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1 Introduction

This report describes activities of Work package 3, Task 3.2 / Sub-Task 3.2.1 of the ALICE project. The aim of ALICE is to build an adaptive and innovative environment for e-learning. To this end, personalization, collaboration, and simulation aspects are combined and also affective and emotional aspects are considered. In particular, two specific contexts will be considered in ALICE: university instruction and training about emergency and civil defence.

1.1 Purpose

As the purpose of WP3 is to develop new forms of Live and Virtualized Collaboration, the main objective of Task 3.2 is to develop methodologies for the creation and management of Collaborative Complex Learning Objects (CC-LO). CC-LOs can be considered as educational tools developed in diverse levels and formats with the goal to answer to actual education needs. What makes them *complex* is associated with a reinterpretation of traditional learning objects, which refers to a reinterpretation of common criteria, such as applicability, evaluability, internal dynamism and composability. To this end, as a first step, the goal of Subtask 3.2.1 is to study and assess the state of the art of Collaborative and Social Learning, and Collaborative Complex Learning Objects (CC-LO). Therefore, the aim of this document is to outline and summarize findings of research with respect to Collaborative and Social Learning and define the purpose and aspects of Collaborative Complex Learning Objects (CC-LO). In particular, we will present the state-of-the-art research based on a broad literature review of recent research in Psychology, Pedagogy, and Computer Science.

We organized this paper as follows: In Section 2, we will first give a broad overview about basic theories of learning (Behaviorist, Constructivist and Cognitive). In Section 3, we will focus on collaborative learning from both theoretical and technological point of view. Section 4 will then describe the theoretical and technical models of social learning. In Section 5, we will examine the way CSCL models can be used to construct collaborative and social learning scenarios and how these scenarios can be employed in the context of formal, informal and intentional learning experiences. Section 6 will introduce the issue of assessing collaborative and social learning, initially, in a more general term and consequently will define and describe forms and types of assessment. Then it defines assessment more precisely from the viewpoints of collaborative, cognitive and social theories, and continues by describing the state-of-the-art of e-assessment models and software in general and of CSCL systems and online discussion tools in particular. 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, in Section 7 we will provide an overview a new issue that constitutes one of the backbone pieces of our project, the Collaborative Complex Learning Object (CC-LO), and it will analyze all the aspects that concern this topic of research.

1.2 Overall Summary

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 behavioral aspects of the collaboration. Visualization techniques of this information have also a great impact on on-line social tools.

All above approaches and ideas lead to new needs and expectations for collaborative learning. In this document, 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 sum up, in this document we not only give a review of the state of the art of collaborative and social learning but we will also go a step further by introducing new concepts and issues that will play an important role in this area of research. For instance, we will present the design, construction and execution of new collaborative and social learning scenarios. Furthermore, we will present an overview of assessment and software models of collaborative and social learning and will define new collaborative elements - the CC-LO - and their importance in this research area.

1.3 Methodology

As the aim of this document is to provide a state-of-the-art overview on Collaborative and Social Learning, and Collaborative Complex Learning Objects (CC-LO), an extensive literature research was conducted. In a first step, we searched in data bases and search engines for general terms (e.g., “learning theories”, “learning theories & review”, “collaborative/social learning & assessment”) to get a basic idea and common knowledge of the terms and definitions. In a second step, we then refined the search, using more specific terms (e.g., “CSCL” within “learning theories”). In general, our search terms remained broadly during the first steps to cover technical, psychological, and pedagogical approaches in collaborative learning and assessment. The following data bases and search engines were used to find relevant literature:

- ISI Web of Knowledge
- PsycINFO
- ScienceDirect
- Google

Further resources were technical and psychological journals and special issues of these journals (e.g., “Learning and Instruction”, Special Issue: Unravelling assessment, August 2010), books (e.g, Bransford, Brown, & Cocking, 2004; Gardner, 2006), and conference proceedings. Access to those media was either provided via the libraries of Open University of Catalonia or the media were freely accessible via internet.

Moreover, references from relevant articles were checked for other studies and projects. We also considered information provided from special track papers, workshops, and working groups. For other projects of the European Community and other funding organizations relevant for this review, we searched through the respective websites (e.g. CORDIS website http://cordis.europa.eu/home_en.html).

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). More information about these issues, as well as about the different theories that have influenced and shaped learning, such as behaviorist, constructivist, and cognitive theories of learning can be found in chapter of deliverable D5.1.1.

2.1 Learning

Lefrancois (1994) defines learning as all behavioural changing because of personal experiences; variation 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 meant: 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 (Schumann, 1996; Ebner & Holzinger, 2002).

Schumann (1996) gives a short description of these three learning theories (for more information about learning theories you can refer to chapter 2 in deliverable D5.1.1):

- Behaviourism: Is based on visible changes in behaviour and therefore focusing on new behavioral 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 our 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 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) name 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 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 variegated 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 learnerempathy which is the main contrary to e-Learning 2.0 (Thalheimer, 2008).

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 '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.

3.1 Theories of collaborative learning

Diana Laurillard (2008) 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 1).

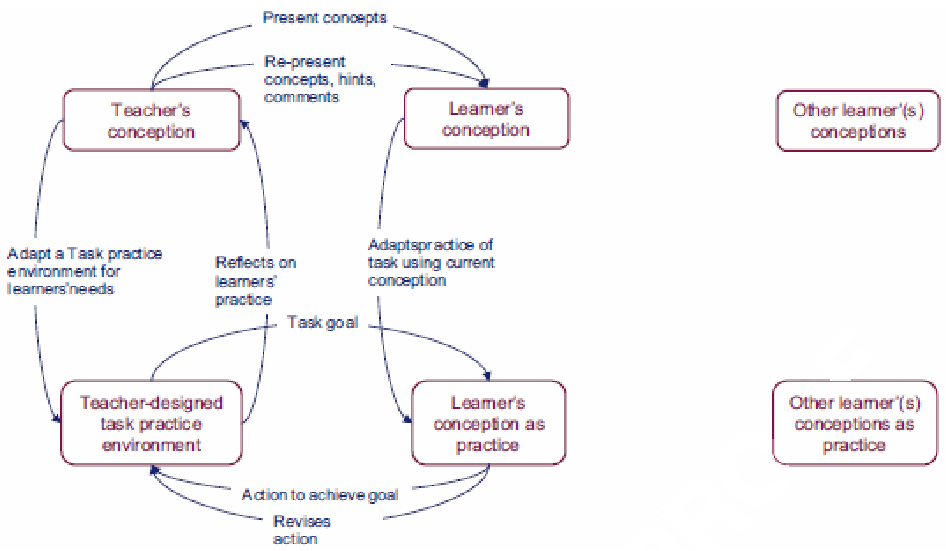

Figure 1: Instructionism

(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, 2008).

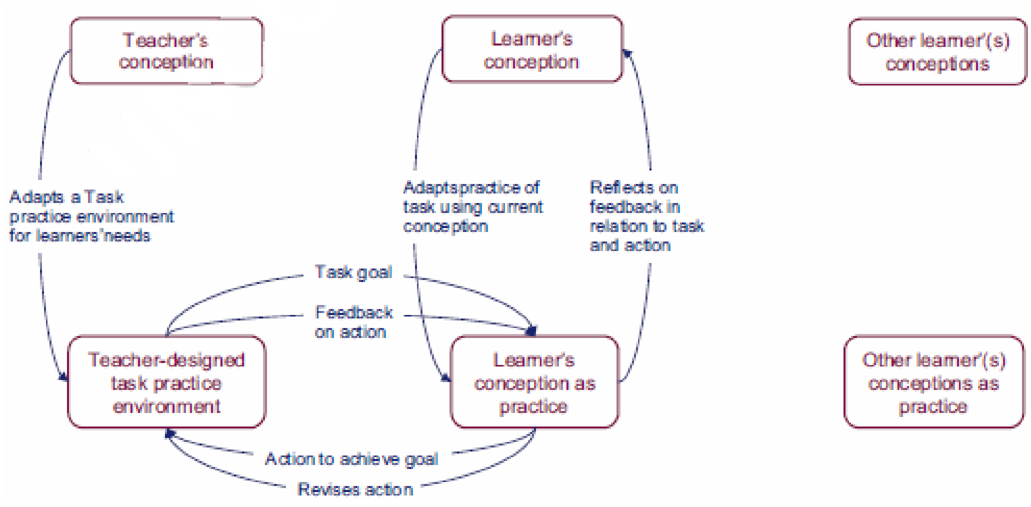

Figure 2: Constructionism

(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).

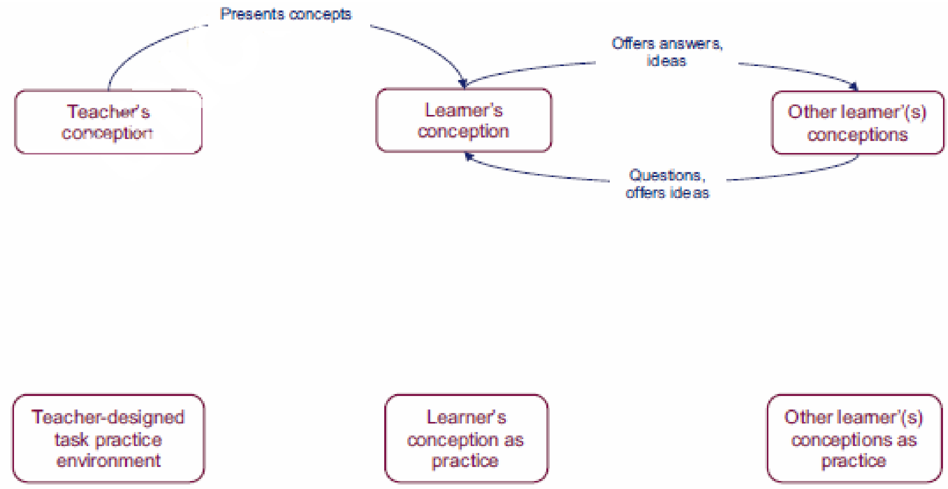

Figure 3: Social learning

(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).

