

## SECTION 2

### Adaptation and Collaboration

Adaptive hypermedia has been widely used for the development of adaptive Web-based courses [Brusilovsky01] [Brusilovsky98a]. In this environment, learners usually interact with the course alone, learning at their own time frame and at their own pace. Very often, this situation makes them feel frustrated: they get lost in the contents of the course and give up. Trying to help in working out the former problem, educational adaptive hypermedia environments guide the students through the course, adapting both contents and learning paths to specific characteristics of the users. For this customisation to take place, adaptive systems take into account static features of the students (i.e. the students' background) [Sanrach00] as well as their behaviour during the learning process [Murray99] [Murray03]. In addition, it is also possible to support extensible criteria for adaptation, as explained in [Carro01].

Apart from the above-mentioned traditional scenario, based on a single student learning process, some approaches in the area of web-based learning look at the possibilities opened by collaborative learning scenarios, pointing its clear advantages in traditional sessions (face to face). From this point of view, Internet provides a basic collaborative environment where people can find suitable partners who share similar aims and interests. These collaborative approaches show that Internet is not only an information repository but also a mechanism able to connect persons [Laister02].

At present, collaboration tools have already been used in educational contexts [Dillenbourg99a] for supporting communication and collaboration among students [Borghoff00], discussions about topics [Suthers02], cooperative problem resolution [Vizcaíno00], knowledge sharing, and collaborative knowledge construction [Schlichter97]. A proper use of these tools reduces student isolation and facilitates the development of personal [Barros98] and social skills [Slavin80] [Johnson84b].

It is worthwhile to mention that the terms '*Collaborative Learning*' and '*Cooperative Learning*' have become mixed in popular usage and, often distinctions are not made between the two concepts. According to [Panitz97], collaborative learning is a personal philosophy, not just a classroom technique. In most of the situations where people come together in groups, individual group members' abilities and contributions are respected and highlighted. There is usually a sharing of authority and acceptance of responsibility among group members: collaborative learning shifts the responsibility for learning away from the teacher as expert to the student [Bruffee95]. The underlying premise of collaborative learning is based upon consensus built through cooperation by group members, in contrast to competition in which individuals best other group members.

Beside collaborative learning, cooperative learning is frequently defined by a set of processes which help people interact together in order to accomplish a specific goal or develop an end product which is usually content specific. It is more directive than a collaborative system of governance and closely controlled by the teacher [Panitz97]. In [Dillenbourg96], a different definition about these terms (cooperation versus collaboration) is exposed: *‘Collaboration is distinguished from "cooperation" in that cooperative work "... is accomplished by the division of labour among participants, as an activity where each person is responsible for a portion of the problem solving...", whereas collaboration involves the "... mutual engagement of participants in a coordinated effort to solve the problem together”*.

In the rest of this section, it is firstly presented the basis of adaptive hypermedia, as well as some examples of educational hypermedia systems. Secondly, the benefits of collaborative and cooperative learning in traditional classrooms (face to face) are briefly introduced, including different types of collaboration, CSCL main issues and examples of CSCL systems. Finally, the characteristics of some educational hypermedia systems that include adaptation capabilities and collaborative activities are exposed.

## 2.1. Adaptation

As it has been mentioned before, the main goal of adaptive hypermedia (**AH**) is that students are personally guided during the learning process in courses through Internet. Brusilovsky identifies six different areas of applications for **Adaptive Hypermedia Systems**:

- i) *‘on-line information systems’* that allow the access to information, which is adapted to the needs of each user (i.e. goals, previous knowledge, age, learning style) and guide him/her through the hyperspace contents (i.e. documentation in Internet, electronic encyclopedias, virtual museums, e-commerce systems),
- ii) *‘on-line help systems’* that have the same goal that *‘on-line information systems’* (information accessing), but also help the users about the management of specific applications,
- iii) *‘information retrieval hypermedia’* that combines the traditional information retrieval techniques with the possibility of hypertext information access.
- iv) *‘institutional hypermedia’* that facilitates all the information required to support the daily work to different users into an institution.
- v) *‘personalized views systems’* that allow the users to define personalized views of the whole hyperspace,
- vi) and finally, the most popular area for adaptive hypermedia *‘educational hypermedia systems’* [Brusilovsky01] whose goal is to guide the students during the learning process by adapting the available information to their user’s needs [Brusilovsky96a].

Though the former areas are not orthogonal (in fact, some of them are similar and share the same problems) in the rest of this work we will refer specifically to adaptive educational hypermedia systems.

In '*educational hypermedia systems*' [Brusilovsky01], there are two main sets of features to which a system can adapt: the user's data and the characteristics of the device used for learning. The user's data can be divided into two groups: the user personal features (age, knowledge, learning style, interests, etc.) and the usage data (data about the user interaction with the system) [Kobsa99]. The adaptation to the device features refers to the types of contents that is supported by each device, and that is determined by its own software and hardware.

