977). 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. This in itself relates back to why serious games are highly valued in the first place: to take an example such as mathematics, the value lies not in the immediate ability to transfer knowledge, which can be as easily done through a textbook or chalk-board; rather, it lies in the ability to foster the intrinsic motivation amongst students who would otherwise fail to engage with simpler mediums. We describe how these methods may be implemented in more detail in Section 3.5, moving on now in this section to consider more specifically *complexity* with respect to CC-LOs.

So, then, what makes a *complex* learning object? The chief sources of may be defined firstly with respect to pedagogy, and secondly with respect to the technical implications complex these pedagogic affordances imply.

- *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 a virtual world or serious game 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: for example, the object could be given physical form as a Virtual Scientific Experiment (VSE). Further applicability to content rating systems (Kumar, Nesbit et al.,2005) is also a worthy consideration. In their case a Bayesian approach is adopted, though this is not the only method for large-scale assessment and evaluation of LOs. A CC-LO is required to provide additional support for this abstracted process of converting what may be a coherent object in a virtual space, back to a pedagogic representation and form which allows it to be applied in different learning contexts.

- *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. 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, 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, Ocana, and Sheremetov (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 the next section 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: 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 version evolve.

- *Composability*. Macedonia and Zyda (1997) have long spoke of the need for virtual environment content to be more easily composable; frequently objects are created which are explicitly linked to a single virtual world or 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. This should extend to the representation of various elements, such as geometric data, images, and interaction modalities in a form abstracted from the requirements of individual game engines or virtual worlds. For example, rather than define specific animation paths for virtual components of CC-LOs, their physical attributes should be modeled such that behaviour is emergent and hence adaptive.

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

- Augmentation with author-generated information. This can take multiple forms:
  - Questions & answers: discussively-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: Crucially, 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 require these are well-defined. They may take the form of either interdependencies with other CC-LOs, dependencies on other simple LOs, or dependences on the learning environment, which could be virtual. For example, a learning object seeking to teach physics and mechanics may rely on the physics system of the virtual world, rather than embedding it within the CC-LO.

- 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. Or, this animation can be a more sophisticated virtual simulation. The principles remain the same throughout: 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.

- They are an efficient evaluation tool. The CC-LO collect data from the user activities, interactions and goals achieved. The data collected must be, preferably collected using automatic data collection methods, because manual collection is not efficient and reliable. The data must be tagged to discern and locate the time, action and effects produced by each member action. It is interesting to explore the possibility of automatically categorize the posts on different tags selected (Caballé et al., 2009).

Following the similar work of (Weimer et al., 2007), for each post, we can construct a feature vector using the following methodology: (i) First a list with the total words present in all the posts is generated. (ii) From this list, we removed the words that appear only once, in order to mitigate the effects of orthographic errors. (iii) Using the resulting words, we compute the frequency count of each word on each text. Based on the previous assumptions, all contributions can be recorded as exchange moves, which are later on analyzed and presented as knowledge to participants either in just-in-time fashion (to guide directly students during the learning activity) or after the task is over (in order to understand the collaborative process). Finally, relevant feedback is provided to the discussants and tutors based on the data collected and the following methodology that identifies and measures relevant dimensions of the discussion process. It is necessary to develop a feedback tool that blends iconographic information, color, and textual information in the same environment.

# 3.4 Existing methodologies to create, manage and execute CC-LO

In this section, we consider the range of existing methods for creating, managing, and executing learning objects, and how they 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, Liburd et al.,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 categorise them effectively. This is particularly true of a collaborative LO, and hence the virtual collaborative session is defined within ALICE 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, Treu et al.,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(Singh, Bernard et al.,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. Sources such as the semantically-annotated DBPedia (Auer, Bizer et al.,2007) are particularly appealing sources of educational material, containing the entire corpus of the online WikiPedia in a semantically-structured form. 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 (Wang, Zhu et al.,2010). Of course, autonomous sourcing and creation is not the only method for LO creation: for example, participatory techniques have also been used. 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). In the example of Abad (2008), course topics were assigned to pairs of students who were then tasked with creating a learning object for other students within the course. Though positive feedback was received from students, the composability of these learning objects may prove a concern, as students are not best-placed to act as pedagogic designers. Hence, whilst the process proved effective for the group of students involved in the creation, the resulting learning objects require careful validation and development to ensure quality.

Early LCMS systems were closely integrated into existing e-Learning configurations as extensions or additions to content acquisition and control systems (Meinel, Sack et al.,2002). More recently, the management of learning objects has benefited significantly from the application of semantic technology. Using a service-oriented architecture, the SULOM system (Su, Yang et al.,2008) provides an LCMS which supports both bottom-up processes such as support registration, management, and sharing methods, but also creates high-level elements such as courseware and e-learning tools autonomously. Su et al.,(2008) cite the benefits of the system as its ubiquity and interoperability, in-line with tutors needs. Similarly, methods to extrapolate semantic relationships by direct and automated analysis of learning objects also exist, having been explored by the EU SLOOP project (Taibi, Gentile et al.,2007). This can be achieved through the use of content representation models such as SCORM to enable the provision of a wide range of comparators. Similarly, peer-to-peer approaches to learning object management have also been shown to have benefits in load distribution (Prakash, Saini et al.,2009), though bring with them the concerns common to peer-to-peer configurations around security and validity. Once adequately addressed through infrastructural design, a peer-to-peer management approach has strong long-term potential, and is of particular relevance to collaborative learning objects and CC-LOs: ownership must be carefully considered and assigned when deploying and devising learning objects for peer input and use.

An early review of LOM-based repositories demonstrated significant advances in global standards for representation (Neven & Duval 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, and there are illustrated in some existing examples. Fundamentally, for a learning object used as part of a tutor-led course, it is insufficient for an LO to merely be customized to the learner – it must also be effectively adapted to the needs of the educator. Although LOM-based repositories offer strong potential to support independent learners working solely through e-Learning systems, 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 ALICE.

The execution of learning objects has previously been achieved through methods such as the SCORM run-time environment (RTE) (Costagliola, Ferrucci et al.,2006). The RTE defines a model by which LOs can be launched within the 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 such as PHP or Perl, 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. In the case of video learning objects, Fadde describes the need for these objects to possess an easily-identifiable format, and support the ability for users to know what content a video learning object contains, since it is hard to produce an effective synopsis (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.

Relating this to CC-LOs, we note firstly that widespread usage of CC-LOs would imply conformance to core SCORM standards and representation formats, with CC elements added as independent extensions. Incorporation into more sophisticated systems such as SULOM (Su, Yang et al.,2008) would require the CC-LO be enabled with the information required to generate the high-level tools required for collaboration, and support for complexity. Integration in the IWT platform within ALICE places clear emphasis on the need for the adoption of standards whilst retaining adaptivity and dynamicism of content, and similarly the notion of the VCS allows the CC-LO to evolve over time whilst retaining a core template. Furthermore, from the example of video, we highlight that providing a synopsis of content for a non-textual learning object is seldom straightforward, and in particular, collaborative content due to its morphology presents a demanding challenge in this area.

As an initial approach, existing methodologies can be largely grouped under three headings:

- Tutor-centric: the tutor assumes the role of author, moderator, and deployer of the CC-LO. This tutor-centric approach is largely at odds with serious gaming and virtual worlds, which are typically more learner-centric in their approach.

- Technology-centric: creation, management, and execution are handled by technology. Though some element of automation is common to any LO-management system, the technology-centric case focuses on situations where an element of artificial intelligence or intelligent filtering is applied *in lieu* of a human expert. The semantic web demonstrates strong potential here for allowing smart filters to be created; for example Dunwell et al., (2010) show how geolocation and geocoding can be used to populate a virtual reconstruction of Ancient Rome using material ultimately sourced from peer-driven repositories such as Wikipedia. The flow of information here, from raw web data (e.g. Wikipedia), to semantic format (DBPedia), retrieval (SPARQL/RDF), consolidation into learning objects, and implementation in the virtual world, places human subject matter experts into the role of evaluators rather than creators of learning objects.

- Learner-centric: these methods advocate techniques such as participatory design to allow learners to be involved in the creation and management of CC-LOs.

# 3.5 Definition of interactive and attractive resources to be played by learners in several and different learning experiences

## 3.5.1 Definition and Purpose of Virtualized Collaborative Sessions (VCS)

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 is illustrated below (Figure 3.1).
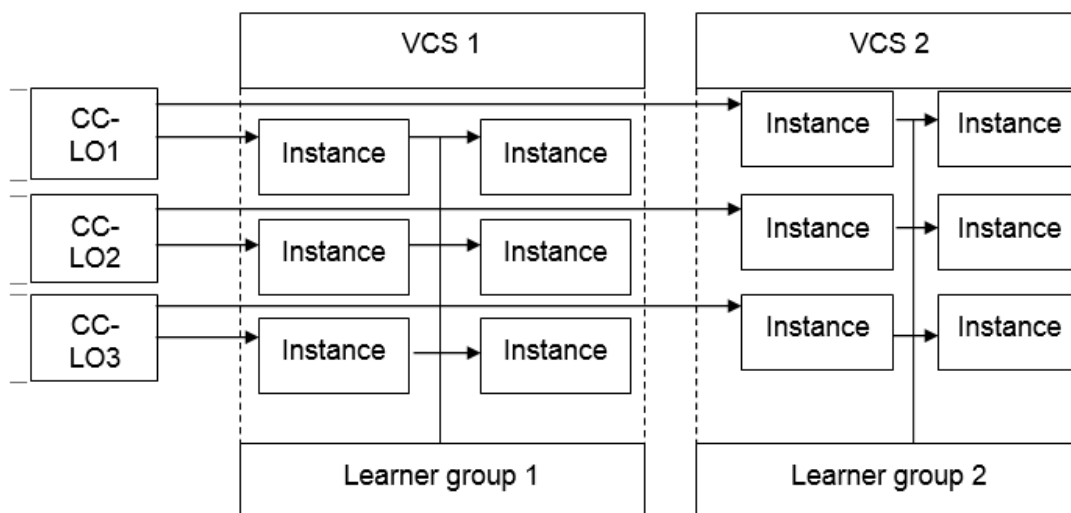


*Figure 3.1: Instances of Virtualized Collaborative Sessions (VCS)*

Effectively, we capitalize on the instantiability of CC-LOs defined in Section 3.3 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 for this time-evolution defined in Section 3.5.2. The benefit of this approach is 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 (for example game engines or persistent worlds such as Second Life), can be facilitated through a driver interface to the CC-LO which, through middleware, converts it into the technical format required for representation within a given virtual world.

Online virtual world frameworks can be used to realize the virtualization component of a VCS. We have previously mentioned platforms such as Second Life used for learning (Iqbal, Hammerm et al.,2010; Corder 2011; Ranathunga, Cranefield et al.,2011), and particular regard

here must be given to the integration of external technologies, over which the CC-LO may not have low-level control, into the learning process. In the case of such externalization, the core component of the CC-LO is the pedagogic structure and content, as well as the model for its deployment into the virtual space. As such, repurposability may still be satisfied by placing sufficient constraints of this definition and structure so as to facilitate platform-independent distribution. This is particularly significant as established mediums for virtual interactions such as second life are increasingly challenged by research linking fidelity to learning outcomes; either showing that many features from off-the-shelf environments are extraneous (Toups, Kerne et al.,2011), or that more specific, simulator-based pedagogic approaches require a level of fidelity or benefit from particular human-computer interaction approaches that such commercial environments struggle to support (Protopsaltis, Auneau et al., 2011). In the latter case, scenario development tools such as those proposed by Protopsaltis et al. (2011),can offer a means to define virtual collaborative sessions in generic yet detailed forms and formats.

Hence, the aforementioned driver linking CC-LO to virtual world representation must carefully consider both sides of its interface. Firstly, the interface to CC-LO must support, in broad terms, the ability to define and structure collaborative learning sessions, as well as place requirements on the preconfiguration of the virtual space, both in terms of its virtual structure and real-world participants. Composable virtual content (Zyda 2005) is increasingly viable to transition between different platforms and visualization engines, a result of both improvements in how this content is defined as well as hardware advances which imply less of a need for optimization through methods which constrain content definition and structure such as binary space partitioning (Krishnaswamy, Alijani et al.,1990). Whilst these optimization techniques still play a key role in supporting high-fidelity virtual spaces, in cases where fidelity is less critical to learning requirements exploiting this performance advantage to support increased composability amongst simulative assets is a viable route.

A variety of markup languages has been proposed for behaviour planning of animated agents, or life-like characters.

Among the first scripting languages there is the Virtual Human Markup Language (VHML) (Marriott, 2001), an XML-based language that addresses the control of various aspects of human–computer interaction, including facial animation, body animation, and dialogue management. The language also provides controls for speech, emotion, and gesture.

Behaviour Markup Language (BML) extends and supersedes markup languages that were previously developed by BML project members, including BEAT (Behaviour Expression Animation Toolkit) (Cassell et. al., 2001), MURML (Multimodal Utterance Representation Markup Language) (Kopp & Wachsmuth, 2004) APML (Affective Presentation Markup Language) (Carolis, et. al., 2004), and RRL (Rich Representation Language) (Piwek, et. al., 2002). The BML project aims to develop a representation framework for describing both non-verbal and verbal real-time behaviour that is independent of the particular graphical realization. BML is an XML-based language that supports the description of behaviours at different levels of detail, e.g., by embedding a more detailed behaviour specification into the BML tagging structure.

Freewalk (Nakanishi & Ishida, 2004) is a platform for social interaction between multiple users and agents. Central aspects of this work are a shared environment, an interaction model, and

an interaction scenario. The description language Q (Ishida, 2002) is used to describe the interaction scenarios and to define the roles of the agents.

Following we will provide an idea for realizing a VCS system. It's important that this component is compatible with different kinds of chats, forums or collaborative sessions in general, in order to create CC-LO as much general as possible. For this purpose, the input of VCS system will be a file containing the collaborative session data in a common format called CSML (CSML stands for Collaborative Session Markup Language, based on xml). The process of conversion between the source collaborative session data and CSML should be done by a specific plug-in or converter, which will be different for each kind of source.

The VCS system processes data in CSML format and creates a VCSCLO (Virtual Collaborative Session Complex Learning Object), containing information about scenes, characters, and other artefacts used during the later visualization of this learning object. VCSCLO will be editable by the use of an editor tool which will allow to change scenes order, adding or removing content, adding special scenes, defining workflow, etc. Concrete use cases yet to be defined. Finally, the viewer tool will enable students and moderators to see the virtualized collaborative session in an interactive but read-only way. Viewer functionalities are also to be defined yet.

The following diagram (Figure 3.2) resumes the process explained above (Caballé & Mora et al., 2014; Gañán et al., 2015):
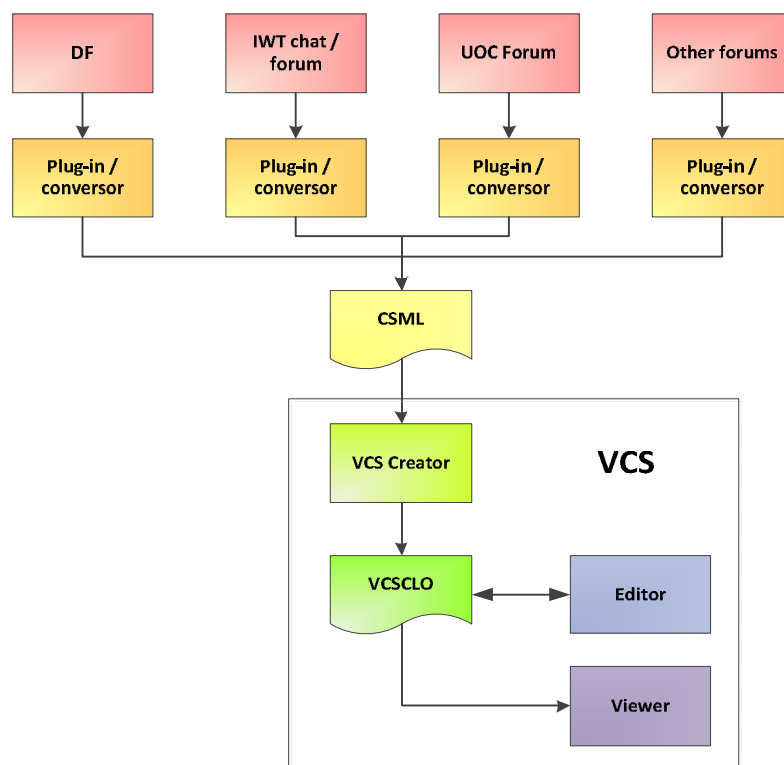


*Figure 3.2: A general architectural view of a VCS system. (Note: DF in the first box stands for Discussion Forum, which is an internal academic forum system (Caballé et al., 2011a).*

Now, we give some details related to the components of Figure 3.2:

- **Collaborative Session Markup Language (CSML)**

  This language takes in input the collaborative data that specific plug-in/ convertor elaborate taking into account different kind of sources (IWT chat/forum…).

  Concrete syntax for CSML supports collaborative session data coming from different environments. It should be also extensible in the sense of allowing optional data (like categorization of collaborative entries), that will be used on VSC process if available. CSML can be based on SIOC ontological schemas.

- **Virtual Collaborative Session Complex Learning Object (VCSCLO)**

  A VCSCLO is the result of VCS process from a CSML input. VCSCLOs can be edited with VCS editor tool and visualized with VCS Viewer. There are some questions that must be raised about VCSCLO structure and format, which are enumerated below. One of the decision about VCSCLO is about which must be the type of media files used to store the virtualized information. This requirement is about video streams, but provided that the visual output required for this requirement is quite simple, it also exists the possibility of using audio files (for speech), plus Silverlight animations for painting and changing characters gestures.

  Audio approach has various advantages in comparison to video approach, because it is easier to implement, and might perform better. The big disadvantage of using audio (+ animations) instead video is that this may difficult sharing the editor and viewer tools with WP6. Nevertheless, viewer and editor tools can be defined as modular tools so one module may consist on view / edit a video scene (for storytelling) while another module may allow VCS scene visualization / edition. Workflow and questionnaire or other modules can be shared between the two work packages.

  VCSCLO data can be stored in a database or xml file, depending on data size. A priori, xml option is recommended to improve integration with viewer / editor tool.

- **Editor / viewer tools**

  The first approach is to define, design and implement such tools as a part of VCS system. They are planned to be implemented with Silverlight so they can be accessed on web. It is pending to study if there is any existing tool or technology that can be reused as a start point.
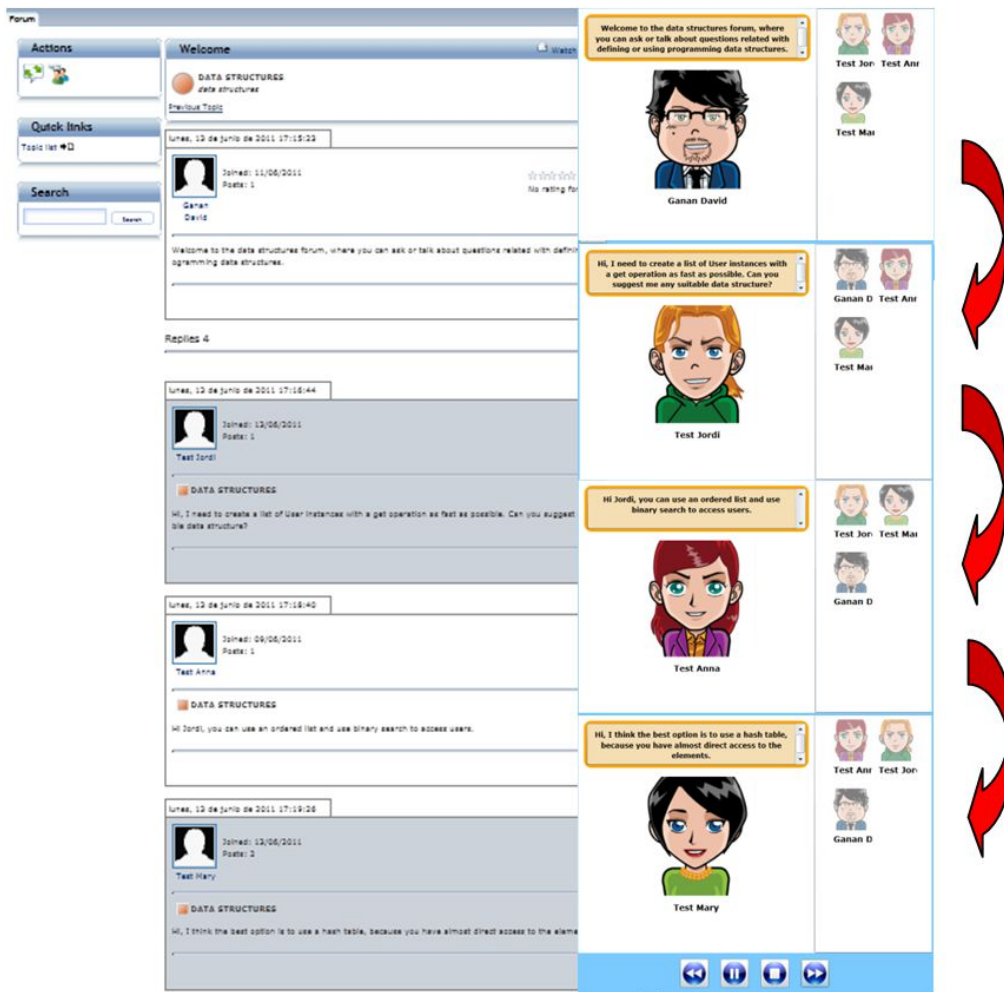
*Figure 3.3: Screenshot of a CC-LO from the VCS prototype showing a discussion that evolves over time, produced by the virtualization of live collaborative session performed in a web forum.*

## 3.5.2 Animation of VCS

In this section, we consider the evolution of CC-LOs over time across single and multiple virtualized collaborative sessions.

A VCS is a registered collaboration session augmented by alternative flows, additional content, etc. during an authoring phase (subsequent to the registration phase). The VCS can be animated (execution phase) and learners can observe how people discuss and collaborate about one or more topics, how discussion threads grow and how knowledge is constructed, refined and consolidated (see Figure 3.3).

In order to support the virtualization of collaborative sessions we will use Semantic Web techniques. Our aim is to integrate and possibly enrich the ontological schemas SIOC, FOAF in order to track and organize data produced during on-line collaborative sessions (Conesa et al., 2012).

We think that this choice can represent a good solution allowing manipulation and augmentation of data and could permit a variety of animation, analysis and visualization operations. In order to harmonize, manipulate and query data produced by collaborative session we will investigate: (i) the use of the Ontology Web Language (OWL) to model data by applying description logics, (ii) the use of Rules Languages and Frameworks (e.g. SWRL, RIF, etc.) in order to perform inference to obtain new facts from already stated ones, and (iii) the use of query languages (e.g. SPARQL, RDQL, etc.).

Main advantages of the proposed approach are the automatization of competency profiles updates and the simplification of knowledge sharing about existing competencies. The possibility to use common query languages, like SPARQL, enables the realization of new user scenarios like, for instance, searching people with specific competencies.

### 3.5.3 Learner interaction with CC-LO

Integrating a learning object into its usage context is a principal concern (Hawryszkiewycz, 2002). CC-LOs are no exception to this rule, with the added complexities collaboration brings forming the basis of a considerable challenge. Context may not be ubiquitous amongst users, and therefore integration into the usage context requires customization to end-users whilst retaining the equality and connectivity required for effective collaboration. Taking the balance of difficulty to ability commonly cited as integral to a flow experience (Cziksentmihalyi 1997), achieving this for one user requires careful pedagogic design; achieving it for many users working in isolation requires adaptivity. However, achieving it for many users who are *interacting* with one another is almost impossibility. The unpredictable nature of peer interactions between learners can have both strong positive and negative effects on motivation (Lin 2007), with corresponding impact on intent to learn. Much as deviation from the challenge to perceived ability within the flow process can result in anxiety or boredom, so can interactions amongst peer groups with different ability levels and motives.

Therefore, can we define a CC-LO such that these issues can be circumvented, or must we settle for ameliorating them through compromises in both design and efficacy? The more constraints we place on pedagogic design, particularly with respect to context, the less composable and reusable our learning objects become. If we adopt a four-dimensional viewpoint (de Freitas & Oliver 2005), then alongside context we must also consider learners and representational medium, both clearly elements which the CC-LO intends to address in the broadest possible terms through its mutability. The learner interaction, therefore, must balance elements specified intrinsically by the CC-LO, with customizability in interface, and moreover, supporting pedagogic scaffolding to accommodate the learners who fall outside of the difficulty-skill balance. Here the distributed nature of e-Learning can be advantageous in allowing peer groups to be formed and selected according to criteria such as ability level, or more advanced peer-group models designed to enable outcomes such as behavioural change (Schunk 1987).

From the learner's perspective, interactions must be as seamless as possible: profiling should come from a system which understands the learner rather than interrogates them. Again this understanding can benefit from a multilevel view of ability not only in terms of quantifiable measures such as marks and assessment outcomes, but also through progression curves and

preferences in content selection (Jackson, Krajcik et al.,1998). Such "learner-adaptable" support can extend not just to the immediate application of the CC-LO, but also the broader learning environment in which it is deployed. We have noted previously the concept of a virtualized collaborative session, and restate it here as central to effective interactions between learners and CC-LOs (and also amongst learners themselves). Through their instantative nature, VCS have the potential for deployment to small groups of learners for single sessions, followed by adaptation and reflection. Given the unpredictability of these groups, it is desirable that CC-LOs obey the typical principle guiding LOs of adopting the minimum size required for full pedagogic encapsulation (Laleuf & Spalter 2001). We can thus assume that a typical learner interaction with a single CC-LO will be designed with brevity in mind, and whilst this need not extend to the educational session as a whole, which could involve multiple CC-LO interactions, such design is desirable from the perspective of both learner and educator. However, establishing effective learning transfer has occurred becomes an increasing concern as the duration of the VCS is reduced. Linking CC-LOs, though immediately appealing, goes against the core nature of an LO as a repurposable and standalone element of instruction, with defined learning outcomes. Yet some degree of compromise may be afforded between the need to create isolable sessions whilst ensuring effective learning transfer.

One option unique to virtual environments is the opportunity to embody a learning object within a single or collective group of virtual objects, giving body and form to learning tools. In such a case, the learning object may form a basis for entertainment, drawing on Vygotskyan paradigms of learning through abstraction and play (Vygotsky 1978). In this case the immediate question is who assumes the role of the 'more-able partner', scaffolding the transition from learning in the virtual world, to tangible real world learning outcomes. In the case of blended learning, a tutor may be able to fulfil this role, and is largely the most desirable choice. However, for e-Learning, peers can assume a similar role, forming a basis for collaboration (Dillenbourg 1999), or even social-replication based learning (Bandura 1977). Yet virtual worlds offer one last affordance through the ability of virtual, machine driven agents to provide some degree of feedback and interaction with the learner. For them to fully assume the role of more-able partner requires a degree of learner insight precluded by current technology (Dunwell, Jarvis et al.,2011), though it is worth noting advances in agency and learner profiling are steadily increasing the support that can be given. Furthermore, in situations where blended learning is not possible, a virtual agent may be a desirable alternative to more static material, given its ability to engage with the learner.

In concluding this section, we note that learner interaction is often impossible to fully predict, due to the nature of learners themselves. Therefore, creating an effective learning object for interaction, whether CC-LO or simple LO, requires mechanisms are in place for establishing and monitoring this efficacy across domains of learners, contexts, and representational media. This is particularly important in the case of serious games, given the aforementioned need to balance entertainment with instruction (Zyda 2005). Implementing a learning object in a virtual form may grant it corpus, but this must be supplemented by an environment which fully encapsulates the non-corporeal elements of the object, such as its pedagogic roots.

Learner interaction with CC-LO should satisfy an important interaction function: the assessment and visualization feedback. The assessment function must be integrated in two new modules. The first module must be responsible of real-time evaluation, while the second

will be responsible for deferred evaluation once the task has been completed. Both must include data collection, data processing, evaluator, and feedback visualization capabilities.

# 3.6 Definition of methodologies for Collaborative Complex Learning Objects

In this section we will study in depth themes belonging to collaborative learning based on the paradigm of Collaborative Complex Learning Objects (CC-LO) containing Virtualized Collaborative Sessions. The aforementioned paradigm aims to exploit the advantages of collaborative and social learning also when real collaboration is not possible. As side-effects, the proposed paradigm induces the construction of a collaborative learning environment also usable for live sessions, fosters re-use of collaborative sessions and provides a concrete solution to embed collaborative learning approaches inside both formal and informal/intentional contexts.

For this purpose Semantic Web techniques will be investigated and applied in new forms in order to model, represent and access knowledge (coming from textual and non-textual content) to support the creation and execution of CC-LOs.

## 3.6.1 Extension of existing collaboration tools for the creation of CC-LO

In the last years some projects, co-funded by European Commission, have been focused on Collaborative and Social Learning. In this section we analyze someone in order to put in result the thesis advancements with respect to these initiatives.

The aim of the **ARGUNAUT** project (www.argunaut.org) is to develop a computerized system that supports moderators in their endeavour to increase the quality of argumentative e-discussions. The most salient features of ARGUNAUT's Moderator's Interface are: (a) awareness tools that provide immediate representations of aspects of e-discussions; (b) pre-defined alerting rules; (c) a remote control intervention panel from which the moderator can send textual comments and images to targeted students or the whole group in a variety of ways; and (d) tools for off-line reflection (see Figure 3.4). These aids are envisioned to help the teacher monitor, evaluate and direct the discussion without disrupting the flow of the on-going collective argumentation.

Figure 3.4: The ARGUNAUT Moderator's Interface at its current state of development

The design of the tools is based on a user-centered design approach, involving teachers, tutors and (high school and university) student discussants. Currently, the system supports moderation of e-discussions within two different platforms, but the system could also be relevant for other synchronous discussion tools as well, particularly graphical tools.

In **iCAMP** the main idea is to gather people (learners, facilitators, peers, etc.) into one common virtual learning environment composed of various interoperable tools and platforms compliant with an innovative pedagogical model built upon a social-constructivist approach. The iCamp pedagogical model will be drafted out of four models that are all guided by the overall principle of self-directed learning. Scaffolding self-directed learning will support the learners in identifying their needs and in planning and carrying out learning projects in non-formal and informal settings. An incentives model shall provide new approaches to learning contracts combined with an easy access to distributed and networked resources, and personal and collaborative Web publishing tools. Weblog authoring has not only been identified as being instrumental for the formation of informal learning networks that are highly decentralized and self-organizing, it has also been documented that technologies, tools, and practices related to personal and collaborative Web publishing create a fruitful context for developing open, unstructured, and supportive learning environments. The collaboration amongst students across countries also implies cultural differences in learning and these have to be respected and supported by the learning environment. In this context, iCamp will perform an analysis of emerging personal and collaborative web publishing practices such as Weblog authoring in order to provide insights into the codification and standardization of cross-cultural and cross-disciplinary social networking and information sharing in open, networked environments.

Moreover **MATURE** project has the objective to define a Personal Learning & Maturing Environment (PLME), embedded into the working environment, enabling and encouraging the individual to engage in maturing activities within communities.

The expected advancements of this thesis with respect to the above initiatives are related to the investigation of new forms of convergence between formal and social/collaborative learning. In our approach the collaborative sessions are virtualized and reused in different formal learning experiences and in informal/intentional learning activities. Reuse happen when a whole collaborative session is virtualized and when single parts of the session are extracted and shared. Furthermore, not only the knowledge elicited during collaborative sessions, but also the elicitation process is shown (after an augmentation phase) to the learners. So, learners interacting with the VCS acquire both domain specific competencies and collaboration/communication competencies.

## 3.6.2 Construction of specific authoring tools for the creation of CC-LO

Nowadays, Semantic Web technologies are exploited also in the e-learning domain in order to provide adaptive learning experiences, semantic annotation of learning contents and learner profiling. The approaches of the Web 2.0 are used to implement and deploy knowledge exchange services based on the concept of social collaboration. A key research objective in this area is the innovative use of Semantic Web techniques in the e-learning area in order to support the virtualization of collaborative sessions. Our aim is to integrate and possibly enrich SIOC, FOAF and other schemas like SCOT and MOAT in order to track and organize data produced during on-line collaborative sessions.

However, supporting pedagogic design in LO construction through semantics only provides a platform to solve the larger question of how this pedagogic design might be optimally implemented. As instructors have a key role in this implementation, as does the learning context and learners themselves, stimulating uptake of developed solutions using CC-LOs must carefully consider how this pedagogic structure is best constructed and conveyed to educators. Research has suggested the impact of sessions such as those facilitated by CC-LOs to transfer effectively from the context of virtual learning environment to real world application (Qiu, Tay et al.,2009), and this must be capitalized on to identify key scenarios where this is most viable. If we can bridge the gap between physical and virtual media (Everitt, Klemmer et al.,2003), it becomes increasingly viable to created blended or mixed approaches to collaborative learning which apply the benefits of virtualized elements, whilst avoiding some of their principal drawbacks, such as difficulty in conveying feedback on interpretive, probing, or understanding levels (Dunwell, Jarvis et al.,2011). Certain aspects of collaboration, such as leadership, have also been shown to benefit from virtualization (Lewis, Ellis et al.,2010), and since the CC-LO model defined does not place pre-requisites on the structure or nature of the collaborative sessions it supports, exploring these other aspects of collaboration is possible within a CC-LO driven environment.

Relating this more specifically to the case of authoring tool construction, some important principles emerge: these tools must not only give educators a means to compose collaborative sessions from semantic objects, but to track and organize this data as previously described. Returning to the model of a CC-LO as a time-mutable construct as described in Section 3.5, this implies the provision of tools able to track the evolution of the CC-LO over time. As concepts such as the virtual classroom increasingly enter the mainstream (Rajaei and

Aldhalaan 2011), these tools will play a key role in empowering users with the specific functionalities they require to construct, compose, deliver, and learn from CC-LOs. Though collaborative virtual reality is a key application area for these objects, the potential may well exist to move beyond simulative expectations of virtual environments, and explore more abstract mediums for collaborative interactions to occur. Certain types of problem solving can benefit from a more abstract approach

The role of the more-able partner (Vygotsky 1978) can also be explored through the technologies enabled by virtualization and CC-LOs. Comparisons of individual, paired-peer, and virtual instruction supported by virtual learning environments have shown that even with a paucity of understanding amongst learners regarding how interaction and human communication is best conducted, learning outcomes and curriculum integration can still be effective (Jackson and Fagan 2000). More sophisticated future tools for handling CC-LOs should consider how a more-able partner may be introduced as an AI or agent-driven technology embedded in an avatar, allowing for greater composability as collaborative learning is supported in the absence of real-world collaboration. This is, of course, a far from straightforward task as other attempts to create intelligent virtual agents to support learning have demonstrated (Ashoori, Miao et al.,2007). However, these technologies offer a range of possibilities to enhance support for learners and subsequent transfer; hence a long-term goal of CC-LO support includes the provision of the flexibility such technologies add when defining collaborative experiences.

# 3.7 From CC-LO to CC-LR: Reusing Collaborative Complex Learning Resources

From the previous section, we extend our research in the direction of devising an innovative learning resource based on the CC-LO approach. As a result, we propose as an important contribution of this thesis the notion of Collaborative Complex Learning Resource (CC-LR) as the materialization of the CC-LO as complex learning material to be used, adapted and reused extensively in academic courses beyond the original collaboration. To this end, the CC-LOs can be edited by the VCS to include complex aspects of the learning process, such as alternative paths and cognitive assessment. 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 are exploited when proposing the new CC-LR: cognitive assessment (See Section 3.7.1) and emotional awareness (see 3.7.2). The latter is out of scope of this thesis work and is briefly discussed. In order to address them for the purpose of this research, a time dimensional methodology is used. For both extensions a deferred time and immediate time approach is considered. These extensions are reported next from the literature in our context of the VCS with CC-LRs embedded.
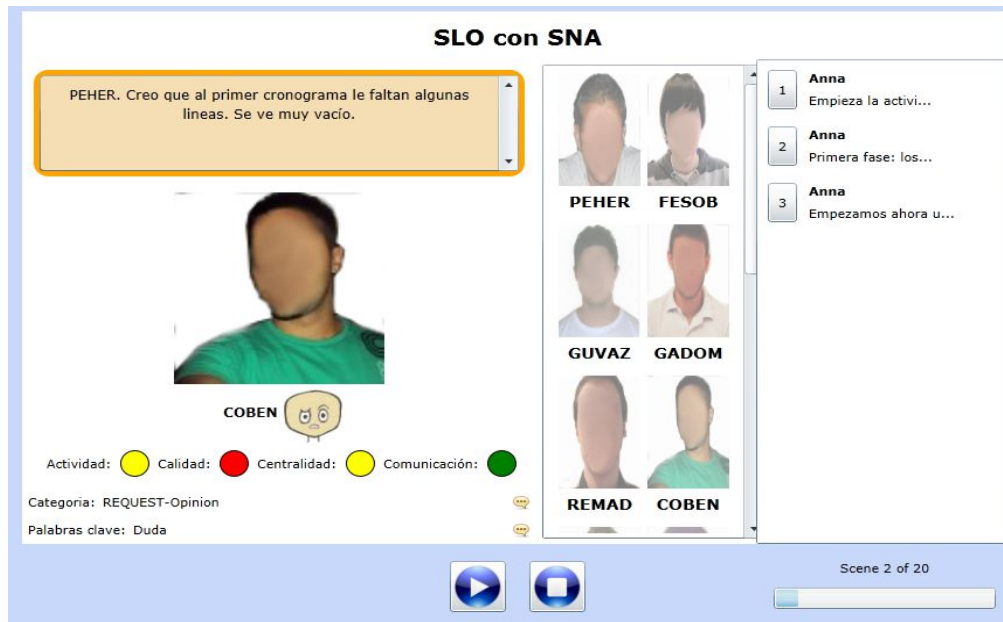
*Figure 3.5: A CC-LR prototype showing cognitive and social assessment*

## 3.7.1 Cognitive assessment

Assessment is a systematic process for making inferences about the learning and development of students (Erwin & Dary, 1991; Swan et al., 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 between group members as well as a formative evaluation of the group activity (Dillenbourg, 1999). These assessment methods have a significant effect on on-line collaborative learning processes because it engages learners through accountability and constructive feedback (Stahl, 2006). From this perspective, the grounds for designing enriched collaborative learning experiences are self-regulation of formative activities, evaluation of contributions and encouraging of participation behaviour, knowledge building and performance through selected assessment feedback (Caballé & Mora et al., 2011b).