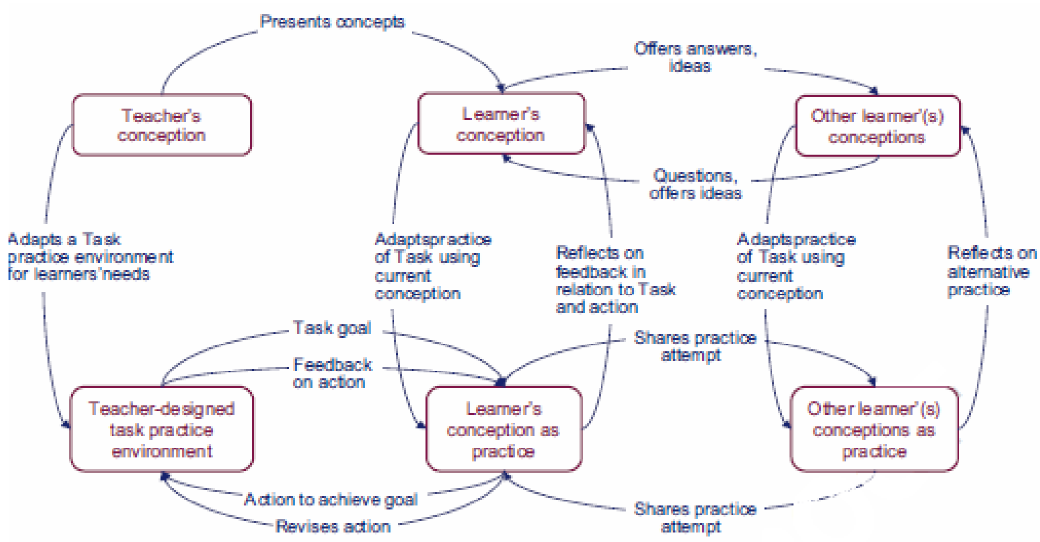

Figure 4: Collaborative learning

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.

3.1.1 Situated Learning (J. Lave)[1]

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.

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

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

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.

3.1.2 Social Development Theory (L. Vygotsky)[2]

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 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:

- Cognitive development is limited to a certain range at any given age.
- Full cognitive development requires social interaction.

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

3.1.3 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-centered, 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 reconceptualized 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 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 5.

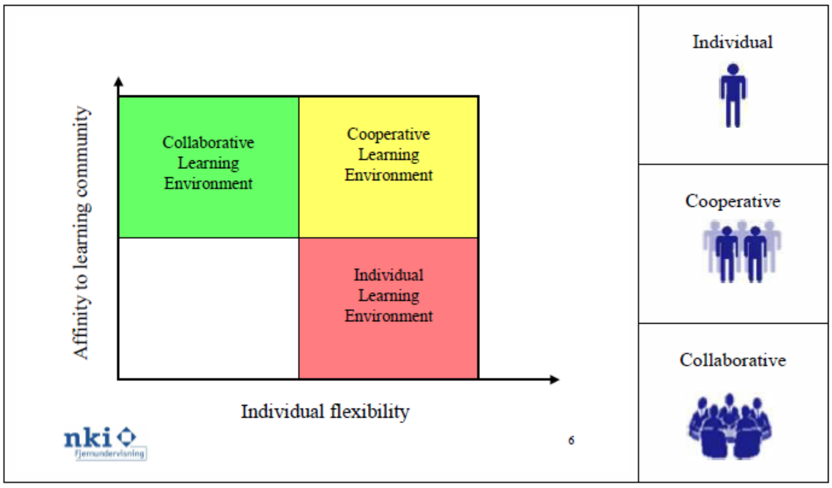

Figure 5: Individual, cooperative and collaborative learning theories

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)[3,4]. 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 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[5] 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.

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

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

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

(7) **Jigsaw:** The jigsaw technique was first developed in the early 1970s by Elliot Aronson [6,7] 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 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**[8]: 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**[9]: 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**[10]: 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) **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).

- 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.

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

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

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

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

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

- 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.)
- *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.
- *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)

- <u>Peer Editing:</u> 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.
- <u>Dyadic Essay Confrontation:</u> 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.

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, et al., 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).

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.

3.4.1 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, (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*: Engestrφm'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 (Engestrφm, 1987). Engestrφm's model is based on a learning cycle consisting of the following seven stages in its ideal form (383-384; cf. Engestrφm 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.

3.4.2 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, 1996). 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.

3.4.3 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).

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 categorization of technologies of cooperation are proposed by the Institute for the Future[11].

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

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

- Project and Team Management Software
- Community Management Tools

3.6 Summary of the Chapter

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 supporting collaborative learning during the past decade (e. g., Crook, 1994; Koschmann, 1996; O'Malley, 1995). 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 Chapter 3 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).

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 modeling. This theory has often been called a bridge between behaviorist 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 behaviors by watching other people. Known as observational learning (or modeling), this type of learning can be used to explain a wide variety of behaviors. 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.

4.1 Bandura's Social Learning Theory [12]

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:

- Attention, including modeled events (distinctiveness, affective valence, complexity, prevalence, functional value) and observer characteristics (sensory capacities, arousal level, perceptual set, past reinforcement),
- Retention, including symbolic coding, cognitive organization, symbolic rehearsal, motor rehearsal),
- Motor Reproduction, including physical capabilities, self-observation of reproduction, accuracy of feedback, and
- 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

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

used in training programs. In recent years, Bandura has 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:

- The highest level of observational learning is achieved by first organizing and rehearsing the modeled behaviour symbolically and then enacting it overtly. Coding modeled behaviour into words, labels or images results in better retention than simply observing.
- Individuals are more likely to adopt a modeled behaviour if it results in outcomes they value.
- Individuals are more likely to adopt a modeled behaviour if the model is similar to the observer and has admired status and the behaviour 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[13] aim to use social collaboration within a gaming context as a means to develop teamworking 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 behavioural 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

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

- 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 behavioural 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 behavioural change are ultimately seeking to persuade individuals to move from behaviour 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 behaviour of adolescents, as the peer group emerges as a key behavioural driver. Therefore, manipulation of behaviour can often be more readily achieved 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.

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 knowledgable 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 must *understand* this 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 Etienne 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 current work with Roma Nova (Panzoli, Qureshi 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.

4.3 Social Learning systems and tools

Social learning systems and tools therefore are also build upon this theoretical basis. In our work on Roma Nova for example, we have developed a concept around distributed tutoring environments that scaffold learning of the individual and leave scope for authoring team missions involving collaborative and peer learning and assessment. In ALICE we envisage the serious game itself and the learning system will become the learning system, joining 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[14] 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. 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*, we 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.

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.

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

4.4 Summary of the Chapter

In this chapter, 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 ALICE project.

5 Design, Construction and Execution of Collaborative and Social Learning Scenarios

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. (Hakkarainen, Palonen, Paavola, & Lehtinen, 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 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.

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

In this section, we consider the application of computer-support collaborative learning 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 model 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[15] (IMS-LD), an educational modelling language that 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[16], CopperAuthor[17] and Cosmos 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., 2005).

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.

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 Modes18 (a system that includes

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

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

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

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

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[19] that still does not overcome quoted IMSLD 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.

Finally, other methods for constructing collaborative and social learning scenarios may include CSCL scripts (micro and macro scripts).

5.2 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). 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 (Julian 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

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

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).

In his excellent and highly informative overview of literature on informal learning, Sefton-Green (2004) points out that the distinction between formal and informal learning may involve more than one factor (kind of setting), see Figure 6.

"*Rather, the distinction between informal and formal learning, as we will use it in this report can more clearly be made around the intentions and structure of the learning experience. If this sounds rather abstract, another way of thinking about it is to imagine two kinds of continua. The first contrasts formally organized learning with casual or 'disorganized' 'accidental' learning (examples here might range from a lecture through to playing a computer game respectively). The second ranges from formal settings (schools) through intermediate kinds of learning spaces (like museums and galleries) right through to social structures we don't tend to think of as learning organizations (like families or friendship groups). In other words we could have both formal and informal learning occurring in both formal and non formal spaces; it is quite possible to have formal learning in the home (doing homework, for example) or informal learning in a school (smoking behind the bike sheds).*"(Sefton-Green, 2004, p 6)

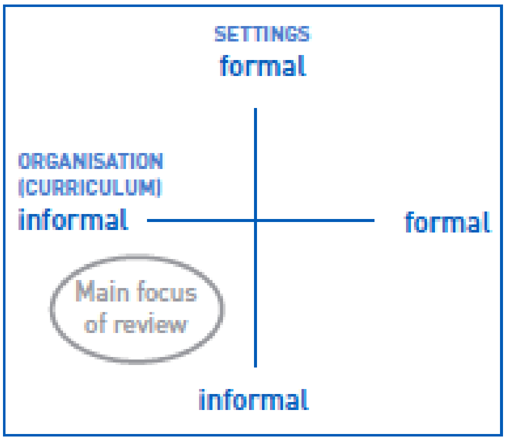


Figure 6: Dimensions of formality in learning (Sefton-Green, 2004)

In the formal learning context, the Collaborative process can be seen as a specific didactic approach that can be realised through different didactic methods that, generally, bring to the creation and execution of learning experiences in which collaboration and communication among participants play a key role.