User's personal features include the following aspects:

- Individual traits. This set includes the static characteristics of a user that are not to vary, at least in the short term (i.e. date of birth, language, etc.). The system can obtain some of the individual traits by asking the users for them when they register for the first time in the system, storing them in the user's model. However, other features of this set can not be acquired so easily, such as the students' learning style, that has to be acquired using specific psychological tests [Laroussi98] [Paredes02] [Paredes03].
- Previous knowledge. Awareness of the user's previous knowledge and beliefs is usually required to provide the student with useful explanations. It is usually represented by means of an estimation and storage of the user's knowledge of some concepts. This value can be binary (known/unknown), a qualitative measure (i.e. high/medium/low), or a quantitative measure such as the user's probability of knowing the concept. Some systems make use of user models based on stereotypes (i.e. novice/intermediate/advanced).

Also, the user knowledge can be represented in AH systems as a semantic network [Brusilovsky96a]. In this case, the concepts are related among them by means of one of several relationships. For example, a relationship labeled "precondition" can relate two nodes meaning that the knowledge about the first one is necessary in order to understand the other; or a "part-of" one can relate one node with others, if the second decomposes the knowledge represented by the first one.

The users' previous knowledge can be directly asked to them at registration time; constructed by remembering which are the web pages that they have already visited, studied or passed; or inferred from tests they had done.

- Navigation experience. It is important to know the user's familiarity with hypermedia structures of hyperspace, given that it will condition his/her facility at the browsing

process: the complexity of dynamically generated web pages might be different depending on it, and an adaptive system might show more hyperlinks and navigate options to experienced users than to novice ones.

- Interests and goals. The user goal is related to the user context in each case, and it can be related to working, searching or learning tasks. These goals can vary along the time and adaptive hypermedia systems need to know which the current goal is to be able to satisfy it. Furthermore, not all students that share the same kind of goal have the same interests; for instance, some of them can want to obtain global information about a certain subject and others can desire detailed information.

By adapting course materials to the student's personal characteristics and the usage data, students can learn more in less time, because the contents are adapted to their needs, making it possible for them to apprehend the concepts in a shorter time, keeping a higher a level of satisfaction.

With respect to the kind of adaptation, Brusilovsky defines two different classes: '*adaptive presentation*' (content-level adaptation) and '*adaptive navigation support*' (link-level adaptation) [Brusilovsky96a]. In '*adaptive presentation*' the objective is to adapt the materials presented in each page to the user characteristics and the goal of '*adaptive navigation support*' is to help users to find their paths in hyperspace by adapting the way of presenting links to the user characteristics. At present, there are many different methods and techniques to achieve this adaptation, more details about them can be found in [Brusilovsky01].

## 2.2. Adaptive Educational Hypermedia Systems

As it has been presented in previous section, the most popular area of application for adaptive hypermedia systems is the educational area. The goal of adaptive educational hypermedia systems is to adapt the contents of a course to each one of users so they can learn more in less time. Some of the most well-known systems in this area are **InterBook** [Brusilovsky96a] [Brusilovsky98b], **AHA!** [DeBra98] [DeBra02a] [DeBra02b] [DeBra03], **ELM-ART II** [Brusilovsky96b] [Weber97] [Weber01], **MetaLinks** [Murray99] [Murray03] and **TANGOW** [Carro01]. The main characteristics of each of them systems are presented next.

**InterBook** [Brusilovsky96a] [Brusilovsky98b] is a tool for authoring and delivering adaptive electronic textbooks on the web. It provides a technology for developing electronic textbooks from a plain text to a specially annotated HTML. It stores a domain model of concepts and their structure. Furthermore, it maintains a model of the user's knowledge and applies this model to provide adaptive guidance, adaptive navigation support and adaptive help for these electronic books for each user. Also, the system

provides direct guidance through of a ‘Teach me’ button by applying heuristics that are able to determine the most suitable node that is ready to be learned. In addition, there is a ‘Help’ button which provides adaptively-sorted links to sections that present information about background concepts of the current section.

**AHA!** (*Adaptive Hypermedia Architecture*) is starting in **AHA**, whose first version was developed in 1998 [DeBra98] and that has been evolving since then [DeBra2002a] [DeBra2002b] [DeBra2003]. It was originally developed to support on-line courses with some user guidance through extra explanations and conditional link hiding. The adaptation updates the user model which is constituted by concepts with attributes. The pages of a course can have requirements, which are defined by the author of the course. The scheme of the student’s course will be update in each step and its links are marked with different colours for indicating available links, unavailable and visited.