In addition, collaborative learning has an important social foundation (Bandura, 1977). Collaborative and social assessment has the mission of detecting problems in the interaction attributes 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 a useful feedback to partners. This assessment feedback meets the purpose of producing an enriched collaborative learning experience (Zumback et al., 2003).

The focus of this section is on the cognitive assessment procedures that are embedded in discussion activities with the aim to provide an enriched collaborative learning experience. Based on the above, two assessment models based on a time dimensional approach are proposed to develop an assessment component that allows for incorporating cognitive information into the learning resources:

- **Deferred time assessment** allows for understanding how the original collaborative interactions developed 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 & Mora et al, 2011b). 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 et al., 1957). Large amounts of information data are considered from asynchronous interaction, which includes complex issues of the collaborative work and learning process (e.g., group well-being as well as self-, peer- and group activity evaluation).

- **Immediate time assessment**, the data generated is to be collected 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. The diagnose inputs are the interaction moves data and some information related with a personal user, group, a resource or the environment. It is possible to detect problems with interaction human-human, human-resource or human-environment. These responses can be processed as human feedback or as changes in the interaction response of resources and environment. Learners, on the other hand, must be able to understand and manage the feedback supplied by the assessment system in order to have an enriched learning experience and a feeling of deeply controlling their learning process (Zumback et al., 2003).

Both types of cognitive assessment can be combined and realized together, each evaluating special aspects of the learning produced by collaborative interactions. Generally speaking, deferred assessment can be realized as individual or group activity and be generated in many formats, such as storyboards, forum dialogs and collaborative material creation. On the other hand, immediate assessment evaluates the questionnaires' questions and answers, the interaction with the storyboard and the time elapsed in every action o response. This information is processed and enriched with contextual information about the users' profile and cognitive state as well as environmental data.

All the interactions with the learning environment, resources, task, and among students are essential part of the learning process, thus collecting and processing data about interaction with the aim of creating an effective assessment feedback response. The first step is to set a storyboard scenes sequence where the collaboration can be developed and the learning tasks and assessment can be performed. The storyboard information is then to be managed and augmented with author information by incorporating learning materials, resources, and evaluation mechanisms.

Finally, in order to ensure that the learning experience can be adapted and personalized from the cognitive perspective, the system also interacts with and 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.

## 3.7.2 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 et al., 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 (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 on-line collaborative learning environments, are gradually enhanced with emotion awareness (detect and respond) capabilities (Afzal and 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 of adequate empirically proven strategies to address the presence of emotions in learning (D' Mello et al., 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.

Based on the above, we consider the development of a component to measure emotions based on three time approaches for e-learning systems, namely before the task, in parallel with the task, and after the task (see Section 6.4 for further information)):

- **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).

Affective feedback design is aiming at sending appropriate affective or cognitive signals to the user, in response to their emotional state detection, 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). These authors propose 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).

# 3.8 Summary of the chapter

In this chapter we have first presented and discussed a new issue and concept, called 'collaborative complex learning object' (CC-LO). To understand this new notion better, we set off from the known concept of 'learning object' and we proposed an extension of it to define the new concept of CC-LO. We justified the reason and purpose of this new notion by setting up two research questions that current standard learning objects are not able to respond. The answer to these questions sets the basis to provide the key differentiations between the two concepts as well as the need to define a new concept, called CC-LO. The need is found in the fact that we should be able to define and 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 this end, we searched for existing methods for creating, managing, and executing learning objects, and examined how they may be applied to the case of CC-LOs.

After this preliminary research, we specifically focused on the objectives of the thesis, and we tried to define examples of CC-LOs which address the requirements of learners in collaborative scenarios, pedagogically designed with reference to the concepts of social and collaborative learning emerging from the theories of Vygotsky and Bandura cited in previous chapters. As a consequence, we identified the concept of the "Virtualised Collaborative Session" (VCS) as an event in which CC-LOs can be applied and consumed by learners, how these sessions evolve ("animate") over time, and how the ultimate end-user interactions with CC-LOs can be handled. Finally, we addressed how CC-LOs might be created through either the extension of existing tools, or creation of proprietary tools which seek to allow for their formation (either through bespoke creation or repurposing of existing LOs / CC-LOs). In the research which is currently being conducted in the project, we need to identify the exact processes need to create CC-LOs, whether the content itself requires creation or rather the CC-LO may be formed by

appropriately recognising the pedagogic relationship between existing technical and conceptual components and consolidating them into the CC-LO.

Following with the objectives of the thesis 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, the CC-LO approach was turned to the development of a new type of learning resource called 'collaborative complex learning resource' (CC-LR). The notion and concept of CC-LR has been introduced as CC-LO that registers live collaborative sessions and produces an animated storyboard such 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 in the CC-LRs. Specifically, cognitive assessment and emotional awareness were addressed and developed in the CC-LR. In addition, lecturers and tutors are provided with edition capabilities of the CC-LRs, such as cutting scenes, modifying involved characters, selecting emotional states, dialogues and connected concepts.

Although this research has not addressed the issue of the data representation standardization, it is interesting to note that there are data starndads for the specification of collaborative activities that occur during the e-Learning experience,  A relevant specification  is  Dublin Core (Conesa et al., 2012), which   was developed from international consensus between professionals and experts in library and informatics in orer to describe learning resources, such as books, videlos and web pages. Its main goal isto facilitate resource description and, combine metadata vocabularies in order to provide interoperability among these metadata vocabularies. In future developments of this thesis, Dublin core will be taken into account for resource description and data interoperability.

# A Multi-fold Assessment Framework for Virtualized Collaborative and Social Learning Scenarios

## Chapter 4: An assessment Framework for CSCL and Social Learning scenarios

# 4.1 Chapter overview

The expression Collaborative Learning describes educational practices in which - without detracting other factors such as learning materials and interactions with teachers - peer interactions are the most important factor for learning.

The term computer-supported collaborative learning (CSCL) was used as early as 1989 by O'Malley and Scanlon and was recognized by Koschmann as an important area of research focus in 1996 (Lipponen, Hakkarainen, & Paavola, 2004). CSCL is emerging as a dynamic, interdisciplinary, and international field of research focused on how technology can facilitate the sharing and creation of knowledge and expertise through peer interaction and group learning processes.

In particular, 'Computer-supported' terms refer not only to connecting remote students, but also to using technologies to shape face-to-face interactions (Dillenbourg et al., 2008)."

The last few decades have seen drastic developments in the context of computer-supported collaborative learning, due to the rapid development of information technology and to the consequent change of the computer's role in education. Furthermore, the rapid development of social media technologies and the increasing need of individuals to understand and use those technologies has brought researchers from many disciplines to the field of CSCL (Resta, P. & Laferrière, T., 2007).

It represents a confluence of trends: the development of new tools to support collaboration (Johnson & Johnson, 1996), the emergence of constructivist-based approaches to teaching and learning (Kirschner, Martens, & Strijbos, 2004), and the need to create more powerful and engaging learning environments (Oblinger & Oblinger, 2005)

In this sense, the paradigm CSCL is a response to the first uses of information technologies in education which were mainly focused on supporting individual activities and progresses and in finding individualized teaching methods through computers (CAI - Computer Aided Instruction). So it was not take into account the social interaction as a key element in learning. As a result, there was little social interaction (Lehtinen 2003).

Also, collaborative learning is today more focused on the interaction between peers and teachers, and not exclusively on the role of technology. Of course, technology plays a significant role, the improved use of information technology and internet based programs allow social interaction between teachers, students, and among students themselves.

Research in the field of CSCL is based upon theoretical frameworks and constructs derived from constructivism.

Looking at the paradigms of learning that have influenced the field, we find a distinction among three main metaphors of learning: acquisition, participation and knowledge creation/building (Sfard, 1998; Lehtinen, 2003; Lipponen, Hakkarainen& Paavola, 2004). These three metaphors are based on different views on knowledge and learning.

The acquisition metaphor is founded on theories of knowledge structures and is explained as acquisition of something in an individual mind and knowledge is seen as property or possession, i.e. moving information from books or teachers into students' mind. In this

metaphor, collaboration or social interaction has been seen as minor issue to facilitating individual cognition while the focus has been on the acquisition of domain-specific knowledge (Sfard, 1998).

The participation metaphor has foundations in situated and distributed cognition as well as Vygotskyan tradition. Here - borrowing from traditional apprentice-master model - learning is depicted as becoming participant in cultural practices and knowledge as an aspect of practice, discourse and group activities (Suthers, 2006). Collaboration provides the enculturation and scaffolding needed to internalize the abilities that first arose on a social level. (Sfard, 1998; Lehtinen, 2003; Lipponen, Hakkarainen& Paavola, 2004)

The third metaphor proposed by Hakkarainen et al., (1998) (Lipponen, L., Rahikainen, M., Hakkarainen, K. and Palonen, 2002), knowledge creation, is related to Bereiter's (2002) knowledge building and Engström's (1987) expansive learning models. Learning is explained as knowledge creation, the phenomenon of creating, not acquiring, new knowledge and skills through cultural practices. In this model the nature of knowledge is more dynamic, i.e. knowledge is something that is developed and worked on in collaborative practices. (Hakkarainen, Palonen, Paavola, & Lehtinen, 2002; Lipponen, Hakkarainen& Paavola, 2004).

The emergence of the CSCL reflects technological evolution and the evolution of learning theories (Dillenbourg et al., 2008) and takes advantage from the usefulness of ICT in education: synchronous and asynchronous communication, multimedia, real-life simulations, Internet and its information sources, etc. Such evolution has not only changed the whole activity environment but also the theoretical approach on learning and instruction (Lehtinen, 2003)

Without detracting from the face to face collaboration, there are advantages that are characteristic to the CSCL. CSCL environments do offer affordances for collaboration that are unique and (almost) impossible in face-to-face learning environments.

Computer-supported learning environment makes communication, guidance and support easier. It forces students to think visibly, externalize cognitive processes. Dillenbourg (2005:260) summarizes: "these environments turn communication into substance". In CSCL this substance can be evaluated and elaborated by others. CSCL environments enable the transformation of the internal processes of participants into a shared working memory acting as joint representation of the problem which can be further examined, re-interpreted and refined. (Lehtinen, 2003; Suthers, 2006; Stahl, Koschmann & Suthers, 2006; Dillenbourg, 2005; Paavola & Hakkarainen, 2005.)

Also, the externalization process itself fosters learning and cognitive achievements because one forces oneself to organize the knowledge (on problems, solutions, etc.) in a comprehensible and coherent way. Before one is able to teach the content to other learners, one has to combine and formulate the essential elements of the problem in a meaningful way (e.g. Lehtinen, 2003).

Socio-cognitive load is shared between learners and the learning environment. (Nivala et al., 2008). In computer environments the interaction and the inquiry process are visible, as well as the decision making paths and argumentation structures (Lehtinen, 2003).

The benefits of computer-supported externalization of individuals' mental models are not limited to the traditional view of learning as something that happens and is measured individually. This view of learning is problematic in the CSCL framework for two reasons. Firstly, learning happens everywhere and all the time, and thus, it is impossible to pinpoint the actual cause of it and the moment it took place. Secondly, learning cannot be observed, only the consequences of it (Stahl 2006). Stahl (2006) suggests a shift of focus in CSCL research from learning outcomes to the knowledge building process of CSCL, because it "refers to specific, identifiable occurrences" and "one can directly and empirically observe the knowledge being built, because it necessarily takes place in observable media, like talking. Moreover, it produces knowledge objects or artifacts, which provide lasting evidence and a basis for evaluating the knowledge building."

In addition to "make thinking visible", using computer-mediated communication also enable to trace the history of a discussion, i.e. the evolution of joint problem solving task, argumentation structures, trajectories of participation (e.g. Lehtinen, 2003; Suthers, 2006). These traces of collaboration can be used to foster groups' knowledge building process.

Furthermore, digital artifacts are reconfigurable, dynamic, easy to manipulate and replicate, making it possible to elaborate ideas and refine artifacts not possible in many traditional media (Suthers, 2006; Stahl, Koschmann & Suthers, 2006) and thus, the ideal collaboration tool.

This chapter takes these approaches further by the provision of a framework for assessing CSCL activities. The framework is reported in Section 4.3 from the conceptualization and design while Section 4.4 prototypes and tests am extension of CC-LO, named CC-LR with the framework embedded for e-assessment purposes. Finally, Section 4.5 summarizes the chapter.

# 4.2 Design, Construction and Execution of Collaborative and Social Learning Scenarios

This section extends the way CSCL models can be used to construct collaborative and social learning scenarios and describes how these scenarios can be employed in the context of formal, informal and intentional learning experiences.

## 4.2.1 Use of CSCL models, methods and tools for the design, construction and execution of Collaborative and Social Learning scenarios

In this subsection, we consider the application of CSCL models to define specific scenarios. Scenario definition for collaborative learning can be particularly complex, since it relies on interactions between learners which are by nature unpredictable. Therefore, the function of a design methodology is to not only provide a backdrop against which learning can occur, but also to provide adequate scaffolding and structuring of collaborative interaction to avoid learners diverging from required learning outcomes (Dillenbourg 1999). In a computer-

supported context, particularly one in which the educator may be absent or learning is not blended into a wider curricula, technology must provide this scaffolding either in-whole or in-part. Since a computer cannot wholly fulfil the role of an educator, in particular a consequence of its inability to enact all levels of feedback which would be required for it to be considered a ubiquitous replacement (Dunwell, Jarvis et al., 2011), it is preferable to consider this limitation at the learning requirement stage, and hence manage expectations of computer-supported collaborative approaches in the case the tutor is wholly absent.

Scenario creation, therefore, must reflect firstly on learning requirements. If technology is applied as a solution to scenario design, then for an educator to use it effectively, they must be able to understand its use and limitations in pedagogic as well as practical terms. Though it could be argued Bloom's taxonomy (Bloom, Englehart et al.,1957) is a dated classification system, given the behavioural ambitions of many technology-augmented learning solutions and in particular serious games, it does provide a useful basis for classifying learning requirements. The lowest levels of Bloom's taxonomy, knowledge transfer, are arguably seldom an ultimate goal of social and cognitive techniques, since social learning is frequently related to higher order reasoning and motivational applications (Bandura 1977), Bandura's requirements of social learning can be summarised as (refer to Section 4.1 for more detail):

- The ability to observe the modelled behaviour

- The ability to recall this behaviour

- The ability to reproduce the behaviour; here Bandura considers this ability in the simplest terms, i.e. the ability to physically copy another

- Motivation and opportunity. Bandura tends to refer to motivation in terms of incentivisation; in game –based learning we can consider the benefits of the intrinsic motivation of gameplay, though in more static e-learning context a degree of extrinsic motivation may be required.

It is worthwhile to consider these requirements when constructing a social learning scenario using a CSCL model. In particular, if we virtualise the environment, then the ability to observe the modelled behaviour is to a degree abstracted from the real world: much as the exploratory or experiential models must compensate for a weakened link between virtual experience and real world reflection (de Freitas and Neumann, 2009), so must the constructor of a social learning scenario accommodate this consideration. These implications could potentially manifest themselves as poor learning transfer from the virtual to real environment, cognitive recollection in terms of events rather than their causes or meaning, or frustration on the part of the learner as they are unable to reproduce behaviour as a constraint of the technology, rather than their ability.

Constructing collaborative and social learning experiences which are designed to appeal to a broad learner demographic is particularly challenging; few pedagogies exist which do not attempt to classify learners, for example Kolb's experiential learning (Kolb 1984) adopts a categorisation approach to denote the specific support required for differing learner types: diverging, assimilating, converging, and accommodating. Similarly, social learning theory notes the important of inclusion and its impact on the educational process as a whole (Baker 1995). In the general case of e-Learning, the general technological competency of learners can vary widely across a single group as a result of backgrounds, interests, and experience.

Though there is little question younger generations across Europe are increasingly engaged with technology in an entertainment context (see, for example, the recent European report in which over 50% of a representative sample described themselves as 'gamers' (ISFE 2010)), though dangers exist in the assumption that all children in a group will be highly technology-literate. The authors can speak from their own experience in developing a serious game for childhood obesity (Powell, Robertson et al., 2010), that in a focus group of 30 children, one child simply refused to participate on the basis they "didn't like video games". The dangers of generalisation and consequential exclusion from social learning in a technology-driven environment are thus apparent.

Computer-supported collaborative learning tools commonly focus on the provision of design aids to educators, which seek to ensure best-practice in pedagogy is facilitated, or required, by the software and its user interface (Abdullah & Abbas 2006). This has the potential to address the common concern in technology-supported learning of technologists, rather than educators, taking a lead role (Zyda 2005), by lowering the technological skills required to create and implement scenarios. The research drive here is in creating scenario tools which are to a degree abstracted from low-level technical implementation, yet though the concept of a tool allowing scenarios to be created which are composable between e-Learning systems, virtual environments, or serious games, it is demanding to realise in practice. Such demand arises from the evolving nature of technology and its increasing ability to facilitate various learning styles and content items – few educators would be willing to design for the lowest common denominator amongst educational systems, and therefore transfer of pedagogic content between technologies requires some ability to adapt this content autonomously to meet the capability of the system.

This plays well into the concept of learning objects, as much research has been undertaken to consider the ability to repurpose these objects between groups of learners, contexts, and even representational medium (Protopsaltis, Panzoli et al.,2010). Encapsulating content and pedagogy within a single object can then allow an e-Learning system or virtual world to extract the salient elements and selectively deploy the learning object (LO) in accordance with educator-defined parameters.

Recently, developments in terms of languages and tools for collaborative experience design have taken place. They have been integrated within learning processes and tools naturally involving figures like students, learners, teachers, instructional designers and didactical managers.

The main issue here is that complex learning experiences and, mainly, collaborative ones, need coordination mechanisms that current methods and design specifications are not able to provide.

To building a collaborative process, collaborative tools - such audio conferencing, chat, instant messaging, forum, email, news reader, video conferencing, voting, surveying, etc. - should be arranged and orchestrated in some way during a learning experience. To do that the IMS Consortium has defined Learning Design[16] (IMS-LD), an educational modelling language that

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[16] http://www.imsproject.org/learningdesign/

enables the description of any learning process in a formal way. IMS-LD is strongly influenced by the theatre play-act scene metaphor where actors proceed sequentially through the acts, while proceeding in parallel within acts or activity structures. One of the most interesting features in IMS-LD is the possibility to synchronize actors in multi-actor process based scenarios.

There are several IMS-LD editors available. As stated in (Griffiths, et. al., 2005) they can be classified in two dimensions: higher vs. lower level tools with respect to the level of expertise in IMS-LD it is required by the user (i.e. how much the tool interface is influenced by IMS-LD and how many specification details it hides) and general purpose vs. specific purpose tools with respect to the pedagogical scope. Teachers using a defined pedagogical approach (e.g. collaborative learning) would not need all IMS-LD functions and capabilities. Authoring tools more tightly focused on that approach might present only needed functionality, reducing significantly the complexity of authoring.

Tools as Reload[17], CopperAuthor[18] and Cosmos[19] are examples of general purpose editors. If they would be employed to model collaborative learning processes, they have some limitations related to the need of defining groups or classes. Collaborative Learning Flow Patterns templates have been defined to overcome these limitations. Basing on that, the Collage project (Hernández-Leo, et. al., 2006) developed an editor able to use patterns to design collaborative activities and related flows. Nevertheless, the support of this approach has some deficiencies and the collaborative tools that can be defined in such way are limited. Thus, some newer research proposed an extension to IMS-LD (and to Collage too) that enables to specify several characteristics of the use of tools that mediate collaboration (Hernández-Leo, et. al., 2005b). In such a direction there is the Common Cartridge specification (IMS-CC, 2011) offering a framework to host a new version of the IMS-LD allowing many more possibilities in terms of learning activities. IMS-LD 2.0 (Durand and Downes, 2009) rethinks the learning design in the Technology Enhanced Education context while keeping the most essential features of IMS-LD.

An alternative approach is MISA (Paquett et al., 2008), an instructional engineering method graphically describing the instructional design processes and their products. MISA supports 35 main tasks or processes and around 150 subtasks. The method has been totally represented within the MOT+ editor.

There are also other design tools inspired by IMS-LD. DialogPlus Toolkit (DialogPlus, 2011) is an example of an enhanced editor for a form-based scenario definition. This editor supports a variety of instructional design models, so it definitely fits a modern activity-based instructional design perspective, e.g. as an alternative to more traditional lesson planners and in the spirit of more powerful tools like MOT+, but being easier to learn. DialogPlus could be also used to model collaborative learning activities, although this new informal way which it applies is still far to be completed.

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[17] RELOAD Project Web Site: http://www.reload.ac.uk.

[18] CopperAuthor Project Web Site: http://copperauthor.sourceforge.net/

[19] Base100 Web Site: http://www.base100.com/en/products/cosmos01en.html

A Multi-fold Assessment Framework for Virtualized Collaborative and Social Learning Scenarios

Research activities in Computer Supported Collaborative Learning (CSCL) started to work on modelling scripts and developing notational systems (Kobbe, et. al., 2007). Collaboration scripts are the most important design elements in CSCL and aim to support learning activities by structuring otherwise deficient interactions. A script describes the way learners have to collaborate: task distribution or roles, turn taking rules, work phases, deliverables, etc. This contract may be conveyed through initial instructions or encompassed in the learning environment.

The CSCL scripts are specific suggestions, usually defined at a micro-design level, about how students should behave during their collaboration activities. While such techniques are generally proposed by tutors, the scripts are implemented through prompts provided, often automatically, to students, in order to guide them step by step through the different stages of the activity and/or to improve the quality of their subjects.

In Dillenbourg and Hong (2008) the authors have proposed the concept of macro-script which, generalizing the scripts described above, leads to a less rigid work structure. Micro-scripts refer instead to processes that should be internalized by the learners. They usually describe the fine-grained actions that each participant should accomplish within activities.

Several works (Weinberger et al., 2005) present two examples of micro-scripts that guide the argumentation processes. Their goal leads the students to learn how to argument in order to construct the knowledge together. In contrast, the  macro-scripts aim at organizing situations that encourage productive targeted interactions and lead to learning outcomes (e.g. the script arranges fruitful discussions by grouping students with different results in previous activities) defining flows of coarse-grained activities (Hernández-Leo et al., 2005).

Both macro and micro scripting can be regarded as two complementary ways of supporting the students during their collaborative work: the former is more general and suggests a procedure which can be modified at any moment by the person in charge of the activities (teacher, tutor or students themselves), the latter specifies more in detail the steps and behaviors the students should adopt through (semi) automatic prompts and therefore is more rigid.

From these studies have been issued projects like CPM (Laforcade, et. al., 2003) (a UML profile and system somewhere in between CSCL and learning design), Cool Modes[20] (a system that includes several visual design tools for learners and teachers) and other systems that include visual design languages. Currently only two systems are in production: the first one is LAMS[21]  that still does not overcome quoted IMS-LD limitations; the second one is CeLS (Ronen, et. al. 2006) (Collaborative e-Learning Structures), a Web-based environment to create and run structured collaborative activities and incorporate them in existing instructional settings. CeLS is able to create and reuse activity structures: Its formats reflect various collaborative instructional strategies (e.g. creating and analyzing a common database, reaching an agreement, peer-product evaluation, contest, creating a group product, etc.) Unfortunately it is limited only to asynchronous activities.

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[20] Cool Modes Page: http://www.collide.info/index.php/Cool_Modes.

[21] LAMS International Web Site: http://www.lamsinternational.com/.

## 4.2.2 Utilization of Collaborative and Social Learning scenarios in the context of formal, informal and intentional learning experiences

The research community on learning design recognizes that the collaborative dimension of a learning experience is one of the most important elements to take into account in order to ensure a high level sustainability of e-learning (Wilson, et. al. 2006). The Computer Supported Collaborative Learning (CSCL) today is a well-recognized concept in literature and is evolving in parallel with the development of models and methods that support the design of efficient networking activities and processes in different learning contexts and groups (Dillenbourg and Fischer, 2007). On the other side, despite that collaboration is often used in informal learning contexts, it is still difficult to be integrated in formal ones and often it still results as an experimental didactic modality (Capuano, et. al., 2010).

But, what do we mean by 'informal' learning? Does this 'informality' refer to **how** we learn, **where** we learn, **what** we learn, or the relationship between the activity and what is valued as knowledge today? Does informal learning simply mean learning that happens in a different way from that offered inside the schools, in a different place, about different things, or does it refer to anything that is learnt that isn't currently valued by our education system? Today, the term 'informal learning' is used quite loosely to describe all or any of these. Some people use it to describe the location of learning – suggesting that all learning outside the school is 'informal'. Others have recourse to it to describe the purposes of learning – suggesting that all learning that is part of leisure activity, rather than being a matter of examination purposes, is informal (Sefton-Green, 2004).

**Informal learning** differs from formal learning in that it occurs as the side effect of activities and observations that have not learning itself as their aim (Cerri, 1994). We learn from our experiences: by performing actions and by making observations. These actions and observations are hardly ever directly aimed at learning; they are primarily intended to cope with actual situations. Informal, experiential learning occurs unnoticed and does not require some special effort or attention

In a **formal learning context** there are specific educational settings consisting of a distribution of complementary roles, explicit didactic goals to reach and levels of performance to gain as well as didactic models to apply. Didactic models, in particular, determine the design, the planning, the execution and the evaluation of learning activities. In this context, a collaboration process must have a well-structured model to adhere to, with precise, predefined objectives connected with specific learning activities. In (Capuano, et. al., 2010), authors propose a novel approach for the definition and the execution of dynamic collaborative learning experiences in formal learning contexts through the aggregation of learning activities on the basis of pre-defined schemas. The purpose is to reduce the difficulty implied in modelling collaborative learning processes and in defining and structuring groups or flows of collaborative activities, by facilitating the design of fine-grained learning activities placing teaching and learning at the centre of the design process. The proposed design process does not start from scratch but basing on the use and integration of pedagogical templates, patterns used in order to capture and communicate recurrent learning design problems and opportunities (Goodyear, 2005).

Particularly, in a formal learning context, an efficient collaboration process must have a well-structured model to adhere to, with predefined rules and objectives connected with specific learning activities. It is widely acknowledged that in the CSCL the spontaneous collaboration through standard collaborative software does not necessarily lead learners to play functional and complementing roles that can foster group discussion, knowledge sharing and argumentation (Wilson et al., 2006).

Nevertheless, structuring the collaborative learning process in an appropriate way is relevant, since free collaboration does not necessarily produce learning. Moreover, the unguided collaboration among team members can lead to detrimental learning. As stated in (Laurillard, 2008b), "never before there has been such a clear link between the needs and requirements of education, and the capability of technology to meet them". This is also true with respect to the difficulty implied in modelling collaborative learning processes and in defining and structuring groups or flows of collaborative activities.

In order to overcome this difficulty, the scientific community has recently developed and sustained the validity of new theoretical approaches related to the CSCL scripts (Griffiths et al., 2005). The CSCL (or collaboration) scripts are didactic scenarios that specify a sequence of collaborative phases through complex instructions. Different authors define CSCL scripts as "instructional sequences" that organize learning activities into phases. Each phase is defined by specific items: the activity (or activities) that learners have to perform, the group composition, the assignment of roles (to learners within the group), the interaction modes and the phase timing. These scripts are fundamental to guide collaboration.

The CSCL environments have to include more applications to support collaborative activities and to make the preparation of the CSCL script easier. *When teachers engage students in collaborative learning, they give global instructions such as "do this task by group of 3". These instructions are completed with implicit expectations with respect to the way students should work together. The teacher's way of grading collaborative work strengthens this implicit contract. A collaboration script is a more detailed and more explicit didactic contract between the teacher and the group of students regarding to their collaboration mode. Most scripts are a linear sequence of phases. Each phase specifies the task that the students have to perform, the composition of the group, the way that the task is distributed within and among groups, the interaction mode and the timing of the phase (Dillenbourg, 2004).*

The CSCL scripts are expected to facilitate learning by guiding peers collaboration and engaging all participants in activities that trigger the activation of their cognitive and metacognitive processes. The scripts need to be designed by an authoring tool able to formalize the learning activities in collaborative workflows. This tool has to respect several educational design requirements which we have identified in the CSCL literature: namely, group composition, role and resource distribution, coordination and flexibility. Each requirement implies a different challenge.

We present a novel approach to design and deliver dynamic collaborative learning processes and a tool able to apply such approach. The design process will not start from scratch but basing on the use and integration of pedagogical templates based on CSCL scripts. Pedagogical templates or patterns are used in order to capture and communicate recurrent

learning design problems and opportunities (Goodyear, 2005). Each pattern describes a problem that occurs repeatedly and the solution core to that problem (Alexander et al., 1977).

The templates can be applied to instructional design at two levels: for learning materials and multimedia production, i.e. to define patterns for learning management systems (Avgeriou et al., 2003) and for instructional activities of different scale, i.e. to organize an entire course or to define specific learning activities (Bergin, 2003). In this work we consider the second approach.

The development and management of collaborative activities as part of a formal learning process requires a conceptual model that, on the one hand, aims at describing the architectural strategies and methods and, on the other hand, helps define the communication processes, the description of groups, and the selection of tools and services for the interaction.

The approach we propose is based on the definition of a Collaborative Didactic Model able to describe collaborative learning experiences as workflows involving users, content and IWT collaborative services. The first thing to do is to define Learning Goals from the available Ontology concepts. Then, it is necessary to define, at an upper level, the specific collaborative strategies to apply. A collaborative strategy corresponds to a CCSL macro-script and is seen as a given configuration of learning parameters like learning type, orientation, types of course content, educational goal, learning focus and interactions.

Table 3.1 summarizes feasible values for the defined learning parameters. Once the parameters are clear, a collaborative strategy can be represented at a bottom level, through a workflow of didactic activities to be executed corresponding to a CSCL micro-script. This workflow is the Collaborative Didactic Model, allowing to:

- Design structured experiences, according to the principles known by the scientific community to be of high-impact effect on the learning class activity;

- Associate content as well as collaborative and Web 2.0 services to each activity to enhance the model and to define, in the form of didactic package, the final cognitive product of the group activity;

- Reuse such a product in different didactic contexts as a collaborative learning component.

After having defined the Collaborative Didactic Model, setting all the activities and related resources and services, it is possible for the teacher to associate specific learners and to run the class activity. The model can be directly executed or saved as a pedagogical template that can be revised and reused in other learning contexts. The use of pedagogical templates is a technique broadly accepted among practitioners when they need to structure learning activities (Dillenbourg, 2002). They can be seen as a way of collecting "best practices" in instructional design.

In our case, these best practices refer to suitable ways of arranging participants in a collaborative learning situation, sequencing types of collaborative learning activities in order to promote the achievement of a set of desired educational objectives. Among other advantages, they provide a way of communicating collaborative learning expertise to other (novice) practitioners: instead of trying to create their own collaborative designs from scratch,

practitioners can reuse the templates as instructional guides for structuring their own collaborative experiences.

| Learning Parameter | Feasible Values |
|---|---|
| Learning type | Content and Support; Wrap Around; Integrated; Individual Exploration; Networking Learning / Informal e-Learning |
| Type of course contents | Facts; Concepts; Procedures |
| Educational goal | Information Storing; Relations Understanding; Application of Simple Skills; Application of General Skills; Interdisciplinary |
| Orientation | Content and Personalization; Interaction and Collaboration; Cooperation and Project Work |
| Learning Focus | Cognitive Domain; Topic; Problem; Interdisciplinary |
| Interactions | Individual / Group; Human / Systemic |

*Table 4.1: Learning Parameters*

# 4.3 Characterizing Cognitive and Social assessment in CSCL

In this section we provide, first, an overview of interaction data and social network analysis and specific case studies of e-assessment in CSCL that serve as the main requirements and needs of our assessment framework. Then, we present a summary of our cognitive assessment approach based on collaborative outcomes that leverage a dialogue model for managing collaborative interaction integrated with the specific e-learning technology of CC-LR, making up the state of the art of our research (Caballé & Mora et al., 2013). Then, we enrich this model with learning analytics (LA) and social network analysis (SNA) techniques for learning assessment purposes with the aim to present the grounds for extending our assessment model with new indicators regarding the social networking behavior of the learning group members. This last approach concerning social network assessment in on-line collaborative learning makes up the innovative part of our research presented in this thesis. Finally, we prototype and naively test the approach by incorporating our framework of cognitive and social assessment into the CC-LR. Implications and discussions are provided at his stage of the evaluation process and before the full experimentation and validation provided in next chapter (see Chapter 5).

## 4.3.1 CSCL Interaction Data and Social Network Analysis

Computer-Supported Collaborative Learning (CSCL) is one of the most influencing research paradigms dedicated to improve teaching and learning with the help of modern information and communication technology (Koschmann, 1991; Dillenbourg P, 1999; Strijbos et al., 2006; Stahl, 2006). A vast literature production and outstanding contributions have been published

reporting on studies where the CSCL interaction process has been exhaustively analyzed (Fahy, 2006; Michinon, & Michinon, 2005; Chou, 2004; Perakyla, 2004). (In Schellens, & Valcke, 2006) it was investigated whether CSCL in asynchronous discussion groups results in enhancing academic discourse and knowledge construction. Their research work showed that students in the discussion groups were fundamentally task-oriented and that higher proportions of high phases of knowledge construction were observed. It was also evidenced by (Wang et al., 2008; Stahl, 2006; Puntambekar, 2006.) that students were able to construct their own understanding based on their interactions.

In addition, intensive and successful research from the interaction analysis field has been achieved over the last decade to facilitate the management by computers of the large amounts of interaction data from online discussions. Recently, the interaction analysis field have been incorporated into the general of methods of techniques of data analysis named Learning Analytics (LA) (Siemens, 2013; Romero & Ventura, 2010). A variaety of efforts to extract useful data from CSCL interactions (De Wever, 2006; Soller, 2001; Pena-Shaff, & Nicholls, 2004; Strijbos. et al, 2006; Schrire, 2006) aim to alleviate manual procedures while considering relevant aspects of the collaboration, such as how all participants are actually performing during the discussion and the dynamics of each participant with respect to the group. To this end, two levels of interaction analysis in LA are considered, quantitative and qualitative level (Caballé & Mora et al., 2011b). Quantitative indicators measure the participants' performance and dynamics (e.g., number of contributions written and read by each participant) as relevant information to model the group functioning and task performance (Daradoumis et al., 2006). Qualitative information has been also considered valuable to complete the labored task of interaction analysis and evaluation of contributions. Strijbos, et al, (2006) and Schrire, (2006) used a merging view of quantitative analysis within a qualitative methodology to build a model for the analysis of collaborative knowledge building in asynchronous discussion. However, the mere consideration of the depth of discussion threads, the number of messages and he relation among messages do not guarantee by itself the quality of the discussion; students' postings can be simply driven by socialization reasons and not directly linked to the development of the learning tasks (Caballé et al., 2011a).

Quantitative indicators measure the participants' performance and dynamics (e.g., number of contributions written and read by each participant) as relevant information to model the group functioning and task performance (Daradoumis et al., 2006). An initial model based on the above considerations was already built and evaluated in previous research (Schwartz, 1999). In this research work we enhance the social perspective of our model by incorporating LA and SNA techniques in order to provide a clear way of analyzing the network structure and discovering the collaborative knowledge hidden in large volumes of well-structured data. The use of LA and SNA in the context of CSCL is reviewed next.

Historically, LA appears from research about the processing, analysis and visualization of knowledge about the learning process. This knowledge may be gathered from large data sets of events at different levels of abstraction, such as the interactions of students with learning management systems, other students and instructors throughout the learning process (Siemens, 2013). In this sense, LA is built upon previous works (Romero & Ventura, 2010) in which the interactive processing of learning data has been exhaustively analyzed. There are many results and applications in education, such as providing effective assessment and

automatic feedback to students; supporting instructors by monitoring and predicting student performance; and modeling user profiles for content and process customization, according to the student needs, goals and individual skills.

SNA is a method of Educational Data Mining whose goal is to understand and measure the relationships between entities in networked information (Romero & Ventura 2013). SNA views social relationships in terms of network theory consisting of nodes (representing individual actors within the network) and connections or links, which represent relationships between the individuals (Reihaneh, 2011). In EDM, SNA can be used for mining in order to interpret and analyze the structure and relations in collaborative tasks and interactions with communication tools (Reihaneh, 2011; Romero & Ventura 2013) To this end, the specialists performing the analysis must collect and process data through mining techniques (Romero & Ventura 2013) and do the required inference for filling up those indicators defined for measuring and evaluating the collaboration acts. In order to measure collaboration, SNA techniques include centrality indices, which are related with the position and relevance within a network (Marin et al., 2011) and measure how influential a person is within a social network.

When measuring collaboration by LA and SNA, most works (Marin et al., 2011; Reihaneh, 2011) show a three-step process of collecting the information, analyzing and presenting the results. In (Reihaneh, 2011), for instance, SNA techniques are used in the context of discussion forums to measure effective participation. First, log files of the e-learning course are used to extract the social network underneath the discussion threads. Second, appropriate social network measures for effective participation are selected, and, finally, the measures are reported (i.e. visualized) appropriately. The attributes of messages in a forum, such as time, task phase, sender and how the message is received (degree centrality, eigenvector, etc), as well as the content, reveal the nature of the social relationships (de Laat et al., 2007).