In detail, among the possible didactic methods, we will consider the following ones:

- Virtual classroom;
- Synchronous instant communication;

- Virtual meeting;
- Problem-based learning method;
- Collaborative apprenticeship method;
- Jigsaw Method.

Pragmatically, the concrete result will be a Learning Experience, composed by Learning Objects (LOs) that are structured according to the C&C approach and the Didactic Methods, which will contain the activities identified in the following methods.

In concrete, some of the above Didactic Methods consists at least of the following macro-activities:

- The teacher plans the cooperation. In this macro-activity the teacher is involved in the Task Distribution process. S/He can negotiate the task with the learners, assigns roles and tasks to the learners within a group. Inside each group each learner executes the task. Indeed, this process of planning the cooperation can be recursive, in the sense that tasks can be refined and re-assigned also inside a group;
- A teacher or a learner (having the role of coordinator) coordinates the tasks' execution and monitors the results;
- During the task's execution, the learners can communicate among them and with the teacher. Communication can be structured according to a Conversational process. This means that it is regulated by turn-taking protocols, participant share a common ground, etc. In this macro-activity, the instantiation of collaborative tools (like could be flash meeting, GSD, etc.) is expected.

In a formal setting, in particular, the work of Soller et al. (2005) proposes a collaboration management cycle for CSCL. It includes four phases and for each of them we also report the major functional property of tools (Figure 7).

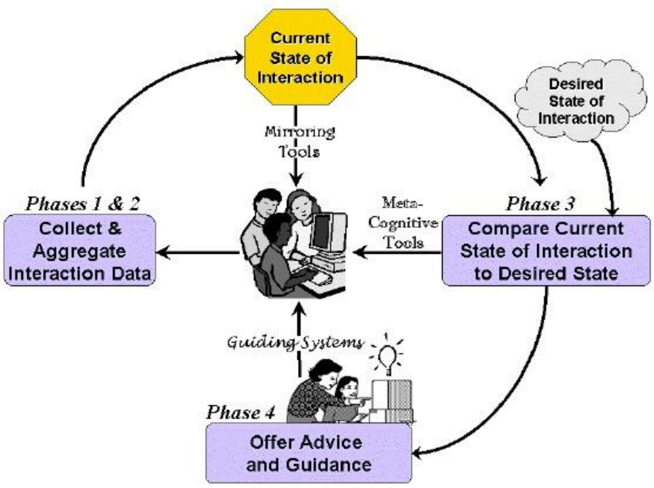


Figure 7: Cooperation management cycle for CSCL (Soller et al, 2005)

"*Phase 1*: *Collect Interaction Data* .The data collection phase involves the observing and recording of the interaction. Typically, users' actions (e.g. 'user1 clicked on I agree', 'user1 changed a parameter', 'user1 created a text node') are logged and stored for later processing. An important decision that must be made in phase 1 as to whether the eventual model will call for an activity-based analysis, requiring a historical log of student actions across time, or a state-based analysis, requiring the logging of “snapshots” of collaborative interaction, without history information (Gassner, Jansen, Harrer, Herrmann, & Hoppe, 2003).

Phase 2: Construct a Model of Interaction. The next phase involves selecting and computing one or more higher-level variables, termed *indicators*, to represent the current state of interaction. For example, an agreement indicator might be derived by comparing the problem solving actions of two or more students, or asymmetry indicator might result from a comparison of participation indicators.

Phase 3: Compare the Current State of Interaction to the Desired State. The interaction can then be “diagnosed” by comparing the current state of interaction to a desired model of interaction. We define the desired model as a set of indicator values that differentiate between productive and unproductive interaction states. A productive state, given by a desired indicator configuration, typically corresponds to a representation of interaction that might positively influence learning. For instance, we might want learners to be verbose (i.e. to attain a high value on a verbosity indicator), to interact frequently (i.e. maintain a high value on a reciprocity indicator), and participate equally (i.e. to minimize the value on an asymmetry indicator). We do not further circumscribe desired interaction because our objective is to parameterize the analysis process rather than present the results of a particular interaction analysis. From an implementation standpoint, the difference between phases 2 and 3 does not seem significant. From a theoretical perspective, however, these phases describe the difference between a system that reflects the group’s activities back to the members, and requires them to manage their own interaction, and a system that prepares interaction data so that it can be assessed by computer models, or analyzed by researchers in an effort to understand and explain the interaction.

Phase 4: Advise/ Guide the Interaction. Finally, if there are discrepancies between the current state of interaction (as described by the indicator values) and the desired state of interaction, some remedial actions might be proposed. Simple remedial actions (e.g. ‘Try letting your partner have control for a while’) might result from analyzing a model containing only one indicator (e.g. word or action count), which can be directly computed from the data, whereas more complex remedial actions (e.g. ‘Try explaining the concept of generalization to your partner using a common analogy’) might require more sophisticated computational analysis. Phase 4 is not the final phase in this process. Remediation by the system or human instructor will have an impact on the students’ future interaction, and this impact should be re-evaluated to ensure that it produced the desired effects. The arrows that run from phase 4 back through the illustration representing the logging of learners’ actions, to phase 1 indicates the cyclic nature of the collaboration management cycle, and the importance of evaluation and reassessment at the diagnostic level.”

5.3 Summary of the Chapter

This chapter investigates issues concerning the design, construction and execution of 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. Given that a scenario definition for collaborative learning may be a particularly complex endeavor, we first should take Bandura’s requirements of social learning into account and then consider CSCL pedagogies and tools that can help educators construct effective collaborative and social learning experiences, 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 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 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 seen as a specific didactic approach that can be realized through different didactic methods and phases.

6 Assessment of Collaborative and Social Learning

In this chapter 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 Section 7). 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 ALICE project, 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.

6.1 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 et al., 2009, 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, 2007:181). 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??, 2004). 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.

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.

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 more attracts 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 porduct. 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 artifact has formal semantics. For instance expert solutions can be used calculate the similarity between the concept's map extracted from the group artifact (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-centered 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).

Next, we will show some insights from literature on using online forums and wikis for CSCL. Then, the following section 6.3 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.

6.2 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.

6.2.1 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, 2009, 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., centered 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) 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, Martens, Prins, & Jochems, 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 labored task of interaction analysis and evaluation of contributions. Strijbos, Martens, Prins, and Jochems, 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.

In overall, there are more evident 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. By explicitly feeding back these elements to the participants our discussion model 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.

6.2.2 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 Macdonalds' (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.

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?*

6.3 Knowledge extraction from collaborative and social learning activities

In this section, 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.

6.3.1 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-user and user-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 behavioral 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 of 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, 2010b). This allows the design of effective computational models (Caballé & Xhafa, 2010b) 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).

6.3.2 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., 2010a). 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 of ALICE. The complete process is explained in Caballé et al., 2010. Then, following the process started in D3.1.1 (See Section 5.2.1) by a dialogue model for modelling collaborative interaction data that collected and classified this information according to the classes and relationships of the newly created ontology CS^2, is transformed in sub section 6.3.1.2 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 presented in D3.1.1 and in sub section 6.3.1.2 can be seen as a particularization of the previous general process for CSCL into collaborative interaction data.

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 8 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.