**ELM-ART II** [Weber01] is based in **ELM-ART** (*Episodic Learner Model-Adaptive Remote Tutor*) [Brusilovsky96b] [Weber97]. **ELM-ART** is an intelligent learning environment that supports example-based programming, intelligent analysis of problem solutions, and advanced testing and debugging facilities. The students’ interactions are recorded in the learner model and update it. According to the student knowledge the system generates the links, which are annotated visually corresponding to a simple traffic lights metaphor (red, green, yellow and orange colours). These colours are using to mark the availability and the state of the associated page. This system offers to the learner the possibility to communicate with others students of the same course using collaborative tools such as a forum, chat, shared documents and email. It is available on-line with a LISP course in the following URL: <http://www.psychologie.uni-trier.de:8000/elmart>. When a student is registering in the system, he or she fills up a form with questions about his/her experience with www browsers, programming languages and use of computers. The guide through the course is stricter when a student has less previous knowledge about these three questions, and it is more flexible if the student has more experience in these subjects.

**MetaLinks** [Murray99] [Murray03] is a system for authoring and presenting adaptive hypermedia books, influenced by previous systems such as InterBook and ELM-ART. The goal of this system is to help students to find an optimal path through the contents. It maintains a user history (how he or she has arrived at each page and the time spent on each of them) but makes no inferences about student knowledge level, and thus does not contain a working user model. The contents of the books are divided into modular smaller pages and the books are structured in a parent-child relationship. In **MetaLinks**’ hyperbooks a parent page is considered a summary, overview, or introduction to all of its children pages (unless the page has no children). This system constructs the pages on the fly and shows to the student the visited pages and the current one. Direct guidance is given through ‘Next’ and ‘Explain more’ buttons. The ‘Next’ button directs the users to the next sibling page, while the ‘Explain more’ button, descends a level and iterates over the child

nodes. Each page has a set of related links to other ones. These links are marked to indicate the type of relationship (defined through authoring tool) that they represent.

Finally, **TANGOW** (*Task-based Adaptive learner Guidance On the Web*) [Carro01] is an adaptive educational hypermedia system that supports the adaptation of both the contents and the structure to each user, and also the variation of the navigational guidance offered depending on the user profile. For doing it, the course structure is described separately from the contents. The course structure is defined by means of teaching tasks (basic units that represent theoretical explanations, examples or exercises to be solved individually and they are linked with a list of identifiers of content fragments that composes the generated pages of this task) and course structure rules (they described the organization of tasks, the time at which tasks will be presented, the order in which subtasks must be performed, and if there are requirements for performing certain tasks and which are them) [Carro01]. The teacher of the course might provide the course structure, the contents of the course and the features that constitute the student's user model to the system by specifying the values (discrete or range) for each of them. During the delivery phase, the adaptation mechanism selects, at each step, the set of available and most suitable tasks and contents for each student by choosing the rules that describe the current task composition, and by checking which activation conditions are satisfied by the student (according with the user model). Through this procedure, the mechanism gives rise to a particular course structure dynamically for each student during the course execution. When the student concludes an activity, the dynamic parameters related to his/her actions (i.e. pages visited, scores, used time) are propagated and recursively recalculated to maintain constantly up-to-date the student user model. It is also possible to include additional dynamic adaptation based on learning styles [Paredes02] [Paredes03]. This system is available on-line in <http://tangow.ii.uam.es>.

### **2.3. Collaboration**

In this subsection, the benefits of collaborative learning in traditional sessions are briefly introduced, as well as its difficulties, which are mainly due to the great variety of possible configurations of these environments. These possible configurations motivated the work of pedagogical community, which has presented some methods of pedagogic intervention for collaborative learning environments such as *Student Team Learning*, *Group Investigation* and *Learning Together*. These methods offer different criteria for group formation, all of them aimed to obtain work groups with high performance. Finally, the basis of CSCL systems is presented.

The origins of collaboration activities are based on the real world, given that everybody is member of several groups. In our daily activity we are continuously interacting inside groups: in the family life, with our friends, in our work, etc. Our personal identity

stems from the way of perceiving and of treating with other members of the groups. Within the group we learn to behave, to think, to educate ourselves and to learn from our interaction with the rest of the members of the group [Johnson02].

Face-to-face collaborative learning has been applied in traditional classrooms since the 70s, although most of theoretical studies related with it date back of the 80s [Slavin80]. In these years different methods and studies arose trying to apply collaborative learning technologies to pupils of diverse ages and levels. These experiences pointed out that the learning process is not only the own identification of the knowledge finally acquired, but also includes the explanations that are provided in order to identify which information is missed, the inconsistencies that are detected, what needs to be clarified or is discussed from different points of view by different members of the group [Webb89] [Vygotsky78].