It is worth mentioning here that learning networks are considered whole networks (Marin et al., 2011), because there are not privileged nodes or ties, thus relations can be measured as directed or undirected and as binary or valued. Directed ties present a directional relation, while undirected ties have no particular direction. Directed ties may be reciprocated or they may exist in only one direction as when only one gives emotional support to the other (Plickert, 2007). Some kinds of directed ties preclude the possibility of reciprocity. The unidirectional ties can be symptom of a dysfunctional group.

Both directed and undirected ties can be measured as binary ties that either exist or do not exist within each dyad, or can be measured as valued ties that can be stronger or weaker, transmit more or fewer resources, or have more or less frequent contact. To evaluate and assign a value to each tie, a good defined reference is needed (Marin et al., 2011).

On the other hand, there are diverse ways to determine the boundaries of a social network (Marin et al., 2011; Bogartti et al., 2009). A straightforward way uses event-based approach to defining the boundaries of the network instead of identifying the participants of the collaborative tasks (Laumann, 1983). A different perspective starts from a relation-based approach and a small set of nodes deemed centred in the network and then expands the selection including others nodes sharing particular types of relations with (Laumann, 1983). These approaches are not mutually exclusive and can be used together (Bogartti et al., 2009). Following this approach in the context of e-learning, once the network boundaries are known, outside

students can be identified even if they still formally are involved in the network. This is found by realizing the lack of informal ties between these students and the rest of the group, showing the existence of some formal relationships but no actual involvement in the group (de Laat et al., 2007).

The next question in SNA is about the type of interactions produced within the learning network. SNA study patterns of relations, not just relations between pairs (Marin et al., 2011). Relations are measured in pairs of nodes, but the study of the effect and meaning of this relation requires broader patterns of ties within the network (Barnes, 1972). In Reihaneh (2011), the interaction patterns in the network were also analyzed in order to understand many aspects of the collaboration, such as how the discussion was developed over time, collaborative work sequences, planning issues, delays, etc. Therefore, SNA may help identify patterns of relationship between people who are part of a social network (de Laat et al., 2007), and the social environment can be mapped as patterns of relationships among interacting members (Wasserman, & Faust, 1997).

According to (Hernández-Leo, 2005b), patterns in social networks can be identified and constructed using mainly two methodologies: inductive pattern mining, seeking what is the pattern from a set of models, or deductive pattern mining, identifying the essence of generic models for solutions to recurrent problems that learning designers identified previously (Baggetun, 2004). Depending on the granularity or the detail level, pre-structuring collaboration can be accomplished in a coarse-grained process level and/or fine-grained level of detailed learning actions.

Finally, students' roles in the learning network may be relevant for the collaborative learning process (Johnson, & Johnson, 1991; Millis, & Cottell, 1998; Smith, 1996):

- Group facilitator: moderates discussions, keeps the group on task, assures work is done by all, and makes sure all have opportunity to participate and learn.

- Timekeeper: monitors time and moves group along so that they complete the task in the available time. Sometimes assumes the role of wildcard member.

- Recorder: takes notes of the group's discussion and prepares a written conclusion.

- Checker: makes sure that all group members understand the concepts and the group's conclusions.

- Summarizer: restates the group's conclusions or answers.

- Elaborator: relates the discussion with prior concepts and knowledge.

- Research-Runner: gets needed materials and is the liaison between groups and partners.

- Wildcard: assumes role of any missing member.

Sometimes more than one role can be assumed by one student, but all roles are necessary to create functional collaborative learning network. If a learning network shows a dysfunctional behavior, it is interesting inspect if there are some missing roles. It is also interesting study how the student role evolves over time, since certain changes may be due to role dysfunctions to be addressed.

## 4.3.2 Cases of Assessment in CSCL

Two collaborative learning scenarios are analyzed in this section to exemplify the assessment in online collaborative learning settings: First, assessment of online collaborative discussions and then assessment of Wiki-based collaborative learning.

**Assessment in Online Discussions**

Current online learning usually includes the participation of students' in-class discussions with the aim of sharing and discussing their ideas (Lytras et al., 2008, Lytras & Ordóñez de Pablos, 2007, Stahl, 2006 and Wang et al., 2008). Given the added value and the extensive use of on-line discussions in the current educational institutions' pedagogical models, great research efforts have been carried out to understand the cognitive processes underlying the collaboration. Schellens and Valcke, (2006) investigated whether collaborative learning in asynchronous discussion groups results in enhancing academic discourse and knowledge construction. Their research work showed that students in the discussion groups were fundamentally task-oriented and that higher proportions of high phases of knowledge construction were observed. It was evidenced by (Stahl, 2006 and Wang et al., 2008) and (Puntambekar, 2006) that students were able to construct their own understanding based on their interactions with others during the discussion while shared knowledge building become richer over time.

Indeed, the discussion process plays an important social task in CSCL where participants can think about the activity being performed, collaborate with each other through the exchange of ideas that may arise, propose new resolution mechanisms, as well as justify and refine their own contributions and thus acquire new knowledge (Salomon, 1993). Indeed, learning by discussion when applied to collaborative learning scenarios can provide significant benefits for students in the context of project-based collaboration learning, and in education in general (Stahl, 2006). Moreover, learn by discussion in the context of CSCL fits the current shifting from a traditional educational paradigm (i.e., centred on the figure of a masterful instructor) to an emergent educational paradigm (Kulesza & Reinalda, 2006) which considers students as active and central actors in their learning process while the instructor's role is moving from one related to a knowledge transmission agent to another related to a specialist agent who designs the course, guides, assists and supervises the student's learning process (Simonson et al., 2003).

Following this increasing interest, current e-learning systems are incorporating advanced interactive support to on-line discussions resulting in the generation of large amounts of interaction data, which include complex issues of the collaborative work and learning process (e.g., group well-being (McGrath, 1991 and Pillania, 2009) as well as self, peer and group activity evaluation (Daradoumis, Martínez, & Xhafa, 2006). As a consequence, manual monitoring and evaluation of large on-line discussion processes, typically carried out by tutors and moderators, become tedious, error-prone, and highly unreliable.

Moreover, since the evaluation process is done after the completion of the learning activity, it has less impact on it (McDonald, 2003). Indeed, the lack of constantly feeding back immediate assessment from the tutor on the dynamics and performance of the collaborative activity may negatively impact on participant's motivation, emotional state and problem-solving abilities,

and as a result diminish the performance and acquisition of knowledge (Zumbach, Hillers, & Reimann, 2003).

Schellens and Valcke (2006) investigated whether collaborative learning in asynchronous discussion groups results in enhancing academic discourse and knowledge construction. Their research work showed that students in the discussion groups were very task-oriented and that higher proportions of high phases of knowledge construction were observed. Moreover, significant increases in the cognitive interaction, task-orientation and higher phases of knowledge construction were detected.

Furthermore, an important issue raised in collaborative learning interactions is the change from divergence to shared understanding and to possible construction of knowledge. The point is to understand how collaborative interactions develop over time: whether students raise new issues (ideas) more frequently as they become more familiar with the discussion and discussants, and whether shared knowledge building becomes richer over time, and subsequent evidence that students were able to construct their own understanding based on their interactions with others (Puntambekar, 2006). To this end, our model annotates and examines a variety of elements that contribute to the understanding of the nature of the collaborative interactions, such as the students' passivity, proactivity, reactivity as well as the effectiveness and impact of their contributions to the overall goal of the discussion.

Large amounts of information data are generated from asynchronous discussion which includes complex issues of the collaborative work and learning process (e.g., group well-being (McGrath, 1991) as well as self, peer and group activity evaluation (Daradoumis, Martínez, & Xhafa, 2006)). On the one hand, quantitative information can be managed by applying a structured process where the users' interactions are tagged with certain indicators according to a collaborative learning conversation skill taxonomy (Soller, 2001) that models the various types of interactions at different levels. Moreover, typical quantitative indicators about the participants' performance and dynamics (e.g., number of contributions written and read by each participant) are also considered as relevant to model the group functioning and task performance (Daradoumis et al., 2006).

Intensive and successful research from the interaction analysis field has been achieved over the last years to facilitate the management by computers of the large amounts of interaction data from on-line discussions. Current efforts (Angehrn et al., 2009, Bardis et al., 2009, De Wever et al., 2006, Ordóñez de Pablos, 2005, Pena-Shaff & Nicholls, 2004, Schrire, 2006, Soller, 2001, Strijbos et al., 2006 and Vargas-Vera & Lytras, 2008; Santos & Boticario, 2015; Patil & Kulkarni, 2016, Heafner et al., 2016 ) aim to alleviate manual procedures while considering relevant aspects of the collaboration, such as how all participants are actually performing during the discussion and the dynamics of each participant with respect to the group. To this end, two levels of interaction analysis are considered, quantitative and qualitative level.

Quantitative indicators measure the participants' performance and dynamics (e.g., number of contributions written and read by each participant) as relevant information to model the group functioning and task performance (Daradoumis et al., 2006). According to (De Wever et al., 2006), quantitative content analysis has been increasingly used to surpass surface level analyses in collaborative learning (e.g., counting messages) and several content analysis

schemes have been employed to analyze transcripts of on-line asynchronous discussion groups in formal educational settings. (Soller, 2001) also proposed to manage large amounts of quantitative information by applying a structured process where the users' interactions are tagged with certain indicators according to a collaborative learning conversation skill taxonomy that models the various types of interactions at different levels. Although this research technique has been often used, standards are not yet established. As a consequence, the empirical base of the validity of the instruments is limited. Several open questions still exist, especially as concerns the unit of analysis and segmentation procedure to be followed (Strijbos et al., 2006; Pena-Shaff & Nicholls, 2004). In a different study, a content analysis scheme has been applied to analyze the way online peer tutoring (conducted by fourth-year students) supports asynchronous discussion groups of first-year students (De Smet, et. al. 2008). This study demonstrates the important role that tutoring plays in online asynchronous discussions, which is taken into account and constitutes a contributing element of our model.

On the other hand, qualitative information has been also considered valuable to complete the laboured task of interaction analysis and evaluation of contributions. Strijbos et al., (2006); Schrire, (2006), and Pena-Shaff and Nicholls (2004) used a merging view of quantitative analysis within a qualitative methodology to build a model for the analysis of collaborative knowledge building in asynchronous discussion. Quantitative analysis was used to examine participation and interaction rates, at a number of levels, focusing on the discussion forum itself, the discussion threads, the messages, and the exchanges and moves among the messages. Qualitative procedures were used to analyze knowledge construction processes and to refine a category system of indicators and descriptors. Results showed that students got engaged in a knowledge construction process by means of integrating the interactive, cognitive and discourse dimensions in collaborative learning. However, the mere consideration of the depth of discussion threads, the number of messages and he relation among messages do not guarantee by itself the quality of the discussion; students' postings can be simply driven by socialization reasons and not directly linked to the development of the learning tasks.

Moreover, a study by Schrire (2006) applies a merging of quantitative analysis within a qualitative methodology to build a model for the analysis of collaborative knowledge building in asynchronous discussion. The model allows examination of the communication from the multiple perspectives of interaction, cognition and discourse analysis. Content analysis of the discourse was done at a number of levels, focusing on the discussion forum itself, the discussion threads, the messages, and the exchanges and moves among the messages. As a result, it was possible to build a scheme for assessing knowledge building in asynchronous discussion groups. The scheme integrates the interactive, cognitive and discourse dimensions in CSCL. Similarly, Bratitsis and Dimitracopoulou (2006) analyze the quality of group interactions in asynchronous discussion by means of a multi-indicator model based on quantitative aspects of the active and passive behaviour of participants (i.e., number of messages written/replied and read). This may help tutor infer problematic situations occurring during the learning process as well as identify individual behaviour that may influence collaboration, such as passivity and arrogance.

In a more recent work, Hew and Cheung (2008) report a qualitative study examining the facilitation techniques used by student facilitators to attract their course mates to participate in asynchronous online discussions. This study differs from previous ones in the sense that it

does not focus on the role of the tutor as facilitator and promoter of student participation, but it explores peer facilitation. To explore the extent to which student participation in an online discussion forum is successful, the study looks at the depth of discussion threads. Finally, it reports the facilitation techniques that were exhibited by the student facilitators. However, the mere consideration of the depth of discussion threads does not guarantee by itself the quality of the discussion; students' postings can be simply driven by socialization reasons and not directly linked to the development of the learning tasks.

Finally, Caballé & Mora et al, (2011b) show an approach to support evaluation in online discussion forums that shows key discourse elements and aspects that play an important role both for promoting student participation and enhancing group and individual performance, such as, the impact and effectiveness of students' contributions, among others, that we explore in our work (see Figure 4.1). By explicitly feeding back these elements to the participants the discussion model proposed accomplishes high students' participation rates and contribution quality in a more natural and effective way. Indeed, this approach goes beyond a mere interaction analysis of asynchronous discussion in the sense that it builds a multi-functional model that fosters knowledge sharing and construction, develops a strong sense of community among students, provides the tutor a powerful tool for students' monitoring and evaluation, discussion regulation, while allowing for peer facilitation through effective self, peer and group feedback.

| | Profile |
| | User directory |
| | Preferences |
| | Change course |
| | Start |

**You got NEWS:**

⚐ FOLDER #1 - *Proves Debat 1 (Santi Caballe [T]) 59/61*
⚐ FOLDER #3 - *Debat 2 (Santi Codola [T]) 35/91*

[RUBEN]
[STUDENT]
[MGPI]
[AULA 2]

**FOLDER:** #2 - Debat1

**Description:** Carpeta per al Debat 1 de l'assignatura MGPI Curs 2007-08(2)
**Created by:** Santi Codola [TUTOR] on 28-mar-2008 18:02:51
**FOLDER DATA:**
N. contributions:: 200   Quality of this folder: C+   Usefulness of this folder: 7.0/10 [289 Vots]

**STUDENT STATISTICS**

| STUDENT POSITION | | ACTIVITY | | | | PASSIVITY | | IMPACT | | EFFECTIVITY | | ASSESSMENT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pos. | Student | Total contributions | Proactivity | Reactivity | Support | Pending to read | Pending to evaluate | Particip. impact | Replies received | Assientment rebut | Peer assessment | Tutor assessment |
| [1] | MiguelAngel Cabot | 3/200 1.5% | 2/3 66% | 1/3 33% | 0/3 0% | 0/197 | 197/197 | 26.5 | 0/3 | 39/39 100% | 8.2/10 (6) | B |
| [2] | Javier Gomez | 3/200 1.5% | 2/3 66% | 0/3 0% | 1/3 33% | 197/197 | 197/197 | 22.0 | 0/3 | 22/22 100% | 7.0/10 (9) | B |
| [3] | Jordi Serra | 3/200 1.5% | 3/3 100% | 0/3 0% | 0/3 0% | 0/197 | 197/197 | 24.0 | 3/3 | 24/24 100% | 7.0/10 (10) | B |
| [4] | Josep Vano | 11/200 5.5% | 8/11 72% | 3/11 27% | 0/11 0% | 183/189 | 189/189 | 87.0 | 6/11 | 124/130 95% | 7.2/10 (12) | C+ |
| [5] | Jose Vizcaino | 2/200 1.0% | 2/2 100% | 0/2 0% | 0/2 0% | 174/198 | 193/198 | 10.0 | 0/2 | 10/10 100% | 10.0/10 (2) | B |
| >[6] | Ruben Haro | 12/200 6.0% | 7/12 58% | 5/12 41% | 0/12 0% | 0/188 | 117/188 | 59.5 | 4/12 | 104/108 96% | 7.0/10 (10) | C+ |
| [7] | Antoni Perez | 5/200 2.5% | 4/5 80% | 1/5 20% | 0/5 0% | 190/195 | 195/195 | 26.5 | 0/5 | 40/40 100% | 7.2/10 (5) | B |
| [8] | Emilio Garcia | 17/200 8.5% | 10/17 58% | 7/17 41% | 0/17 0% | 89/183 | 140/183 | 67.5 | 5/17 | 143/143 100% | 7.6/10 (34) | C+ |
| [9] | Carlos Guerra | 1/200 0.5% | 1/1 100% | 0/1 0% | 0/1 0% | 197/199 | 199/199 | 14.0 | 0/1 | 14/14 100% | 8.3/10 (3) | B |
| [10] | Abel Vilalta | 4/200 2.0% | 4/4 100% | 0/4 0% | 0/4 0% | 135/196 | 196/196 | 48.5 | 1/4 | 49/50 98% | 7.3/10 (6) | C+ |
| [11] | Rafael Alonso | 9/200 4.5% | 6/9 66% | 3/9 33% | 0/9 0% | 113/191 | 119/191 | 65.0 | 3/9 | 67/68 98% | 6.4/10 (17) | C+ |
| [12] | RafaelGuillermo Fernandez | 1/200 0.5% | 1/1 100% | 0/1 0% | 0/1 0% | 183/199 | 199/199 | 10.0 | 0/1 | 10/10 100% | N | A |
| [13] | Daniel Cortes | 1/200 0.5% | 1/1 100% | 0/1 0% | 0/1 0% | 195/199 | 199/199 | 9.0 | 0/1 | 10/10 100% | 8.0/10 (1) | B |
| [14] | Carles Patino | 4/200 2.0% | 2/4 50% | 1/4 25% | 0/4 0% | 49/196 | 196/196 | 20.5 | 1/4 | 32/33 97% | 7.5/10 (8) | B |
| [15] | Yolanda Aubanell | 1/200 0.5% | 1/1 100% | 0/1 0% | 0/1 0% | 197/199 | 199/199 | 12.0 | 0/1 | 12/12 100% | 7.7/10 (3) | B |

*Figure. 4.1: A snapshot of complex and updated feedback provided to all participants (Caballé et al, 2011a).*

**Assessment of Wiki-based Collaborative Learning**

Several researches have been conducted to investigate the validity of using wiki systems in CSCL. The use of wikis in CSCL lacks some incentives to motivate students to contribute to the wiki such as assessment procedures (Judd et al., 2010). However, this goes in line with Macdonald (2003) guidelines for CSCL assessment as he argued the CSCL activities should be linked to assessment procedures in order to more attract students and increase their motivation and engagement to learning activity. Despite that wiki constitutes from semiotic contributions, wiki plays an interesting double role of medium and product of the collaborating

(Reimann & Kay, 2010). However, wikis prevent users from editing the same page simultaneously which may be a disadvantage in some scenarios like using wikis for co-writing. However, this may be avoided in distance learning as the probability of simultaneous editing for the same page is less than in-campus learning.

Wikis are designed to log all the users' edits and comments, with the ability of page editing notifications (e-mail, RSS). Such ability of automatically logging users' contributions and activities can be used to analyze and interpret the nature, scope, context of user contributions (Zumbach & Reimann, 2003; Swan et al., 2006; Hirsch et. al., 2009; Trentin, 2009; Khandaker & Soh, 2010; Judd et al., 2010). In the work of Trentin (2009), the author tested an approach for co-writing using wiki where the students used online discussion forum for co-planning and structuring the content for the co-writing phase. Moreover, they used online discussion forum for peer-review where they were required to peer-review their peers contributions and writings. The student's collaborative activities had been evaluated according to: the product of co-writing, the process implemented by groups, and the learning of the subject content. Within the process evaluation, objective (number of messages and amount of produced material) and subjective (teachers and peers evaluation) data extracted from the wiki logs and discussion forum posts analysis were used to evaluate the co-writing process.

Reimann et al., (2010) proposes an assessment approach for team practices in CSCL – in particular wiki-based collaboration- based on formal process model represented as a transition diagram. Such process model can be formalized automatically based on tracing student's behaviour (log file). Moreover, can be used for both formative feedback – provide feedback in terms of visualized knowledge, see section 5.3-, and summative valuation (evidence-based evaluation) – by comparing created graphs with an optimum one.

Another example of providing assessment activities within wiki-based learning is the work of (Kumar et al., 2010), in this research the authors discuss an ontological approach to perform assessment in the process assessment within CSCL activities. In this approach the learners interactions are tracked into XML-based log file and mapped onto ontology they named CILT. CILT covers four main domains namely: *content* (refers to the learning content related to the application domain), *interaction* (defines interactions the learner can take within an application), *learner* (identifies the learner knowledge state, skills, and preferences), and *time* (time information imported from DAML-Time ontology). The whole approach has been designed to support students in self-regulated learning trend, to maintain flexibility among different application domains, and to provide sharable and Interoperable framework.

The work of (Khandaker & Soh, 2010) in which the authors tracked and learners' interactions with a wiki designed for education they named "ClassroomWiki". According to the authors, ClassrommWiki assessment approach: (1) tracks students' interactions and textual contributions, (2) evaluation of concept-based contribution, (3) evaluates peer-ratings towards group progress. Moreover, their first findings shows that teachers were capable to better evaluate the individual's contribution, and supported with tools to provide timely feedback and support to the students who are not contributing to the group work- i.e. scaffold learner path.

However, wikis should be enhanced and enriched with new forms of assessment such as self, peer-assessment so that the processes of co-writing can be peer-reviewed. Moreover, some enhanced visualization tools should be implemented to provide both students and teachers

valuable feedback about the collaborative learning using wiki. The visualization tools and techniques should foster answering the following research questions: *How much has each student contributed to the assignment product? How collaboration is taking place? To what extent the students are collaborating within the group? Who did what and when?* (AL-Smadi, Hoefler, & Guetl, 2011). According to AL-Smadi et al,.(2011) integrating assessment forms such as self, and peer-assessment within tools used in co-writing can support students to maintain task-awareness, enhance their contribution towards the group production function, and increase their motivation and their engagement accordingly. The authors discuss their findings based on a study they have conducted using tool they have developed to collaborative writing and peer-review. The tool which is named "Co-writing Wiki" has been enhanced with the following integrated forms of assessment:

- Self-assessment: During the edit of an assignment page students are required to select their edits intentions (e.g. add text, delete text, and change style) as well as to rate the importance and the added value of their edits. Moreover, they can provide some comments to be fed back to the assignment homepage as part of the actions feed section, see Figure 4.2.



*Figure 4.2: Intention based self-assessment*

- Peer-assessment: An internal peer-review follows this action as other group members can review this action and also rate it and provide feedback. The internal peer-review can be configured to be mandatory on each action, just for the final action on the page, or to be selective as in Figure 4.3.

Compare Page Revisions
2 ▾ Current ▾ Compare

Color key: added text / removed text / edited text / edited style.

1  The ASP.NET MVC Framework is a web application framework that implements the model-view-controller pattern. Based on ASP.NET, it allows SW developers to build a Web application as a composition of three roles: Model, View and Controller. A model represents the state of a particular aspect of the application. Frequently, a model maps to a database table with the entries in the table representing the state of the application. A controller handles interactions and updates the model to reflect a change in state of the application, and then passes information to the view. A view accepts necessary information from the controller and renders a user interface to display that.
2
3  Razor is the newest engine by MS MS. It is very good for HTML

Peer Review
Comment: More explanations please
Importance: ☆☆☆☆☆
Edit current version

*Figure 4.3: Internal peer-review for formative feedback and assessment*

- Group-assessment: Co-writing wiki provides a tool for group's peer-assessment. By using this tool students and teachers can peer-assess other group's final product of the assignment and provide feedback. Moreover, they can assess a specific page from the assignment by clicking on 'Assess Page' from the action list. See Figure 4.4.

Group assessment for : AspNET

Explore groups | Navigation Back Main Wiki player for group WebForms on page User-Controls | Actions
⊞ Groups WebForms | User controls are encapsulations of sections of pages which are registered and used as controls in ASP.NET. User controls are created as ASCX markup files. These files usually contain static (X)HTML markup, as well as markup defining server-side web controls. These are the locations where the developer can place the required static and dynamic content. | Assess group
Pages for WebForms | A user control is compiled when its containing page is requested and is stored in memory for subsequent requests. User controls have their own events which are handled during the life of ASP.NET requests. An event bubbling mechanism provides the ability to pass an event fired by a user control up to its containing page. Unlike an ASP.NET page, a user control cannot be requested independently; one of its containing pages is requested instead. | Assess page
User-Controls ▾
Show Page

*Figure 4.4:  A tool for group-assessment- Student view for the group named AspNET*

- Assessment Rubrics: The Group-assessment tool is enhanced with assessment rubrics to facilitate the assessment process, provide feedback, and to maintain persistence and reliable assessment, see Figure 4.5.

Assessment for group MVC

| References 8 / 10% | Amount of References | Quality of References | | | | |
| | Comment: | Comment: Great | | | | |
| | Importance: ☆☆☆☆☆ | Importance: ☆☆☆☆☆ | | | | |
| Content 33 / 70% | Abstract | Introduction | Historic Overview and Classification | Selected Aspects | Lessons Learned | Summary and Future Work |
| | Comment: | Comment: | Comment: Ok | Comment: | Comment: Is missing! | Comment: |
| | Importance: ☆☆☆☆☆ | Importance: ☆☆☆☆☆ | Importance: ☆☆☆☆☆ | Importance: ☆☆☆☆☆ | Importance: ☆☆☆☆☆ | Importance: ☆☆☆☆☆ |
| Formal Aspects 14 / 20% | References and Citations | Style | Structure | Appendix | | |
| | Comment: | Comment: | Comment: | Comment: | | |
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*Figure 4.5: Rubric to facilitate group-assessment*

## Assessment strategies in online collaborative Learning

Learning is strongly linked to assessment, because learning quality and quantity must be measured for reasons of reliability or feedback. As e-learning is more important as an educational option, the e-assessment has become increasingly relevant and is becoming a focus for research.

Earliest forms of computer assisted learning used simple evaluation tools, like multiple choice questions, sometimes with feedback algorithms that responded to individual choices. E-assessments have therefore largely evolved from the conventional forms of 'objective'

assessment so that paper-based versions of multiple choice, true-false-abstain, multiple response and extended matching questions have been converted into electronic versions. However, once this process has occurred, a number of opportunities and advantages became apparent which can transform assessment and make it a much more relevant, valid, exciting and meaningful process (Dennick et al, 2009). Some of these opportunities and advantages will be discussed further as well as some disadvantages and practical difficulties that derive from the computer-based medium itself.

Next we outline some of the arguments for the use of online assessments and some of the key principles of assessment that apply to these situations. Students entering higher education today, typically:

- Have experience of computer technology in both their school and home lives

- Expect interaction

- Want a visual experience

- Desire rapid feedback on their activities

- Want technologically modern courses

- Want a more holistically challenging assessment environment.

These expectations are directly related to unwanted effects cited in Section 5.1 of this document: Lack of awareness, coordination and communication problems. All these expectations are more or less related to assessment and feedback communication.

The importance of good assessment is highlighted in Boud's (1995) statement, 'Students can, with difficulty, escape from the effects of poor teaching, they cannot . . . escape the effects of poor assessment.

It is important to underline two necessary aspects involved in both assessment and e-assessment: reliability and validity.

*Reliability*: The reliability of an assessment refers to its ability to consistently give the same measure of learning when used repeatedly despite sampling error (Dennick et al, 2009). The most common cause of unreliability in testing is a lack of consistency in the use of assessment criteria by a corrector. In the sort of objective testing we are describing here, where objective criteria are decided beforehand and questions are marked electronically, this type of reliability problem is diminished.

However, another form of reliability is the internal consistency of the assessment task, usually measured by correlating individual item scores to other items or to the global test score which can be processed to give a value of reliability such as Cronbach's alpha (Cronbach 1951).

Reliability can also be influenced by learners' personal factors such as their propensity to guess, whether they have dyslexia or how easily they are fatigued by using a Visual Display Unit (VDU). The influence of these factors on reliability will be discussed later.

*Validity*: In general, assessment validity is concerned with whether an assessment measures what it is designed to measure and can be sub-divided into a variety of different types (Dent & Harden 2005):

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- Content validity: 'Does the test measure and evaluate relevant learning objectives or outcomes?'

- Construct validity: 'Does the test measure an underlying cognitive trait, e.g. intelligence?'

- Concurrent validity: 'Does the test correlate with the results of an established test?'

- Predictive validity: 'Does the test predict future performance?'

- Face validity: 'Does it seem like a fair test to the candidates?'

The most important elements that might be influenced by being online would be content validity and possibly the related concept of construct validity. However, Schuwirth and van der Vleuten (2006) argue that assessments must also have face validity for students. This is an important issue particularly when introducing online e-assessment for the first time to students who may be unfamiliar or uncomfortable with evaluation process and feedback visualization.

In a CSCL environment it is possible to employ two different types of assessment, according to the time factor scale used: real time assessment and deferred time assessment.

**Real Time Assessment**

Real time assessment focuses on those elements that contribute to the understanding of the nature of the collaborative interactions, such as the students' passivity, proactivity, reactivity as well as the effectiveness and impact of their contributions to the overall goal of the online discussion (Caballé et al, 2004). To understand real time assessment is important, because learning, student engagement or awareness are not dynamical variables to be collected and analyzed to control a device or machine. Real time assessment can be related to actions or impressions produced in a specific moment or time space (e. g. empathetic reaction produced for a message inserted in an online discussion).

It is evident that social interaction is necessary for collaboration and collaborative learning. There appear to be at least two identifiable factors which can be seen as pitfalls to social interaction: communication and social interaction.

The communication factor is crucial in CSCL (Kreijns et al., 2003). The special nature of computer-mediated communication subsystems embedded in the CSCL environment (e.g. text-based e-mail, forums, chat) affects the type of messages exchanged and how the messages are interpreted (Daft & Lengel, 1984; Daft et al., 1987). This appears to alter interpersonal communication (Rice, 1992; Short et al., 1976) and consequently the development of both interpersonal relationships and groups (Culnan & Markus, 1987; Walther, 1996; Walthers et al., 1994) as well. In addition, CSCL environments are used predominantly during task execution, excluding social off-task communication.

As regards the social interaction factor, Rourke (2000b) remarks that "if students are to offer their tentative ideas to their peers, if they are to critique the ideas of their peers, and if they are to interpret others' critiques as valuable rather than as personal affronts, certain conditions must exist. Students need to trust each other, feel a sense of warmth and belonging, and feel close to each other before they will engage wilfully in collaboration and recognize the collaboration as a valuable experience". The later is especially emphasized. Northrup (2001),

Gunawardena (1995), and Cockburn and Greenberg (1993) stress the need for relationship building and sharing a sense of community and a common goal. Finally, Wegerif (1998) noted that "forming a sense of community, where people feel they will be treated sympathetically by their fellows, seems to be a necessary first step for collaborative learning. Without a feeling of community people are on their own, likely to be anxious, defensive and unwilling to take the risks involved in learning".

Wegerif (1998) emphasizes the point that "many evaluations of asynchronous learning networks understandably focus upon the educational dimension, either learning outcomes or the educational quality of interactions, overlooking the social dimension which underlie this". Kreijns et al., (2003) adapts Gilroy's (2001) to propose an interesting formula (see Figure 4.6):

Valued Learning Experience = F [Pedagogy; Content; Community]
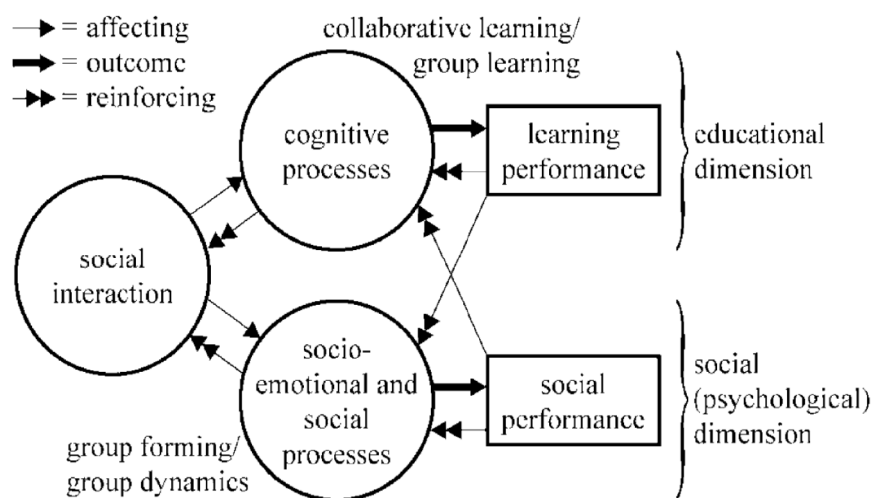


Figure 4.6: Factors that Evaluate the Real Time Learning Experience

If any one of the three variables approaches zero, the function also approaches zero (Kreijns et al., 2003). This means that we need all the three variables to exist at the same time, i.e. a functional pedagogy for instruction, relevant content to be learned, and a working community of learning. Otherwise the learning experience will be low or non-existent.

Real time assessment needs a set of rubrics capable to evaluate these two factors and offer an effective feedback to collaborative task, member and group. The rubrics can be similar to those usually used to evaluate transversal competences which show the levels of consecution and semantic description about what is involved to achieve each level.

The rubric lower levels are related with basic communication and interaction skills. The members are capable to exchange basic ideas but are not involved in the common task. The successive levels grow in complexity and ideas are interchanged. The highest level is achieved when the learning community and the membership awareness appear.

Building an affective structure entails a process of affiliation, impression formation, and interpersonal attraction to induce and promote social relationships and group cohesion. Affiliation is the propensity according to which people have to get in contact with others. Affiliation will occur if group members perceive that they are mutually dependent on each other

to successfully accomplish the working- and learning tasks leading them to get in contact with each other (Kreijns et al., 2003).

Social relationships contribute to group cohesion, common understanding, an orientation towards cooperation and the desire to remain in their group. An important attribute of group cohesion is mutual trust amongst group members: the cognitive and affective assurance that group members respect each others' interests and, therefore, can orient themselves towards each others' words, actions, and decisions with an easy conscience (Emans et al., 1996). Social relationships, group cohesion, and trust define the affective structure in the social space that in turn reinforces social interaction.

The rubric can also consider the member role as an important aspect to evaluate the real time communication and interaction. Roles provide the structure to facilitate collaboration and task completion (Morris et al., 2010). When structure is provided through roles, students perceive a sense of security and, therefore, are able to concentrate on the task. Roles can be defined as prescribed functions that guide individual behaviour and group collaboration (Slavin, 1995). They may also be viewed as a scaffold in the learning process where the goal of collaboration is to acquire new knowledge, including cognitive and collaborative skills. Assigning roles may foster interdependence while concurrently requiring individual accountability (Slavin, 1995). Roles can further be classified as procedural/functional roles and cognitive/intellectual roles (Palincsar & Herrenkohl, 2002).

But providing students with roles to aid collaboration may not be sufficient to change collaborative processes and outcomes completion (Morris et al., 2010). Students may not know how to carry out the role or may need additional structure to feel confident to collaborate or complete a task. It is necessary to build a competence level in order to develop the role and advance in the e-learning task. These competences can be acquired previously or be developed during the same task. The benefits of structure in collaboration are especially prominent when tasks are demanding and may potentially result in cognitive overload. To improve efficiency, students may require additional scaffolds to help deal with task completion and collaboration (Rummel & Spada, 2005). Providing structure or information about how to carry out a role does not have to involve human guidance in the CSCL environment (Ge & Land, 2004). Computer-based collaborative environments offer potential in that support for collaboration can be provided automatically through scripts and prompts (Morris et al., 2010). Scripts are rubrics description about how to develop a role step by step. Prompts are guides about what to do or say within that role. Scripts and prompts can be possibly evaluated more reliably if each member is doing its task and is aware about the level achieved.

**Deferred Time Assessment**

Why makes a deferred-time assessment? There are two main reasons. The first one is related to the virtual learning environment. If the learning environment has limitations to assess in real time, we can only do it later in a deferred process. The second reason is related to the type of indicators that we desire to obtain. The deferred time assessment will be used if we wish to obtain indicators which can only be obtained once we have collected a sufficient amount of data.

How to understand the collaborative learning process? Based on the work of Self (1994), Pilkington (1999), and Soller (2001), partners are involved in a process of realizing a great number of learning actions which lead to the completion of the exchange goal (Caballé & Mora et al, 2011b). Each move type captures and controls the evolution of the learning action performed by a participant by setting the expectations of the type of learning actions which has to be realized next by the other participants so that the goal set by the initial move be accomplished.

Quantity and quality of move types performed are measured by the collaborative effort of the members involved to achieve the discourse goal of an exchange. The term collaborative effort means both the number of contributing and supporting moves issued by a participant, which indicates an active participation (proactive o reactive) or passive one. It is also considered the type and effectiveness of these moves, which indicate the way a participant contributes toward the achievement of the shared discourse goal, as regards knowledge possession and transfer, reasoning capability and positive attitude.

Participants are proactive when they take the initiative to open a new exchange of the type give-information, or raise-an-issue. Participants are reactive when they reply to moves such as elicit-information, set-up-an issue/problem, or provide-solution. Passive participants are considered those who just read others' contributions, as well as the ones who also evaluate the usefulness of these contributions. Passivity becomes an essential indicator for the discussion process' dynamics as it identifies certain important profiles of the participant, such as arrogance (participant who just contributes but does not read the contributions of others) and also promotes reactive attitudes and social grounding skills by engaging the participant in the collaborative process (Dillenbourg, 1999).

Completion of an exchange expresses the mutual beliefs of all participants about the accomplishment of its discourse goal. Moreover, it implies the achievement of certain degree of knowledge building and distribution among the different participants. This degree can be deduced and measured by exploring the principal interaction indicators. It is necessary to collect relevant data to determine the total number of interaction moves, type of interaction (proactive, reactive, or supportive-passive), the effectiveness and relevance of each interaction move in the discourse and in the achievement of the current discourse goal, as well as the evaluation of the move content and significance by his/her peers and the tutor (Caballé & Mora et al, 2011b).

In general, the three general types of exchanges (proactive, reactive or passive) represent standard discourse structures for handling information and suggest a certain type of knowledge building (Caballé, & Mora et al, 2011b). These discursive structures enable the participants to take turns, share information, exchange views, monitor the work done and plan ahead. Most importantly, they provide a means to represent the cognitive product at individual level, that is, the way the reasoning process is distributed over the participants as it is shared in a collaborative discourse. Consequently, interaction analysis must take into account the way the interaction is structured and the types of contributions, which are explicitly defined and expressed (Caballé et al, 2009). The analysis results yield very useful conclusions on aspects such as individual and group working, dynamics, performance and success, which allows the

tutor to obtain a global account of the progress of the individual and group work and thus to identify possible conflicts and monitor the whole learning process much better.