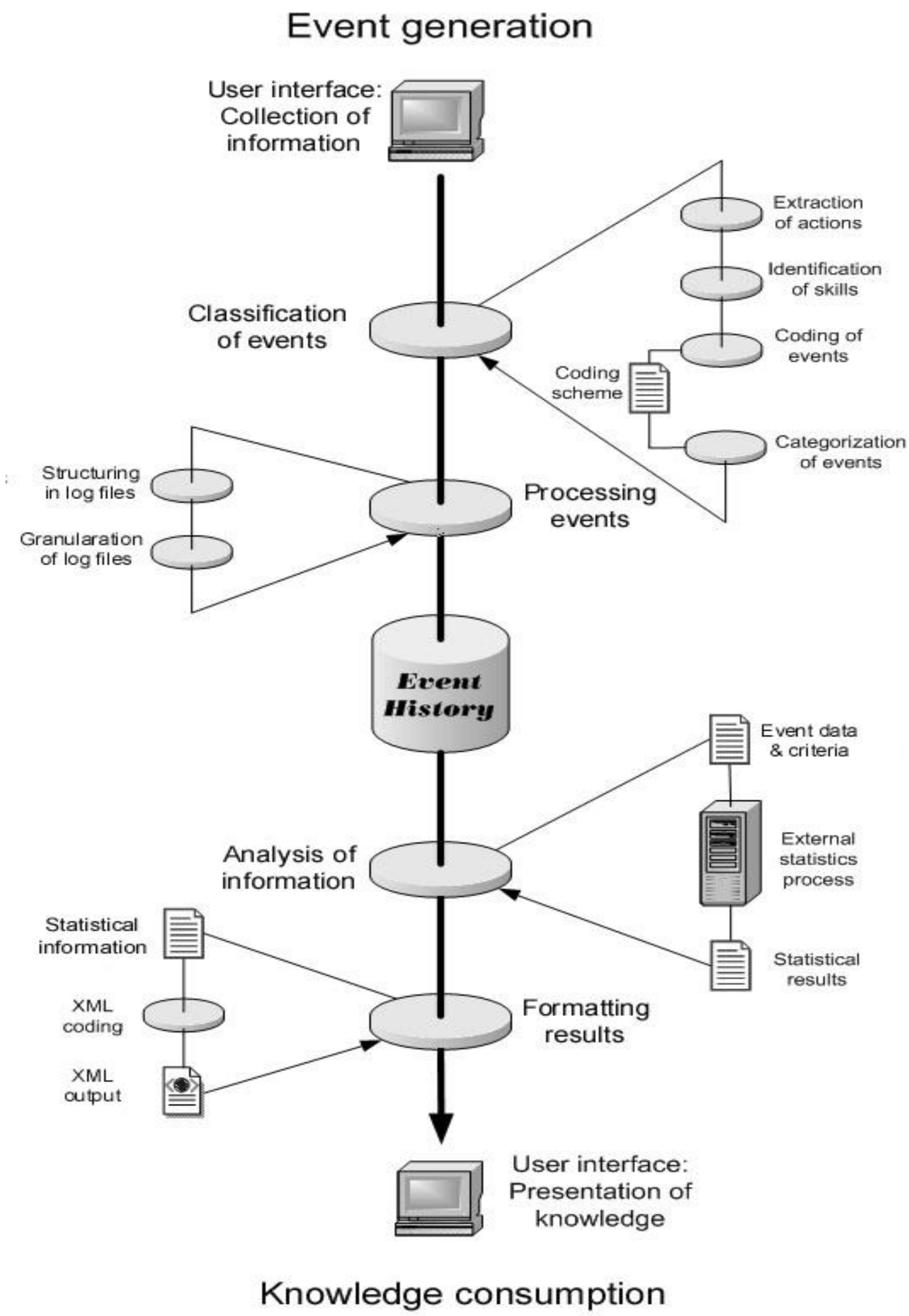


Figure 8: Three Stages in Providing Information and Knowledge

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.

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 (see Figure 8). 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 8).

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.

6.3.3 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 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

- Participation behavior 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 behavior 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, behavior 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 behavior 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

6.3.4 Knowledge extraction in Social Learning: Visualizing Knowledge Extracted from Wiki-based 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 wiki-based 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 9. 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 behavior, 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.

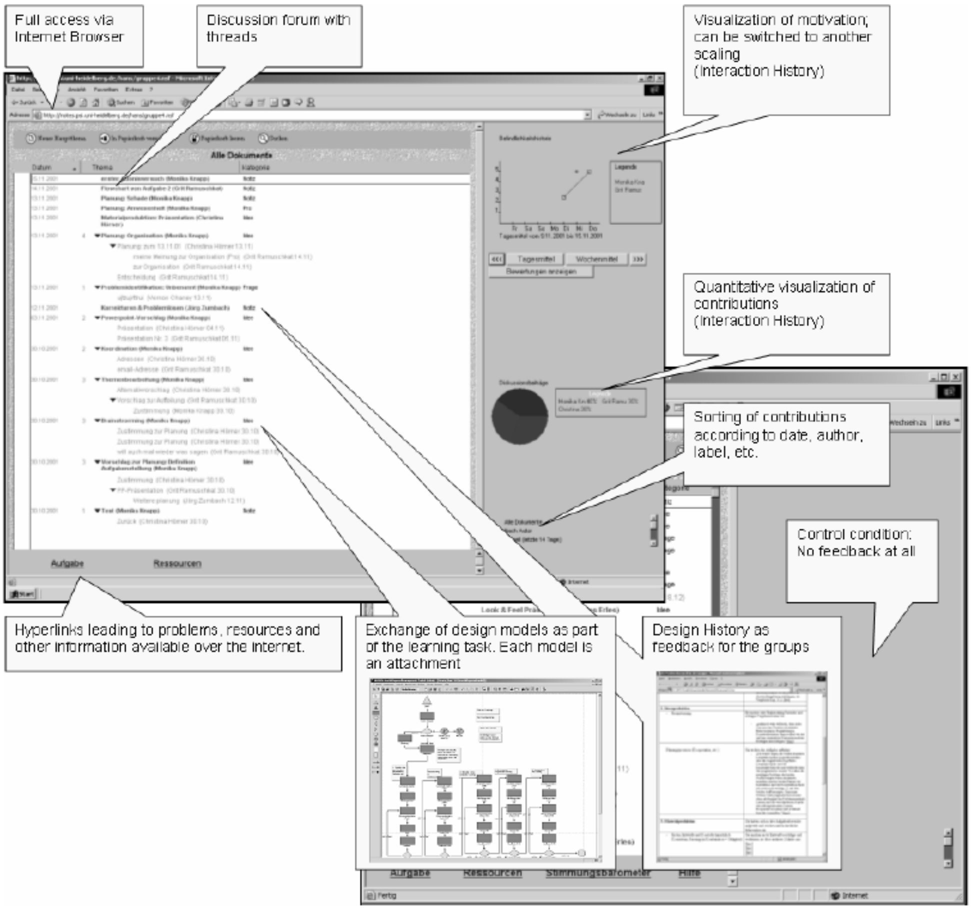


Figure 9: Asynchronous collaboration platform with feedback mechanisms (Zumbach & Reimann, 2003).

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. 3D graphic projections had been used to visualize both the interaction among participants and among the links between the hypertext pages. Figure 10 demonstrates the distribution of forum contributions during collaborative planning of the document's structure. Figure 11 demonstrates a 3D graphic projection for group member's contribution to the peer review. Figure 12 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.

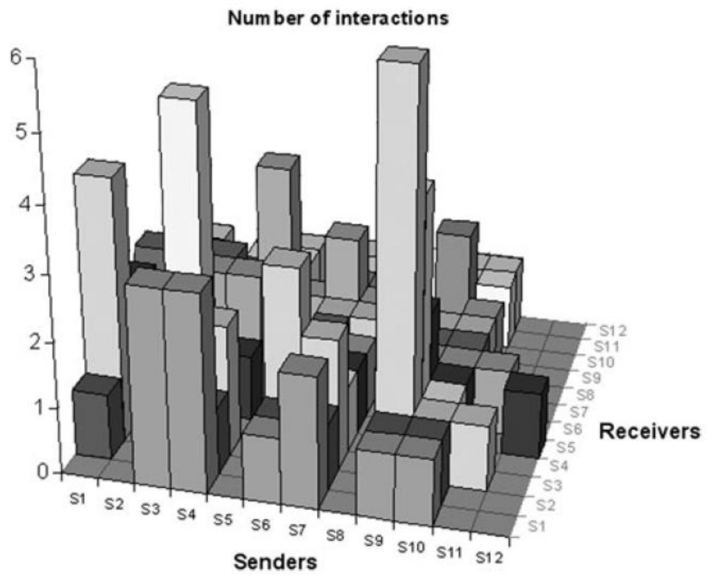


Figure 10: Projection of the forum interactions (Trentin, 2009).

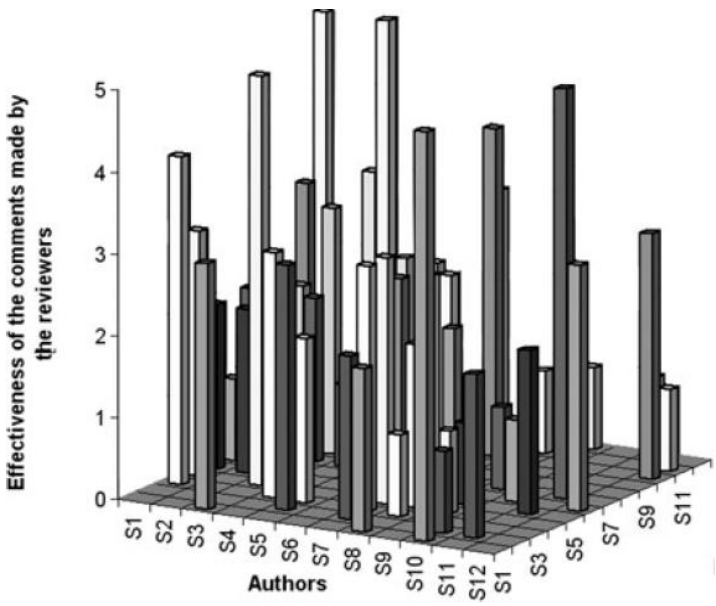


Figure 11: 3D graphic projection for group member's contribution to the peer review (Trentin, 2009).