In this one sense, collaborative learning is a social activity that involves a pupils' community in which some knowledge is shared and other new one is acquired (knowledge construction) [Schlichter97] [Palincsar84] [Bruner66] [Koschman96]. It means that, apart from the solution itself, it is also important the process that has made it possible to reach that solution [Brown89]. Then, the goal of collaborative learning is that the students were actively involved in the exploratory learning process [Slavin90] working together [Webb82]. Collaboration has great **benefits** such as to promote the **cooperation** [Johnson84a], the **interaction** and the **familiarity** among students and teachers [http\_ref01]. Moreover, from the computer scientists' point of view, collaborative environments facilitate the development of **reasoning skills** [Johnson85] [Palincsar84] such as making ideas explicit, arguing, interacting with other students to build a common solution, and so on [Barros98] [http\_ref03]. There are some experiences that demonstrate that the student's **motivation**, **participation** and **auto esteem** increase when they obtain good results in the accomplished collaborative activities, as the one in [http\_ref01].

Also, there is another fact that has to be taken into, and has to with the huge number of students that have difficulties to express their opinions in public. In traditional classrooms when the teacher asks to one student, the focus of the attention is centred in him or her, while in collaborative environments the focus of attention is distributed among the members of a group. Therefore, collaborative learning creates a safe environment in which students can express and explore their own ideas without fear to failure or critics, helping to develop their **skills of communication**. The student companions can make constructive critics to the different ideas that are proposed [Johnson84b], while the teacher can evaluate the learning process as a whole (the reasoning process), not only the final solution of the activity. In this sense, some studies on cooperative learning among students of different ethnics state that their communication skills have been clearly increased [Slavin80] [Johnson72], due to the fact that students have been actively involved in the learning process, being able to understand the differences, and helping them to learn how to solve the social problems that could arise among them.

A **difficulty** of these systems, it is that they have a great ***variety of possible configurations depending on many variables***, such as size of the collaborative group, the different criteria for grouping students, the nature of the collaborative activity, the distribution of the work among the members of the group, how long the students must stay at the same group and so on. Different configurations, depending on those variables, are presented in some **methods of pedagogic intervention**. These models offer some ways to construct the diverse roles (teacher's role and students' role) and to build collaborative work groups, as well as different approaches to the resolution of problems and the planning of the activities of a group.

Starting with the methods applied in face to face learning, it is possible to extract the initial proposals and to adapt them to web-based collaborative learning. These methods of pedagogic intervention are *Student Team Learning* [Slavin80] [Slavin90] [Slavin96], *Group Investigation* [Sharan94] and *Learning Together* [Johnson75] [Johnson84a] [Johnson84b] [Johnson98] [Johnson02] among others.

In ***Student Team Learning***, Slavin developed a set of pedagogical methods for cooperative learning. One of them is '*Cooperative Integrated Reading and Composition*', in which the students are joined into groups formed by eight to fifteen members. The teacher explains the subject about the texts which have been read by the students and he or she can guide and help the students in the reading process. After reading the text, students must work on a set of group activities aimed at a better text comprehension (reading for their partners, discussion about the text, writing related stories and exposing a summary of the text read). Following the collaborative activities, the students must answer a test to check the text comprehension, also checking the new words they found in it. Other Slavin's method, '*Team Assisted Individualization*', combines the group learning with individual learning applied in mathematics area. The groups are constituted by four or five persons, and a subject is assigned to each learner which he or she works by his/her own. The members of each group work by exchanging their answers and reviewing the exercises of the others partners. By observing the results obtained in his methods, Slavin's stated, in [Slavin90], that the use of cooperative incentive structures (where two or more individuals depend on each other for a reward that they will share if they are successful) contribute to the success of the cooperative learning process only in the those group rewards are given according to the individual learning of all group members. Then, it is necessary to prevent that only one or two members of the group perform all the work while the rest of the members maintain a passive attitude. So, it is necessary to provide the group members with some procedures that guarantee them all to learn, helping one another in achieving the goals associated to each task, and making the individual learning successful.

Another method for pedagogic intervention was developed by Sharan, who built up the ***Group Investigation***. This method attempts to eliminate the competition entirely. It involves cooperative group inquiry that emphasizes data gathering by students, interpretation of information through group discussion, and synthesis of individual

contributions into a group project. Students are responsible of their own group formation and of the selection of the questions that they want to work in. These groups are made up by a minimum of two and a maximum of six persons. Then, each group choose part of the unit that they are studying, and then the part chosen is divided into several subtasks that they are worked out individually or in groups of two persons. Once each group has obtained its partial solution, all of them are put together, constituting the final “common” solution. The partial contributions have to expose to the rest of the classroom. Then, the teacher evaluates the presentations taken into account their clarity, interest and quality.

