CA-OLE: A COLLABORATIVE AND ADAPTIVE ONLINE LEARNING ENVIRONMENT

by

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Presented to the Faculty of the Graduate School of

The University of Texas at Arlington in Partial Fulfillment

of the Requirements

for the Degree of

MASTER OF SCIENCE IN COMPUTER SCIENCE AND ENGINEERING

THE UNIVERSITY OF TEXAS AT ARLINGTON

December 2006

ACKNOWLEDGEMENTS

I would like to thank my husband for all his understanding and support. Lindo, you have been there for me all this time and I could not have done it without your encouragement and motivation. I would also like to thank my dad, who has always believed in me and my potential. My mom and sister, who with all their support and love have always helped me through the tough times.

I would like to thank my supervisor, David Levine, for his guidance and support. I would also like to thank Manfred Hubber, for all his direction and assistance. Thank you both for willing to accommodate your schedules so we could get together. I enjoyed all the meetings we had and all the discussions about research and design challenges. Additionally, I would like to thank Paul De Bra for his feedback on my questions regarding AHA!.

I would also like to thank American Leather, who supported me economically and who accommodated my working time so I could assist to my classes.

To finish, thanks to anyone else that contributed to this great accomplishment!

November 17, 2006

ABSTRACT

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Publication No. ______

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The University of Texas at Arlington, 2006

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Demand for online learning environments has grown in the past few years, and schools have been offering more distance courses to their students. Designing adequate online learning environments is considerably more challenging than conventional Face-To-Face courses. This thesis proposes the creation of a Collaborative and Adaptive Online Learning Environment (CA-OLE) that provides a structure where instructors can combine their lesson materials with an adaptive system and collaborative tools.

CA-OLE's innovative approach consists of an adaptive framework that changes the way the learning materials prepared by instructors are presented to the students depending on the student individual performance. By adapting presentation and content we show how the learning skills and methods are improved. CA-OLE also integrates a

collaborative forum where students can interact with other peers by sharing comments about the specific subject they are working on. Besides, CA-OLE allows for group formation by placing students with a similar level of knowledge in the same group. By allowing collaboration between students within the group, teamwork and group effort develops and the learning experience improves.

In general, we show how the adaptation of presentation and content, as well as the collaboration between the different actors improves their learning skills and methods, as well as their knowledge on the concepts presented and evaluated.

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CHAPTER 1

INTRODUCTION

Incorporating technology into education has become a key to modern educational methods. With the rapid growth of computer and computer-based technologies, participants in learning communities are required to interact in one way or another with technology. For example, for most young people, use of the Internet [1], plays a major role in their relationships with their friends, their families, and their schools. Is a consequence, they have incorporated this media as part of their day to day lives.

Demand for online learning environments has grown considerably and by introducing technology in education, the role of the members in the learning community has changed considerably, where collaborative learning has become a key element. On one hand, teachers have moved from being deliverers of knowledge, to being facilitators of the learning activity [2]. Therefore, they need to be motivated to be able to motivate their students. On the other hand, students have become active participants in the learning experience were they not just wait to receive information, but dynamically work in educational activities and learn from each other, learn about the advantages of collaboration and teamwork, and about the importance of using technology on the different contexts of the educational activity.

As a result of demand for online learning environments growing considerably, the need to design appealing online learning environments has been growing as well. And one of the very important factors when designing learning environments is to be aware of the fact that people have different learning styles, this means, interfaces that can adapt to the student and their learning model. Adaptive systems build a model of the goals, preferences and knowledge of each individual user [4] and use this model throughout the interaction with the user in order to adapt to the needs of that user.

This thesis presents CA-OLE, a Collaborative and Adaptive Online Learning Environment where adaptive systems, collaborative tools and group formation systems are integrated to enrich the educational experience. CA-OLE combines the advantages and benefits of these technologies, and by integrating them improves the overall learning experience and increases the knowledge acquired by the students. CA-OLE increases the team effort and group bonding experience, by allowing students to cooperate with each other. CA-OLE improves the overall individual and group knowledge by categorizing students into groups with similar characteristics. Additionally CA-OLE uses an adaptive framework to present students with personalized learning material in order to enrich the learning experience. We show how the adaptation of presentation and content, improves students knowledge on the concepts presented and evaluated.

For evaluation purposes, experiments have been performed within the application domain of cosmology and astronomy. Lesson materials were collected from the NASA and WMAP Science Team website (no copyright restrictions).

The rest of this document is organized in this manner: Chapter 2 presents related work. Chapter 3 introduces CA-OLE and the implementation of the prototype tool. Chapter 4 reports the results of our experiments. Chapter 5 presents conclusions and future work.

CHAPTER 2

RELATED WORK

Learning communities have been supported using a variety of technologies; from simple electronic mail to collaborative virtual spaces. The successful integration of computer-based tools and learning methods is key to the role technology will play in the future of education.