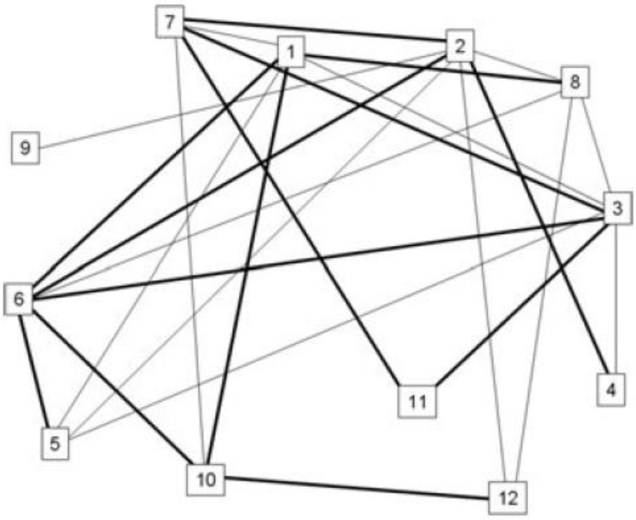


Figure 12: Network of connections between the wiki pages clusters of the hypertext (Trentin, 2009).

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 13.

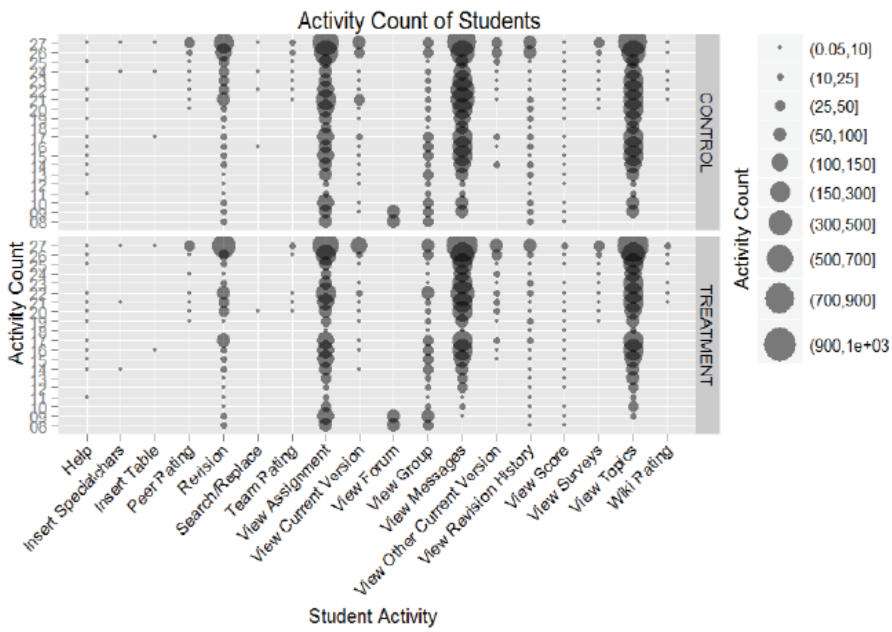


Figure 13: Detailed student's activity plan on ClassroomWiki (Khandaker & Soh, 2010).

Another example that shows how visualizations aspects can be used to facilitate the assessment of wiki-based collaborative writing is the work of (Biuk-Aghai, Kelen, & Venkatesan, 2008). In this research the authors customized the "MediaWiki" to what they named "TransWiki" in order to be used in translation courses. Moreover, they developed visualizations in order to support the teacher answering the following research questions: How much has each student contributed to the final product? What is the process of collaboration? What is the depth of collaboration? Nevertheless, they used *color-coded textual visualization* to show individuals contribution to a wiki-page, the differences between two versions, as well as the depth of collaboration, see Figure 14. They used the *analysis graph* (single/all users) to demonstrate the evolution of an article with all users or the evolution of a single user interaction per page, see Figure 15. They also used *Contribution summary graph* to demonstrate the amount of contribution per user, see Figure 16.

Figure 14: Analysis of text authors (Biuk-Aghai, Kelen, & Venkatesan, 2008).

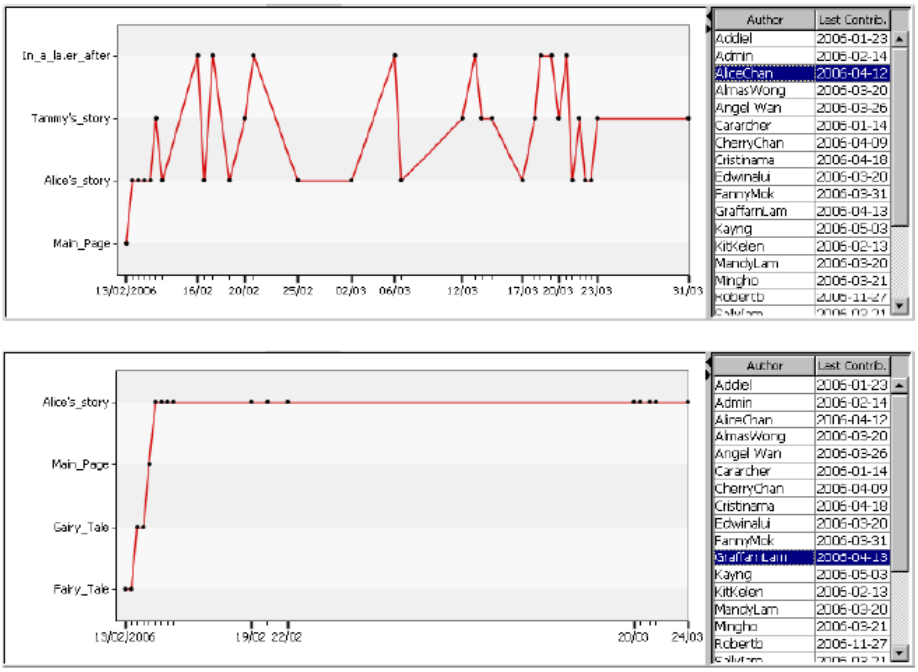


Figure 15: User participation graphs for users Alice (top) and Graffarn (bottom) (Biuk-Aghai, Kelen, & Venkatesan, 2008).

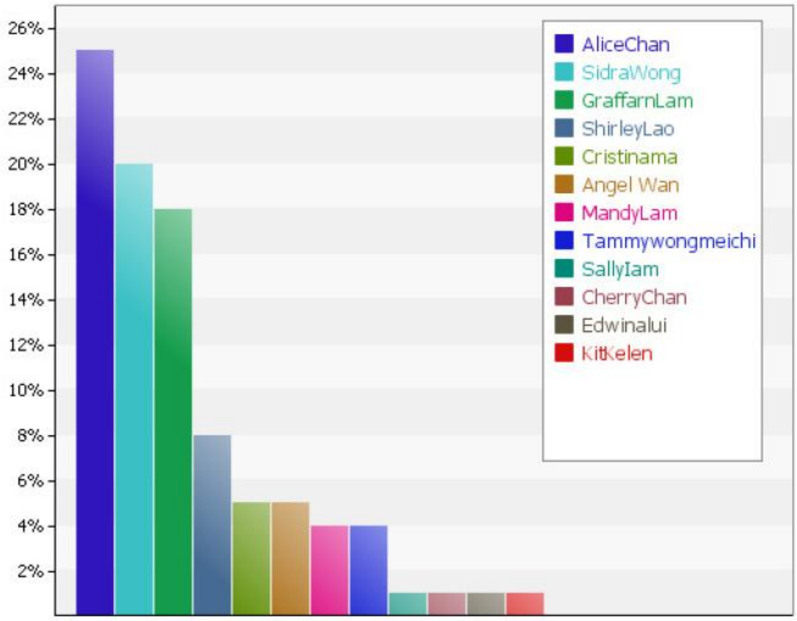


Figure 16: Contribution summary graph for students involved in the wiki-based article (Biuk-Aghai, Kelen, & Venkatesan, 2008).

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 17, 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 18 shows the balance of students' interactions as each corner on the triangle represents an action. The top corner represents reading actions and the bottom left and right corners represent writing blogposts and comments actions, respectively. Students (circles) are placed within or around the triangle depending on the balance of their execution of the three actions. If a student performs any particular action more than others his/her circle is pulled towards the corner representing that action. An equal balance of the actions places the student at the centre of the triangle. Having done only a single action places a student outside the triangle but close to the relevant corner. Figure 19 demonstrates the conversation locator by which students and teachers can locate conversations within the blog-o-sphere. "On our blog-wiki each student is required to assign predefined tags to their blogposts that match the lecture topics each week. Each circle represents a conversation that is taking place between two or more students on a particular topic. The circle gets larger as more participants join the conversation. The number of contributions (comments) in the conversation is shown inside the circle. The length of the conversation (word count) determines the blue colour of the circle – longer conversations (more words) have a darker colour. Clicking on a circle takes one to the location of the particular conversation on the wiki". Figure 20 shows how students interactions based on the main actions are visualized as a networked graph that explains the interaction (arrow) between students (circles). "Green arrows indicate what blogs the selected student has read or commented on. Red arrows point toward the selected student and reveal what students have read or commented on his/her blog. The arrow "weight" can correlate with the degree of interaction".

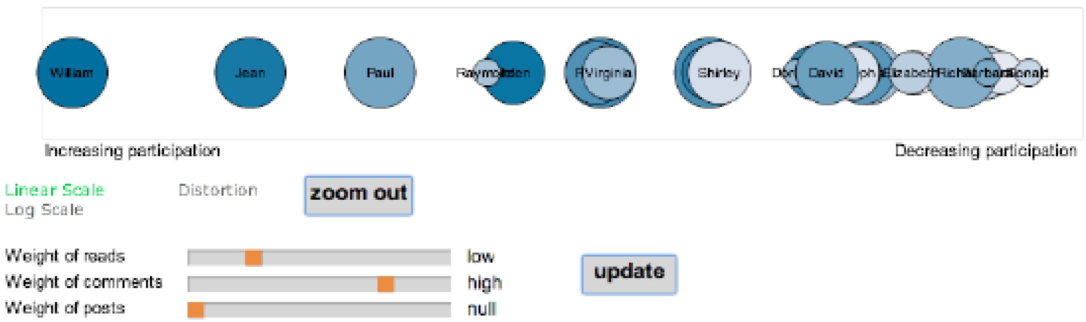


Figure 17: Students' level of participation (Larusson & Alterman, 2009).