The last method of pedagogic intervention presented, was developed by Johnson and Johnson. They presented ***Learning Together***, in which students work together in one or more activities. In this method, the size of the groups depends on *T.E.A.M.* (*time* limits, student's *experience* in working in groups, student's *age* and *materials* and equipment available). Although collaborative learning groups typically are constituted by two to four persons, the basic rule is: *'the smaller the better'*. However, there is not an ideal size for collaborative learning group. The teacher can decide the size of the groups, but he or she must take into account that: i) the addition of a new group member can increase the resources of the group, as a whole, for solving the collaboration activity (abilities, skills, number of different minds for acquiring / processing information, diversity of viewpoints); ii) the shorter the period of time available, the smaller the learning group should be in order to obtain an effective group (smaller groups take less time to get organized and they operate faster); iii) smaller groups increase the student's efforts for resolving a collaborative activity, do grown the interactions among the group members and cause that the students were actively involved and participate equally (it is more difficult to hide themselves among the other members of the group); iv) the materials available and the specific nature of the task may influence the group size; v) smaller groups help to identify any difficulties students could have working together (unresolved conflicts among group members, leadership or control issues), trends such as sitting back and waiting for others to do the work). In [Schwartz91], similar criteria for group formation are presented: *'Pairs of student working together represent the most effective form of interaction, followed by threesomes and larger groups'*. In both of them [Johnson75] [Schwartz91], it is reflected that the collaborative work groups should be constituted by the minimal number of persons for working better.

As already suggested, the group's productivity is determined by how well the members work together. Usually, homogeneous groups can achieve better specific aims, however, when students with different abilities, experiences and interests are combined (heterogeneous groups), they can obtain more advantages than homogeneous groups [Johnson75]. In addition, if the students are allowed to organize themselves, they usually create homogeneous groups, and if the teacher is responsible for making up the groups, he or she selects homogeneous or heterogeneous groups according with his/her personal criteria.

Also, in general terms, in collaborative learning environments it is possible to distribute the work related with the accomplishment of a collaborative activity into several subactivities. Each of them will be carried out by individual peers. In this framework, the members of the groups have to agree on some procedures aimed to reach their common goal, including agreements about the roles that each student is to take inside each group [Johnson75], the criteria that they will use in order to reach and to accept solutions, or to generate alternative solutions, as well as the methods they will use to explain, justify and evaluate solutions among others [Johnson02]. The above-mentioned roles can be assigned by the members of the group or by the course teacher [http\_ref10].

With respect to the life-cycle of the groups, groups usually tend to stay together until they complete an activity, unit or course, though the teacher may determine the group life (associating it to a specific task, to a set of activities or to a whole course). Furthermore, a teacher could combine students who are members of different groups for creating new ones [Johnson75].

As a summary of all the former, we can say that, in collaborative work:

- Groups can be formed considering several students' features, or randomly.
- The result of each activity must be evaluated, and students can receive marks about the performance of the group.
- The students must be persuaded to work together: each member of the group and his or her work is necessary for all other members and the global result of the activity.
- Each member is responsible of his or her own work, because if one member of the group does not work well, then the global result is affected. Also, it is necessary to promote the opportunities of communication between the students for allowing them to help one another, and to teach them how they can work in collaborative groups.

Some experiences on the diverse methods of cooperative learning demonstrate that their efficiency depends on the goals to be reached in each case, as well as on the personal features of the students (age, competition, motivation, autonomy, etc) and the characteristics of each application (tasks, homogeneity versus heterogeneity of the group, etc) [http\_ref09].

The first approaches of computer scientist to the area of collaborative learning began at the end of the 80's [Singer88], and made use of the computer as a mere tool for accessing and organizing the information. Later, thanks to development of the communications and the technologies derived from the area of groupware, there arose new applications in an area of study that was named '*Computer Support for Collaborative Learning*' (CSCCL) [Kaye92]. CSCCL arose from the application of '*Computer Supported Cooperative Work*' (CSCW) to the area of collaborative learning.

CSCW is defined as a computer-based network system that supports group work in a common task, and provides a shared interface for groups to work with [Ellis91] [http\_ref02]. The differences between CSCW and CSCL are that CSCW trends to focus on communication techniques themselves, and CSCL focuses on what is being communicated. CSCW is used mainly in the business environments to facilitate group communication and productivity, while CSCL is applied in educational environments to try to support students learning together effectively. The research around CSCL and CSCW covers not only groupware techniques, but also their social, psychological, organizational and learning effects. However, it is not easy to give a unique definition of the term CSCL, among other because of the difficulty of defining the concept of collaborative learning. Dillenbourg said in [Dillenbourg99b] that *'the words collaborative learning describe a situation in which particular forms of interaction among people are expected to occur, which would trigger learning mechanisms, but there is no guarantee that the expected interactions will actually occur'*. From all the above-mentioned, it is clear that CSCL systems allow the communication and the interaction between students with common goals to facilitate a deeper understanding of the problems.

From a theoretical point of view, CSCL is based on a few theories [Koschman96] such as *Sociocultural Theory*, *Constructivism Theory* and *Situated Cognition*. All those theories assume that individuals are active agents that are seeking and constructing knowledge within a meaningful context [http\_ref02], also assuming that knowledge is evolving continually.