The impact indicator can be related with the number and type of reactions received after an interaction move occurs in a current discourse or task. The reaction can be considered as positive, negative or null. A positive impact means that the interaction move is accepted and included in the discourse or task. If the interaction move is rejected it can be consider as a negative reaction, but if the interaction move is ignored it can be considered as null.

The effectiveness indicator of a move is calculated by the mean value of the number of assent moves received. Only give-information and raise-an-issue exchange acts can be assented. A negative assent requires a reason to be rejected, which generates another move interaction in the current discourse or task.

Other indicators can be also included. Peer and/or tutor assessment indicators can evaluate the quality of the contribution's content, being the tutor the one who monitors the discussion process and the usefulness of the student contribution who participates in the discussion. All quantitative and qualitative indicators are to be weighted adequately according to the specific goals and procedures of each discussion. To that end, a fully customizable environment is necessary to parameterize and adjust each indicator with an appropriate weight by the tutor at any moment of the discussion process.

Finally, relevant feedback is provided to the discussants and tutors based on the data collected and following a methodology that identifies and measures relevant dimensions of the discussion process.

## 4.3.3 A cognitive assessment approach for evaluating collaboration in CC-LR

The assessment model proposed in this research is based on the integration of several models and methods (see Table 4.2 and Caballé, & Mora et al., 2011b, for the details of this model).

| Exchange moves | Categories |
| --- | --- |
| *support* | Greeting |
| | Encouragement |
| | Motivation |
| *elicit-information* | REQUEST-Information |
| | REQUEST -Elaboration |
| | REQUEST -Clarification |
| | REQUEST -Justification |
| | REQUEST -Opinion |
| | REQUEST –Illustration |
| *give-information* | INFORM-Extend |
| | INFORM-Lead |
| | INFORM-Suggest |
| | INFORM-Elaboration |
| | INFORM-Explain/Clarification |

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| | | |
|---|---|---|
| | INFORM-Justify | |
| | INFORM-State | |
| | INFORM-Agree | |
| | INFORM-Disagree | |
| *set-up-an-issue* | PROBLEM-Statement | |
| *provide-solution* | PROBLEM-Solution | |
| *consent-solution* | PROBLEM-Extend solution | |
| | PROBLEM-Assent solution | |

*Table 4.2: List of moves and categories to classify a discussion contribution.*

The structure of a long interaction in a collaborative discussion is constructed cooperatively by using the exchange as the basic unit for communicating knowledge. Three general exchange structure categories are considered: give-information, elicit-information and raise-an-issue, which consist of different types of moves (Self, 1994) and describe a generic discourse goal. More specifically, the goal of the actor who initiates the give-information exchange is to inform his/her partners about a certain situation with the aim to change the partners' mental states. Informing includes moves that explain, give an opinion, describe or remind a situation in different ways. The actor goal of the elicit-information exchange is to elicit the partners' state of mind (knowledge, beliefs, attitude, desire or abilities) of a situation, in which the actor is not aware or certain about. The actor goal of the raise-an-issue exchange is to raise a problem or question to be resolved by the participants, which causes to explore their state of mind (knowledge, beliefs, etc). Finally, peer assessment can be effected to complete the evaluation of each contribution made. The roles that these moves play in the exchange as well as the degree of success of that role determine the successful completion of the exchange goal (see Table 4.3 for the whole picture of indicators that assess collaboration and the exchanges involved).

Based on the above considerations, deferred or retrospective time assessment of live discussions allows for understanding how the original collaborative interactions developed over time. This information is displayed in the CC-LR by 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 (see Table 4.3). Note that passivity is related to participation frequency, while proactivity is related to contents' quality (Caballé, & Mora et al., 2011b).

| Activity | | Number of contributions | ANY |
|---|---|---|---|
| | *Proactivity* | Active participation No replied contribution | INFORM REQUEST PROBLEM STAT. |
| | *Reactivity* | Active participation Replied contribution | ANY – Greetings Encouragement Motivation |
| | *Support* | Participation to motivate and encourage | Encouragement Motivation |
| Passivity | | Passive participation | |
| | *Pending to read* | Number of contrib. pending to read | ANY – Greetings Encouragement Motivation |
| | *Pending to evaluate* | Number of contrib. pending to evaluate | ANY – Greetings Encouragement Motivation |
| Impact | | Impact of a contrib. on the discussion process | |
| | *Positive* | Reply+REQUEST Reply+PROBLEM-SOL | INFORM PROBLEM-ASSEN/ PROBLEM-EXTEN |
| | *Negative* | Reply+INFORM Reply+PROBLEM-SOL | REQUEST REQUEST/INFORM |
| Effectiveness | | Participant consents a contribution | |
| | *Positive* | Assientment YES | INFORM/PROBLEM |
| | *Negative* | Assientment NO | INFORM/PROBLEM |
| Assessment | | Quality content assessment | |
| | *Tutor assessment* | Tutor assessment | ANY – Greetings Encouragement Motivation |
| | *Peer assessment* | Peer assessment | ANY – Greetings Encouragement Motivation |

*Table 4.3. Indicators that assess participation behavior, knowledge building, and performance in a collaborative process. Second column shows the qualifiers for each indicator. Third column describes further each indicator and how to qualify them. Last column shows the specific post categories involved in each indicator (see Table 4.1).*

Therefore, the learner consuming a CC-LR achieves a better understanding of the collaborative learning process while improving the overall collaborative and social experience. For instance, by constantly showing in the CC-LR cognitive assessment information about the live collaboration, the learner can develop reflective and experiential learning skills by analysis and application. Large amounts of information data are considered in the CC-LR from asynchronous interaction, which includes complex issues of the collaborative work and learning process (e.g., group well-being as well as self-, peer- and group activity evaluation) (Daradoumis et al., 2006).

## 4.3.4 A Social Network Approach for e-Assessment in Collaborative Complex Learning Resources

As mentioned in Chapter 3, students use CC–LRs to develop their collaborative abilities and competences through a sequential and integrated process, in which assessment and emotional indicators, rules, and the use of the CC–LR are continuously evaluated. In this section, new forms of social network assessment are incorporated to empower the learning experience and improve the student's engagement.

First, in order to measure the networking interactions from the live discussion, we consider the following social indicators from SNA (Marin et al., 2011) (see also Table 4.4):

- **Degree centrality**: It is measured counting the number of connections to other persons. In other words, centrality indicates how a student communicates directly with the others. In directed graphs, this centrality measure has two components: in-degree centrality (number of incoming connections) and out-degree centrality (number of outgoing connections). A high value of centrality indicates a student's predisposition to receive information (and to be influenced) by others. Conversely, a high out-degree value indicates a person's ability to have an influence on others.

- **Closeness centrality**: it shows the distance between one student and the other in the network. It shows the communication facility of a pair of students. Nodes with small centrality values mean that they are "close" to each other. In other words, we expect that the smaller the centrality value is, the higher the influence of the node in the network is.

- **Betweenness centrality**: it measures how important a student is in bridging two different parts of a network. The removal of a student with high Betweenness could create an important dysfunction in the network. These specific nodes are very influential in the network topology.

- **Eigenvector centrality** is a measure of the importance of a node in a network. A student's position in the network is influenced by the other student's position. In other words, a person's position (influence) in the network increases due to people with high position (influence).

Next, in order to understand and measure the social perspective of the networking interactions, we follow and consider the following SNA indicators, which help identify the network members (nodes) and the relations between them (see Table 4.4):

- **Member similarities** occur when two nodes share the kinds of attributes frequently studied in variable-based approaches, such as demographic characteristics, attitudes, locations, or group memberships.

- **Social relations** include kinship or other types of commonly-defined role relations (e.g., friend, student); affective ties, which are based on network members' feelings for one another (e.g., liking, disliking); or cognitive awareness (e.g., knowing).

- **Social interactions** refer to behavior-based ties such as speaking with, helping, or inviting in one's home. For example, researchers may measure discussion networks as proxies for core support networks (Bloom, 1956; Marsdeb, 1987).

- **Social flows** are relations based on exchanges or transfers between nodes. These may include relations in which resources, information, or influence flow through networks. Like interactions, flow-based relations often occur within other social relations, and researchers frequently assume or study their co-existence.

In overall, this social network approach annotates and examines a variety of elements that contribute to the understanding of the social nature of the collaborative interactions in the network, such as the students' influential position to other students, communicative behavior, social relations, profile and role, etc. The aim is to provide the overall assessment model.

| SNA indices & indicators | Metrics from the original CSCL sessions |
|---|---|
| *Degree centrality* | Number of ties directed to each node Indegree). Number of ties that each node directs to others (Outdegree) |
| *Closeness centrality* | Measured for each pair of nodes: number of nodes in the path from one node to other |
| *Betweenness centrality* | Number of times a node acts as a bridge along the shortest path between two other nodes |
| *Eigenvector centrality* | Assigns scores to all nodes in the network. Connections to high-scoring nodes contribute more to the score of the node in question than equal connections to low-scoring nodes |
| *Member similarities* | Based on previous collected data, from a previous test or institutional data base |
| *Social relation* | Social relation is qualified from the emotional information added and messages collected |
| *Social interaction* | Measured by comparing a pre and post test of the collaborative activity |
| *Social flow* | Measured from the material exchanged during the collaborative activity. |

*Table 4.4. Metrics from the original CSCL task produces the SNA indices and indicators to be used for e-assessment in CC-LR.*

# 4.4 Prototyping and testing

Here we show the construction of an early version of the CC-LR prototype from an original discussion (see Figure 4.7) considering only those social network assessment indicators coming from our SNA approach (see (Caballé, & Mora et al., 2013) for the CC-LR prototype with cognitive assessment).

## 4.4.1 Prototyping
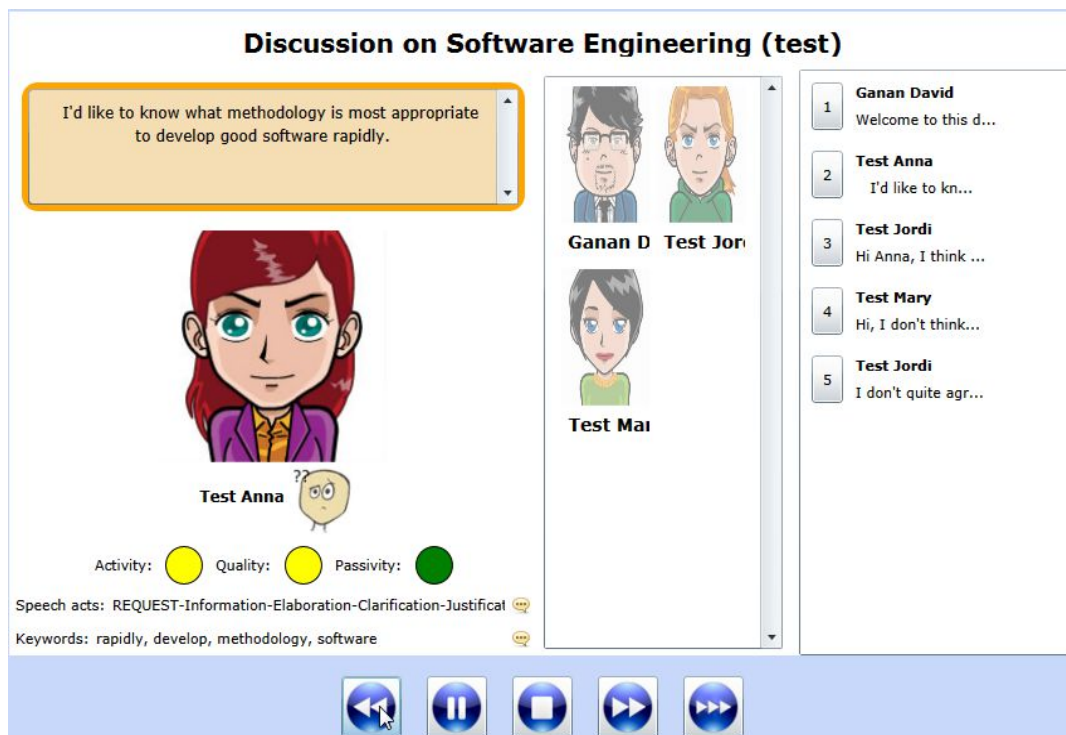


*Figure 4.7:    A CC-LR prototype showing cognitive and social network assessment (traffic light data).*

The target CC-LR comes from a live on-line discussion on engineering education. The management of social network assessment was based on SNA and presented in the CC-LR as assessment information on the original discussion and participants, in terms of Centrality and Communication indicators (see Figure 4.7 and also Table 4.4):

- **Activity-Centrality** refers to the degree of integration into the learning group. A greater centrality means greater involvement in collaborative group dynamics whilst little centrality means a peripheral social situation or simply a not participating role in the discussion. Centrality indicator is addressed by considering the Degree and Betweeness indices, which in turn are extracted from the number of posts in each thread.

- **Quality-Relevance** refers the importance or relevance of the intervention within the dialogue that is being performed.

- **Passivity-Communication** indicates the level of transmission within the learning group. Communication indicator is addressed by the direction of the interactions that each student presents. However, interactions are sometimes unidirectional without any interactive purpose.

These indicators are represented in the CC-LR as social network assessment information and displayed as traffic-light data, in order to rate each indicator with 3 possible values, namely red, yellow and green (see Figure 4.7). The indicators values have been obtained from the

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study and analysis of real data forum from which the activity has been designed. These values represent the level of social network behavior of each participant throughout the CC-LR, thus all the appearances of the avatar in the CC-LR shows the same values. Therefore, students consuming the CC-LR as a teaching material will learn about the original participants of the discussion from these indicators and will figure out better the meaning, intention and reliability of the contributions according to the information displayed on the participant.

## 4.4.2 Testing

This section presents a methodological approach to technically test our definition of the notion and nature of CC-LRs presented in previous sections by testing a proof of concept that enables the embedding of a CC-LR into the VCS prototype. The results of the tests will be shown based on a set of indicators we incorporated and present here to measure and ultimately analyze our prototype.

### *Procedure*

A user assessment of the prototype was carried out to evaluate the proof of concept at the Open University of Catalonia. A group of three testers formed by an expert (i.e., researcher in e-learning), a skilled technician and a novice user performed testing of the VCS prototype by using different data input and running several executions of the prototype. The aim was to test the prototype focusing on the following four indicators of interest presented to the testers in this questionnaire in terms of usability, performance and overall satisfaction (note that our assessment framework is not yet directly evaluated here, next chapter will provide an intensive experimentation and validation of the assessment framework):

1.  Build automatically an effective draft storyboard (CC-LR) 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-LR (i.e., in a friendly way and efficiently). Score on scale 0-5.

3.  Create, edit, manage, store and playback the generated CC-LR. 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.

The procedure of the experiment at UOC consisted in running five rounds of the same tests in a row by each tester and the results were collected.

### *Results*

*Quantitative Results*

Table 4.5 shows 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 in the last section. Each tester performed 5 executions in a row before providing the scores.

| Testers | Indicators of interest | | | | |
|---|---|---|---|---|---|
| | #1 | #2 | #3 | #4 | Total (M) |
| # Expert | 4 | 4 | 2 | 2 | 3.0 |
| # Technician | 5 | 4 | 4 | 3 | 4.0 |
| # Novice | 5 | 4 | 4 | 2 | 3.8 |
| Total M(SD) | 4.6(0.6) | 4.0(0) | 3.3(1.1) | 2.3(0.6) | 3.6(0.5) |

*Table 4.5. Mean (M) and Standard Deviation (SD) score in the 0-5 scale.*

*Qualitative Results*

Table 4.6 shows an extract of the qualitative results from those indicators with open comments provided by the testers after the test.

| Indicators of interest with open comments | Excerpt of testers' 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) <br><br> "The automatically created SLO follows the same structure as the threaded discussion " (T) <br><br> The draft SLO should be larger to be tested appropriately" (E) |
| Create, edit, manage, store and playback the generated storyboard | "I could fully control the storyboard with the play, pause, stop, back and forward controls and playback the discussion many times." (N) <br><br> "The player only gives a sequential view of the knowledge " (T) |
| VCS prototype allows users to observe how knowledge is constructed. | "Yes, it was possible to observe some knowledge building but it still misses the editor tool to remove some scenes that cause noise" (E) <br><br> "It is very interesting and much easier to follow a discussion!" (N) |

*Table 4.6. Selected open comments of the testers on the VCS prototype.*

*Discussion*

From the quantitative results collected at UOC site, we can see that despite the total score is promising it is not high due to the VCS prototype currently offers the player tool only. In particular, variables #3 and #4 were scored low by the expert tester since the prototype could not still offer all its potential regarding the edition of the storyboard, which in turn limited the improvement of the storyboard-based discussion.

In contrast, from the data collected of the novice user tester it is evident the potential of the VCS player tool as it provides a great leap forward by the provision of an attractive resource that motivated and engaged the tester in the test discussions.

It is worth mentioning that, the effectiveness and real application of this prototype were determined by the circumstances of the educational environment where it was implemented. As a result, the prototype tests were not designed for in-depth checking of knowledge

acquisition, but the usefulness and usability of the tool by users. The tool potential can be considered as promising, requiring adequate educational planning.

To sum up, the results of the tests reported here are not conclusive due to its exploratory nature. However, they showed the main processes and concepts of the new paradigm of CC-LO as well as guidelines for their use by educators on a wide scale.

## 4.5   Summary of the Chapter

This chapter investigates issues concerning the design, construction and execution of an assessment framework for online collaborative and social Learning scenarios. To this end, we first examined the use of CSCL models, methods and tools for the design, construction and execution of Collaborative and Social Learning scenarios reviewed in Chapter 2. Given that a scenario definition for collaborative learning may be a particularly complex endeavour, we first should take into account Bandura's requirements of social learning and then consider CSCL pedagogies and tools that can help educators construct effective collaborative and social learning experiences for e-assessment purposes, by providing them specific design aids. Such design aids span from the use of Learning Design (IMS-LD) as an educational modeling language that enables the description of any learning process in a formal way to the employment of collaboration scripts that aim to support and assess learning activities by structuring otherwise deficient interactions in a way that describes how learners have to collaborate (through task distribution or roles, turn taking rules, work phases, deliverables, etc.). Subsequently, we turned to explore how to use collaborative and social learning scenarios for assessment purposes in the context of formal, informal and intentional learning experiences. In each of these three learning experiences, we examined how the collaborative process can be assessed as a specific assessment approach that can be realized through different assessment methods and phases.

Our assessment framework is then incorporated into the CC-LR approach described in Chapter 3 for prototyping and testing purposes. The results of the tests reported here are not conclusive due to its 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. Main concern is to 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-LRs. This is fundamental to applying the main processes and concepts of the new paradigm of the CC-LR, as well as providing guidelines for their use by educators on a wide scale.

Next chapter (Chapter 5) of the thesis will carry out intensive evaluation and validation activities in real contexts of eLearning on the specific model and indicators of the assessment framework presented in this chapter integrated into the CC-LR approach to support and enhance virtualized collaborative learning activities.

# A Multi-fold Assessment Framework for Virtualized Collaborative and Social Learning Scenarios

## Chapter 5: Evaluation and validations

## Case studies

# 5.1 Chapter overview

This chapter describes the results of the experimentations, evaluation and validation activities of this thesis research.

The aim of this thesis research is to develop an innovative assessment framework for CSCL combining personalization, collaboration and networking aspects within a cognitive and social based approach. The ultimate goal is to overcome the quoted limitations of interactivity, challenging and context aware of current e-learning systems and content, while enabling learners' demand of empowerment, social identity, and authentic learning experience.

Following this goal, the aim of this chapter is to present the results of the execution of the different rounds of experimentation and validation of the research and technology developed in this thesis. To this end, a practical method oriented to the experimentation of the tools developed and organized as prototype scenarios and its validation in real situations in different educational sites is followed.

It is worth clarifying at this initial point that the experimentation, evaluation and validation activities reported here are not intended to report a technical testing plan of each of the individual developments of the thesis nor their integration process into the different LMS involved. A technical testing was instead conducted in last stages of the whole thesis developments to validate the beta prototypes with the intent of finding software bugs and first feedback from a small set of testers in a very controlled situations (see Section 4.4 of Chapter 4).

Therefore, this chapter reports the final results of the experimentation, evaluation and validation of the thesis' prototypes and considering all individual developments have been tested and integrated into the referenced LMS performing the role of the e-learning system. To this end, Annex A of this document reports the integration activities performed in each pilot site (UOC, UCA).

## 5.1.1 Purpose

This chapter has the objective of experimenting the developed tools and methodologies in order to provide feedback to theoretical and technological activities of previous chapters. It includes, as well, the evaluation and validation of the impacts of the innovative features offered by CC-LR inside the selected learning environments. There are two different educational sites or scenarios of use where the developed tool in the form of prototypes will be experimented:

- UOC

- UCA

In addition, the purpose of this chapter is to collect information about the experience of incorporating the multi-fold assessment framework based on cognitive and social aspects into real collaborative learning and its impact in the on-line learning process.

Therefore, the objectives and research goals to be achieved by experimentation and validation are to provide evidence, through extended episodes of trials by real learners and teachers, that the developed technological solution of this thesis is effective towards covering the

identified user requirements and implementing the developed scenarios of use, as well as towards enhancing the learning experiences of the various users by contributing to more effective and efficient learning activities, more motivation and inspiration for learners and teachers in various formal and informal learning circumstances.

## 5.1.2 General methodology

A comprehensive experimentation study is developed in this chapter describing all activities that have been undertaken during the experimentation, evaluation and validation stages of the thesis.

The study includes, for each of the two mentioned scenarios of use, details on the goals and hypotheses, the method (including number and type of participants, apparatus and stimuli, and procedure), and the evaluation and validation results. This is the standard structure to report empirical results following APA guidelines (Schellens et al, 2006) and Table 5.2.

| Step | Description/Questions to be considered |
|---|---|
| **1. Evaluation and Validation Procedure** | Which are the goals and the corresponding hypotheses to be verified for evaluating the functional requirements?<br><br>Which are the criteria and the corresponding metrics to be considered for validating the methodology? |
| **2. Method** | |
| **2.1 Participants** | Selection/Description of the participants.<br><br>• How many subjects are necessary/available?<br>• More detailed description (age, gender…)<br>• Are there any constraints? (e.g., only undergraduates, gender, age …)<br>• Selection criteria (e.g., volunteers, participation for course credit…).<br>• Are they informed about the goal of the study? |
| **2.2 Apparatus and Stimuli** | How is the problem investigated in detail (with respect to the hypotheses)?<br><br>What is measured? (e.g., students' knowledge of Topic XY)<br><br>How is the outcome measured/quantified? (e.g., questionnaire, frequencies of log-ins, …) |
| **2.3 Procedure** | Description of the procedure of the planned study<br><br>• Short summary of the main design, assignment of the subjects to the groups, …<br>• What is - in detail - the course of events during the study? (e.g., subject is assigned to the group X, has to fill out a questionnaire (pre-test); learning tool is introduced to the subject; subject is allowed to learn XY minutes; gets a further questionnaire (post-test)…) |
| **3. Evaluation Results** | What about the usability/functionality of the tool? (e.g., Was the system easy to use?)<br><br>What did the students like/not like regarding the tool?<br><br>Were the students aware of the functions (contribution graphs, actions) of the tool?<br><br>What can be improved regarding the tool? |

A Multi-fold Assessment Framework for Virtualized Collaborative and Social Learning Scenarios

| Step | Description/Questions to be considered |
|---|---|
| **4. Validation Results** | Results from the pedagogical and psychological perspective<br><br>• Were the students motivated regarding the experiment?<br>• Did the tool support their learning process? |
| **5. Conclusion** | What are the most important results with respect to the predefined goals? |

*Table 5.2: Reporting a study (APA style) (Bortz, 2006)*

The experimentation study has been localised to better address the local circumstances pertaining in each experimentation site of user groups. Implementation parameters have been determined, such as necessary adjustments to the agenda and needs of the different user groups, technical and organisational preparations, additional technological tools development, selection of the best technical configuration for the specific purposes, etc.

This methodology takes as inputs the user scenarios from the thesis' research plan: "A Multi-fold Assessment Framework for Virtualized Collaborative Learning and Social Networking Scenarios" approved in June 2014 (Research plan, 2014) and performs the definition, integration and experimentation tasks of the resulting software components.

To pursue these goals, communities of user groups (in general, students and teachers/lecturers) were organised in each pilot site (i.e., UOC and UCA), which are educational environments with full or relatively limited e-learning quotes (i.e. full virtual education and blended learning), and in which the extended computational capabilities of this thesis enabled the exploitation by teachers and students of existing advanced educational technologies. For each scenario of use a devoted user group was developed drawing from two different academic contexts, namely Software Engineering and Computing Fundamentals.

All of the experiments are based on the VCS system and the embedded CC-LR learning resource (see Chapter 3) developed, experimented and validated in the context of the European project ALICE (ALICE D8.1.2, 2012) participated by this PhD candidate. This thesis enriched the ALICE project by incorporating a complete **cognitive and social assessment framework** into the CC-LR approach. Therefore, the development, experimentation and validation of the content augmentation of the CC-LR learning resource in terms of assessment was conducted in this thesis and then transferred to the ALICE project. In some experiments reported below, the ALICE project results were used as a reference (i.e. control group), which facilitated the data comparison and interpretation of the results extracted from this thesis.

The deployed VCS system with the CC-LRs embedded and scenarios of its use were exposed, through demonstration activities, to numbers of real users in real settings, with the aim to validate the findings of the pilots with feedback from, and observations of, random users in various educational contexts. In each validation site, several experiments with numerous users performing authentic technology-enhanced learning tasks were performed.

Therefore, a main issue of the experiments is the organization and the management of the user-centred activities in the participating pilot sites. The exact way of implementation as well as the necessary parameters was determined. The timetable of the proposed activities was designed in order to be discussed with the teachers involved. The structure, functionality and features of the prototype used for testing can be found in Annex I.

Finally, the goals and hypotheses formulated for the next user scenarios are related to the current stage of the VCS prototype. In particular, the usability and functionality of the VCS tool to play and observe text-based discussions in a multimedia attractive format. Most importantly, all the scenarios reported evaluate and validate the impact of the multi-fold assessment framework presented in this thesis in terms of impact in the cognitive and social aspects of the learning process.

### *Experiments*

The following three scenarios were experimented at UOC and UCA sites (see Table 5.2): It is worth mentioning that the final results obtained from the experiments are determined by the real circumstances in which the prototype has been tested. The circumstances of the experiment at the UOC and the two experiments run in the UCA are very different (full online vs. blended learning, mandatory vs. optional learning activities, etc) and hence present very different results. Results are therefore to be analyzed according to these different circumstances of each experiment and without comparing to each other in order to extract consistent conclusions.

### UOC

This scenario provides live sessions of collaborative learning based in CC-LR tools to be experienced and played by learners. During the resource execution, learners observe how avatars discuss and collaborate, how discussion threads grow, and how knowledge is constructed, refined and consolidated. The novelty of this experiment is the evaluation of multi-fold cognitive assessment approach included in the CC-LR that provided effective awareness and constructive feedback to learners from both the live collaborative interaction amongst group members.

### UCA-1

The aim of this scenario is to enhance learning engagement using CC-LR with the multi-fold cognitive assessment approach by adding a social dimension with new SNA-based indicators on the original participants. SNA drives the implementation scenario with special emphasis on social learning dynamics.

### UCA-2

This scenario provides a new step on designing a coherent and efficient assessment system for collaborative and virtual social learning. The experience is centred in assessment by Social Network Analysis (SNA) techniques that are able to analyze and represent social network interaction during the live sessions of collaboration by using collaborative complex learning resources (CC-LR).

| Study | Description | Schedule |
|---|---|---|
| UOC | The experiment consisted of 44 undergraduate students enrolled in the course Organization Management and Computer Science Projects of the Bachelor in Engineering Computing degree at the UOC were involved in this experience. These same 44 students formed two groups and both participated during the Spring term of 2012 in the same course: the control group participated in the middle of the course (May 2012) while the experimental group participated at the end of the course (June 2012). | Spring term 2012 |
| UCA-1 | Experimenting with the UCA classroom with 117 undergraduate students enrolled in the first-grade course "Computer Structure Fundamentals" of the Electrical and Computer Engineering program. Eventually, 17 students participated in the experiment" during the first 2 weeks of April 2014. | April 2014 |
| UCA-2 | Experimenting with the UCA classroom with 24 participants enrolled in the third-grade course "Advanced Computer Structure" (ASC) and first year master subject: "Ubiquitous Systems" (US). The experiment was performed in the last week of April and the first week of May 2015. | April 2015 |

*Table 5.3: Overview about the studies*

# 5.2 Evaluation and validation

## 5.2.1 Experiment at UOC

### *Introduction*

The purpose of this experiment at the Open University of Catalonia (UOC) is to validate the innovative Collaborative Complex Learning Resources (CC-LR) augmented with authoring information by means of the SLO Editor, thus showing the **provision of the cognitive assessment designed and implemented from this thesis' assessment framework** (See Chapter 5), which makes the CC-LRs highly interactive. See Figure 5.1 below and (Caballé, & Mora et al.; 2014) for more details.

The CC-LR tools (VCS Editor) were experimented at UOC site with real students who used the CC-LR to complement the official learning material of the course. From the experimentation data obtained, the CC-LR without assessment information was evaluated and validated from different aspects and perspectives related to impact on students and the learning process.

To experiment with the CC-LR approach **enriched with assessment information** from the student's viewpoint and evaluate and validate it as for the usability, emotional, impact in the learning process, etc., we focused on the following scenario goals and hypotheses as well as criteria and metrics derived from:

### *Scenario goals*

- G5.1: To employ the CC-LR in online courses in order to enhance the cognitive aspects of the teaching/learning process.
- G5.2: To identify possible ways of improving further the utility of the CC-LR in online courses.

- G5.3: To create, store and playback the generated CC-LR through a user friendly interface.
- G5.4: To build (automatically) a draft CC-LR from a collaborative activity effectively
- G5.5: To build (automatically) a draft CC-LR from a collaborative activity efficiently

***Scenario hypotheses***

- H5.1: Use CC-LR by non-expert users (i.e., in a friendly way and efficiently).
- H5.2: Use of CC-LR contributes to significantly improve students' motivation.
- H5.3: Use of CC-LR to significantly increase students' activity levels, both in individual and collaborative activities.
- H5.4: Use of CC-LR contributes to significantly improve students' understanding of key concepts and students' results.
- H5.5: CC-LR is considered as a worthy educational resource by students.

***Method***

*Participants*

The real context of this experience is the virtual learning environment of the Open University of Catalonia (UOC).

In order to evaluate the CC-LR enriched with assessment information and analyze its effects in the learning process, the sample of the experiment consisted of 44 undergraduate students enrolled in the course Organization Management and Computer Science Projects of the Bachelor in Engineering Computing degree at the UOC were involved in this experience.

These same 44 students formed two groups and both participated during the spring term of 2012 in the same course: the control group participated in the middle of the course (May 2012) while the experimental group participated at the end of the course (June 2012).

The control group participated in the mentioned previous experiment of May 2012 with a CC-LR with no content augmentation (i.e. no assessment information was yet incorporated). The goal of that experiment was to evaluate the usability and functionality of the VCS tool to edit and play text-based discussions in a multimedia attractive format (CC-LR) from the student' view in support for a formal in-class assignment of collaborative learning based on a discussion. The experiment was run in the context of the European project ALICE and the results are taken here in this thesis as the control group to be compared to the experimental group.

Despite all 44 students participated in this experience, only 24 out of them (54.5%) submitted the final questionnaire, the rest of students (20) dropped out the course for personal reasons. It is worth mentioning that the 45% dropout ratio found is considered normal at the end of the UOC academic term when the experience was run[20]. Each group was supervised by the same tutor as the official lecturer in charge of the course.

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[20] 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.

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*Apparatus and Stimuli*

Students of the experimental group were required to use a standard forum equipped with the multimedia-based VCS tools, SLO Editor and Player (see Figure 5.1). The mentioned CC-LR was previously prepared by using the VCS tools and uploaded on the UOC on-line classroom as regular teaching materials.



*Figure 5.1: An SLO generated from a live discussion in a standard web forum is edited by the VCS-SLO Editor to create a CC-LR, which contains different types of scenes and author information.*

The CC-LR contained cognitive assessment information, both deferred and immediate (see Section 3.7 for further information). Deferred cognitive assessment of past sessions can be added in the CC-LR by the editor tool (see Figure 5.2) 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 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 is to help learners during knowledge acquisition.
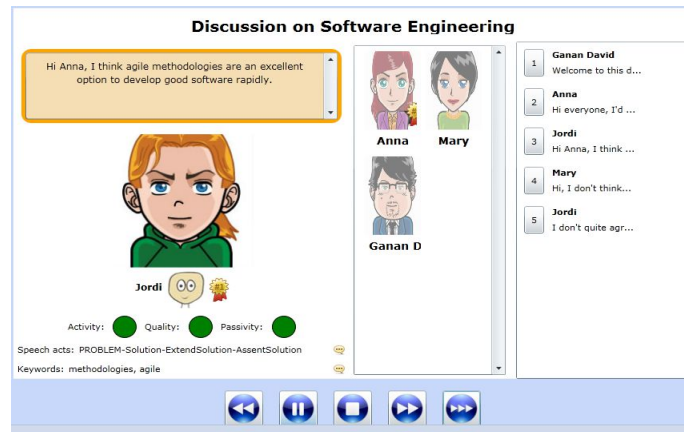
*Figure 5.2: Cognitive information of the original participant is added below the avatar in the form of performance indicators (Red, Amber and Green representation.*

Immediate cognitive assessment was 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 consumed (see Figure 5.3). 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 5.3a). In case of failing the test repeatedly the learner is leaded to a special scene with content augmentation about the topic of the discussion (Figure 5.3b).



*Figure 5.3: Immediate cognitive assessment; on the left (a) an evaluation test is shown with automatic feedback, and on the right (b) additional information is proposed after failing the test several times.*

### Procedure

A formal learning assignment was scheduled during the last 2 weeks of June 2012 in the mentioned course of Software Engineering from the Bachelor in Engineering Computing degree at the UOC. The participants of the experimental group participated in this activity.

The activity was individual and mandatory for all students and consisted in filling a test about questions on Software projects management. A part from the usual didactical material of the course the students of the experimental group also received a new material to support specifically this activity in the form of a CC-LR (CC-LR) called "Factors that lead a Software

project to failure" which contained a discussion about project management. This material was greatly enriched with special types of scenes with assessment information, which made the material highly interactive. The students entered the on-line classroom to find and watch this interactive as a sort of CC-LR.

Finally, since the participants of the experimental group were the same as the participants of the previous experiment, they had been already experimented with the VCS tools and in particular the CC-LR. Therefore, we will compare the evaluation and validation aspects with those results of the previous experiment forming the control group. All this data was already reported in the ALICE project (ALICE D8.1.2) (de Laat et al.; 2007) and the feedback provided served to improve the prototypes for this new experiment.

After the assignment, the students were required to fill out a questionnaire, which included the following 7 sections: (i) identification data (names and username); (ii) open questions about the knowledge acquired during the discussion; (iii) test-based evaluation of the supporting CC-LR (CC-LR), which included a motivation test; (iv) test-based evaluation of the CC-LR; (v) test-based evaluation on the usability of the VCS system; (vi) test-based evaluation on the emotional state; (vii) a test-based evaluation of the questionnaire.

For qualitative statistical analysis, we summarized the open answers in the surveys. For the quantitative statistical analysis we employed basic statistics, such as Mean (M), Standard Deviation (SD) and median (Md). Then we compare these statistics between the experimental group and the control group.

For the section v (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. SUS is generally used after the respondent had an opportunity to use the system being evaluated.

Finally, to investigate in which emotional state the students using the new system, which include 12 items of the Computer Emotion Scale (CES) (Kay and Loverock, 2008). The CES scale is used 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.")
- 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".

The data from this experience was collected by means of the web-based forums supporting the discussions in the classroom. Moreover, quantitative and qualitative data were collected from questionnaires containing quantitative and qualitative questions, the answer categories varied between rating scales, multiple choice or open answers. Regarding the rating scales, for the majority of the quantitative questions we used the 5 point Likert scale, so that students could state their level of agreement or disagreement. The rating scale ranged from "I strongly disagree" (1), "I disagree" (2), "neither/nor" (3) to "I agree" (4), "I strongly agree" (5).

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### Evaluation Results

Following the methodology described in Section 5.1, in this section we focus on usability and emotional aspects of the CC-LR (H5.1) of both the control group and experimental group. An evaluation of the questionnaire was included. On the other hand, the analyses of the tool's overall impact on student's learning process are reported (H5.2).

### Activity levels

Due to a technical problem with the log system, we could not collect the interactivity of the experimental group with the CC-LR during the learning activity.

### Usability of the CC-LR (CC-LR) enrich with author information

To evaluate student's satisfaction of the experimental group with the tool, enriched with cognitive and emotional information, as for an efficient and user-friendly management (H4.2.1), we collected data from students' ratings and open comments on the usability/functionality/integration of the tool.

To investigate the overall usability of the CC-LR, we used the SUS scale described above. . As mentioned, the answers were given on the 5-point Likert scale, so that students could state their level of agreement or disagreement. The rating scale ranged from "I strongly disagree" (1), "I disagree" (2), "neither/nor" (3) to "I agree" (4), "I strongly agree" (5).

SUS scores have a range of 0 to 100 with an average score of 68, obtained from 500 studies. A Score above a 68 would be considered above average and anything below 68 is below average. A score above an 80.3 is considered an A (the top 10% of scores). Scoring at the mean score of 68 gets you a C and anything below a 51 is an F (putting you in the bottom 15%).

After calculating the SUS score for each student, we got an average for **24 SUS scores of 69.27**, thus above the SUS mean and also above the control group (25 SUS scores of 68.20). Next, we present the most relevant results of the SUS score by providing several statistics: Mean (M), Standard Deviation (SD) and Median (Md).