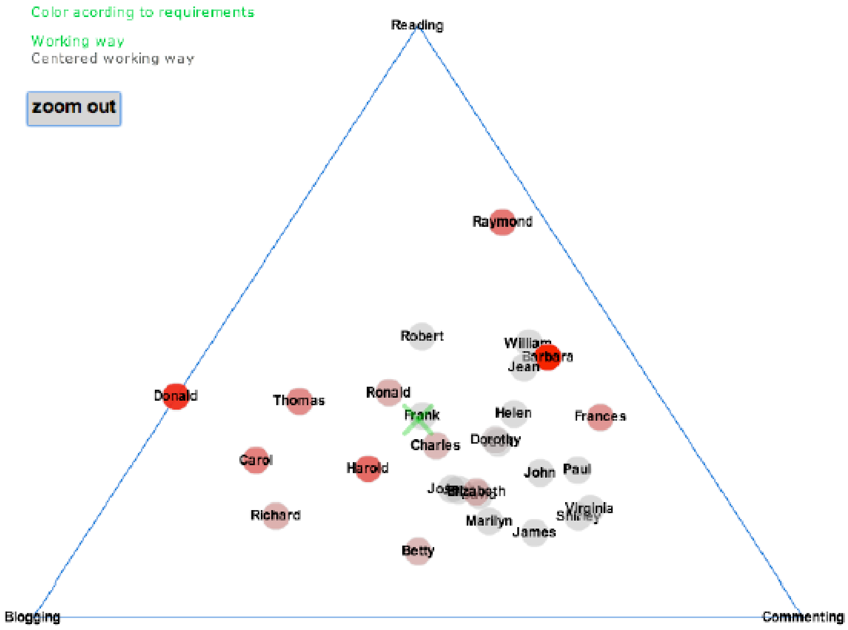


Figure 18: Students' balance of executing the three main actions: reading (top corner), blogging (bottom left) and commenting (bottom right). A perfect balance of the actions places a student at the center (Larusson & Alterman, 2009).

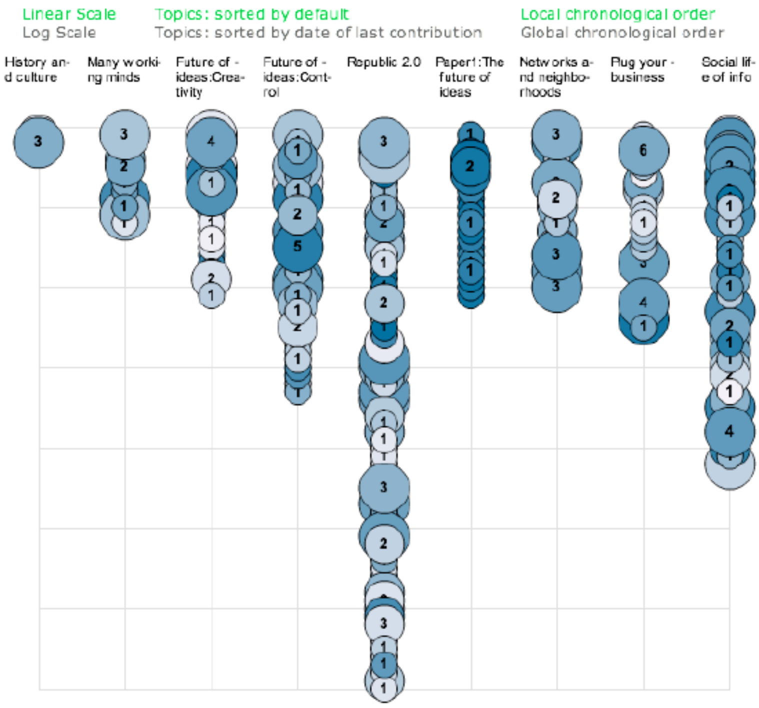


Figure 19: Identifying conversations on the wiki focused on each lecture topic (Larusson & Alterman, 2009).

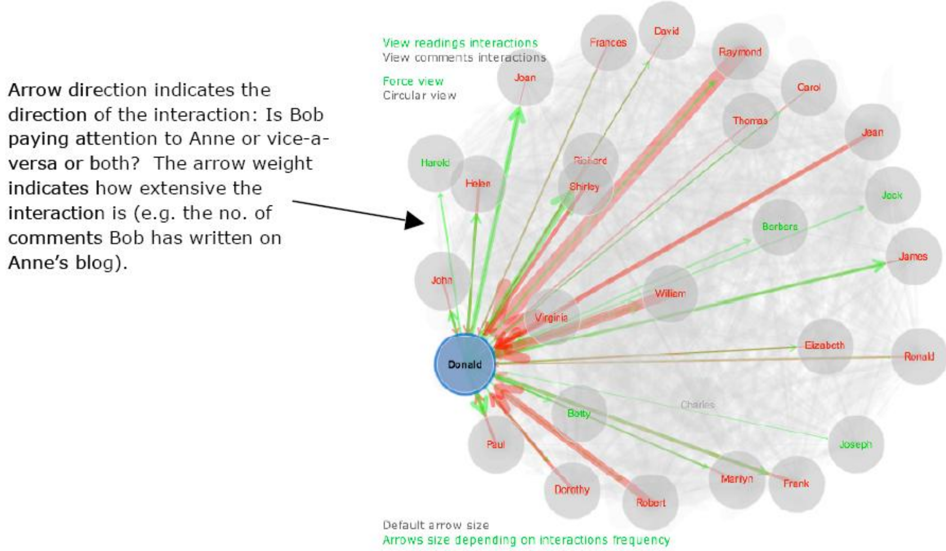


Figure 20: Visualizing (reading or commenting) interactions by drawing arrows between pairs of students (Larusson & Alterman, 2009).

Another good example could be the research of (Reimann & Kay, 2010) in which they have investigated possible visualizations aspects of team performance and their ability to help in group production as well as team coordination i.e. to develop team skills. The research discusses the collaborative wiki writing and possible feedback strategies in order to scaffold group production function and well-being. According to their research they explain the challenges of collaborative wiki witting as wiki pages constitutes from semiotic perspectives of group members. This leads to two main challenges of group coordination on shared meaning of what is collaboratively written as well as wiki content coherence on both levels of text (sentences and paragraphs) and concepts (ideas and arguments). Therefore, in order to improve coordination of team members' activities and increase document coherence, their research is supporting using following forms: (a) by monitoring and visualizing group members' interactions and contributions, (b) by visualizing wiki site structure, and (c) by providing information on wiki page content based on a text-statistical analysis. However, the following visualizations are discussed in this research:

Wattle Trees (Wattle tree is an Australian native plant with fluffy golden yellow round flowers) where each member of the team is a single wattle tree, with its vertical green stem that grows up the page. Wiki-related activity is represented by yellow "flowers," the circles on the left of the trees. The size of the flower indicates the size of the contribution. After first experiences the Wattle Trees was replaced by more interactive visualization of a set of "swim lanes" one for each group member as in Figure 21, area A, with three students S1, S2, S3, and one tutor, T; time is in days, running from bottom to top. Colour is used to represent the type of contribution (wiki, ticket, svn), per day (or other time units) and aggregated over the visualized time period (B). When the user clicks a point in one of the swim lanes that has an activity indicated (i.e., is coloured), the underlying log data for that cell will be rendered on the screen (C).

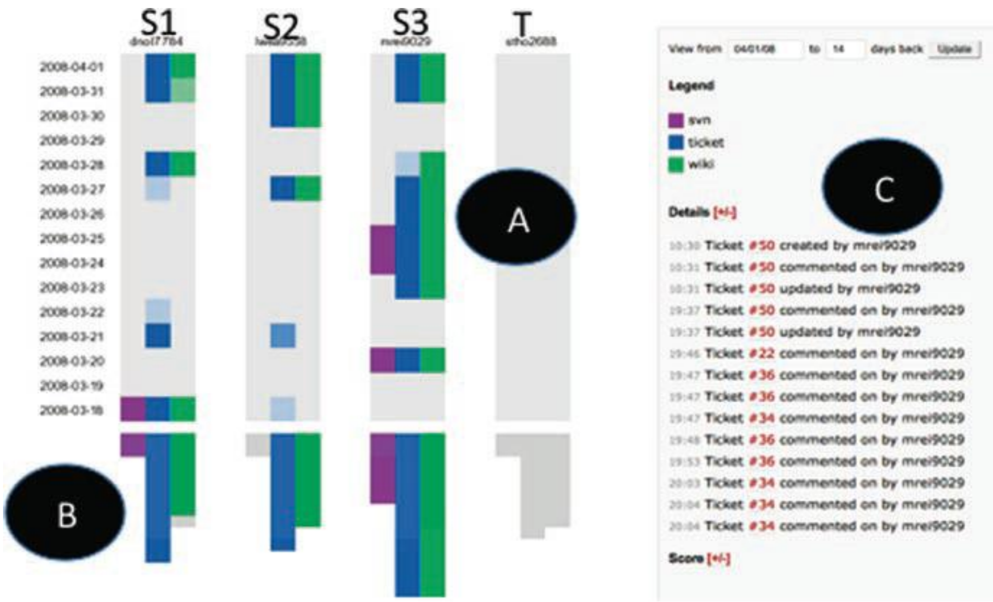


Figure 21: interactive form of interaction visualization based on CSCL environment (Reimann & Kay, 2010).