Firstly, ***Sociocultural Theory*** [Vygotsky78] [Kuutti91] [Kuutti92] [Engeström97] emphasizes that the human intelligence originates our society or culture, and that individual cognitive gain mainly occurs through the interaction with the social environment and the knowledge internalisation. Knowledge is constructed and discovered by students and transformed into concepts, which students can relate [Johnson91]. Learning consists of active participation by the student versus passive acceptance of information presented by an expert lecturer. Students are actively constructing their own individual knowledge, and learn how to understand and appreciate different perspectives through a dialogue with their peers.

Secondly, ***Constructivism Theory*** [Bruner66] [http\_ref07] says that knowledge is not a fixed object but an object continuously evolving. It is constructed by an individual through his or her own experience of that object. Learners have to assume the responsibilities related to their own learning: they have to develop abilities to monitor and direct their own learning and performance. When people work collaboratively in an activity, they can see a problem from different perspectives and are able to negotiate, to generate meanings and solution through shared understanding [http\_ref02].

Finally, other researches in this area argue that meaningful learning will only take place if it is embedded in the social and physical context within which it will be used (***Situated Cognition***) [Brown89].

In addition, students can be situated in different places and their interactions can be synchronous or asynchronous. Taken in mind these two dimensions, we can have a classification according with the '*space – time taxonomy*' [DeSantis87]. This taxonomy gives as a result a classification of collaborative systems depending on the time and the place in which the students are. The interaction can occur: i) face to face in the same place and the same time (i.e. work groups in traditional classroom), ii) in the same place but in different times (i.e. students working on an activity that can leave and come back to it later), iii) in different places at the same time (i.e. teleconference or chat) and iv) in different places and distinct moments (i.e. email, forum). When students are distributed in different places, it is necessary to provide students with collaborative for making it easier the accomplishment of the collaborative activities, and to allow the communication and exchange of information and ideas among them.

The technological support that systems CSCL can offer includes functions to improve the access or to mediate in the exchange of information, mechanisms of help on the capture of decisions and to facilitate the communication, functions to organize and to manage the knowledge and the structure of the task to be performed. At present, some collaborative tools are commonly used, such as forums, chats, ircs and email [Ortega01] [Benkiran02] [Benkiran03], tools for exchange files and documentation among people [http\_ref07] [http\_ref08], voting systems [Ortega01] [http\_ref04], calendars [Gottdenker02] [http\_ref04], video conferences or teleconferences [Galán03] or shared graphical and text editors [http\_ref05] [http\_ref06] [Vizcaíno00]. There are also some systems that combine many of them, like **PHProjekt**, a modular application for coordination of group activities and sharing of information and documents via Intranet and Internet [http\_ref04].

Thus, any of the methods of pedagogic intervention that we have presented above related to collaboration ('*Student Team Learning*', '*Group Investigation*' and '*Learning Together*') are applicable in Web Education, using systems that implement suitable mechanisms of communication, effective exchange of information among the individuals and the definition of the tasks associated with each learner or group. Each one of them proposes a criteria to organize groups (randomly, auto-organization realized by the students, organization realized by the teacher) and for approaching the understanding and knowledge. In our proposal, we take in mind the characteristics of these methods, though mainly centering in '*Learning Together*' [Johnson75] with respect to group formation.

## **2.4. Collaborative Hypermedia Systems**

As already suggested, collaborative hypermedia systems can combine the power of the technology with the benefits of the team work in CSCL systems. The main characteristics of this kind of systems could be: i) to give support to the student for the

comprehension of new information and for the connection of that new information with the previous acquired knowledge, ii) to provide feedback, iii) to motivate the students, and iv) to offer communications tools in order to facilitate the collaboration among learners.

Nowadays, there are many collaborative hypermedia systems applied to different areas. Some of the most significant are presented next.

**Shadow NetworkSpace** (SNS) [Gottdenker02] is a web-based CSCL environment to support the implementation of a learning community, wherein members (teachers, students, parents, etc) have tools for representing, organizing, sharing and collaborating on their thoughts and efforts. The tools included in this system are secure login, well-defined user roles and group types, file system, calendar, task manager, chat, discussion boards, notes, document creator and homework notification.

Verdejo and Barros [Barros00] developed **DEGREE** (*Distance education Environment for GRoup ExperiencEs*). It is a system to accomplishment and evaluation of experiences of collaborative learning in distance education. This collaborative system supports the accomplishment of a variety of learning tasks in small groups of students. An experience can be formed by one or more activities to be performance, and each activity is constituted by one or more tasks. These activities can be independent among them or are related by contents and temporal restrictions. The collaboration between students is asynchronous. Each student receives individual notifications about the evolution of the common work. All actions and interactions between students are stored to analyze the result of the experience and the process that it is allowed to obtain this result.