The results of the experimental group and control group as for the usability of the the CC-LR are the following:

- Students of the **experimental group** (n=24) thought they will use the *CC-LR* often (M = 3.36, SD = 1.09, Md = 3.5) (See Figure 5.4). Students did not find the tool unnecessarily complex (M = 2.18, SD = 0.96, Md = 2) (See Figure 5.5). In addition, students stated that they did not need the support of a technical person to be able to use the CC-LR (M = 1.68, SD = 1.00, Md = 1) (*Figure* 5.6), they thought that most people would learn to use this system very quickly (M = 4.22, SD = 0.58, Md = 4) (See *Figure* 5.7), and they felt quite confident using the CC-LR (M = 3.86, SD = 0.70, Md = 4) (See *Figure*5.8).
- Students of the **control group** (n=25) thought they will use the CC-LR often (M = 3.13, SD = 1.29, Md = 4). Students did not find the tool unnecessarily complex (M = 2.43, SD = 1.22, Md = 2). Students stated that they did not need the support of a technical person to be able to use the CC-LR (M = 1.47, SD = 0.65, Md = 1), they thought that

most people would learn to use this system very quickly (M = 4.04, SD = 0.61, Md = 4) and they felt confident using the CC-LR (M = 3.69, SD = 0.80, Md = 4).

So far, the results of the experimental group are above the average and better than the control group, though slightly. The results of both the experimental and control groups confirmed that the students found the usability in general satisfactory or very satisfactory in line with the SUS score found.
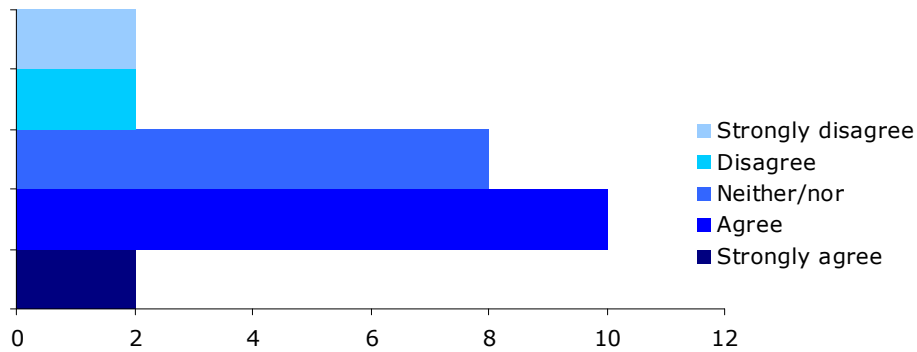


*Figure 5.4: Results on the SUS item "I think I will use the CC-LR often"*
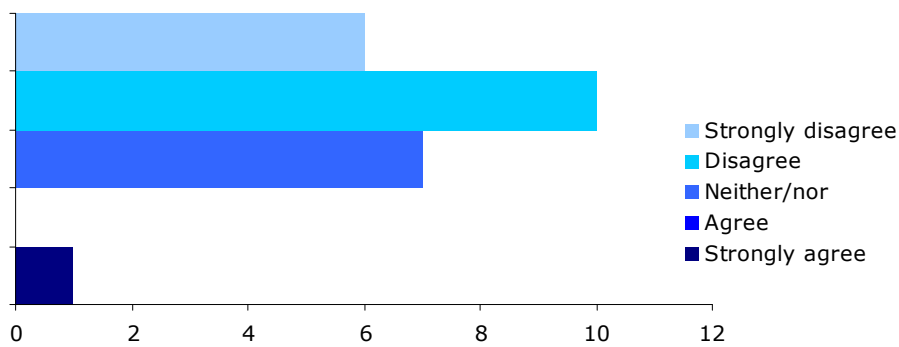


*Figure 5.5: Results on the SUS item "I think the CC-LR was unnecessarily complex".*
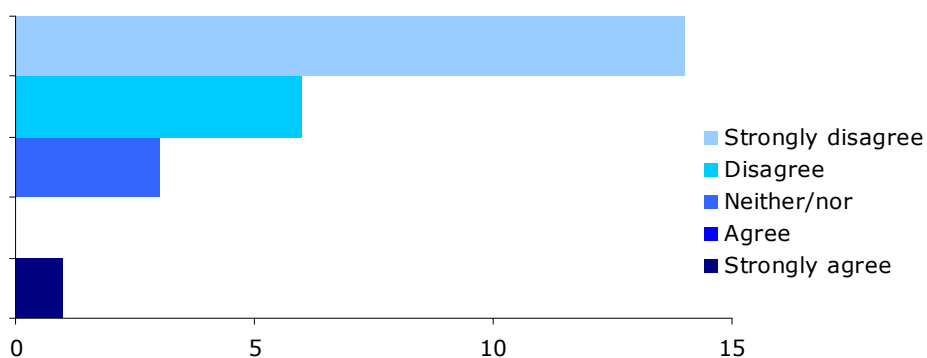


*Figure 5.6: Results on the SUS item "I think that I would need the support of a technical person to be able to use the CC-LR".*
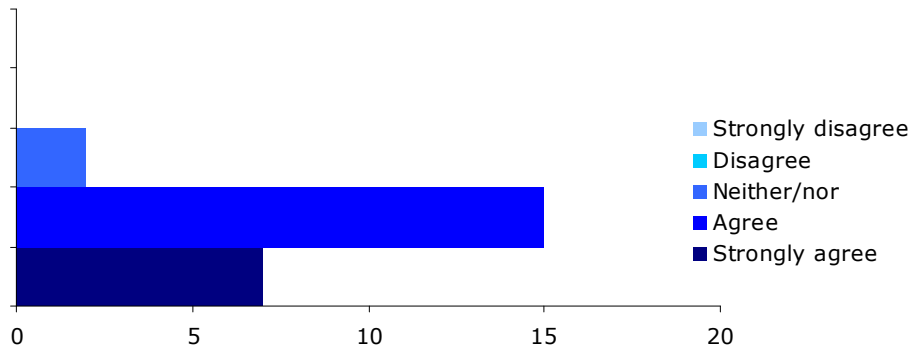
Figure 5.7: Results on the SUS item "I would imagine that most people would learn to use the CC-LR very quickly".
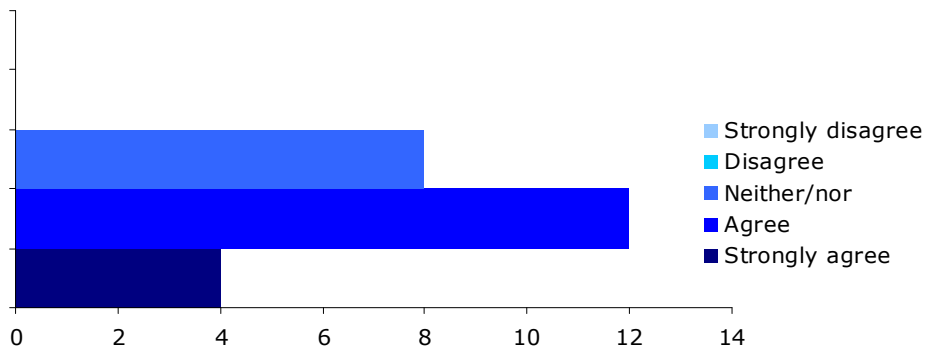


Figure 5.8: Results on the SUS item "I felt very confident using the CC-LR".

Moreover, students of the experimental group stated that the VCS functionality was well integrated (M = 3.95, SD = 0.50, Md = 4) (*Figure 5.9*) and the tool itself was adequately integrated in the UOC virtual campus and in turn in IWT (see Annex A). This result is better than the control group though very similar (M = 3.52, SD = 0.96, Md = 4), which confirms that students did not have problems to gain access to the CC-LR in IWT.
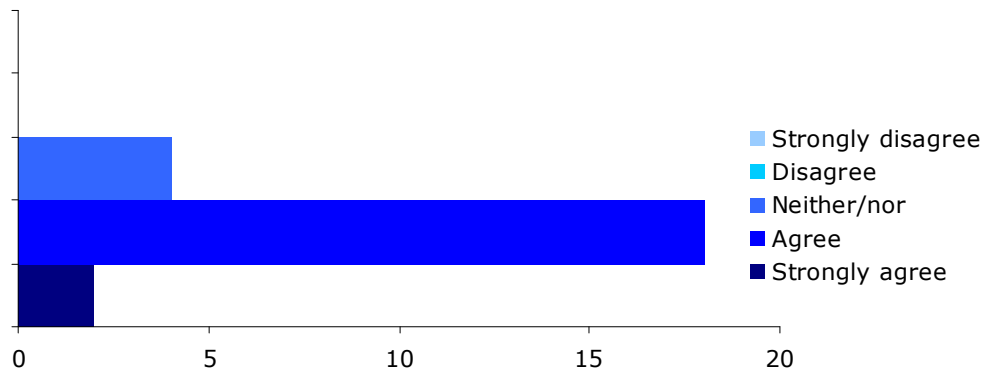


Figure 5.9: Results on the SUS item "I found the various functions in the CC-LR were well integrated".

Finally, students indicated in a balanced way they found the video debates easy to use (M = 3.13, SD = 1.23, Md = 3) (*Figure 5.10*). Despite this result is worse than the control group (M = 3.47, SD = 0.96, Md = 4), it should be considered for this usability aspect the inclusion of interactive scenes in the CC-LR that the control group did not have (users just watch the CC-LR as a regular video), making the study with this new material more complicated (e.g., they

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needed to interact with cognitive tests, select emotional state and interact with an affective agent, etc). Considering this, this result is quite satisfactory and well above the average (2.5).
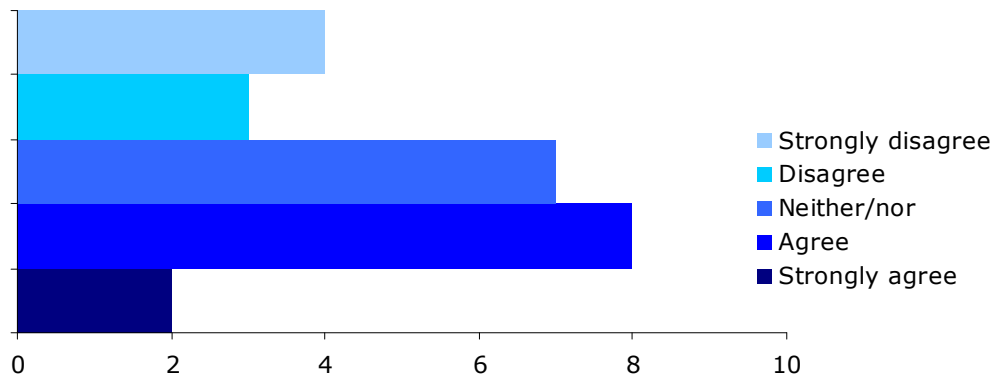


*Figure 5.10: Results on the SUS item "I thought the CC-LR was easy to use".*

In summary, the usability assessment of the CC-LR enriched complex aspects, such as cognitive and emotional information, was quite satisfactory in comparison to both, the control group and the SUS scale as all SUS scores are above or well above the average (2.5). Finally, some improvements made to the VCS tool on usability since the previous experimentation were also noticeable by the students of the experimental group who in general did not report some problems found by the control group.

*Emotional aspects*

Regarding the students' emotions of the experimental group during the work with the CC-LR (H5.1), the results from a 4-point rating scale (n=24) are presented next, and they are compared to the results of the control group (n=25).:

- Happiness (M=1.13, SD=0.67, Md=1) (*Figure 5.11*). This result is slightly better than the control group (M=1.08, SD=0.90, Md=1) showing they were curious with the new type of scenes incorporated in the CC-LR (cognitive and emotional).
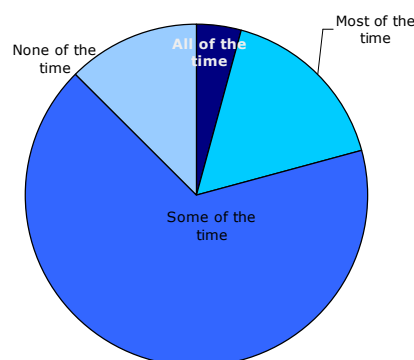


*Figure 5.11: Results on the Happiness emotion*

- Sadness (M=0.50, SD=0.78, Md=0) (*Figure* 5.12). This result is slightly worse than the control group (M=0.48, SD=0.58, Md=0). However, both results are very good with Md=0, which means that students of both groups did not experienced this bad feeling.
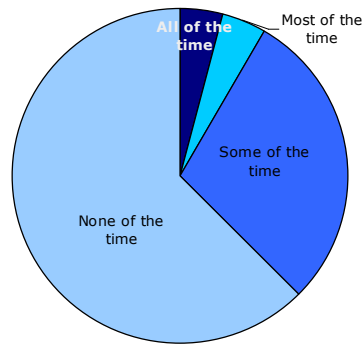
*Figure 5.12: Results on the Sadness emotion*

- Anxiety (M=0.45, SD=0.72, Md=0) (*Figure 5.1*). This result is slightly worse than the control group (M=0.32, SD=0.69, Md=0). However, both results are very good with Md=0, which means that students of both groups did not experienced this bad feeling.
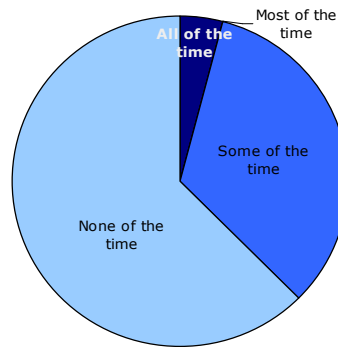


*Figure 5.13: Results on the Anxiety emotion*

- Anger (M=0.54, SD=0.77, Md=0) (*Figure 5.14*,). This result is slightly worse than the control group (M=0.40, SD=0.76, Md=0). However, both results are very good with Md=0, which means that students of both groups did not experienced this bad feeling.
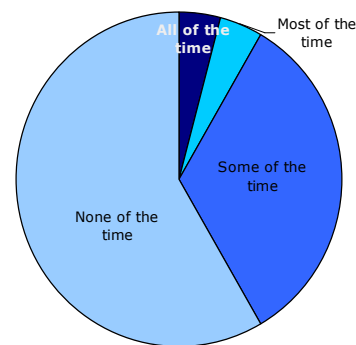


*Figure 5.14: Results on the Anger emotion*

In summary, students felt more often happiness than sadness, anxiety or anger when using the CC-LR to study with the new learning material (CC-LR) The results in general are similar in the experimental group than the control group though, being the most noticeable result the highest value in happiness while the students felt the same level of sadness, anxiety and anger

emotions, which were very low, almost inappreciable (Md=0), being the anxiety emotion the lowest.

A particular increase of the bad feelings (especially anxiety and anger) from the control group is shown, which can be explained by the incorporation of complex information in the CC-LR, such as cognitive tests, that the students had to pass to continue with the video. This might cause higher steps of anxiety and also anger, especially when they would fail the tests. However, as mentioned, bad emotions were assessed very low (Md=0).

In overall, this is a good result considering the students faced a complex type of learning material that was new for them and they had to learn how it worked and how to use it for their benefit. Finally, this result is in line with the results presented above concerning the usability.

***Evaluation of the questionnaire***

The questionnaire was designed not to be very intrusive in the students' responses by avoiding exceeding the length and/or time employed to fill it. Evaluation results of the suitability of the questionnaire design confirmed the expectations resulting in an average time to fill out the questionnaire of about 40 minutes (*Figure* 5.15) and 75% of students found it appropriate to evaluate the experience (*Figure 5.16*) (n=24). These results are worse than the control group (n=24, 30 minutes on average to fill the questionnaire and 97% of appropriateness) due to the questionnaire of the experimental group was more complex in order to evaluate more aspects of the CC-LR.
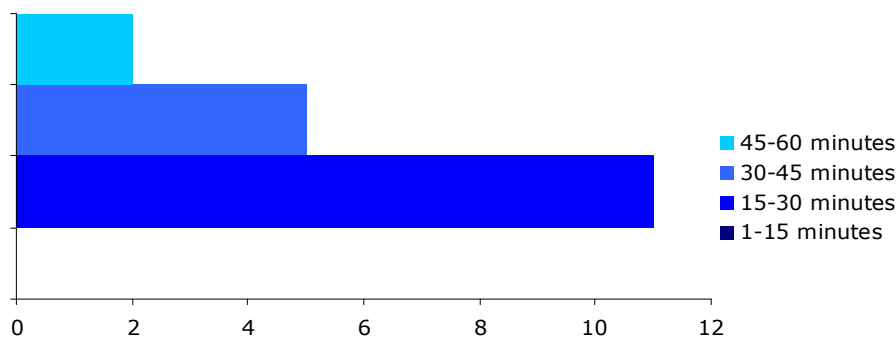


*Figure5.15: Time employed to fill the questionnaire*
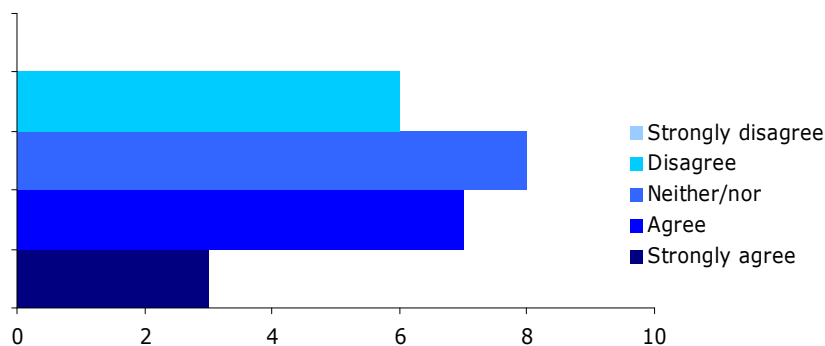


*Figure 5.16: Appropriateness to evaluate the experience with the questionnaire*

*Validation Results*

Following the methodology set out above, we will validate the improvement of motivation (H5.2), worthiness from the control group of the CC-LR (CC-LR) enriched with author information as an educational tool (H5.5) as well as the acquisition of collaborative knowledge with this new type of learning material (H5.4).

*The CC-LR as a valuable resource*

In this section we evaluate the level of worthiness of the new version of the CC-LR enriched with assessment information supported by the VCS as an educational tool (H5.5). To this end, we collected quantitative and qualitative data in order to know the user's satisfaction in the experimental group with the tool. Both quantitative and qualitative data were collected from 5 open questions of the questionnaire addressed to students. All this data was also collected with the same questionnaire and questions from students of the control group. This will make it possible a fair comparison between both groups.

In the questionnaire, the rating scales for the majority of the quantitative questions we used a 0-10 point scale, so that students could assess the value of the CC-LR by a scale they felt very familiar with from their experience in the UOC courses. The scale went from the worst mark (0) to the best mark (10) considering a "good" assessment marks from 5.0 to 10 and a "bad" assessment marks under 5.0.

The following questions related to evaluate the CC-LR were asked:

1- What did you like and what you did not like from the CC-LR (assess the CC-LR from this view in the scale 0-10).
2- Compare the CC-LR with traditional learning material and tools (books, web pages, forums, etc) and indicate pros and cons of the CC-LR (assess the CC-LR from this view in the scale 0-10).
3- Do you think the CC-LR have helped you acquire more knowledge about the discussion topics in comparison to the text-based forums? (assess the CC-LR from this view in the scale 0-10)
4- Express your opinion about the CC-LR in terms of efficiency and performance (assess the CC-LR from this view in the scale 0-10)
5- Let us know your opinion about the potential of the CC-LR to observe how people discuss and collaborate, and how knowledge is constructed (assess the CC-LR from this view in the scale 0-10).
6- Do you think that the both the assessment indicators on each character and test questions integrated in the CC-LR allowed you to understand the contents of the CC-LR and acquire more knowledge? (assess the CC-LR from this view in the scale 0-10)

Questions 1 through 5 are the same as those included in the control group's questionnaire On the other hand, Question 6 is new and particularized to the extensions of the CC-LR with cognitive information. Therefore, Questions 1 through 5 will be compared between the experimental and control groups whilst Question 6 will be analyzed individually to validate the inclusion of author information in the CC-LR as a valuable resource.

All 24 students of the experimental group provided assessment marks. After calculating the 0-10 scale for all the questions of the experimental group we got a general mean score of 6.52

(SD=1.42 and Md=6.7). This result is significantly better than the control group (M=5.43, SD=2.20 and Md=5.60) and in line with the previous results on usability and emotions, hence these results confirm the CC-LR enriched with author information as valuable educational resource.

In particular, students of the experimental group liked the CC-LR enriched with author information (Question 1: M=6.40, SD=1.44, Md=6.75) and liked them more than the control group who liked the CC-LR without this information (Question 1: M=6.24, SD=2.01, Md=6). Some students found the CC-LR quite impressive and original, and considered this as an innovation with respect to the current technology at UOC. On the other hand, others found the interface not very pleasant including the "robotic" voice. Also some students felt the CC-LR simulated a "real" discussion, meaning that it was close to a real discussion with the presence of the discussants.

In addition, students did not find problematic to understand the VCS text-to-voice engine, which was solved 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. However, many of them did not like the "robotic" and monotonous voice of the CC-LR as well as suggested to embed different voices for different characters. Finally, some students indicated the benefits of the CC-LR for disable people.

Question 2 of the experimental group related to compare the CC-LR to traditional learning systems and the impact on the learning process. The experimental group (M=6.33, SD=2.32, Md=7.00) achieved slightly worse scores than the control group (M=5.88, SD=2.09, Md=6). Similarly to the control group, students indicated in general to find this resource more attractive and pleasant to study from the CC-LR rather than from a message or book in a traditional material. Some students indicated that with the CC-LR they felt like studying in a collaborative fashion and as the characters in the CC-LR were based on real students they had the impression to form part of the collaborative activity registered in the CC-LR. On the other hand, others found the study with the CC-LR a different way of individual study and "just yet another forum" where to share experiences in an only-read way. Some of them preferred the traditional way (i.e. read books) and missed a human moderator in the video-discussion (CC-LR). Finally, some students found the CC-LR a "live" material that is interesting to dynamically share experiences and opinions about real life and when reliability is not a must but then it was necessary to get books and traditional material "made by experts" to go deep in particular themes. From this view, they considered the CC-LR as a "complement" rather than a "nuclear" material.

Question 3 of the experimental group related to whether the CC-LR has helped acquire more knowledge on the topic. The experimental group achieved better scores (M=5.92, SD=2.34, Md=6.50) than the control group (M=5.48, SD=2.50, Md=6). This result confirms the didactical purpose of the CC-LR as learning materials and the enrichment with author information reinforces their didactical purpose. Some students mentioned that by observing the different characters' points of view helped them to understand better the main topics in the CC-LR as well as speeding up the understanding. However, they thought this material should "complement" the official material rather than replace it. Others also mentioned that the video-debates in the CC-LR helped them to reflect and reason their ideas and because of the special

format of the CC-LR it made easy to get into the topic easily. Finally, some students found the potential of the CC-LR "huge" since it is more didactic and comfortable to learn from video with people sharing opinions rather than reading a book.

The previous pedagogical result is also confirmed by Question 5 of the experimental group, related to the potential of the system VCS and the CC-LR to observe how the knowledge is built. The experimental group (M=6.54, SD=1.93, Md=7) also achieved significant better scores than the control group (M=6.20, SD=2.14, Md=7). Most students mentioned that they could observe the knowledge construction process in a "natural" way and "progressive". Some students found the CC-LR a "simulative" way to build knowledge from real life, which was appreciated, and mentioned that it fostered to explore new views. The test scenes found in strategic points of the vide-debate (see Question 6) also was mentioned to ease the process of knowledge construction by fostering knowledge retention and consolidation.

Question 4 related to efficiency of the CC-LR got better results (M=6.92, SD=2.41, Md=7.0) in comparison to the control group (M=6.78, SD=2.34, Md=7). In line with the control group, almost all the students indicated the CC-LR were very easy to use, intuitive and fast, very convincing from the efficiency and performance perspective. Only very few students reported problems with installing the application in Linux platforms.

**Question 6 about the incorporation of cognitive aspects were very positive** as the experimental group got a mean score as high as 6.94 (SD=1.12, Md=7.0), being the highest score of the all the questions. Students in general found very didactic to have the chance to self-evaluate the CC-LR by several test scenes in certain points in the video. They reported to consolidate better the concepts and ideas (i.e. knowledge retention). Also the performance indicators showing up by the avatars were found useful to know the knowledge reliability of the avatar and incorporate certain opinions in their general knowledge. Most of students missed more test scenes to reflect, self-assess and check their knowledge. A few students found the test scenes broke the rhythm of the video (CC-LR) reproduction.

Finally, similarly to the control group, some students proposed to promote the use of CC-LR in other courses. They also gave some hints for possible improvements of both pedagogical, such as increase the number of test scenes, and technical, such as distinguish between male and female voices in the CC-LR.

*Motivational aspects*

Students' motivation concerning the formal learning activity supported by the CC-LR was investigated (H5.2) by comparing the difference in motivation between the experimental and control groups (see ALICE project D8.1.2 for the data on motivation in the previous experiments).

The questionnaire included a motivation test for both the experimental and control groups, where all students were asked for the amount of motivation they felt when collaborating in the discussion by means of the required tools. The following answer categories were used: "absolutely unmotivated" (1), "unmotivated" (2), "motivated" (3), "very motivated (4)".

Experimental group scored slightly higher (M=3.27, SD=0.95, Md=3.5) than the control group (M=3.11, SD=0.89, Md=3). The results of the experimental group are in line with the results about the CC-LR as valuable resources reported in the previous Section. The students in

general found the new version of the CC-LR enriched with authoring information on cognitive aspects more attractive and pleasant to follow rather than the CC-LR without these features (control group). In particular, the students appreciated and felt very motivated by the test scenes incorporated in the CC-LR that allowed them to self-evaluate their leaning progress. This way, in overall, they found the CC-LR very intuitive and very good as learning material, which eventually engaged them in both the CC-LR and also in the learning assignment supported by this material.

Finally, clear indications of amounts of motivation came from enthusiastic students who evaluated the CC-LR as "I liked it a lot!", "Impressive!", "Very surprising", "Curious". On the other hand, a few students who did not understand the purpose of the CC-LR or chose not use them due to lack of time or technical problems felt unmotivated. These comments are similar to the control group though the experimental group put more emphasis in the good aspects and the potential applications in other courses, which is in line with the better results achieved.

*Tutor assessment and knowledge acquisition*

All students were evaluated on summarizing both the discussion in the control group and the learning assignment in the experimental group. Both activities addressed the same topic of "Software project management" and the students used the same CC-LR as the control group but enriched with author information. To this end, the questionnaire included 3 evaluative questions about this topic. In order to avoid repeating the same questions already asked to the control group (formed by the same students as the experimental group) in the previous experiment, we proposed to ask different questions to the experimental group though addressing the same topic: 2 first questions to evaluate the topic and the last question to evaluate the knowledge acquisition, as follows:

Control group (from the CC-LR without author information):

1. Indicate and justify whether Human Resources are a key factor in management of Software project
2. Indicate and justify the responsibility of the company managers in a software project when it fails.
3. Comment what you learnt from the CC-LR than can enrich your personal knowledge.

Experimental group (from the CC-LR without author information):

1. Indicate and justify whether the IT budget is a key factor in management of Software project
2. Indicate and justify the degree of recycling of previous projects when it fails.
3. Comment what you learnt from the CC-LR than can enrich your personal knowledge.

This part of each questionnaire was assessed by the lecturer who used the standard 10-point scale to score the students' responses. Table 5.3 shows the results.

| Evaluative questions | Experimental group CC-LR (with assessment information) (n=24) | Control group (ALICE project) CC-LR (without assessment information) (n=25) |
|---|---|---|
| Question 1 | M=8.09 SD=1.91 Md=8 | M=8.12 SD=2.34 Md=8 |
| Question 2 | M=8.16 SD=1.73 Md=8 | M=8.01 SD=1.42 Md=8 |
| Question 3 | M=8.03 SD=1.89 Md=8 | M=7.98 SD=1.61 Md=8 |
| **Overall** | **M=8.09 SD=1.84 Md=8** | **M=8.03 SD=1.79 Md=8** |

*Table 5.3: Results of the knowledge acquisition evaluation*

From the results of Table 5.3, students from the experimental group scored slightly higher than the control group (ALICE D8.1.2, 2012). Both groups got very good marks on average and showed a good level of knowledge acquisition. These results are in line with the potential of knowledge acquisition and construction reported previously, which are better than the control group.

The students obtained greater amounts of knowledge acquisition and retention by the capability to check and self-evaluate their knowledge about the topics of the CC-LR in the own video. The table shows that the values of the mean and median are around 8 points. Students responded the questions positively. The standard deviation measures the degree of dispersion of observations around the mean value. In this case it is between 1.84 on average, indicating that there is a moderate dispersion of values. Therefore, there exist certain level of homogeneity in the perception of the use of the tool.

In summary, we can conclude that the inclusion of assessment information in the CC-LR had an impact in the quality of the student's knowledge acquisition and retention, though no very significantly.

### *Conclusion*

In this Section the results reported above are summarized and discussed by considering the goals which were determined at the beginning of the study. Then, based on the results summarized they were compared with the control group reported in the ALICE project (ALICE D8.1.2, 2012).

In general the students liked the extended features of the CC-LR and found them interesting to understand better the content of the CC-LR and also for knowledge retention and

construction (G5.1), even more than the control group. During the study with the enhanced version of the CC-LR, the students found them very easy to use as no relevant technical problems were reported and also from the usability perspective (G5.3).

The majority of students could generate the CC-LR efficiently (G5.5). Complex aspects of the learning process, such as motivation and emotional were validated showing an impact of the use of the CC-LR, and in particular, the extensions provided, in make the learning process more effective. In particular, the new CC-LR proved to become an effective educational resource (G5.4).

The gain in knowledge acquisition by using the new features though it was increased from the control group (G5.1) were not significant, especially from certain assessment indicators incorporated that were not appreciated by the students and hid part of the real benefits provided by the incorporation of cognitive aspects in the form of test scenes embedded.

Finally, students provided some hints to improve the CC-LR and CC-LR in general (G5.2) as well as they suggested using this type of learning resources in more courses and programs of the UOC.

## 5.2.2 Experiments at UCA

### Introduction

After the UOC preliminary experiment, more experiments were conducted at the University of Cadiz (UCA) with the aim to evaluate and **validate the CC-LR approach by incorporating SNA as a proper and efficient learning analytics method to understand and measure the relationships between entities in the networked information** (Romero & Ventura, 2013).

Real collaborative sessions analyzed by SNA provide relevant information to design, develop and implement a CC-LR scenario that will be used for these experiments (Mora et al., 2014a). As a result, CC-LRs developed, enriched with SNA and cognitive information are used to evaluate and validate the impact in the learning process. In addition, similar to the UOC experiment, the goal of this experiment was also to evaluate the usability, emotional aspects and functionality of the VCS tool to play text-based discussions in a multimedia attractive format (CC-LR) from the student' view in support for a formal in-class assignment of collaborative learning based on a discussion.

### Research goals and hypotheses

The main goal of the experiments is to evaluate the enhancement and improvement of the learning performance and outcomes by means of the CC-LR approach that provides full support to the collaborative and networking interactions occurring during live collaborative learning activities. In particular, the aim is to evaluate the influence in the learning process of the social and networking information included in the CC-LR.

Therefore, the research goals set out for this learning scenario are related to the CC-LR and the collaborative and networking information incorporated. In particular, the usability and functionality of the CC-LR approach as for two main elements: (i) provision of self-evaluation and formative feedback for learners; (ii) CC-LR resources generated from discussion forums and the underlying social networks in a multimedia attractive format. Finally, the learning performance and outcomes by using CC-LR resources will be measured. To these ends, an

experiment was run to pilot this scenario in the real learning context of UCA in support for a formal in-class assignment of learning based on a discussion.

We focused on the following scenario's goals and hypotheses:

*Scenario goals*

- G1: To enhance and improve learning performance and knowledge acquisition by means of the CC-LR approach
- G2: To improve the assessment features of the CC-LR approach by self-evaluation and formative feedback in terms of social information.
- G3: To improve usability, emotional aspects and functionality of the CC-LR approach by CC-LR resources generated from Collaborative Learning and Social Networking.
- G4: To improve the efficiency of the CC-LR.

*Scenario hypotheses*

- H1: The use of SNA indicators applied to CC-LRs allow users to acquire more knowledge from collaborative learning activities.

- H2: The use of the CC-LR created from real collaborative activities enriched with SNA techniques contributes to improve the virtual learning activities, increasing students' motivation and engagement.

- H3: The levels of usability, emotional aspects and functionality of the CC-LR are satisfactory.

- H4: CC-LRs are considered as a valuable educational resource by students.

*Method*

The methodology used is based on the premise that collaborative learning is constructed over an underlying social network and knowledge sharing is obtained through relationships established within the social network (Mora et al., 2014a). In order to study this social learning network, it is necessary first to create a SLO object based on a previous real collaborative activity, such as a discussion supported by a web forum, where the participants and their posts are recorded. Then, the SLO is analyzed and adapted to create a complex learning resource (CC-LR) by augmenting the SLO with collaborative and social networking information from the original activity. Therefore, we can identify three main phases in this methodology (Mora et al., 2014b):

1. The first phase includes the planning and implementation of a real collaborative activity. This includes setting up the virtual collaborative space where the live activity is developed (e.g. web forum, chat, etc), as well as the group of students who participate in the activity. After the activity, the results of the collaboration in terms of dialogues are analyzed. This analysis requires determining the social network created from the collaborative and social networking behaviour during the original activity by means of SNA techniques. The appropriate SNA indicators are used for the specific type of activity and the knowledge is extracted from SNA analysis for further use in the next phase.

2. The second phase corresponds to the creation of the CC-LR from the previous phase and the original activity. The real learning sequence is first converted into a SLO. Then, the resulting knowledge from the formed SNA analysis performed in the previous phase is incorporated in the SLO. Moreover, test scenes are strategically integrated into the SLO for self-evaluation and the results of the tests are shown along with hints and comments for formative feedback (e.g. jump to previous scenes for review or study additional material on the topic). The goal of the evaluation and feedback is to help learners monitor their own learning progress with the SLO though without breaking the learning sequence or making it boring or dysfunctional. Finally, a CC-LR resource is created form the SLO augmented with this new information.

3. The third phase consists of reusing the CC-LR developed in the previous phase as an in-class regular learning resource with the aim of bringing a live collaborative activity to the class so that individual learners can leverage the benefits of others' collaborative experience enriched with cognitive, social and evaluation information. After the use of the CC-LR the learning performance is to be assessed and problems can be corrected as with any other learning resource.

Eventually, in order to evaluate the developed CC-LR enriched with SNA information and analyze its effects in the learning process, the experiments involved undergraduate students of the University of Cádiz (UCA) who formed the experimental groups during a learning activity supported by the CC-LR during May 2014 (UCA-1 experiment) and May 2015 (UCA-2 experiment). The control group for UCA-1 was taken from the UOC experiment carried out in June 2012 (see above in Section 5.1) that participated in the mentioned previous experiment with a CC-LR without SNA indicators (only cognitive assessment indicators). The control group for UCA-2 experiment was UCA-1 results already collected. The results of the experimental groups are to be compared to the control groups.

It is worth mentioning that the UCA-2 experiment as the experimental group will specifically perform the evaluation of the SNA-based assessment indicators only, which will be compared to the evaluation of the same indicators of the UCA-1 experiment acting as control group. **The UCA-2 experiment will not evaluate other features of the CC-LR approach as they are already fully covered by both the UOC and the UCA-1 experiments.**

Next, following the APA guidelines to report empirical results (American Psychological Association, 2010) information about the participants, the apparatus used for experimentation and the procedure of the experiment are provided in this subsection:

*Participants*

Two experiments (UCA1 and UCA2) were run in different moments and with different samples. The specific samples of both experiments are informed in the next sections for each experiment. In both cases, the work with the CC-LR to be evaluated was carried out in a physical Laboratory of UCA supported by desktop computers and lasted 3 hours each.

*First experiment (UCA1) Participants*

The involved students were enrolled in the Electrical and Computer Engineering program. 117 undergraduate students were enrolled in the first-grade course "Computer Structure

Fundamentals" and participated in the in-class assignment based on a live web-based discussion about "Central Processing Unit (CPU) Chronograms" during the first 2 weeks of April 2014. The assignment was not mandatory to pass the course, thus 17 students out of 117 decided not to participate in the discussion.

*Second experiment (UCA2) Participants*

The involved 24 students were enrolled in the Electrical and Computer Engineering program. The involved students were enrolled in the third-grade course "Advanced Computer Structure" (ASC) and first year master subject: "Ubiquitous Systems" (US). The experiment was performed in the last week of April and the first week of May 2015. The sample of the experiment was formed by 10 students of ASC course 14 students of US course. Both courses were based on a number of common themes even though they are placed in different classrooms. This way this activity was performed in a consistent and enriching way for both courses.

*Apparatus and stimuli*

*CC-LR*

The design and development of a CC-LR came from a previous live on-line discussion on engineering education. The design only used those social network assessment indicators from the SNA approach for the CC-LR prototype with cognitive assessment. The management of social network assessment was based on SNA and presented in the CC-LR as assessment information on the original discussion and participants in terms of Centrality and Communication indicators as follows (Romero et al., 2013) (Mora et al., 2014a): (See Figure 5.17):

- **Centrality** refers to the degree of involvement into the learning group. A greater centrality means stronger involvement in collaborative group dynamics whilst little centrality means a peripheral social situation or simply a not participating role in the discussion. Centrality indicator is addressed by considering the Degree and Betweeness indices (Mora et al., 2014a), which in turn are extracted from the number of posts in each thread.

- **Communication** refers to the level of transmission within the learning group. Communication indicator is addressed by the direction of the interactions that each student presents. However, interactions are sometimes unidirectional without any interactive purpose.