Social networks diagrams have been developed to visualize information regarding who contributes to the wiki-page. 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 22 the Interaction Network based on for the wiki shows that every member of the team interacts with every other one, including the tutor.

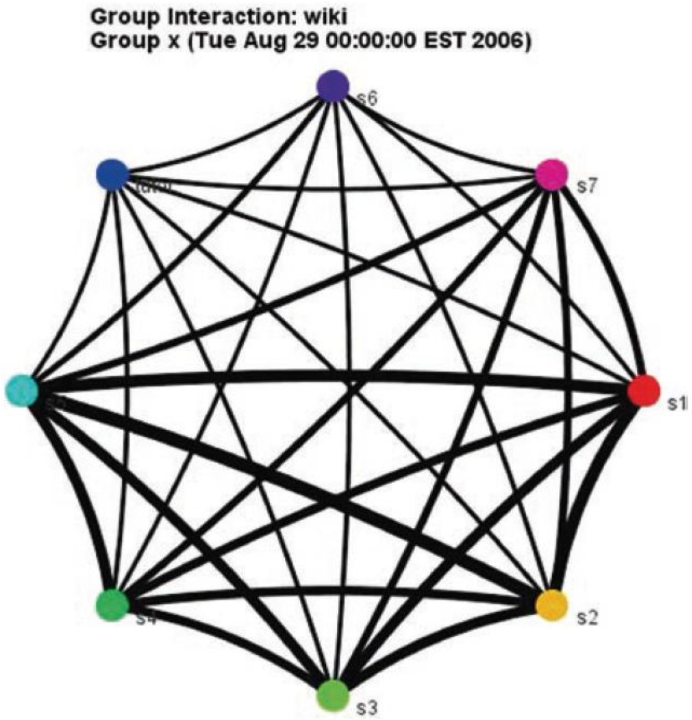


Figure 22: Interaction network based on wiki entries (Reimann & Kay, 2010).

Visualizing wiki site structure: while students are working on a wiki collaborative writing task they may need to know which parts have been changed since their last visit to the site. Or maybe which parts of the wiki have been changed by student "A". Therefore, the authors utilized WikiNavMap (Ullman & Kay, 2007) - a tool that enables the user to customize the view of the wiki in terms of time and in relation to the authorship of activity on the pages - to support answering the following questions: Which are the pages that I have made contributions to? Which are the pages that another nominated person has made contributions to? Which are the pages associated with a certain task? Which are the pages with the most activity? Which pages changed in the last week? Which changed in a particular period of time, such as a particular month? What is the extent of the wiki? As demonstrated in Figure 23, WikiNavMap shows a navigational role, and also increases member and task awareness (hence, affecting coordination), and helps to monitor coherence.

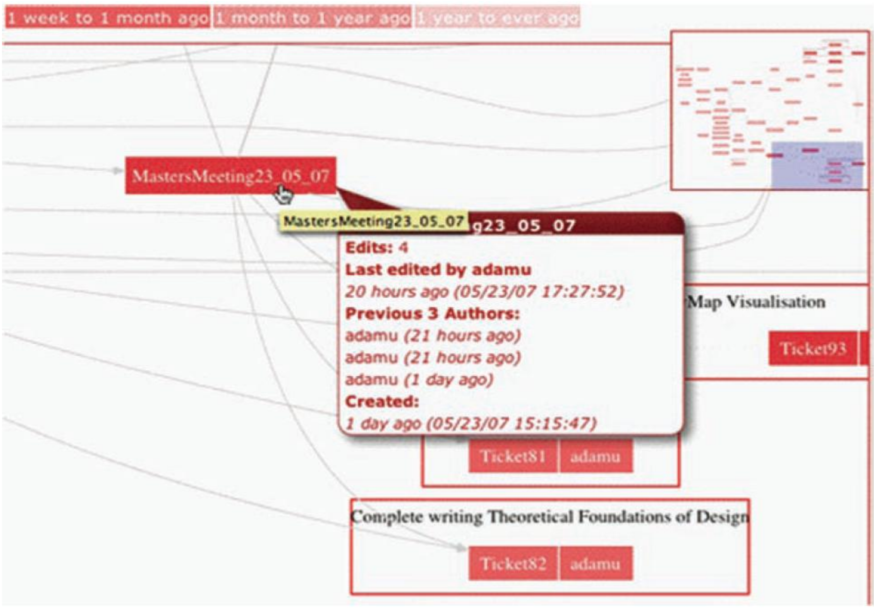


Figure 23: WikiNavMap creates a dynamic visualization of a whole wiki site (Reimann & Kay, 2010).

Visualizing the Conceptual Structure of Wiki Page Content: providing information regarding concepts contained in the wiki-page content and their semantic relations may help group member's collaborative writing. The authors presents an automatic concept analysis method based on "Carley's map analysis technique" and utilizes software called Glosser (Carley, 2007). Glosser uses text-mining techniques (based on Latent Semantic Analysis technique) to provide student writers with information about their text on a number of dimensions, including conceptual coherence. Glosser is capable to define concepts with hierarchical representation on multiple levels of generalization and abstraction. Moreover, it visualizes the concept map extracted from the wiki-page. Figure 24 demonstrates concepts map visualization based on wiki-page content.

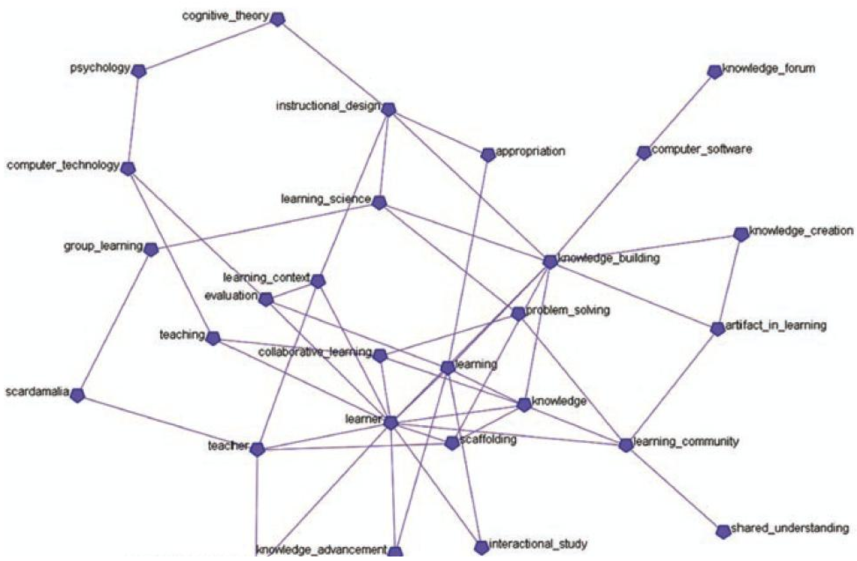


Figure 24: A network view of the concepts identified in a jointly authored wiki page (Reimann & Kay, 2010).

6.4 Summary of the Chapter

This chapter deals with the important issue of assessment of collaborative learning and describes its different forms and types. It examines two main cases of assessment. First, it explores the methods and tools that are used for assessing more formal computer-supported collaborative learning, like online discussions. And then, it discusses how assessment can be performed in more informal or social collaborative learning situations, such as Wiki-based Collaborative Learning. Finally, the chapter concludes by examining another important issue: 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.

7 Collaborative Complex Learning Objects (CC-LO)

In this chapter, we discuss the notion and nature of a 'collaborative complex learning object' (CC-LO). The concept of a learning object is well-defined, as we discuss in Section 7.1, and we extend this to define the concept of a CC-LO and its key differentiators from a standard learning object in Section 7.2. 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 7.3.

Focussing specifically on the objectives of ALICE, in Section 7.4 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. Finally, in Section 7.5, 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. In 7.6, therefore, we summarise the chapter with a review of the processes and concepts covered, and advocate guidelines for the use of CC-LOs both within the ALICE project and by educators on a wider scale.

7.1 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.

- 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.

7.2 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 behavioral 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 7.5, 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.

7.3 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 (discussed in section 7.4.2). 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.