The authors of **Kükäkükä** [Suthers02] built it thinking that students might can reference, manipulate and discuss about the use of external artefacts (sketches, pictures and objects) in online learning. Online discussion environments should allow the inclusion of visual artefacts (data graphs, videos of teacher and student work, or problem solutions under construction). These artefacts should exist outside of individual messages (i.e., attachments are not sufficient), and stay visible during the conversation. Participants should be able to change the artefacts under discussion in a natural way, leading to a new discussion space if necessary. For doing it, they created a web-based interface for threaded discussion of web pages. Artefacts under discussion include sample web sites and screen dumps of example interfaces, students' short essays, solutions to small design assignments, and more extensive documentation of their semester-long projects, as well as the Kükäkükä system itself. The individual messages could be reference multiple artefacts (only one page or group pages). Each discussion group has a home artefact associated with it that provides the global context for the group discussion. Each group potentially contains many discussion threads. Each thread also has a contextual artefact, which defaults to the group contextual artefact unless specified otherwise. Each thread contains potentially many messages. Importantly, the context of every message in a thread is the home artefact of the thread. This constraint helps prevent topic drift and makes it easier to identify all portions

of the discourse that reference a particular artefact. The system allows users to reference other artefacts by embedding these references in the body of their messages.

**Lecture 2000** [Schlichter97] supports the access to knowledge and information and the teaching of skills to construct knowledge alone or in a team. It provides the users with an information space, and supports collaboration facilities which may be used both by students and lecturers. The information space is structured according to the hypertext concept. Depending on the user's interest and knowledge and the currently active context the system will display the appropriate level of detail of the information units. The information space is subject to a continuous evolution resulting in updates of existing and integration of new material. Modifications can be done by teachers as well as by students. They work, integrate and select collaboratively the relevant information units; thus a course can become a joint effort by teachers and students rather than simply an instruction by the teacher alone. Furthermore, Lecture 2000 supports a collaborative work environment which enhances the interaction between participating users providing synchronous and asynchronous tools to them. An important aspect is the creation of electronic discussion groups which students and lectures discuss about course related topics. Lecture 2000 provides project teams with common workspaces in which shared documents may be stored and manipulated by the group members. Modifications to a shared workspace are immediately propagated to other group members. Its framework consists of the private information space with private documents and personal annotations to lecture material, the shared workspaces of the project teams and electronic learning groups, the university information space (course material, guided tours) and the global information space represented by the Internet.

## **2.5. Educational Hypermedia Systems that include Adaptation and Collaboration**

As it has been presented, collaborative systems can benefit the student's learning process. Furthermore, in collaborative environments, it is important that students feel comfortable at an environment that favours the communication and the exchange of ideas with the teacher as well as the visualization of the work performed by the companions.

This idea suggests some possibilities to adapt collaborative issues to the needs of the students in web based systems. There are some attempts to satisfy this need. Some of them are COALE [Furugori02], EPSILON [Soller00a] [Soller00b] [Soller01], WebDL [Gaudio02a] [Gaudio02b], SMART-Learning [Benkiran02] [Benkiran03], HabiPro [Vizcaíno00] and the system described in [Arteaga02]. The characteristics of these collaborative systems that include adaptation features are explained next.

**COALE** (*Collaborative and Adaptive Learning Environment*) is an integrated environment for collaborative learning into individual learning WBT (*Web Based Trained*). In this system the learners take the initiative of their own learning process instead relying it on the system, which does not automatically choose the next step in the course. COALE considers learning materials as exercises (problem questions, answers to the proposed questions and explications) and as knowledge sharing of collaborative activities.

The system recommends different exercises to students for the next step in the course and the appropriate co-learners for synchronous or asynchronous collaboration in collaborative activities. The filter criteria for advices concerns to the students' progress and capacity, learning conditions and didactic strategy. The indicators considered in the filter are the level of comprehension of a concept (correct, incorrect or not answered response), the level of comprehension of the explanation of a content, the level of interest of the student on a concept (actions to solve it, to look, to answer, to discuss) and the level of difficulty of the question to give the correct response. The student is the responsible for choosing his or her next concrete exercise in a collaborative activity, as well as his or her partners.

When the students answer the exercises, the system informs them about whether they are right or wrong, and why. In collaborative activities, the groups are constituted by i) members who have a common target with different levels of knowledge (novice and experts), ii) a teacher who provides the basic learning contents, and that acts as moderator and adjust the behaviour of the system of agreement to the learning strategy and iii) a person who manipulates the system, who is in charge of changing the rules of agreement according to the requests of the teacher, among others.

The recommendations of the system for the next step in the course are adapted by the filtering criteria and the previous selections of the students. However, students have the last decision about which is the next activity that they will accomplish. The system has recommendations but it does not force students to follow their step.