*Figure 5.17: A CC-LR prototype showing cognitive and social network assessment (traffic light data). Centralidad (Centrality) and Comunicación (Communication) indicators are produced by SNA analysis.*

Both indicators are represented in the CC-LR as social network assessment information (Mora et al.,2014a) and displayed as traffic-light data in order to rate each indicator with 3 possible values, namely red, yellow and green. These values represent the level of social network behaviour of each participant throughout the CC-LR, thus all the appearances of the avatar-based participant in the CC-LR shows the same values. Therefore, students consuming the CC-LR as a teaching material could learn about the original participants of the discussion from these indicators and figured out better the meaning, intention and reliability of the contributions according to the information displayed on the participant.

*Procedure*

Quantitative and qualitative data were collected from questionnaires containing quantitative and qualitative questions. The answer categories will vary between rating scales, multiple choice or open answers. Rating scales were selected to make the evaluation by the students easier, and made it possible a fair evaluation in terms of agreement or disagreement levels.

After the assignment, the students were required to fill out a questionnaire, which included the following 7 sections: (i) identification data (names and username); (ii) open questions about the knowledge acquired during the discussion; (iii) test-based evaluation of the supporting CC-LR (CC-LR), which included a motivation test; (iv) test-based evaluation of the CC-LR; (v) test-based evaluation on the usability of the VCS system; (vi) test-based evaluation on the emotional state; (vii) a test-based evaluation of the questionnaire.

For qualitative statistical analysis, open answers were summarized in the questionnaire. For the quantitative statistical analysis basic statistics were employed, such as Mean (M) and Standard Deviation (SD). This quantitative analysis was complemented by employing accepted statistical procedures, such as Chi-square ($X^2$) so as to compare the observed scores to the expected scores (Caballé, & Xhafa, 2010b).

The rating scales for the quantitative questions were based on the usual 0-10 point scale. The rating scale was from the lowest (0) to the highest (10) considering a "good" assessment from

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5 to 10 and a "bad" assessment from 0 to 4, being the "good" assessment the expected scores for each question (df = 1 and p < 0.05 for the calculated χ2).

For the section v (usability of the VCS player showing the CC-LR) we used the System Usability Scale (SUS) developed by Brooke (1996) hich contains 10 items and a 5 point Likert scale to state the level of agreement or disagreement. SUS is generally used after the respondent had an opportunity to use the system being evaluated.

Finally, to investigate in which emotional state the students using the new system, which include 12 items of the Computer Emotion Scale (CES) (Kay and Loverock, 2008). The CES scale is used 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.")
- Anger ("When I used the tool, I felt irritable/frustrated/angry")

The answer categories in this section are "Never", "Sometimes", "Usually" or "Always".

Finally, for one of the experiments (UCA1), an additional procedure was added to evaluate the knowledge acquisition of the group when studying with the CCLR. The procedure was developed in two sequential steps: (1) a pre-evaluation test (before starting the experience with the CC-LR) and (2) a post-evaluation test (right after finishing the study with the CC-LR). The pre-evaluation test measured the previous knowledge of the participants in the CC-LR experiment. Even if the CC-LR is designed as a self-sufficient learning tool, the pre-evaluation test is useful to know what kind of previous concepts students know. The post-evaluation test made a global learning evaluation of the topic. The results of the pre- and post-evaluation tests are calculated in terms of correct and wrong answers with a Mean Median and Standard Deviation of the scores obtained of all the answers. This way we can compare the evolution of the knowledge acquired in the group of participants between both tests through the study with the CC-LR.

### Evaluation Results

Following the methodology described above, in this section we focus on usability and emotional aspects of the CC-LR.

*Usability of the CC-LR enriched with author information*

To evaluate student's satisfaction of the experimental group with the tool, enriched with cognitive and emotional information, as for an efficient and user-friendly management (H3), we collected data from students' ratings and open comments on the usability/functionality/integration of the tool.

To investigate the overall usability of the CC-LR, we used the SUS in the questionnaire. As mentioned, the answers were given on the 5-point Likert scale, so that students could state their level of agreement or disagreement. The rating scale ranged from "Strongly disagree" (1), "Disagree" (2), "Neither agree nor disagree" (3) to "Agree" (4), "Strongly agree" (5).

SUS scores have a range of 0 to 100 with an average score of 68, obtained from 500 studies. A Score above a 68 would be considered above average and anything below 68 is below average. A score above an 80.3 is considered an A (the top 10% of scores). Scoring at the mean score of 68 gets you a C and anything below a 51 is an F (putting you in the bottom 15%).

After calculating the SUS score for each student, we got an average for **17 SUS scores of 72.50**, thus above the SUS mean and also above the control group (25 SUS scores of 69.27). Next, we present the most relevant results of the SUS score by providing several statistics: Mean (M), Standard Deviation (SD) and Median (Md).

The results of the experimental group UCA-1) and control groups (see Section 5.2.1) as for the usability of the CC-LR are the following (rating scale 1 – 5 and next figures show the number of selections in the level of agreement or disagreement):

Students of the **experimental group (UCA-1)** (n=17) thought the students would like to use the CC-LR often (M = 2.47, SD = 1.12, Md = 3) (see Figure 5.18), students did not find the tool unnecessarily complex (M = 1.29, SD = 1.26, Md = 1) (Figure 5.19). Students stated that they did not need the support of a technical person at all to be able to use the CC-LR (M = 0.7, SD = 0.98, Md = 1) (Figure 5.20), they thought that most people would learn to use this system very quickly (M = 3.11, SD = 0.78, Md = 3) (Figure 5.21). Though they found the CC-LR a bit annoying (M = 1.88, SD = 1.21, Md = 2) (Figure 5.22) they felt confident using the CC-LR (M = 2.70, SD = 1.04, Md = 3) (Figure 5.23).

So far, the results of the experimental group are similar to the control group on average, though UCA-1 students would not like to use the CC-LR so often as the UOC group (M = 3.36, SD = 1.09, Md = 3.5). On the other hand, experimental group would need less technical help than the control group (M = 1.68, SD = 1.00, Md = 1).
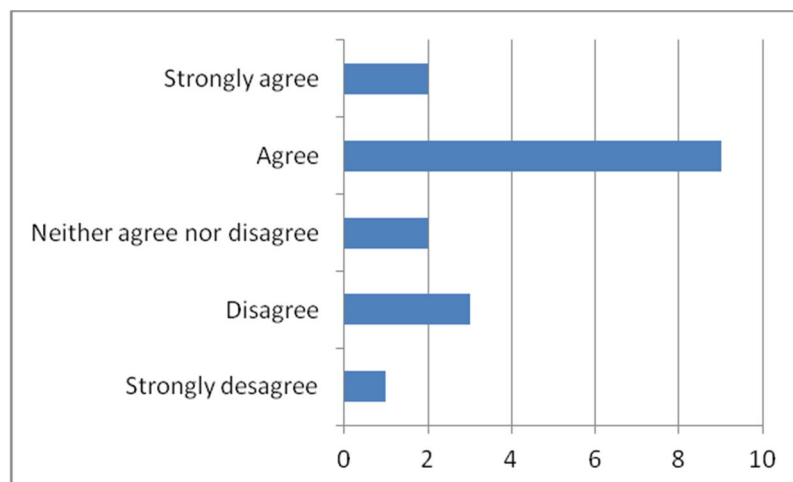


*Figure 5.18: Results on the SUS item "I think I will use the CC-LR often"*
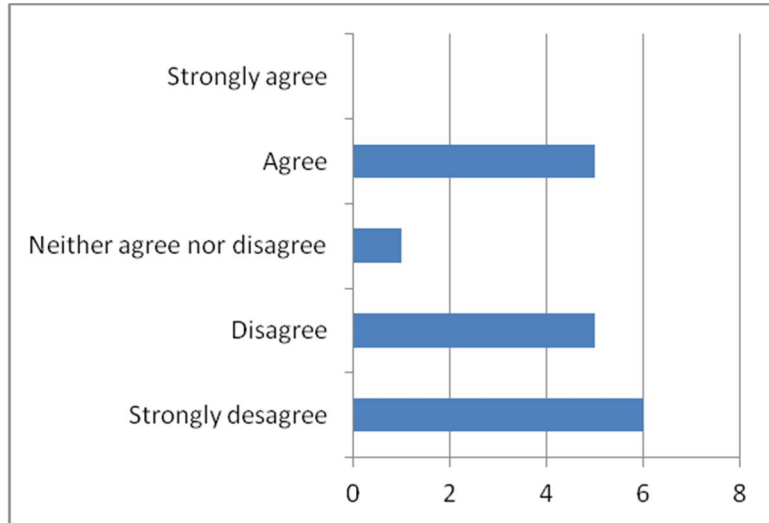
*Figure 5.19: Results on the SUS item "I think the CC-LR was unnecessarily complex".*
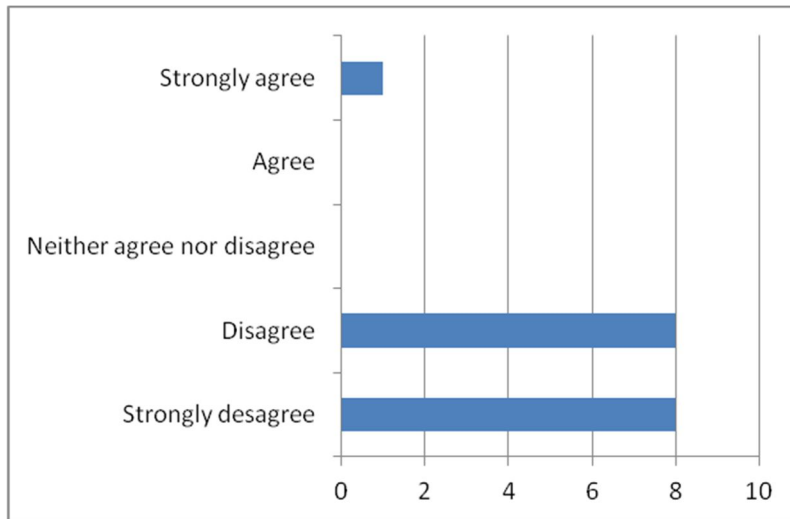


*Figure 5.20: Results on the SUS item "I think that I would need the support of a technical person to be able to use the CC-LR".*
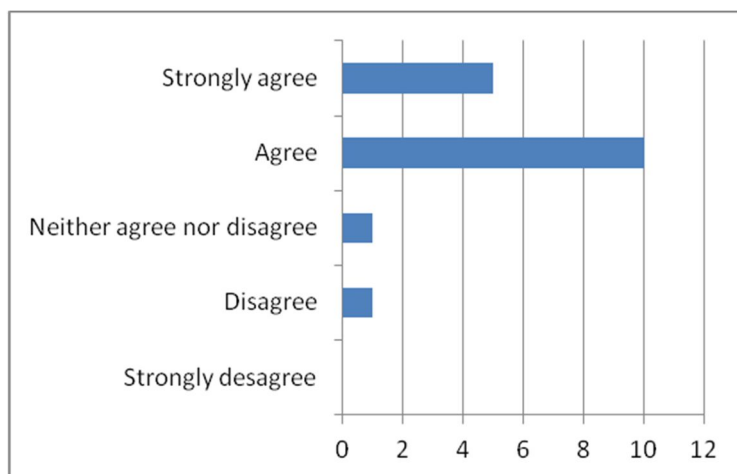


*Figure 5.21: Results on the SUS item "I would imagine that most people would learn to use the CC-LR very quickly".*

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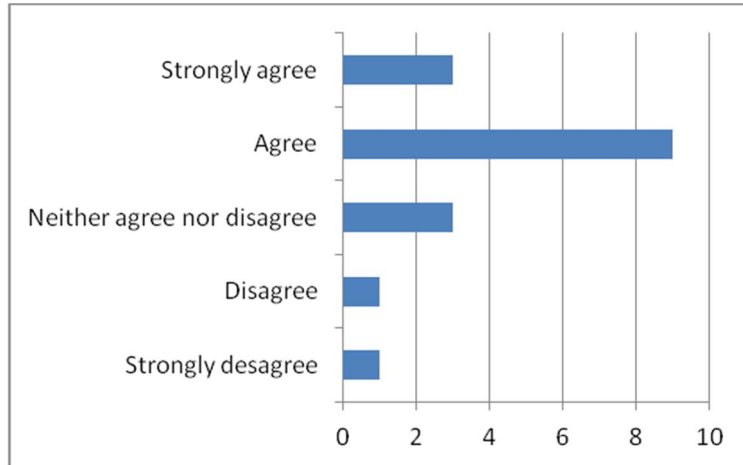
*Figure 5.22: Results on the SUS item "I felt very confident using the CC-LR".*
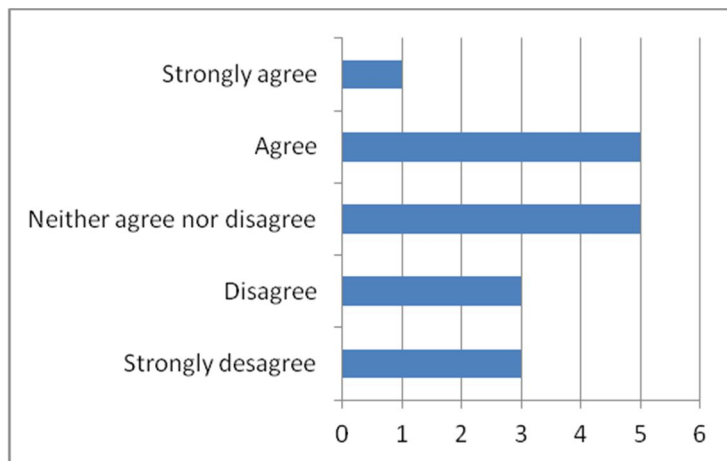


*Figure 5.23: Results on the SUS item "I found the CC-LR annoying".*
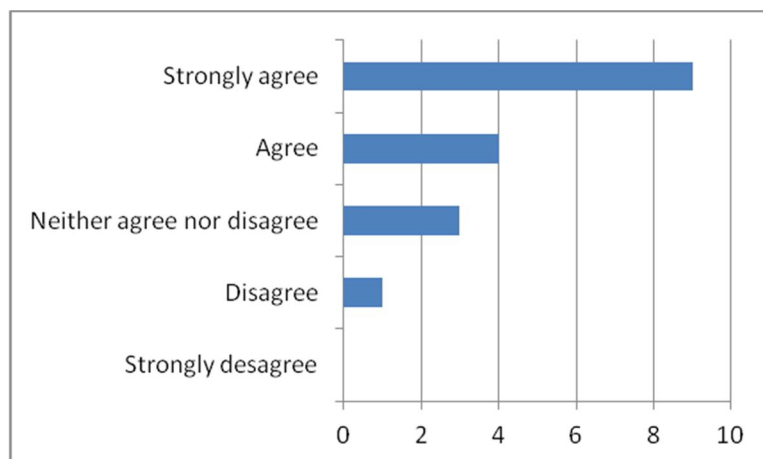


*Figure 5.24: Results on the SUS item "I found the various functions in the CC-LR were well integrated with the Moodle system".*

Moreover, students of both groups stated that the VCS functionality was well integrated (M = 3.20, SD = 1.01, Md = 4) (*Figure 5.9*) and the tool itself was adequately integrated in the Moodle system of UCA (see Annex A). This result is similar though worse than the control

group (M = 3.95, SD = 0.5, Md = 4), which confirms that students did not have problems to gain access to the CC-LR in the UCA Campus Virtual.

Finally, students of UCA-1 indicated that they did not find the CC-LR easy to use (M = 1.7, SD = 0.91, Md = 2) (*Figure 5.10*) though they did not need to learn many things before using the CC-LR in general (M = 0.88, SD = 1.21, Md = 0) (Figure 5.26). These result are different than the control group (M = 3.13, SD = 1.23, Md = 3) and (M = 1.84, SD = 0.88, Md = 2) respectively confirming, on one hand, that the inclusion of complex interactive cognitive scenes in the CC-LR made the study with this new material complicated (e.g., need to interact with cognitive tests). On the other hand, the use in general of the CC-LR (basic controls to navigate in the CC-LR) was not complicated at all. It is worth mentioning that the CC-LR included also complex interactive emotional scenes (out of scope in this thesis) that interfere with the evaluation of the cognitive interactive scenes.
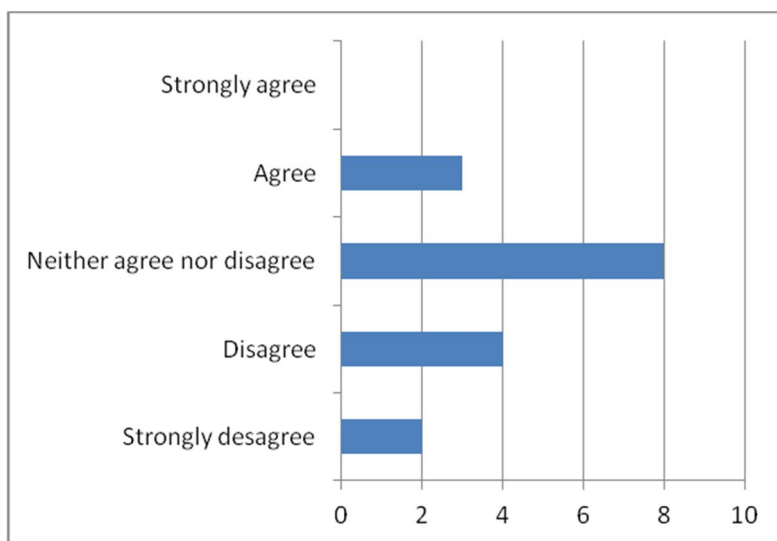


Figure 5.25: Results on the SUS item "I thought the CC-LR was easy to use".
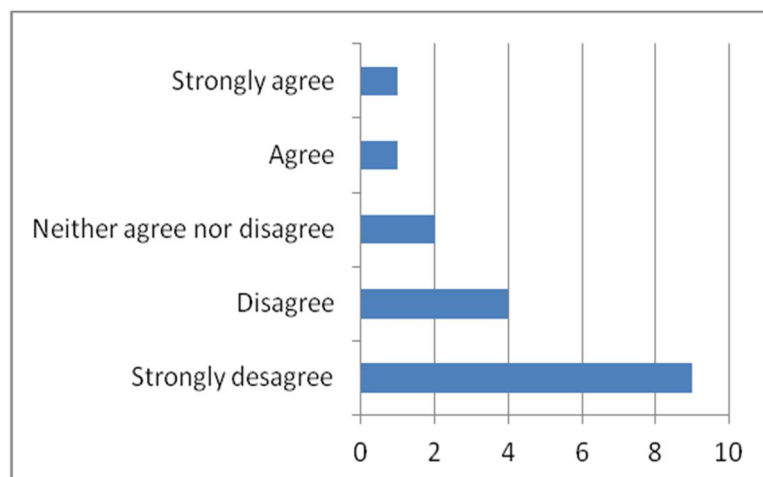


Figure 5.26: Results on the SUS item "I needed to learn many things before using the CC-LR".

In summary, the usability assessment of the CC-LR enriched complex aspects, such as cognitive and social information, was not unsatisfactory in both groups as almost all SUS

scores are above or well above the average (H3). However, the system still needs more improvements specifically with the interactive scenes of the CC-LR (2). Finally, it is worth mentioning that some improvements made to the VCS tool on usability from the previous experimentation were also noticeable by the students of the experimental group who in general did not report some problems found by the control group.

*Emotional aspects*

Regarding the students' emotions of the both experimental group (UCA-1) and control group (UOC) during the work with the CC-LR (H3), the results from a 4-point rating scale (n=17) are presented next, and they are compared to the results of the control group (n=24). See Section 5.1 with the UOC experiment for the statistics and graphical results of the control group:

- Happiness (M=1.52, SD=1, Md=1) (*Figure 5.11* 5.27). This result is slightly better than the control group (M=1.13, SD=0.67, Md=1) showing the students found the CC-LR interesting and were curious with the assessment scenes incorporated in the CC-LR (cognitive and social).
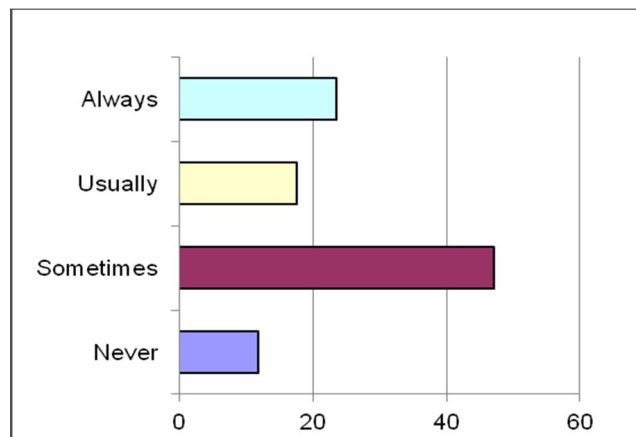


*Figure 5.27: Results on the Happiness emotion*

- Sadness (M=0.88, SD=0.99, Md=1) (*Figure 5.12* 5.28). This result is slightly worse than the control group (M=0.50, SD=0.78, Md=0) though with high SD showing that a few students felt quite sad when using the new resource while others felt not sad at all. All in all, most of students felt no sadness at all or had that negative feeling just sometimes.
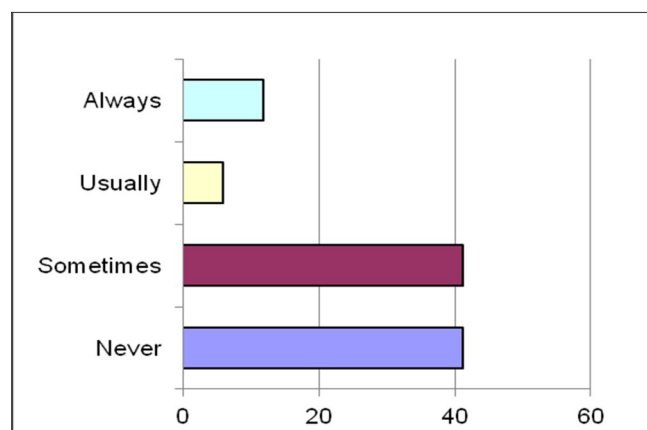


*Figure 5.28: Results on the Sadness emotion*

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- Anxiety (M=0.52, SD=0.79, Md=0) (5.29). This result is slightly worse than the control group (M=0.45, SD=0.72, Md=0). However, this result is still very good with Md=0, which means that students of experimental group did not experienced this bad feeling.
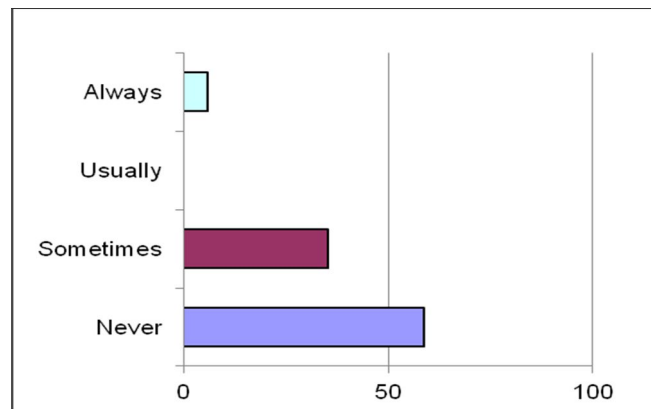


*Figure5.29: Results on the Anxiety emotion*

- Anger (M=0.52, SD=0.79, Md=0) (*Figure 5.14*5.30). This result is slightly better than the control group (M=0.54, SD=0.77, Md=0) and in line with Anxiety, which means that students of experimental group did not experienced these bad feelings.
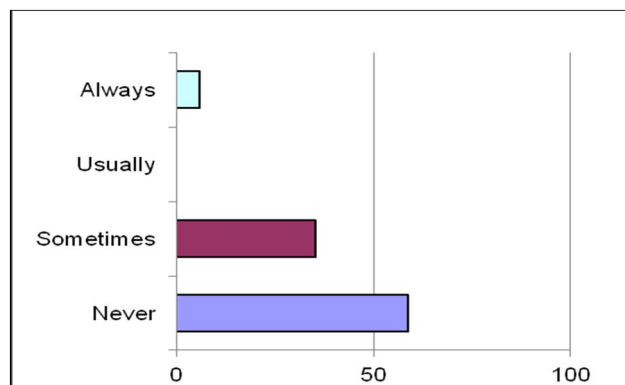


*Figure 5.30: Results on the Anger emotion*

In summary, students felt more often happiness than sadness, anxiety or anger when using the CC-LR to study with the CC-LR equipped with SNA-based assessment indicators The results in general are similar in the experimental group than the control group though, being the most noticeable result the highest value in happiness while the students felt the same very low levels of anxiety and anger.

A particular increase of Sadness from the control group can be explained by the incorporation of SNA information which was not easy to understand. This might have caused higher steps of sadness, especially when a few of students failed to interpret the meaning of SNA indicators. However, as mentioned, negative feelings and in particular sadness emotion was assessed quite low.

In overall, this is a good result that confirms that the incorporation and increase of new assessment indicators based on SNA does not influence the emotions negatively when studying by the CC-LR approach. Finally, this result is in line with the results presented above concerning usability.

### Validation Results

Following the methodology set out above we will validate the improvement of knowledge acquisition (H2), worthiness from the control group of the CC-LR (CC-LR) enriched with assessment information as an educational tool (H4) as well as the acquisition of collaborative knowledge with this new type of learning material (H1). Finally, an evaluation of the design of the questionnaire was included.

### Knowledge acquisition

As mentioned in the methodology, the knowledge acquisition was evaluated by pre- and post-tests. Both included different cognitive questions though very related to the topic shown in the CC-LR. Question of both tests had the same level of knowledge and difficulty so that the results of both groups of tests could be compared.

The **pre-test** (Table 5.4) was developed to assess the previous concepts necessary to understand the CC-LR. Six key questions were considered for assessing the process of making chronograms of numeric digital operations. Some questions had a list of predefined answers to choose the correct one while other questions were open with free text to provide the answer. Open questions were assessed manually. Each question was assessed with a score in the typical academic scale of 0-10.

| # | Pre test - Question | Correct | Wrong | % Correct | % Wrong |
|---|---|---|---|---|---|
| 1 | Select the answer that best defines what a chronogram is. | 13 | 9 | 59,09 | 40,90 |
| 2 | Within a CPU, what elements need to be considered when making a chronogram? | 18 | 4 | 81.81 | 18.18 |
| 3 | Indicate the device related to the three-state logic. | 12 | 10 | 54.54 | 45.45 |
| 4 | What magnitude is plotted on the horizontal axis of a chronogram? | 20 | 2 | 90.90 | 9.090 |
| 5 | Clock signal is a fundamental element for synchronization. Define what a clock signal is. (open question) | 15 | 7 | 68.18 | 31.81 |
| 6 | Consider a register, what happens if we shift 1 bit to right, in the numerical data contained? (open question) | 12 | 10 | 54.54 | 45.45 |

*Table 5.4: Pretest results*

The group scores obtained by the pre-test (M=7.08, SD=1.47; Md=8) showed that most students were able to recognize the main cognitive concepts of the CC-LR, evaluated with a success rate ranging from 54.54% to 90.9%. Only two questions showed low percentages near the 50% (Questions #3 and #6). These two questions were considered advanced as they required deeper understanding of arithmetic digital circuits.

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The **post-test** (Table 5.5) was launched right after the study with the CC-LR. The procedure, type and content of questions and assessment was similar to the pre-test.

| # | Post Test - Question | Correct | Wrong | % Correct | % Wrong |
|---|---|---|---|---|---|
| 1 | What are the most important elements to consider for making a chronogram of an ALU? | 16 | 1 | 94,12 | 5,88 |
| 2 | What is the necessary sequence of actions to produce a correct loading in a data register? | 16 | 1 | 94,12 | 5,88 |
| 3 | What is the necessary sequence of actions to execute a two operands | 16 | 1 | 94,12 | 5,88 |

*Table 5.5: Pretest results*

The group scores obtained by the post-test were better than the pre-test as all the participants answered most of questions correctly (94%), thus showing that most of students understood better the main concepts of the CC-LR after the experience with the CC-LR. All wrong answer were concentrated in a specific student. On the other hand, scores obtained (M=7.26, SD=2.12; Md=8) were quite similar to the pre-test-scores (M=7.08, SD=1.47; Md=8) though slightly better, with SD higher in the post-test as the outlier coming from the specific student with wrong answers, who got very low scores. Overall, these results confirmed the improvements in knowledge acquisition through studying with the CC-LR.

*The CC-LR as a valuable resource*

In this section we evaluated the level of worthiness of the improved version of the CC-LR enriched with SNA indicators for the assessment information supported by the VCS as an educational tool (H4). To this end, we collected quantitative and qualitative data in order to know the user's satisfaction in the experimental group with the tool. Both quantitative and qualitative data were collected from 5 open questions of the questionnaire addressed to students. All this data was also collected with a similar questionnaire and similar questions from students of the control group (see UOC experiment above). This will make it possible a fair comparison between both groups.

The following questions were asked to the experimental group at UCA-1 related to evaluate the CC-LR:

1- What you liked and what you did not like from the CC-LR (assess the CC-LR from this view in the scale 0-10).
2- Let us know your opinion about the potential of the CC-LR to observe how people discuss and collaborate, and how knowledge is constructed (assess the CC-LR from this view in the scale 0-10).
3- Do you think the CC-LR have helped you acquire more knowledge about the discussion topics in comparison to the text-based forums? (assess the CC-LR from this view in the scale 0-10)

4- Let us know how the CC-LR material generated from a real debate by students has helped you to better understand the contents, compared to traditional materials (books, web, etc.).

5- Do you think that both the cognitive indicators (activity and quality) depicted below the avatar and the test questions integrated in the CC-LR allowed you to understand the contents of the CC-LR and acquire more knowledge? (assess the CC-LR from this view in the scale 0-10)

6- Do you think that the social indicators (centrality and communication) depicted below the avatars have helped you to follow the discussion and discern between participants and their contributions? (assess the CC-LR from this view in the scale 0-10).

7- Time to complete the questionnaire (minute likert scale)

8- The questionnaire was long and tedious (agreement-disagreement likert scale)

9- The questionnaire allowed me to evaluate the CC-LR experience exhaustively (agreement-disagreement likert scale)

Questions 1 through 5 are the same as those included in the control group's questionnaire (see the UOC experiment in Section 5.1). On the other hand, Question 6 was new and particularized to the incorporation of SNA indicators into the assessment information provided. Therefore, Questions 1 through 5 were compared between the experimental and control groups whilst Question 6 was analyzed by collecting data from both UCA-1 and UCA-2 experience so as to validate the inclusion of SNA-based indicators into CC-LR as assessment information.

All 17 UCA students of the experimental group (UCA-1) provided assessment marks. After calculating the 0-10 scale for all the questions of the experimental group we got a general Mean score of **6.73** (SD=2.06 and Md=6.8). This result is slightly better than the control group (M=6.52, SD=1.42 and Md=6.7) (see above the UOC experiment) and in line with the previous results on usability and emotions, hence these results confirm the CC-LR enriched with assessment information as valuable educational resource.

In the questionnaire, questions Q1 thru Q6 were rated in a 0-10 point scale for the participants so that students could assess the value of the CC-LR by a scale they felt very familiar with from their experience in the UCA courses. Students tend to understand a 0-10 scale in the same way usually is applied for them (Harkness et al., 2010).

The questions Q7 thru Q9 have a symmetrical grading scale, with an intermediate option. To this end we used the agreement-disagreement scale for rating these questions. The reason for using a different scale is the nature of the questions. Q8 and Q9 questions sought to determine whether the student found the questionnaire suitable to evaluate the experience ('Strongly agree', 'Agree', 'Neither agree nor disagree', 'Disagree' and 'Strongly disagree'). Finally, Q7 used a numerical rating to indicate the time in minutes to complete the questionnaire. The above decisions are summarized as follows:

- 0 through 4 points evaluated as 'Fail'

- 5 or 6 points evaluated as 'Pass'

- 7 or 8 points evaluated as 'Good'

- 9 or 10 points evaluated as 'Excellent'

- Q8 and Q9 use the agreement-disagreement Likert scale, since their content has a different target. Q7 uses a time Likert scale.

- Means, Standard Deviations and Medians were calculated from the numerical evaluation (0-10) selected by the students.

Q1: What did you like and what you did not like from the CC-LR

Students of the experimental group in general liked the CC-LR enriched with SNA information (Question 1: M=6.40, SD=1.44, Md=6.75) (see figure below) more than the control group without this information (Question 1: M=6.76, SD=1.92, Md=7) (see the results of the corresponding question above in the UOC experiment).

.In addition, students did not find problematic to understand the VCS text-to-voice engine, which was solved thanks to the VCS Editor and the opportunity to correct the syntax of the original posts, thus improving the conversion text-to-voice. However, many of them did not like the "robotic" and monotonous voice of the CC-LR as well as suggested to embed different voices for different characters. Finally, some students indicated the benefits of the CC-LR for disable people.
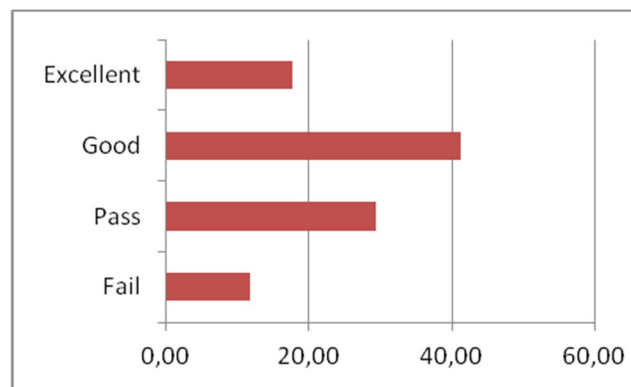


In general, students liked the functionality and video format of the learning resource (talking avatars, test scenes, graphical information to assess the contents, etc) while they did not like the length of the resource as it took too long to study all of it. They also did not like the "robotic" voice of the avatars. As for the assessment aspects, students did not like the too many test questions included in the scenes and that some of the tests were not very related to the CC-LR contents (they needed to check other materials).

Q2: Let us know your opinion about the potential of the CC-LR to observe how people discuss and collaborate, and how knowledge is constructed (assess the CC-LR from this view in the scale 0-10).

Question 2 refers to the potential of the system VCS and the CC-LR to observe how the knowledge is built. The experimental group (M=6.94, SD=1.60, Md=7) (see the below figure) also achieved better scores than the control group (M=6.54, SD=1.93, Md=7) (see the UOC experiment).
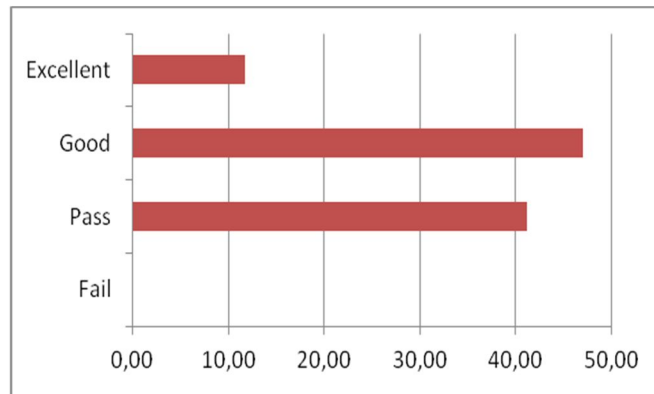
The students in general mentioned that the CC-LR is a powerful learning tool to understand complex topics in an easier way from the contributions of other peers. Other students also provided positive opinions by mentioning that the CC-LR fosters to seek and learn extra-curricular concepts from the material attached in the CC-LR.

Q3: Do you think the CC-LR have helped you acquire more knowledge about the discussion topics in comparison to the text-based forums? (Assess the CC-LR from this view in the scale 0-10)

Question 3 of the experimental group related to whether the CC-LR has helped acquire more knowledge on the topic. The experimental group achieved significant better scores (M=6.82, SD=2.32, Md=7) (see the below figure) than the control group (M=5.92, SD=2.34, Md=6.50). This result confirms the didactical purpose of the CC-LR as learning materials and the enrichment with SNA information reinforces their didactical purpose.
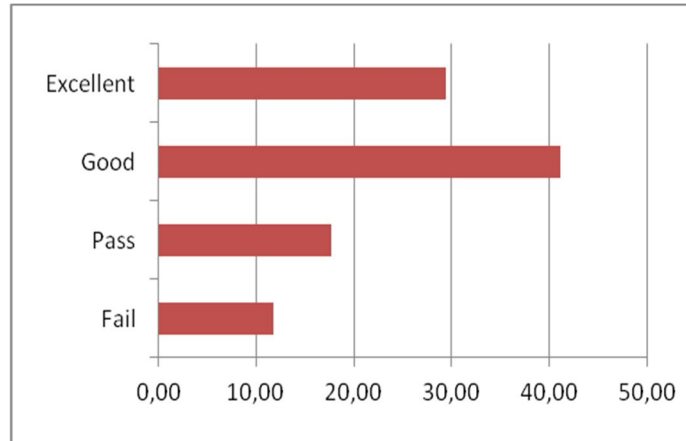


The students in general found the CC-LR easier to read and understand from listening and observe the scenes than traditional reading long lists of posts in traditional web forums, though sometimes requiring a speed rate of learning too fast. Certain students, however, considered the CC-LR was not very helpful though they found that many times it was easier to understand a complex explanation given by peers (within the CC-LR scenes) than from reading text-based posts.

Q4: Evaluate how the CC-LR material generated from a real discussion by students has helped you to better assimilate its contents, compared to traditional materials author (books, websites, etc.).