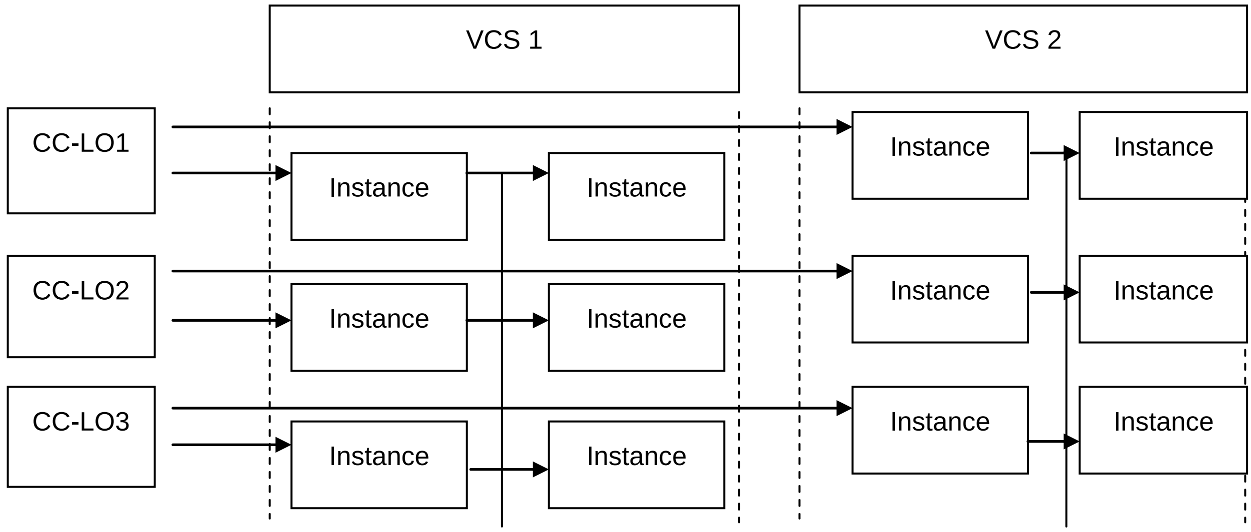
As an initial approach, existing methodologies can be largely grouped under three headings:

- 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.

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

7.4.1 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 25).



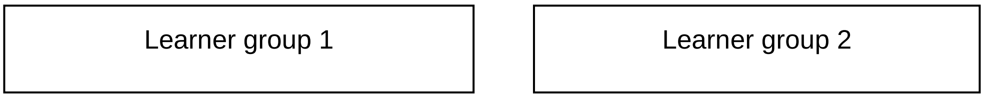


Figure 25: Instances of Virtualized Collaborative Sessions (VCS)

Effectively, we capitalize on the instantiability of CC-LOs defined in Section 7.2 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 7.4.2. 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 worlds frameworks can be used to realize the virtualization part of a VCS.

A variety of markup languages has been proposed for behavior 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

Behavior Markup Language (BML) extends and supersedes markup languages that were previously developed by BML project members, including BEAT (Behavior 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 behavior that is independent of the particular graphical realization. BML is an XML-based language that supports the description of behaviors at different levels of detail, e.g., by embedding a more detailed behavior 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 artifacts 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 26) resumes the process explained above:

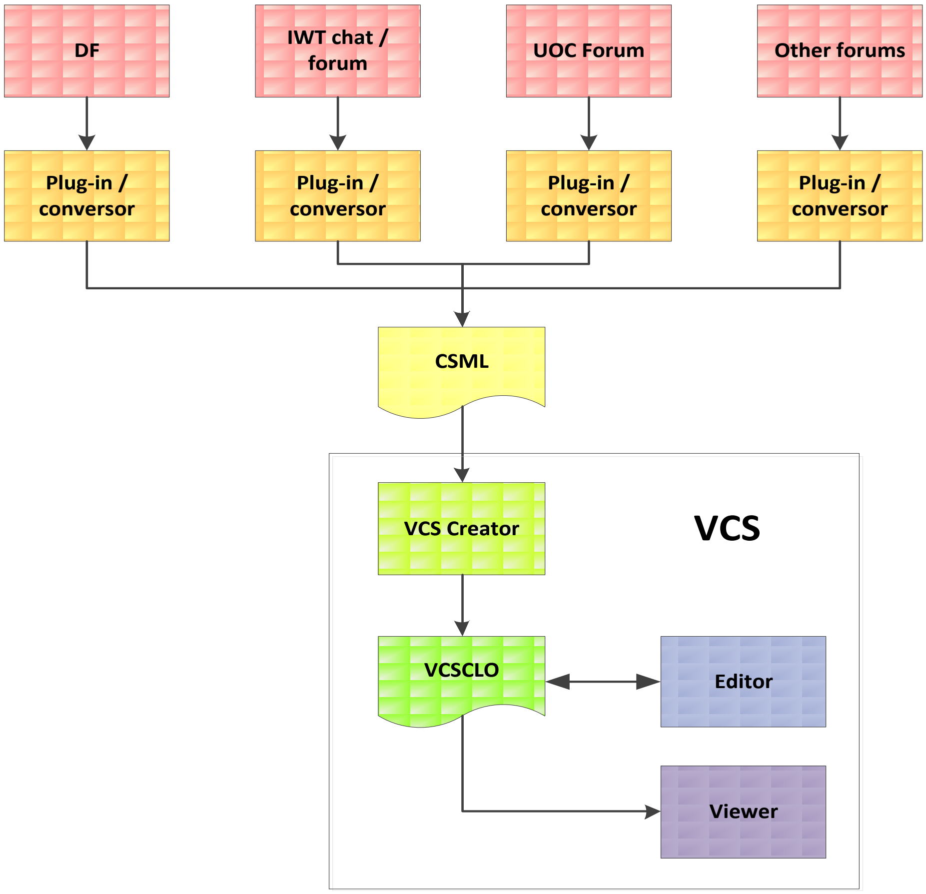


Figure 26: An idea of a VCS system

*DF is an internal academic forum system that we are intending to use for testing purposes.

Now, we give some details related to the components of Figure 26:

- **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 is not defined yet, but it should be general enough to support 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. The Alice 5.4 requirement talks 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.

7.4.2 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.

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.

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 (a feature already available in the learning platform IWT) 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.

7.4.3 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.

A theme explored within ALICE is the application of learning objects within a serious game. In this case, extra affordances for learner interaction must be considered. Games are by nature non-linear, and whilst narrative and other avenues may allow a degree of linearity to be applied, though a "branching dialogue" structure (Mott, McQuiggan et al. 2006), some measure of freedom must be granted to the learner. In games this is commonly a freedom to fail, and learn by worst as well as best-case experience, supporting a reflective cycle of experiential learning (Kolb 1984). Learning objects deployed into this context must run either parallel to the gameplay experience, or synergistically, in the latter case implying a difficult tension between instruction and entertainment (Zyda 2005). This is particularly true when attempting to repurpose learning objects from other sources into serious games, as these objects are seldom designed with entertainment in mind and therefore can prove difficult to integrate. Work within the EU mEducator project has explored the use of serious games for repurposed healthcare learning objects (Protopsaltis, Panzoli et al. 2010), finding through case study with the Climate Health Impact game that serious games can serve equally as a source and end-user of learning objects. Despite these advances, much work must still be done in the development of middleware and APIs to support transitioning learning objects from standard representation formats such as SCORM to immersive game environments.

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.

7.5 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

7.5.1 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 ALICE 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 27). These aids are envisioned to help the teacher monitor, evaluate and direct the discussion without disrupting the flow of the on-going collective argumentation.

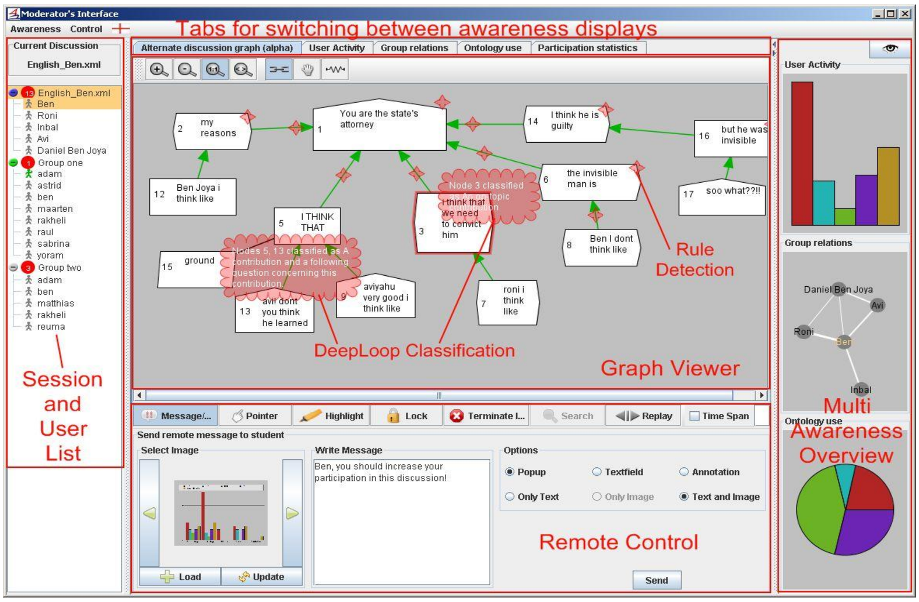


Figure 27: The ARGUNAUT Moderator's Interface at its current state of development.

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 ALICE 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

7.5.2 Construction of specific authoring tools for the creation of CC-LO

Nowadays, the 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, instead, are used to implement and deploy knowledge exchange services based on the concept of social collaboration.

Our objective is an 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.

A more detailed description of this integration will be provide in an updated version of this document.

7.6 Summary of the chapter

In this chapter we have 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 ALICE, 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 Banduras cited in previous chapters. As a consequence, we identified the concept of “Virtualised

Collaborative Session" 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. Further work in ALICE project aims to develop clear guidelines for the creation and use of CC-LOs both within the application domains of the project itself and by educators on a wider scale.

8. References

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