In [Arteaga02], other collaborative adaptive hypermedia system is present, which adapts the students' behaviour when they interact with others in a collaborative task. The adaptation process makes use of four different models: the domain model (that describes the information structure, the student model (that includes information about the student, as knowledge already acquired, nodes visited, etc.), the teacher model (that considers some pedagogical rules about the combination of the domain model and the student model) and the collaboration model (made up by rules for the selection process and the collaborative group formation). The adaptation in the collaborative learning process concerns to the group formation and to the role that the students can play in each of these groups.

**EPSILON** (*Encouraging Positive Social Interaction while Learning ON-Line*) includes an intelligent software agent that provides pedagogical support to students learning

collaboratively on-line. It observes the group conversation, dynamically analyzing the dialogue based on a theory of conversation acts (such as justify, assert, encourage), while identifying team members' actions as correct or incorrect, according to a certain activity model. It helps students to improve their meta-communicative skills by identifying when the group needs social mediation. It is also able to automatically choose the learning companion that best fits to the needs of the group.

In **WebDL** it is used a platform to control the interactions with the services of the system and to organize the students into work groups according to some concrete aspect. In order to do that, it combines information provided directly for user through surveys and forms (name, previous knowledge, preferences), information inferred by means of rules defined by the teacher a priori, and information of the interaction of the user with platform (number of conversations initiated by each student, number of conversations that the student has begun and his companions have not answered yet, and number of conversations in which the student and the tutors have taken part).

Its main goal is to facilitate the access of the user to the services (forums, information sources), making it easier the collaboration among the members of the same group. So, it centres in adaptive support for navigation and collaboration. In the collaborative activities, the system is able to predict the level of activity of each user, as well as his or her level of failure when using a service (the system shows additional help to students and guide while they are interacting with the course, furthermore the teacher could decide if the service is useful for the students).

Finally, **SMART-Learning** (*'System for Multimedia Adaptive and cooperative Telelearning'*) proposes an approach based on a generic course. The specific courses are generated from the generic one taking into account the learner profile. The generic course contains, for each part of the course, learning material and access conditions based on students' profiles. The generic course has a same structure and changes for each profile only the part of the contents related to it. The system presents a course as a set of learning units, considers the use of various media and the presence of optional activities (illustrations, reminders), providing the user with some indications and self evaluation procedures, that allow the learner to know his or her progress.

The learner profile is constituted by general information about the learner (identity, language, objectives, training level to be reached) and by contextual information that changes during the learning process (learner's progression in the course, learning speed or capacity). If the profile is modified by an interaction with the system (e.g. an evaluation) the course will be automatically re-generated, to take into account the new knowledge obtained by the learner.

When students are interacting with their specific courses, the teacher module motivates and encourages them, follows their progression, helps them to answer the

questions, and evaluate them. Also, it integrates synchronous and asynchronous communication tools (email, videoconference, chat), which are available among the various actors (learners, teacher, author, administrator) of the course. In this system, there is a virtual classroom the learners are registered, and that poses some characteristic that are common for them all (the same follow-up for the course period, the same language, etc.). The results of the test and of the interactions between the learners and the teacher are taken into account to allow students to pass each unit.

**HabiPro** (*Habits of Programming*) is a collaborative and pedagogical environment that trains students in the subject of 'Programming in Computer Engineering Degree'. It does not try to teach programming, but to help novice students in developing some skills that are important in this area, such as observation or reflection; skills that are necessary to become a good programmer. The interface of the application has two windows: a chat to allow the communication among students and a shared work window where students must collaboratively solve a problem.

This system is adaptive: depending on the group features, it proposes different pedagogic methodologies and different exercises (finding the mistake in the program, put a program in the correct order, predicting the result and completing a program). The group model also stores different social and pedagogic patterns. Each pattern has characteristics that describe behaviours, and also contains a list of exercises, types of clues and pedagogic techniques. While the group is working, the group model compares the new information with the characteristics stored in the patterns, and tries to classify the group into one of those stereotypes. Once the group is classified, the pattern indicates which exercises and work methodology is the most adequate for a group that has a specific behaviour.

To finish this section, we could say that, on the one hand, the above-mentioned systems are mainly focused on the collaborative activities, but they do not allow both individual and collaborative learning activities at the same time (EPSILON, WebDL, SMART-Learning and HabiPro). On the other hand, they are not adapting the whole workspace in collaborative activities (activity, partners and tools). For instance, SMART-Learning only adapts the collaborative tools taking into account the partners that they are connected at the same time (on-line) to offer synchronous tools, the system proposed in [Arteaga02] and EPSILON adapts only the partners to the student that is interacting with the system, and COALE adapts the recommendations offered, but the student can decide always the activity that he or she wants to accomplish. All these systems use a fixed set of tools, though it could be useful that a teacher could include a specific collaborative tool for a certain course that it is not among the available tools of the system.