Question 4 related to compare the CC-LR to traditional learning systems and the impact on the learning process. The experimental group (M=6.82, SD=2.32, Md=7) (see the below figure)

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also achieved significant better scores than the control group (M=5.88, SD=2.09, Md=6) (see the UOC experiment).
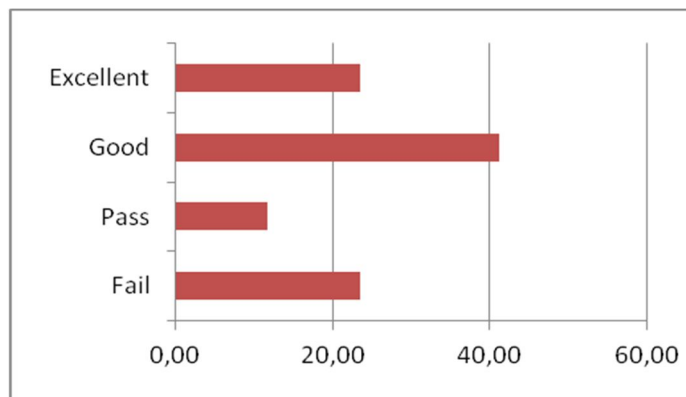


Some students indicated that the CC-LR looks like a video, thus being more attractive than traditional materials. The students also indicated that the CC-LR attracted more their attention. However, some students found the CC-LR useful to complement traditional material as it served to understand certain concepts. Even if the CC-LR contents come from actual collaboration, this material lacks interaction, thus not providing a real collaborative experience. Finally, certain students indicated they preferred to take notes rather than watching the material.

Q5: Do you think that the cognitive indicators (activity and quality) depicted below the avatar and the test questions integrated in the CC-LR allowed you to understand the contents of the CC-LR and acquire more knowledge? (Assess the CC-LR from this view in the scale 0-10).

Question 5 about the incorporation of cognitive aspects were very positive as the experimental group got a mean score as high as 6.53 (SD=2.12, Md=6.0) (see the below figure), and slightly worse scores than the control group (M=6.94 (SD=1.12, Md=7.0) (see the UOC experiment). However, the SD is quite high pointing out the dispersion of opinions. The scores of both groups are well above the average (5.0), which confirms these indicators were useful and are in line with the positive effect in knowledge acquisition with the CC-LR addressed above.
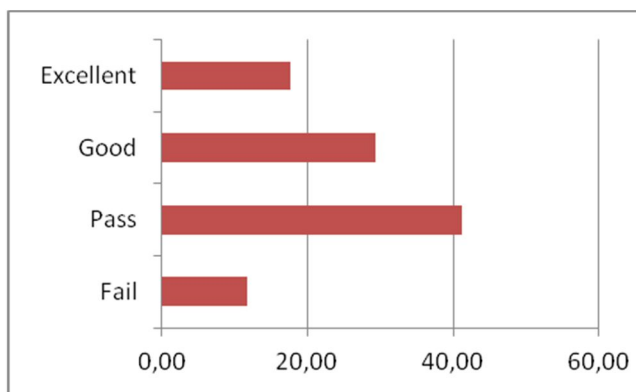


The students in general found the information on assessment useful, specially the tests integrated, which helped them understand better the CC-LR contents. However, they said that some tests were long with too many questions, thus becoming tedious. Regarding the cognitive indicators (quality and activity) displayed below the avatar, the students paid more attention to the avatars with positive indicators (green color), meaning that those contributions with positive

indicators were correct and reliable. Finally, some students found this new way to study supported by interactive tests and assessment information quite funny, which engage them to exploit deeply the CC-LR's contents.

Q6: Do you think that the social indicators (centrality and communication) depicted below the avatars have helped you to follow the discussion and discern between participants and their contributions? (Assess the CC-LR from this view in the scale 0-10).

The sixth question evaluated the new indicators based on SNA and how useful they were to show the social dimension. This question therefore becomes an important one to evaluate the social dimension of the assessment approach proposed in this thesis.

As mentioned in the evaluation methodology above, for this specific question a different methodological approach was followed. The participants from the UCA-2 experiment (May 2015) were used as experimental group while the UCA-1 participants (April 2014) formed the control group (see the details of the UCA-1 and UCA-2 experiment above). It is worth mentioning here that the UCA-2 group had an unforeseeable circumstance as the students of the subject 'Advanced Computer Architecture' consisted of two very different type of students. About half of them were enrolled to obtain necessary "credits" to end the studies, but belonged to other different academic disciplines. Their motivation was much lower than the rest of the students, leading to a poor involvement and showing a subliminal rejection of the activities that took place during the course, especially if these activities required more academic effort. Hence the experience with the CC-LR was negatively influenced for this reason, whose impact on the results was hard to measure.

The following table and figure show that the experimental group (UCA-2) got a mean of 6.38 (SD=1.8, Md=6), which is slightly lower than the control group UCA-1 (M=6.63, SD=2.12, Md=7). However, the scores of both groups are well above the average (5.0), which confirmed that the SNA indicators were also useful and are in line with the positive effect in knowledge acquisition with the CC-LR addressed above.

| | UCA-2 | UCA-1 | Variation |
|---|---|---|---|
| Excellent | 4,17% | 5,88% | -1,72 |
| Good | 37,50% | 52,94% | -15,44 |
| Fair | 29,17% | 17,65% | 11,52 |
| Poor | 29,17% | 23,53% | 5,64 |
| Mean | 6,38 | 6,53 | -0,15 |
| Median | 6 | 7 | -1 |
| SD | 1,80 | 2,12 | -0,33 |
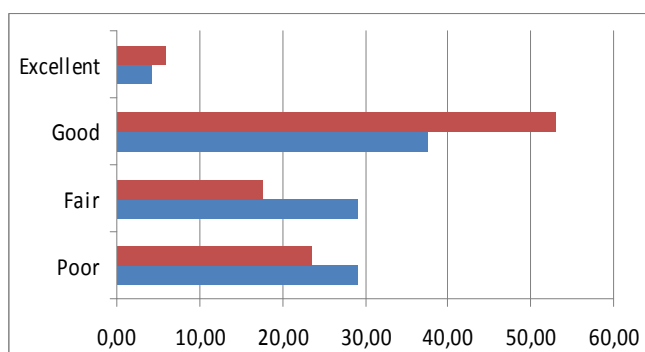


The students of UCA-1 and UCA-2 provided balanced opinions on the SNA indicators. In particular, most of UCA-1 students found interesting to have this information to understand better the content of the scenes. However, they complained that the indicators were hard to see and interpret, and suggested providing better integration of these indicators into the

graphical interface of the CC-LR (e.g., show avatar's faces with social features, etc) so as to best understand the social dimension of the avatar.

The UCA-2 students commented more specifically on the SNA indicators. For instance, some of the students mentioned that the meaning of the "centrality" indicator was not well understood, whether it was 'green' or 'red', while other students pointed out the this indicator was taken into account to understand the degree of acceptance of the avatar's involvement in the discussion. The state of each indicator (green, yellow and red) was also commented by students as during the first part of the study with the CC-LR students paid attention to the state of each indicator (especially if 'green' or 'red') but for long CC-LRs with many scenes, they reported to lose attention as the CC-LR went by.

*Evaluation of the questionnaire*

The aim to evaluate the questionnaire is to find potential co-relations between the collected results on the use and impact of the CC-LR and the design of the questionnaire. Long and tedious questionnaires may lead to collect more negative responses. To this end, three aspects were considered to evaluate the questionnaire: the time it took to respond the questions (Question 9 of the own questionnaire) and the opinions of those who filled it out (Questions 7 and 8). We compared the results from the experimental group and the control group to see if the improvements in the design of the questionnaire from the previous UOC experience were noticeable.

Most of students of the experimental group (53%) reported in Question 9 they took less than 15 minutes to fill out the questionnaire (Figure 5.31) while the control group took between 15 and 30 min (see Figure 5.15 above the results of the UOC experiment). In line with this result, most of students (52%) of the experimental group reported in Question 7 they remained neutral regarding whether the questionnaire was long and tedious (see Figure 5.32) while all of them (100%) agreed in Question 8 that by the questionnaire they could evaluate the CC-LR experience exhaustively. These results are slightly better than those of the control group (see Figure 5.33) and are in line with the low level of negative emotions when using the system reported above.
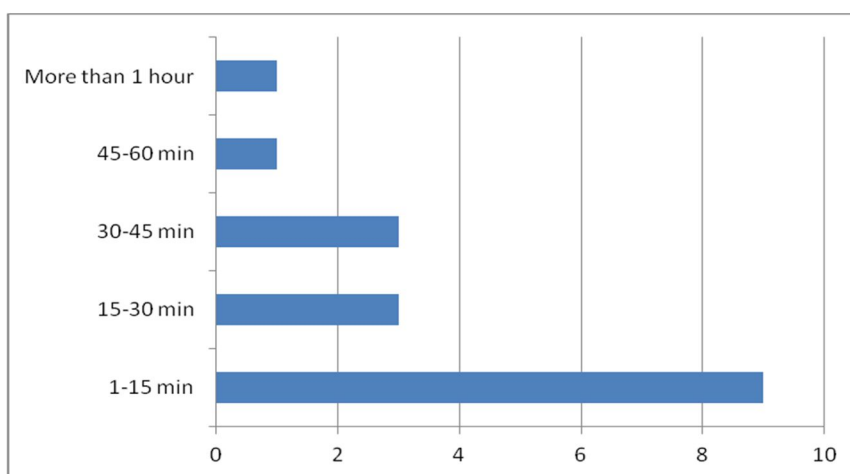


*Figure 5.31: Time to complete the questionnaire*
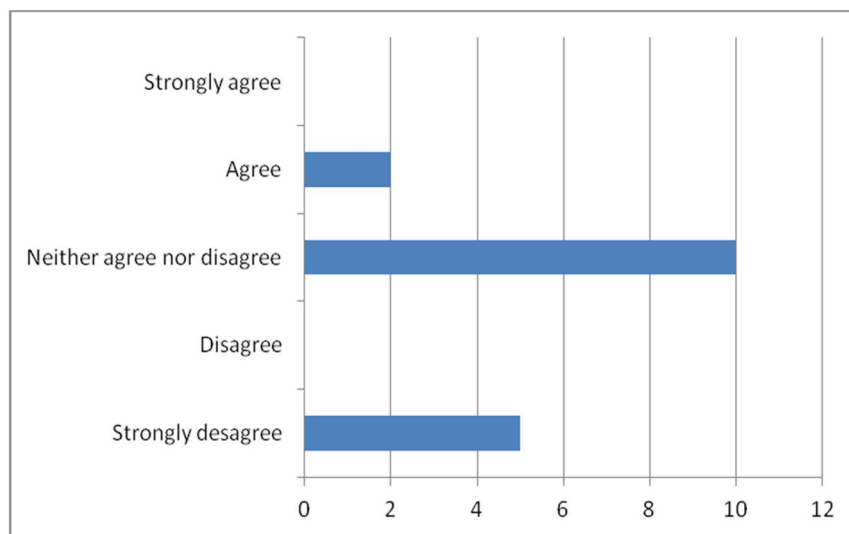
*Figure 5.31: I think the questionnaire is quite long and tedious*
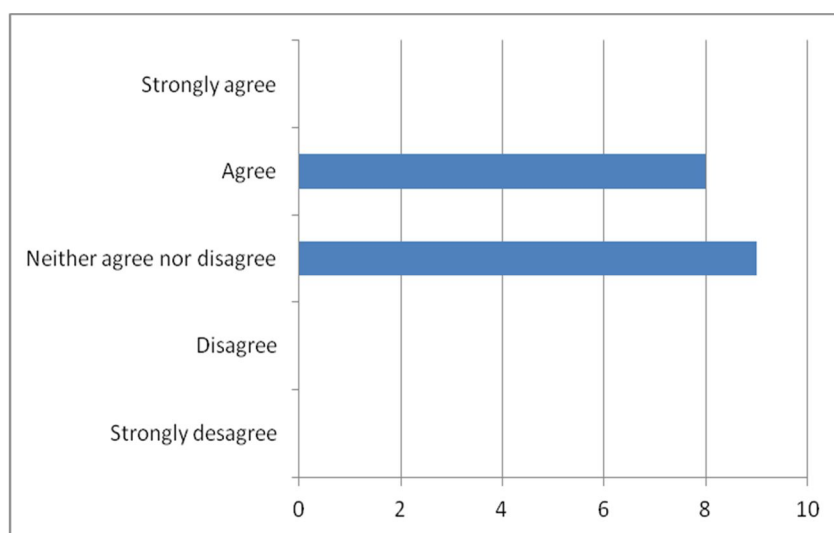


*Figure 5.32: I think the questionnaire could evaluate my CC-LR experience exhaustively*

### Conclusion

To conclude the UCA experiments, the CC-LR approach was found to potentially and easily create a collaborative learning environment anywhere and anytime this learning model is hard to incorporate. Overall, the UCA students understood the CC-LR was a good opportunity to explore further for learning through virtualized collaboration.

The design and implementation of the CC-LR leveraged a previous real collaborative experience from Web discussion forums, which was selected and improved to meet the requirements of the CC-LR, with the main objective of re-creating (ie. virtualizing) a live collaborative learning situation while correcting an improving the learning process. SNA analysis helped to complete the previous collaboration, using the collected relevant information acquired from previous collaborative forums. The data provided information to assess and measure the social interactions and features underlying the collaboration, thus augmenting and visualizing in the CC-LR the information of the collaborative processes.

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Therefore, it is possible to state that the SNA indicators integrated into the CC-LR became a reliable source of information at different level of learning assessment, such as individual and group performance and dynamics. Although the SNA indicators were found useful, experiences conducted in this research showed that this information should be integrated in a more natural way in the CC-LR. In addition, levels of frustration appeared, produced by high expectations to learn faster and easier.

Finally, based on the results obtained in the UCA experiments, the formulated goals (see above in the Methodology section) for these experiments were achieved, as follows:

In general the students liked the extended features of the CC-LR and found them interesting to understand better the content of the CC-LR (G1), even more than the control group. During the study with the new version of the CC-LR, the students found them very easy to use as no relevant technical problems were reported and also from the usability perspective (G3). The majority of students could generate the CC-LR efficiently (G4).

The experience with the CC-LR in terms of SNA indicators to assess the original collaborative was found positive (G2) though the improvements of the assessment approach was found not significant. Further work is required to enhance the social information provided in terms of both number of indicators and better integration in the CC-LR for making it easier their interpretation. All in all, the social information provided was appreciated in line with the cognitive indicators of previous experiences (UOC experiment).

Althoguh the learning processes were positively influenced by using the new assessment features (G1) this increase was not significant, especially from certain social indicators incorporated that were not appreciated by the students and hid part of the real benefits provided by the incorporation of cognitive aspects (test scenes and performance indicators).

Finally, students provided some hints to improve the CC-LR in general (G1-G4) as well as they suggested to use this type of learning resources to learn extra-curricular topics and for complex concepts.

# 5.3 Summary of the Chapter

This chapter evaluates and validates the notion and nature of the CC-LR by experimenting with a prototype of the VCS system that embeds a CC-LR presented in Chapter 3, which was enriched with the assessment framework based on cognitive and social indicators presented in Chapter 4. Experimentation activities were carried out in the real contexts of learning of the UOC and UCA in several on-line courses and in different academic programs and disciplines in order to provide attractive and challenging learning resources to support science and engineering education (Mora et al., 2016).

The main goal of these pilot scenarios was to virtualize live sessions of collaborative learning to produce storyboard learning objects embedded in an attractive learning resource to be experienced and played by learners (VCS). During the resource execution, learners observe how avatars discuss and collaborate, how discussion threads grow, and how knowledge is constructed, refined and consolidated. To this end, a new type of technological resource called CC-LR was introduced as learning material that leverages CC-LO and shows animated storyboards such that learners can interact with the CC-LR and observe the consequences of their decisions. For this purpose, an editor tool was developed as a component of the VCS to augment the CC-LRs with author-generated information, thus showing the provision of complex aspects of the learning process in the CC-LRs. Specifically, cognitive and social assessment was addressed and developed in the CC-LR. In addition, lecturers and tutors were provided with edition capabilities of the CC-LRs, such as cutting scenes, modifying involved characters, selecting emotional states, dialogues and connected concepts.

The notion and nature of the CC-LR was validated by running extensive tests on a proof of concept of the VCS system that embeds a CC-LR. These validation activities were carried out following the same methodological procedures in the UOC and UCA pilot sites with different perspectives and expectations. In general, the tests allowed for exploring how better to convey the underlying process and principles to students, supporting them in developing their understanding of the use and application of CC-LO/SLO in the form of new learning resources (CC-LRs). All the feedback received by the participants in the first experiments was used to improve both the VCS prototype and in turn enhance the features of the sample of the CC-LR used for the later experimentations reported.

Therefore, the goals and hypotheses formulated for the scenarios reported in this chapter were experimented and validated at UOC and UCA in three rounds of experiments involving 3 trials, 81 students in all. The experiments were run from student's viewpoints only and achieved the scenario goals formulated.

The first trial (UOC) was run to evaluate the usability and functionality of the VCS tool to edit and play the current text-based discussion in a multimedia attractive format (CC-LR). To this end, both experiments evaluated the provision of a CC-LR from the student's view playing the virtualization of a formal in-class assignment of collaborative learning based on a discussion. Special attention was drawn to evaluate the assessment framework incorporated in the CC-LR based on cognitive and social indicators and their effects in the learning process. The second and third trials (UCA-1 and UCA-2) were run focused purposely on enriching the assessment framework with social indicators as complex author information edited and

incorporated in the CC-LR. The assessment framework represents the main research work and outcomes of this thesis.

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. Regarding social and cognitive indicators, results indicated that they can become a reliable source of information at different level of learning assessment, such as individual and group performance and dynamics. Although these indicators were found useful, experiences conducted in this particular part of the research showed that this information should be integrated in a more natural way in the CC-LR. In addition, levels of frustration appeared, produced by high expectations to learn faster and easier. On the other hand, the students appreciated the test scenes (cognitive assessment) of the CC-LR for knowledge retention and construction.

During the study with the CC-LR the students found them very easy to use and no relevant technical problems were reported, also from the usability perspective. The majority of students could generate the CC-LR efficiently. Moreover, complex aspects of the learning process, such as knowledge acquisition and emotional (feeling more times happy than negative emotions) were validated in absolute terms and also relatively from the CC-LR. These results impacted in the use of the CC-LR and made the learning process more effective. In particular, the CC-LR proved in general to become a useful educational resource.

Finally, students provided many hints to improve the CC-LR in general as well as they suggested to use this type of learning resources in more courses and programs of the UOC and UCA.

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## Chapter 6: Conclusions and Future Work

# 6.1 Overall conclusions

This thesis presents a complete assessment framework from the collaborative knowledge and social networking interactions found in CSCL from live in-class discussion activities so as to be virtualized and integrated into an innovative learning technological resource, producing higher levels of authentic interactivity, challenging tools and user empowerment, with the ultimate aim to influence learning 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 in this thesis to augment the CC-LRs with author-generated information, thus showing the provision of complex aspects of the learning process, such as cognitive and social assessment.

Therefore, the main achievement of this research work is an e-assessment framework for virtualized collaborative and social learning scenarios that provides assessment information and representation of the actual performance of the original CSCL participants. This in turn improves and enhances the CC-LR experience with cognitive and social outcomes when this learning resource is consumed by individual students as regular teaching material.

From the results achieved, it was proved that the CC-LR is a powerful tool for educational purposes, which increases learning motivation and engagement as well as knowledge acquisition and outcomes. The assessment framework incorporated in the CC-LR approach in the form of social and cognitive indicators becomes a reliable source of information at different level of learning assessment, such as individual and group performance and dynamics. Although these indicators were found useful, experiences conducted in this research showed that this information should be integrated in a more natural way in the CC-LR. In addition, levels of frustration appeared, produced by high expectations to learn faster and easier. Finally, the satisfaction with the CC-LR approach extended with assessment information was found satisfactory.

# 6.2 Main achievements

As formulated in Section 1.7, the main goal of this thesis is to enhance and improve learning engagement and outcomes by means the CC-LR containing the virtualization of on-line collaborative and social learning enriched with a complete e-assessment framework approach that provides full support to the collaborative and networking interactions occurring during live collaborative learning activities. This main goal was achieved through the achievement of a series of goals set in Section 1.7.1, as follows:

> O1.    *Provide methods and tools for assessment in collaborative learning: social and cognitive assessment and its application in the context of formal/informal learning*

> O2.    *Design and prototype Complex Collaborative Learning Resources (CC-LRs) as an extension of traditional Learning Objects, with special emphasis on aspects of cognitive and social assessment.*

O3.    *Design a reference assessment framework for virtualized collaborative and networking scenarios from real online collaborative group experiences, using LA and SNA techniques and tools.*

O4.    *Analyze and discover the social dynamics present in the virtual collaborative learning for knowledge sharing and production. This analysis will come, mainly, from real discussion forum experiences.*

O5.    *Develop some case studies based on the assessment framework previously designed in the CC-LR context.*

O6.    *Experiment with case studies in real situations and evaluate the expected learning improvements using the CC-LR approach extended with the cognitive and social assessment approach.*

O7.    *Validate the experimental results obtained in order to improve the framework.*

These goals O1 – O7 were achieved throughtout the research work reported in Chapters 2 - 5 of this thesis.  Chapter 2 contextualizes the main research topics in terms of learning theories and models involved in this research, specifically collaborative and social learning, and its implications in eLearning from a conceptual, technological and evaluation perspectives. Based on this knowledge, the research addressed the core issue of e-assessment in collaborative and social learning and described its different forms and types. It concluded by clarifying how assessment information can be extracted from collaborative and social learning activities and what methods and tools can be used for enhancing the collaborative knowledge built in these activities (O1).

After this preliminary research, in Chapter 3 we defined instances of learning objects (LOs) which address the assessment requirements in collaborative scenarios, pedagogically designed with reference to the concepts of social and collaborative and social learning emerging from the theories of Vygotsky and Bandura cited in Chapter 2 (O1). To this end, the thesis leveraged a new issue and concept, called 'collaborative complex learning object' (CC-LO) coming from the research conducted in the European project ALICE, which this thesis was greatly involved in. CC-LOs are able to include multiple levels of abstraction from pedagogic context, learners, and representational medium (complexity), as well as intrinsic support for interaction across the object (collaboration). In order to find methods for creating, managing, and executing CC-LOs, the concept of the "Virtualised Collaborative Session" (VCS) was identified as an event in which CC-LOs can be applied and consumed by learners, how these sessions evolve ("animate") over time, and how the ultimate end-user interactions with CC-LOs can be handled. Following with the objectives of ALICE 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, the CC-LO approach was turned to the development of a new type of learning resource called 'collaborative complex learning resource' (CC-LR). The notion and concept of CC-LR was introduced as CC-LO that registers live collaborative sessions and produces an animated storyboard such 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 in Annex I to augment the CC-LRs with author-generated information, thus showing the provision of complex aspects of

the learning process in the CC-LRs (O2). Specifically, assessment information was specifically considered to be incorporated into the CC-LR. In addition, the VCS provides lecturers and tutors with edition capabilities of the CC-LRs, such as cutting scenes, modifying involved characters, dialogues and connected concepts, etc.

Chapter 4 represents the core of this research by providing the design, construction and execution of an assessment framework for online collaborative and social Learning scenarios based on the knowledge acquired in the literature review of Chapter 2. To this end, first, we explored how to use collaborative and social learning scenarios for assessment purposes in the context of online learning experiences and how the collaborative process can be assessed as a specific assessment approach that can be realized through different assessment methods and phases (O3). Then, specific indicators that characterize and model social and cognitive interactive behaviour during CSCL activities are analyzed and discussed, representing the main input of the assessment framework (O4). These indicators and the processes to assess live collaborative sessions are then developed and incorporated into the CC-LR approach described in Chapter 3 for prototyping and testing purposes (O5). This part of the research concludes with the difficulty in balancing ease-of-use and transparency against the need to provide the students with an understanding of the underlying assessment processes and its value, especially in the context of the CC-LR approach. Experimentation activities reported in the next chapter clarifies these issues.

The above theoretical, technological approaches are evaluated in Chapter 5 by experimenting with a prototype of the VCS system that embeds the CC-LR presented in Chapter 3, which was enriched with the assessment framework based on cognitive and social indicators presented Chapter 4. A series of case studies were developed to experience with the assessment framework integrated into a CC-LR with storyboards showing how collaborative knowledge is constructed by peers and how learners interact with the CC-LR for self-assessment purposes and observe consequences of their learning decisions (O5). Specifically, cognitive and social assessment was evaluated in the CC-LR. The cases studies were experimented in real contexts of full online learning (UOC) and blended learning (UCA). The experiments focused on evaluating the assessment framework incorporated in the CC-LR based on cognitive and social indicators and their effects in the learning process (O6). The resuts validated the specific goals and hypotheses formulated for each of these case studies were achieved. In particular, the notion and nature of the CC-LR extended with our assessment framework based on LA and SNA indicators was validated by running extensive tests on a proof of concept of the VCS system that embedded the CC-LR. In addition, all the feedback received by the participants in the experiments was used to improve both the VCS prototype and in turn enhance the features of the sample of the CC-LR used for the later experimentations reported (O7).

Finally, the thesis's hypotheses formulated in Section 1.7.2 were firmly verified throughout Chapter 5 as follows (see also Sections 5.1 and 5.2):

H1.    *The use of cognitive and social indicators applied to CC-LRs allows users to acquire more knowledge from collaborative learning activities.*

        In general students liked the CC-LR extended with assessment indicators and found this new type of learning resource easy to use, interesting and useful, since it

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contributed to better content understanding, knowledge retention and construction. Regarding social and cognitive indicators, results indicated that they can become a reliable source of information at different level of learning assessment, such as individual and group performance and dynamics. Although these indicators were found to be useful, experiences conducted in this particular part of the research showed that this information should be integrated in a more natural way in the CC-LR. On the other hand, the students appreciated the test scenes (cognitive assessment) of the CC-LR for knowledge retention and construction. Therefore, in general we can state that the assessment indicators integrated in the CC-LR as the main output of the assessment framework presented in this thesis had a positive impact in learning process in terms of acquired knowledge,

H2. *The use of the CC-LR created from real collaborative activities enriched with LA and SNA techniques contributes to improve the virtual learning activities, increasing students' motivation and engagement.*

The use of LA and SNA techniques were found suitable to complete the live collaboration in the CC-LR, using the collected relevant information acquired from the discussion forums. The data extracted provided information to assess and measure the cognitive and social interactions and features underlying the collaboration, thus augmenting and visualizing in the CC-LR the information of the collaborative processes. In particular, In general, the students appreciated and felt very motivated by the test scenes incorporated in the CC-LR that allowed them to self-evaluate their leaning progress. This way, in overall, they found the CC-LR intuitive and very good as learning material, which eventually engaged them in both the CC-LR and also in the learning assignment supported by this material. Therefore, we can state that LA and SNA based indicators integrated into the CC-LR became a reliable source of information at different level of learning assessment, such as individual and group performance and dynamics.

H3. *The levels of usability, emotional aspects and functionality of the CC-LR are satisfactory.*

All the experiments conducted in the real pilot sites proved sufficient levels of usability and emotional aspects as well as of functional efficiency when using the CC-LR embedded in the VCS system. In particular, usability scores were above the SUS mean and emotional aspects (feeling more times happy than negative emotions) were validated in absolute terms and also relatively. In addition, each experience showed better results in these aspects from the previous experience by the intermediate improvements developed in the system from the participants' feedback received. Therefore, we can state the levels of usability, emotional aspects and functionality (efficieny) of the CC-LR were satisfactory.

H4. *CC-LRs are considered as a valuable educational resource by students.*

The worthiness of the CC-LR approach was exhaustively evaluated in the different experiences by the design of an effective questionnaire to collect information from the different perspectives of the CC-LR. For each experiment, the results of the intervention

groups were significantly better than those of the control groups. Despite certain levels of frustration appeared, produced by the length of the CC-LR and high expectations to learn faster and easier, students in general found the new version of the CC-LR enriched with authoring information on cognitive and social aspects more attractive and pleasant to follow rather than the CC-LR without these features (first experiment at UOC). These results are in line with the previous results on usability and emotions (H3). Therefore, we can state that the CC-LR approach is a valuable educational resource.

Overall, the CC-LR learning resources extended with cognitive and social assessment provided learners with balanced levels of challenge, interaction and empowerment during the virtuallzed collaborative learning experience. As a result, students were meaningfully engaged in the learning process while improving their learning outcomes, thus achieving the main research goal of this thesis (see Section 1.6).

# 6.3 Future work

From the conceptual view, next direction of research aims at identifying the exact processes needed to create CC-LOs as a base to generate more pedagogically effective CC-LRs, whether the content itself requires creation, or rather CC-LOs may be formed by appropriately recognizing the pedagogic relationship between existing technical and conceptual components, and consolidating them into the LO approach and within the curricula of the engineering courses. From this pedagogic perspective, ongoing work aims to develop clear guidelines for the creation and use of CC-LOs both within different engineering application domains (e.g., software and computer engineering) and by engineering educators on a wider scale.

From the technological perpective, next iterations of the CC-LR approach are providing a full featured version of the VCS prototype to support specific aspects of the engineering curricula, such as systems models and simulation. In addition, it is planned to address the encountered issues with the CC-LR enriched with assessment information (see student's comments in Sections 5.1, 5.2 and 6.2) by shortening and summarizing the CC-LR sequences for achieving significant learning more effectively. We also plan to improve the test scenes embedded in the CC-LR for self-evaluation purposes by providing more dynamic interaction without interrupting the learning process. Finally, next steps will include research on further LA and SNA indicators to assess other dimensions of the cognitive and social networking found in live CSCL activities.

From the evaluation perspective, next steps include further evaluation of the conceptyally improved CC-LO and corresponding CC-LR approaches in a larger scale in the real full online learning context of the Open University of Catalonia an in a greater variety of knowledge areas and pedagogical models. Intensive experimentation and validation activities will be conducted. In this evaluation context, the statistical tools used so far have the inherent limits of descriptive statistics utilized. As the experiments were conducted with subjects randomly assigned, the research could improve the statistical results and conclusions using inferential statistics, thus asserting whether there are significant differences among the studied variables, correlations among variables, etc. We plan to consider this approach in next research steps.

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# Annex I: VCSTools. User guide

## Introduction

The VCS prototypes showed in this guide was designed for creation, managing and execution of **CC-LR** (coming from SLO, see Chapter 3 for more information) )from live collaborative sessions produced in web-based forums. Three main prototypes were developed for these purposes: **VCS Creator**, **SLO Player** and the **SLO Editor**. Instructions to gain access to the prototypes are found in the Annex I of this document. For most convenience the link to the main client, VCS Creator, is reproduced here: http://yaren.uoc.edu/VCS.SLOTools/VCSCreator.aspx

Leveraging the independence of the VCS system from the any forum that provides the appropriate converter, two possible forum sources are used in this prototype for the SLO/CC-LR conversion: the ALICE project's reference platform Intelligent Web Teacher (IWT) and another Web forum named Discussion Forum (DF). Both are exchangeable as shown in Figure A1.1. For the purpose of describing the user guide the IWT source is considered.
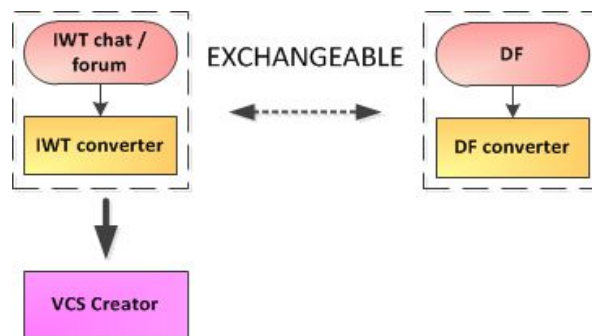


*Figure A1.1: First steps flows and VCS selection screen*

## VCSCreator prototype

The following guide shows step by step the creation and execution process of an SLO from the user perspective by means of the VCS Creator client (Figure A1.2):
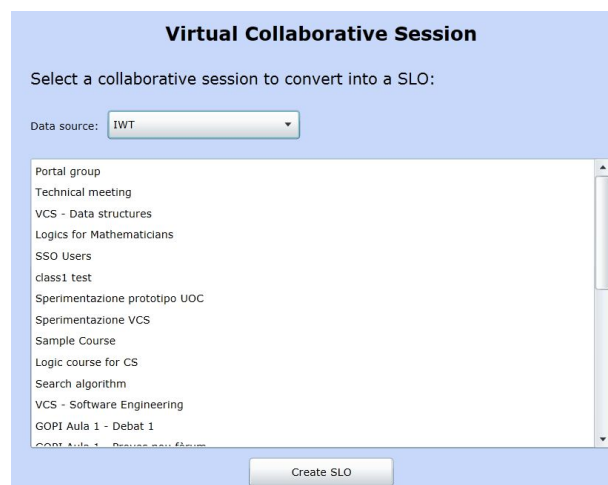


*Figure A1.2: The VCS Creator client*

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1. The VCS Creator first asks the converter the list of available live collaborative sessions in the data source, and shows it to the user. The user selects one collaborative session clicks the "Create SLO" button to create the SLO.
2. Once the user selects one collaborative session and the process starts, the VCS Creator asks the user about some basic properties of the SLO object to be created (see Figure A1.3), such as an identifier name. A name related to the topic of the collaborative session is suggested to ease further identification and selection of the appropriate SLO. The user inputs a name for the SLO and the creation process continues by clicking the "OK" button. Alternatively, the user can stop the creation process by clicking the "Cancel" button. The VCS Creator can automatically open the new created SLO into the SLO Player and / or the SLO Editor client by clicking the corresponding checkbox. Finally the user can select whether to categorize posts automatically or not. This option is unchecked by default because this operation is a very time consuming. The three next sub-steps show the internal process of creation, which is transparent for the user.



*Figure A1.3: SLO properties input*

a. The VCS Creator asks the corresponding converter about the selected collaborative session represented in CS$^2$ format.
b. The VCS Creator calls the CS$^2$ to SLO component to convert the CS$^2$ data into an SLO. The process is showed in the next flow diagram.
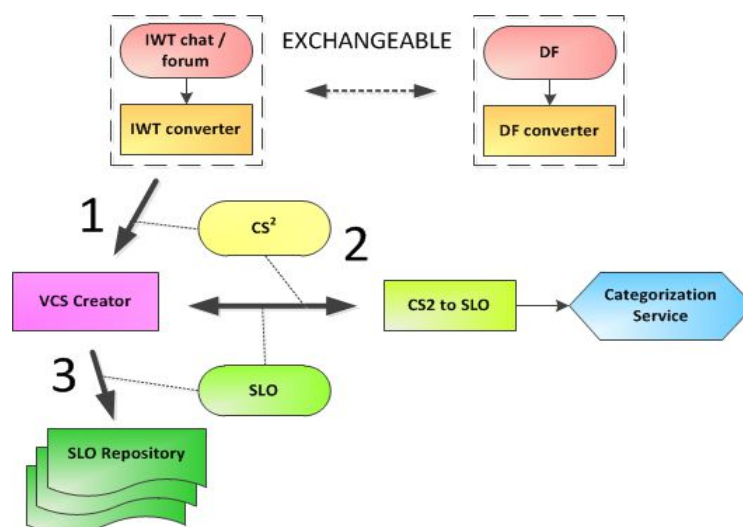


*Figure A1.4: SLO Conversion process*

c. The VCS Creator stores the newly created SLO into the SLO Repository (Figure A1.5).



*Figure A1.5:*
*VCS Creator*

*Relation between*
*and SLO*
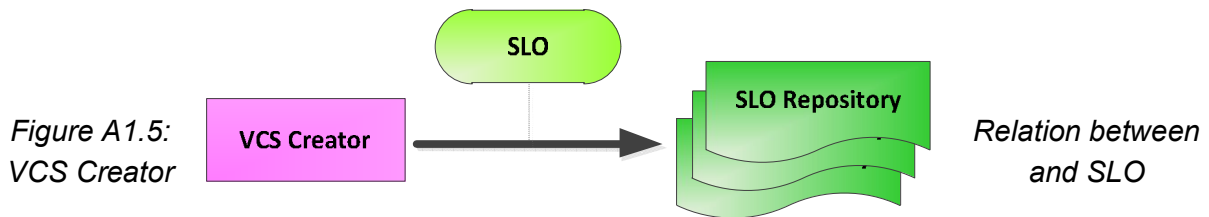
## SLOPlayer prototype

1. Once the SLO is stored in the SLO Repository it can be played from the SLO Player. The SLO is loaded by the SLO Player client and showed in the player window (see Figure A1.6). It is worth noting that the SLO Player client acts here as a pop-up and may be blocked by the browser. Some web browsers show the pop-up blocked windows and some others do not show any message at all. Therefore, it is important to make sure to turn off the pop-up blocking utility to continue with the prototype execution. If the collaborative sequence is not empty, the next screen window will be displayed.
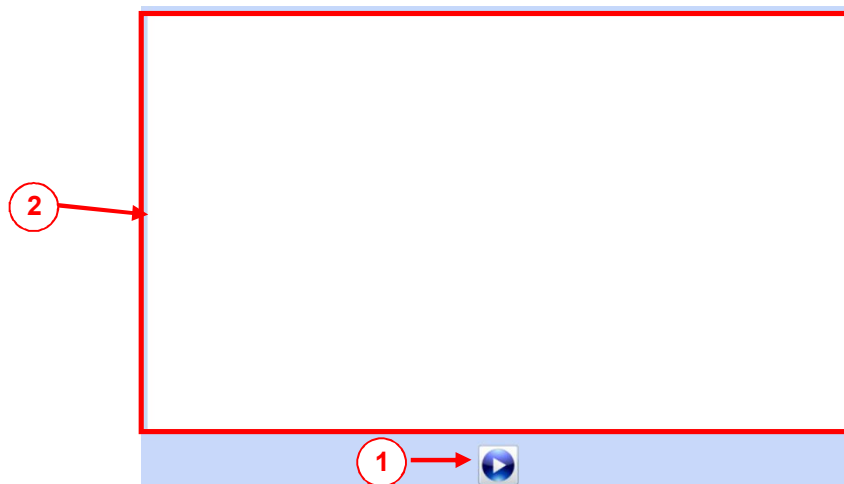


*Figure A1.6: SLO player screen*

There are two elements to consider in this window:

a) Play button, to reproduce the loaded SLO.

b) The screen zone where the SLO scenes are played

2. The SLO Player, as a web client application, is independent from the VCS Creator client and can be accessed directly by following the link in Annex I. The SLO Player first lists the available SLO in the SLO Repository so that the user can select one and load it ready to be played as shown in step 3 (see Figure A1.7). In the future the list of SLOs available from the repository will include the title of the SLO and a little description, and will enable to search SLOs by some properties.

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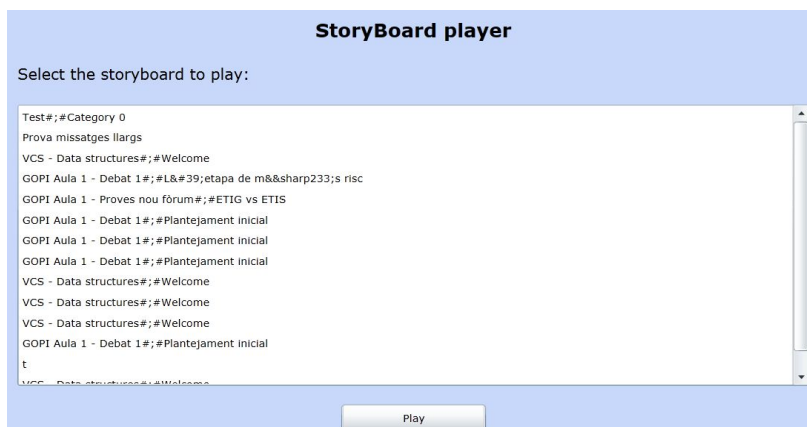
*Figure A1.7: Selecting a SLO in the SLO player*

3. Either through the VCS Creator or directly from the SLO Player clients, at this point of the guide the selected SLO has been loaded and it is ready to be played.

The next steps show an example of a SLO generated from a source text-based discussion thread. Figure A1.8 shows the results of converting the source of the live collaborative session into a SLO, which is played in the SLO Player (Figure A1.8).
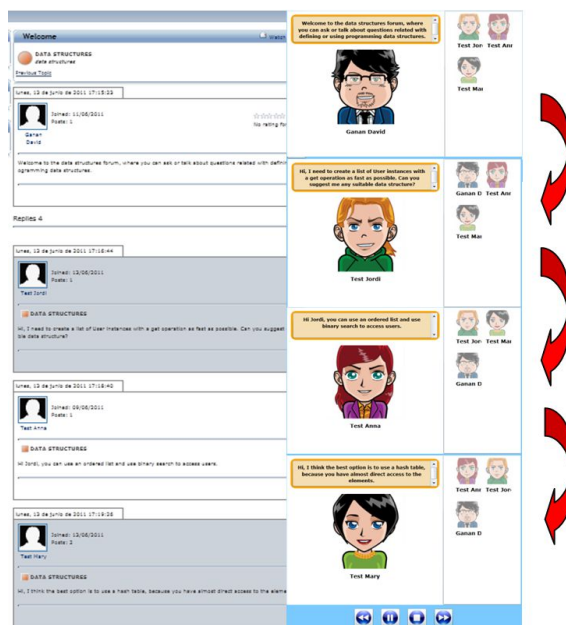


*Figure A1.8: A SLO generated from a text-based discussion thread in a Web forum.*

For the rest of the section use the SLO prepared for testing purposes. Note that this SLO incorporates additional information about cognitive and emotional aspects not found in the IWT original collaboration. This information has been added with the VCS Editor in order to create an enriched learning material. An SLO can be watched in a specific installation of the SLO Player for testing purposes. The link is found in the Annex II of this document and is reproduced here for most convenience:

http://yaren.uoc.edu/VCS.SLOToolsTestingTUG/SLOPlayer.aspx
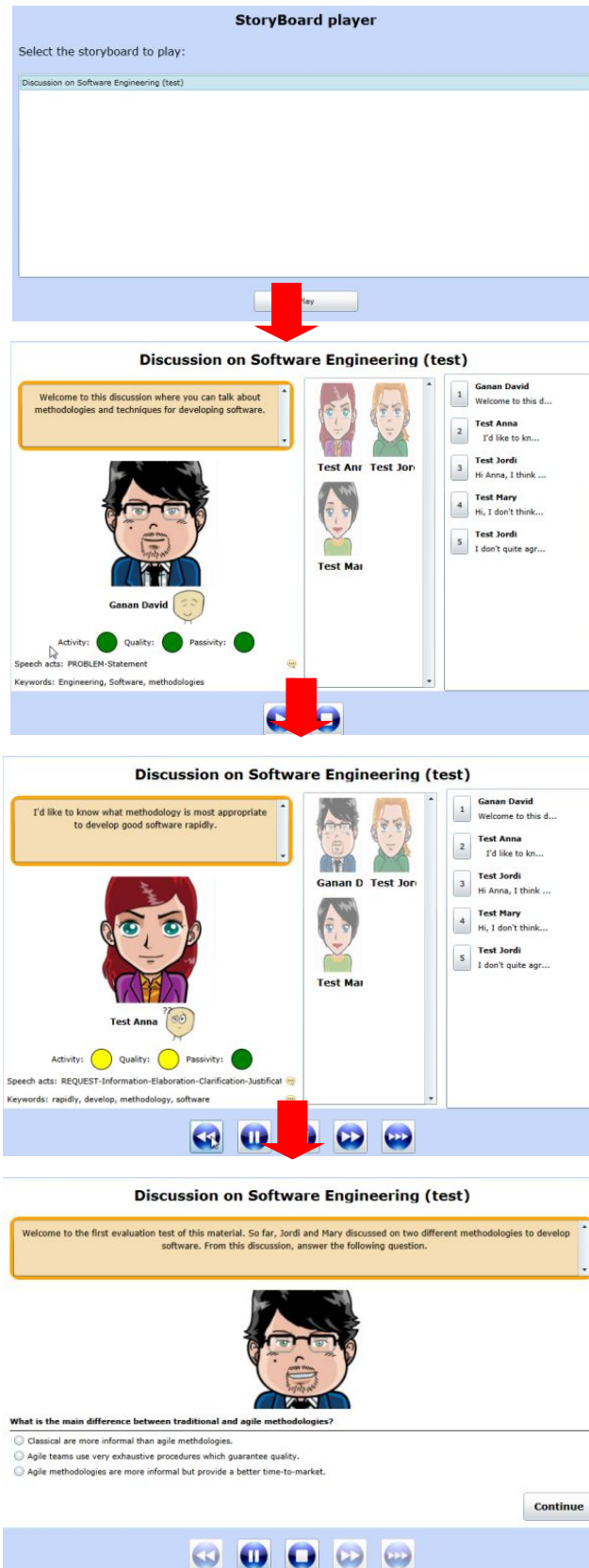
*Figure A1.9: Result: a SLO-based discussion thread played by the SLO Player.*

4. The main screen is split into zones where different aspects of the discussion are shown see Figure A1.10). These zones are described below.

a. **Active participant zone**. Is where the current speaker appears. Depending on the preferences it is represented as an animated avatar or a photograph, with his / her name below.

b. The **dialog balloon** displays the current speech text, which is also played as sound generated by a text-to-speech engine.

c. In the **content augmentation** area some augmented properties of the current speech are shown, like the categories or keywords associated with it.

d. **Passive participant zone**. The rest of participants in the scene other than the current speaker are shown in this area. As the size of this area is small, only $p$ passive participants are displayed at a time. Being $d$ the number of all the participants according to the formula: $p = d - a$; let $a = 1$ and $d > 1$.

   o If $d < 4$ (i.e., $a = 1$ and $p < 3$), the right side of the screen displays $p - a$ passive participants in normal size (see Figure A1.10).

   o If $3 < d < 8$ (i.e., $a = 1$ and $p$ $2 < p < 7$), the right side of the screen displays $p - a$ passive participants in small size in order to fit the available room.

   o If $d > 7$ (i.e., $a = 1$ and $p > 6$), the right side of the screen displays $6$ passive participants in small size and the $p - 6$ passive participants left are hidden and can be reached by scrolling the screen to the right.

   o In this scenario, the player always displays the most recent active participants as the first passive participants being the most recent active the first passive participant that is displayed on top of the right side.
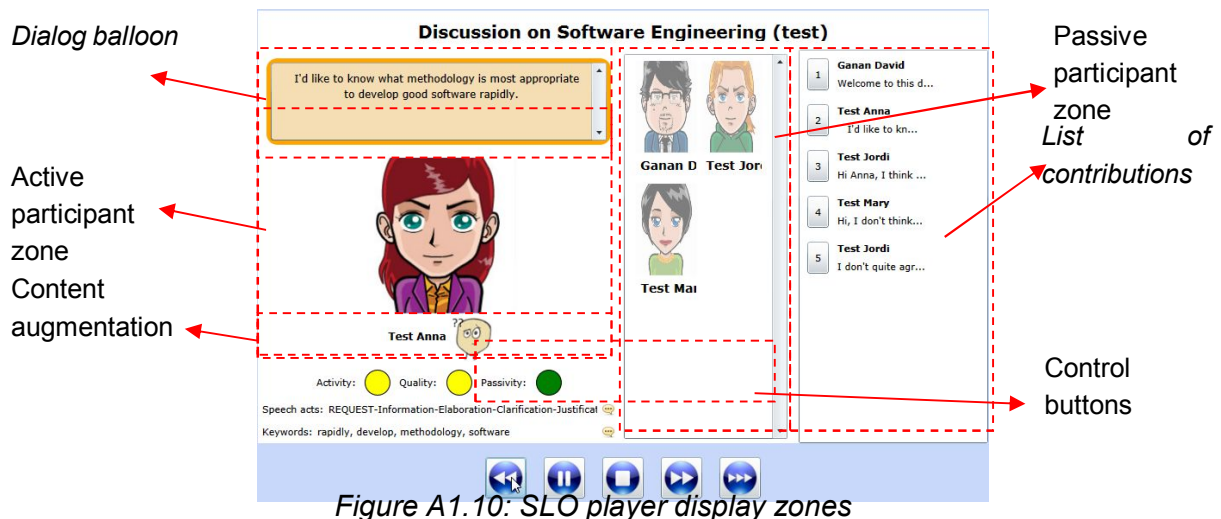

Figure A1.10: SLO player display zones

e. **List of contributions**. This list shows all the contributions available in the scene and enables the user to jump to a specific one directly.

f. Finally at the bottom of the SLO Player the **control buttons** appear. They are specific command controls that add basic playing functionalities as Review , Pause , Stop , Move between messages and move to the next scene . These controls enable the users to play the SLO as many times as needed and navigate throughout the SLO.

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The right-list of buttons allows for acceding directly to any message by clicking on the corresponding button ![button icon: 10 Daniel Segons la n].

5. In the active participant zone there is feedback assessment information about the participant performance (See Figure A1.11):
   a. Deferred emotional status
   b. Deferred assessment aspects as: activity, quality and passivity status. Each indicator in shown in 3 colors (red, yellow and green) according to the performance level of the participant.

Activity: ⬤ (yellow)  Quality: ⬤ (yellow)  Passivity: ⬤ (green)

Red shows a poor level, yellow a average level and green shows a good level
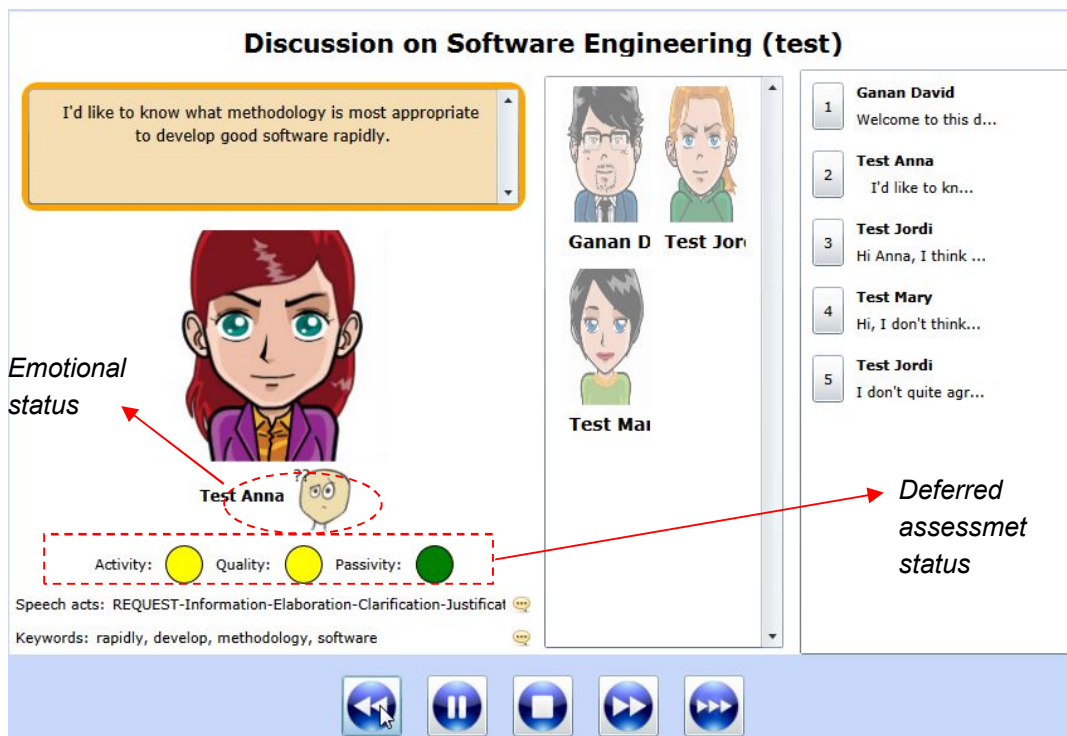


Figure A1.11: SLO player feedback zones

## SLOEditor prototype

SLOEditor is the main tool to modify and create scenes in the SLO sequence. The following is the designed interfaces:

1. Main SLO Editor window. Here it is possible to add a new scene and place the scene where will be played. The refenreced buttons are showed below.

Save SLO Sequence  Save as new SLO Sequence

Return to main page

SLO Sequence Name

Scene list

*Figure A1.12: SLO editor*



Add new scene

Duplicate scene

Remove scene

Edit scene

Exit Sequence Scene

Move scene to first position

Move scene up

Move scene down

Move scene to last position
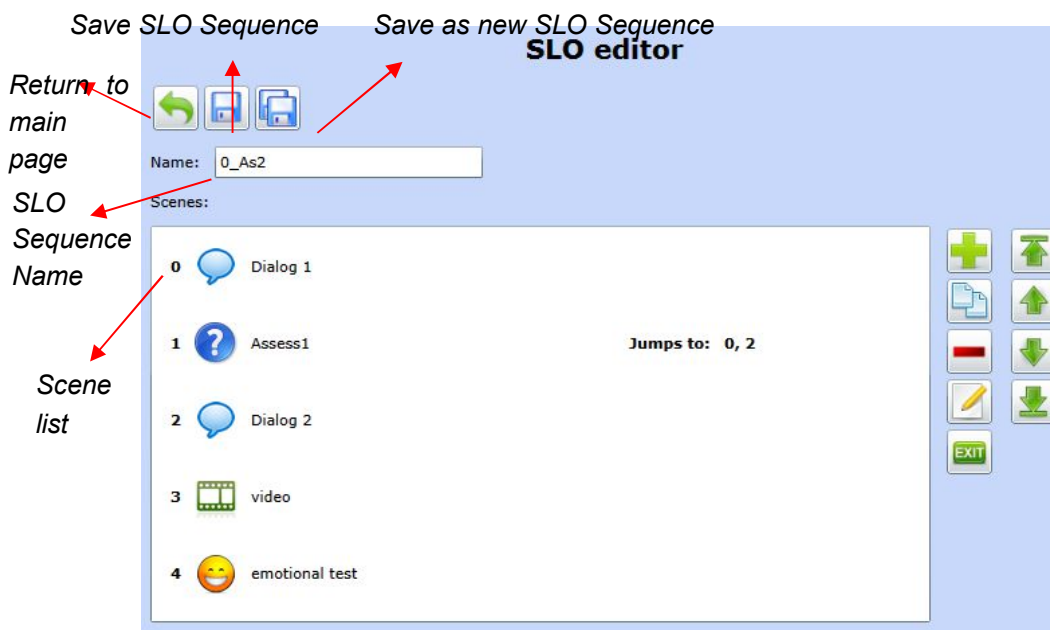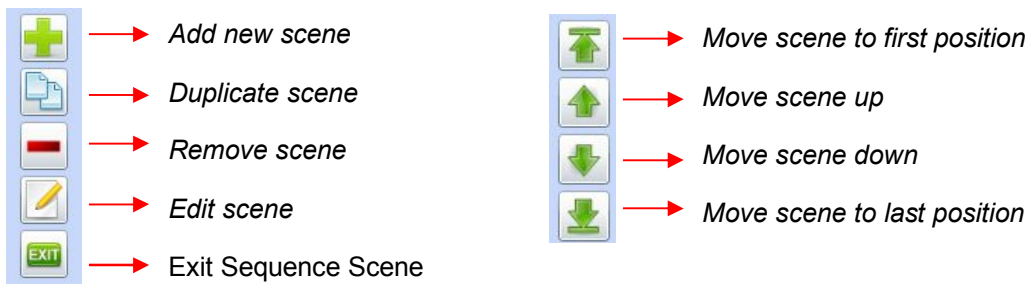
2. Once the "add new scene" has been selected, a new window is showed below:



In this window (Figure A1.13) is to select the scene name and the scene type required:

▪ Dialog: where participants exchange information and interact.

▪ Assessment: where some dialog aspect is evaluated

▪ Video: where to show additional material in the formof video

▪ Emotional test: where to check the student emotional status

*Figure A1.13: Create a new scene*

3. Once a dialog scene has been created we can edit its contain. Here it is possible to create individual dialogs to complete the previous SLO sequence or modify a dialog to adjust the content.
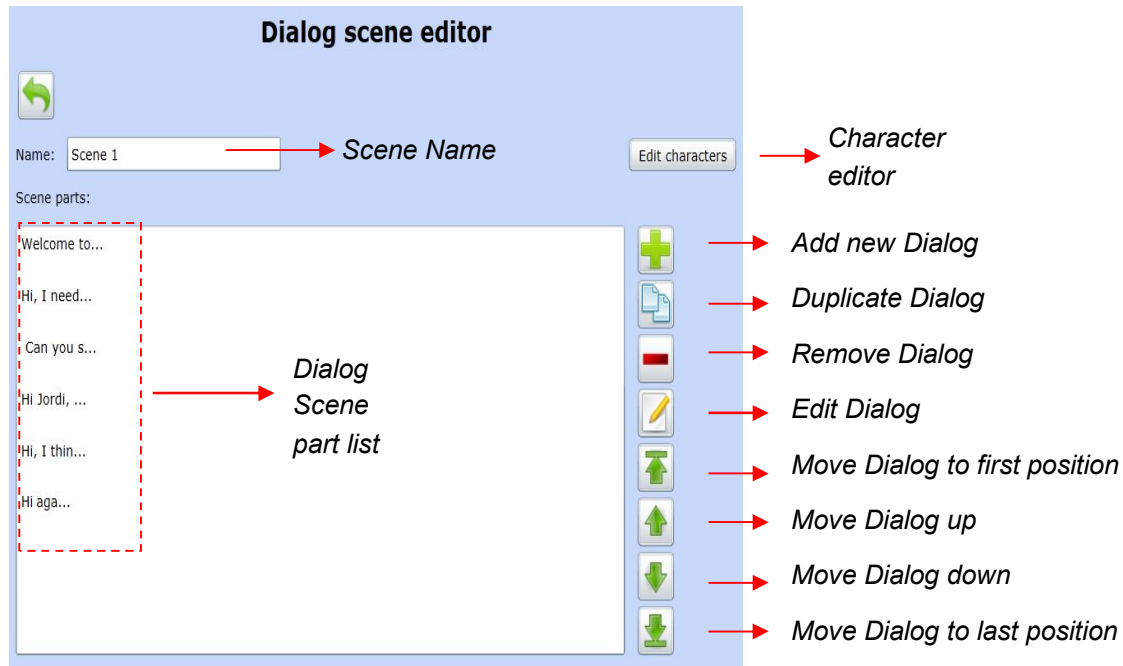
*Figure A1.14: Dialog scene editor*

4. The next window is the Dialog scene part editor where to edit a specific dialog, character, language and character (avatar). The snapshot below shows the dialog scene part editor and the available fields in the first upper menu option: Speech and Character
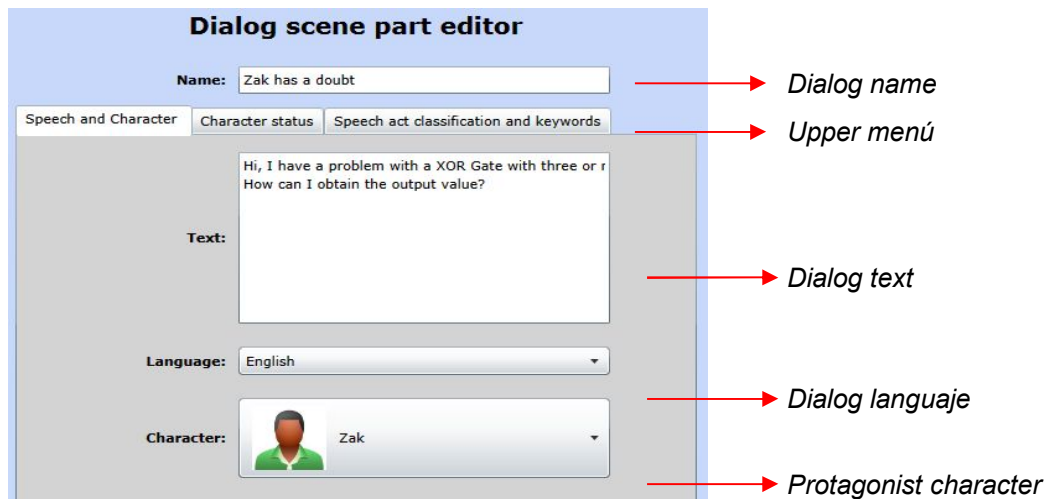


*Figure A1.15: Dialog scene part editor*

5. Second upper menu windows shows the emotional status and some special marks. These special marks are useful to show a special status achieved by the student. Some of the special marks are laudatory but a few show doubt o agree/disagree positions.

Emotional state can be choosed from a set of emotional types with a "emoticon" look . The system is also capable of making a suggest for the emotional state of the character given the current speech (although a human editor is responsible for checking this suggestion and propose the appropriate emotional status .

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The marks and the emotional status are showed during the scene played in the feedback zones (see Fig A1.16).



*Figure A1.16: Character status in Dialog scene part editor*

6.  The next upper menu option is Speech acts classification and keywords tab (see Figure A1.17). In this window a set of categories is available to classify dialogue speechs. The goal is to relate each scene with a dialogue move (primitive moves are: Inform, request, support). The system can suggest a speech act and it is expected a human expert to review and change it if needed.

The speech acts are important to infer the student profile and his/fer performance in the dicussion. The dialog can be identified as support when the participant expresses a salute or personal introduction. There are other speech acts,such as

*   Inform  Explain: response to a request of information or an extension of it

*   Problem Solution: if the student offer a solution to the group

*   Problem Statement: when a problem is stated and needs a solution

*   Request Information: a student requests additional information

As for the keywords, they are useful to summarize the speech and for searching purposes of scenes (not implemented). Keywords are suggested by the system though others can be added by using the functionality shown below. Only those categories and keywords selected will be displayed in the scenes.

*Figure A1.17: Categories and Keyword suggested by the system or selected by the designer*

7. Returning to the scene editor, as evaluators we can edit an assessment scene and edit it. The edition window has three upper taps:

- Questions: to create a set of question to be played one before other.
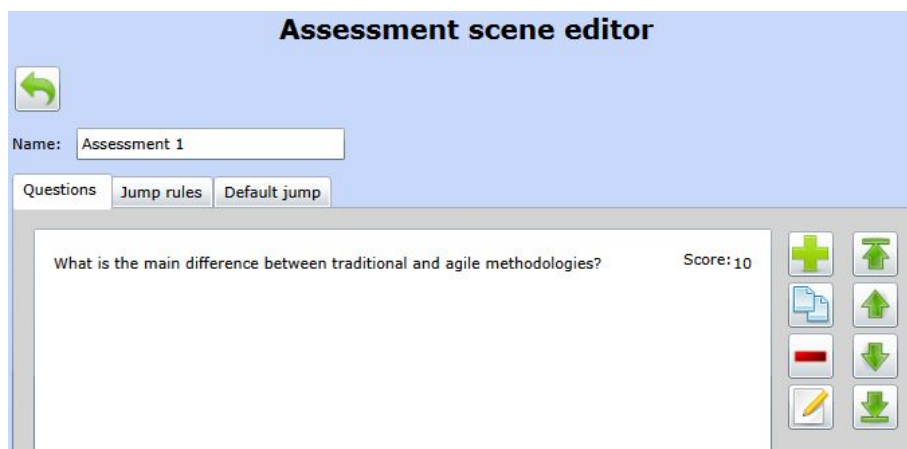


*Figure A1.18: Question editor window*

In this window the next options are available:

New question ← (new question icon) → Send question to top

Clone question ← (clone icon) → One step up

Delete question ← (delete icon) → One step down

Edit question ← (edit icon) → Send question to bottom
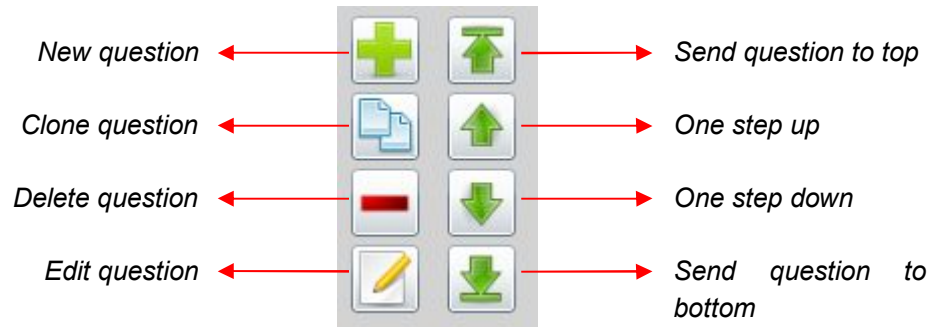
Once the edition option has been selected, a question appears:



## Assessment scene question editor

**Text and score** | Answers | Evaluator

**Question speech:** Welcome to the first evaluation test of this material. So far, Jordi and

**Question text:** What is the main difference between traditional and agile methodologi

**Score:** 10
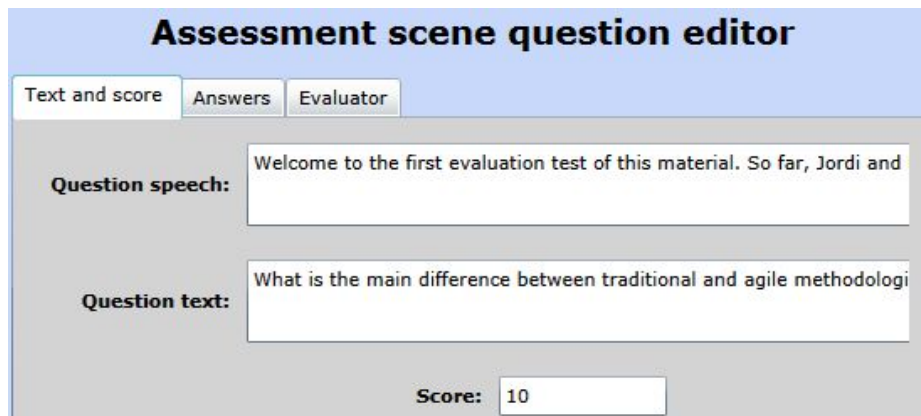
*Figure A1.19: Assessment scene Question editor window (Text and score)*

The evaluator can enter the speech text and and question text, and associate it to a score for evaluating the question

The answers for the question edited can be introduced in the Answers tab. It is possible to add many options and select one as correct.



## Assessment scene question editor

Text and score | **Answers** | Evaluator

Classical are more informal than agile methdologies.

Agile teams use very exhaustive procedures which guarantee quality.

Agile methodologies are more informal but provide a better time-to-marke

*Correct question selector* →
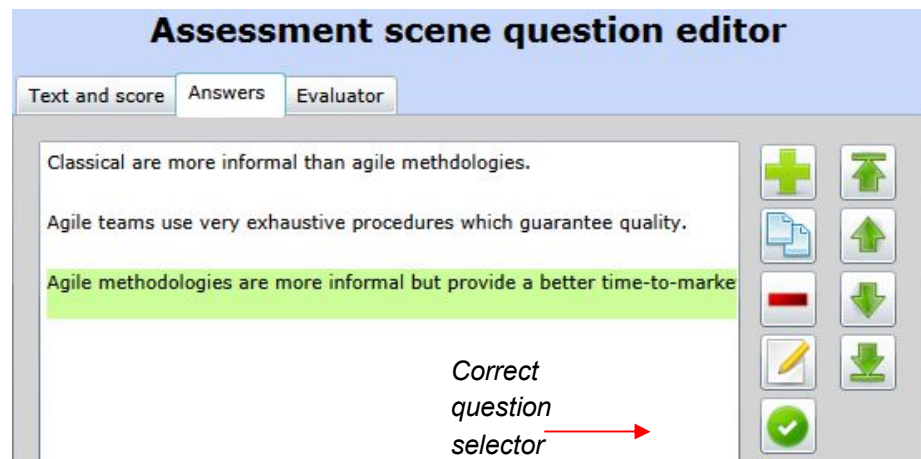
*Figure A1.20: Assessment scene Question editor window*

Also it is possible to select the avatar who represent the Evaluator:
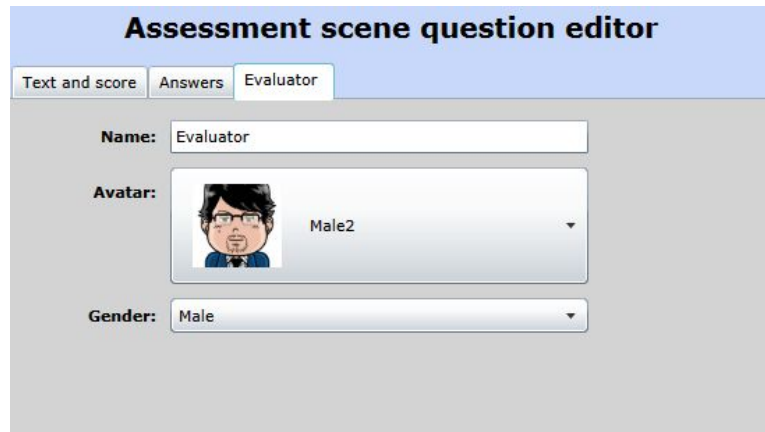
*Figure A1.21: Assessment scene Question editor window*

- Jump rules: The evaluator can enter the target scene associated to a correct or incorrect test answer and some conditions. It is possible to edit the jump conditions using the edition icon.
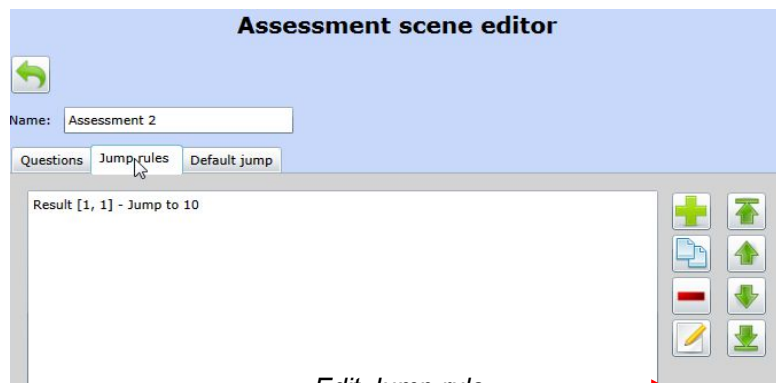


*Figure A1.22: Jump rules window*

Once the edition icon has been selected the Jump rule properties window appears:
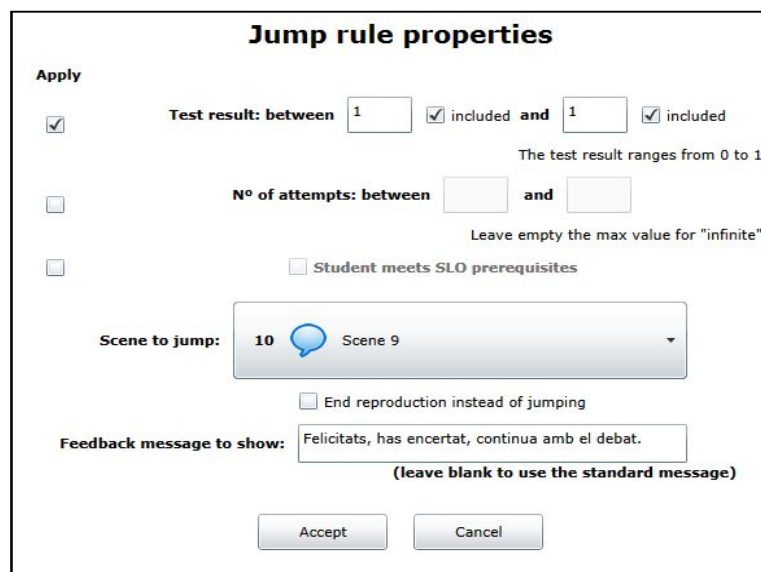


*Figure A1.23: Jump rules properties window*

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The rules have several options to apply:

    i.   Test results: score interval where the rule is effective. The score represents the sum of the scores of all test questions. It is possible select a minimum, maximum or middle interval using the editable limits available.

    ii.   Number of attempts: attempts interval where the rule is effective.

    iii.   Student meets SLO prerequisites. prerequisite option of the SLO (e.g. learning preferences, cognitive state, etc.) to apply for the jump.

- Default jump: It no rules is applicable (i.e. the test is failed), the default jump option takes the control. It is possible to add a text to display.



*Figure A1.24: Default jump selection window*

# Annex II- Access to the prototypes

There are two types of clients developed in the VCS prototype:

1.  VCS Creator for creation of SLOs can be accessed following this link:
    http://yaren.uoc.edu/VCS.SLOTools/VCSCreator.aspx
2.  SLO Player for selecting and play SLOs can be accessed following this link:
    http://yaren.uoc.edu/VCS.SLOToolsTestingTUG/SLOPlayer.aspx

3.  SLO Editor for editing SLOs can be accessed following this link:
    http://yaren.uoc.edu/VCS.SLOToolsTestingTUG/SLOEditor.aspx

For all the clients, no specific credentials are required to gain access.

Once the client is started, follow the user guide described above

# Annex III- Integration of CC-LR into pilot sites

## Integration into UOC Virtual Campus

A CC-LR with a video-discussion was directly available in a UOC virtual classroom as depicted in the figure below (Figure A3.1) for experimentation purposes.
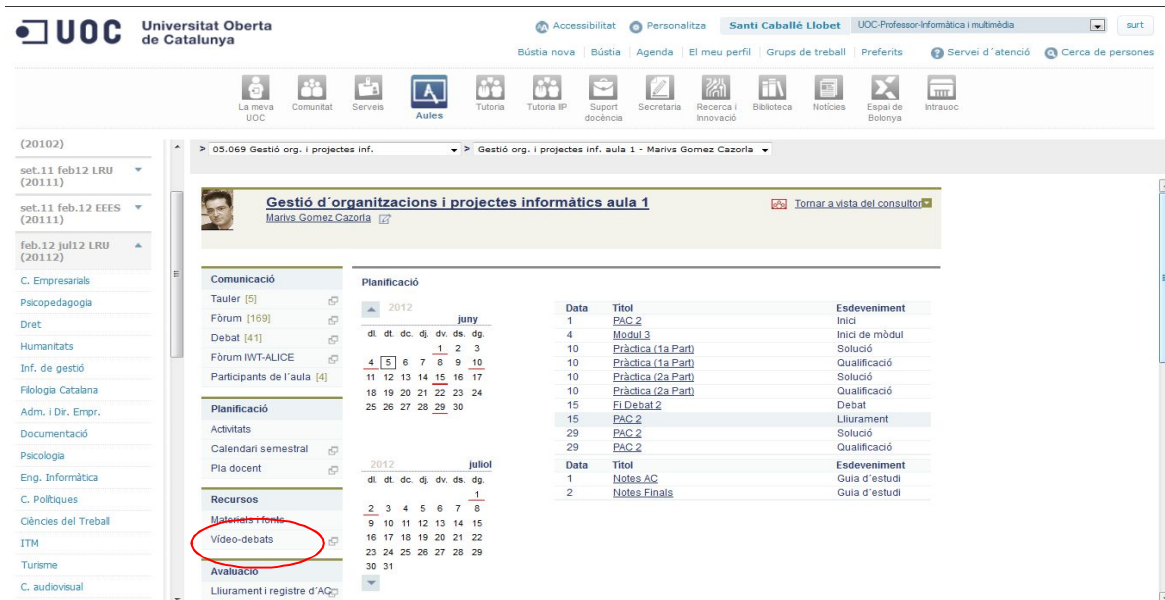


*Figure A3.1: Integration of a CC-LR ("video-debats") with a regular UOC virtual classroom*

The reproduction of CC-LR corresponds to a CC-LR named "*Factors del fracàs de projectes*" as seen in the below figure (Figure A3.2).



*Figure A3.2: Access to a CC-LR*

The instructions for using this CC-LR can be found above in Annex I.

# Integration into UCA Virtual Campus (Moodle)



*Figure A3.3: Integration of a CC-LR with a regular UCA virtual classroom (Moodle)*

The below CC-LR (Figure A3.3) was directly available in a Moodle-based classroom in the UCA Campus Virtual as depicted in the figure above (Figure A3.4) for experimentation purposes.



*Figure A3.4: Overview of a CC-LR*