2.1 Adaptive Web-Based Educational Systems

People have different approaches to learning and acquiring knowledge. Usually a person can learn by vision, audio or by "doing it". Introducing technology in education has evolved as well due to these differences in learning methods. Learning styles, as well as the best ways of responding with corresponding instructional strategies, have been intensively studied in the classical educational (classroom) setting. There is much less research on the application of learning styles in the new educational space, created by the Web [6].

Adaptive Web-based Educational Systems (AIWBES) [7] attempt to be more adaptive than regular educational systems by building a model of the goals, preferences and knowledge of each individual student and using this model throughout the interaction with the student in order to adapt to her/his needs.

2.1.1. Evolution of Adaptive Systems

AIWBES have evolved and now are divided into adaptive hypermedia, adaptive information filtering, intelligent monitoring, intelligent collaborative learning and intelligent tutoring [7]. AIWBES use ideas from different areas such as adaptive hypermedia systems, information retrieval, machine learning, data mining, Computer Supported Collaborative Learning (CSCL), and Intelligent Tutoring System (ITS).

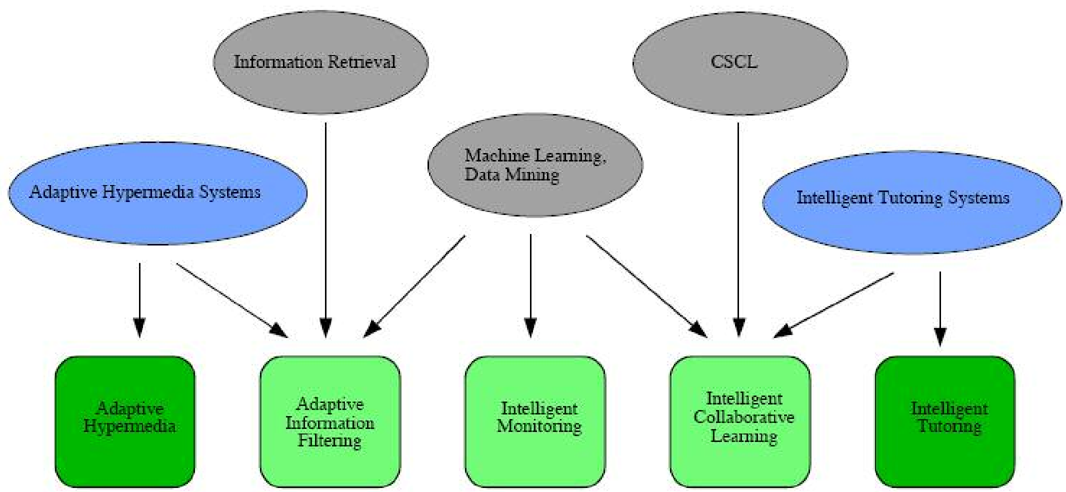

Figure 2.1 AIWBES technologies [8]

Adaptive hypermedia systems explore two major technologies: adaptive presentation and adaptive navigation support. Adaptive presentation technologies [8] adapt the content presented on the page to student goals, knowledge and other information stored in the student model. Some systems are ActiveMath [26] and ELM-ART [25]. Adaptive navigation support [8] helps students finding an "optimal path" through the learning material by changing the appearance of visible links or adaptively sorting links to make it easier to choose where to go next. Some examples are ELM-ART [25], InterBook [27] and De Bra's adaptive hypertext course [28].

The goal of adaptive information filtering [8] is finding a set of items that are relevant to the user interests in a large pool of documents. This technology has been used in the web search and browsing context, by adapting the results of Web search through filtering ordering, and recommending the most relevant documents. There are two types of engines: content-based filtering and collaborative filtering. Content-based filtering relies on document content. Collaborative filtering attempts to match users interested in the same documents. Some systems are MLTutor [29] and WebCOBALT [30].

Online learning systems can track every action of the student, but it is almost impossible for a teacher to make any sense of the large volume of data collected. Intelligent class monitoring [8] attempts to use Artificial Intelligence (AI) to help the teacher identify and understand the data collected. An example system is HyperClassroom [33].

Intelligent collaborative learning [8] puts together CSCL and ITS. There are at least three distinct technologies: adaptive group formation and peer help, adaptive collaboration support, and virtual students. Adaptive group formation and peer help attempts to use knowledge about collaborating peers to create a group that will work together on collaborative problem solving. Adaptive collaboration support attempts to provide an interactive support of a collaboration process. Virtual students instead of supporting learning from a position of someone superior to the students, tries to introduce virtual peers into a learning environment. Some examples are COLER [31] and EPSILON [32].

Major intelligent tutoring technologies [8] include: curriculum sequencing, intelligent solution analysis, and problem solving support. Curriculum sequencing attempts to provide the student with the most appropriate planned sequence of learning activities in order to guide him/her through the hyperspace of information. Intelligent solution analysis attempts to tell if the solution given by a student is correct or not, and provide feedback on what is wrong or incomplete and which pieces of knowledge are responsible for the error. Interactive problem support provides the student with intelligent help on each step of problem solving. Some examples are: ELM-ART [25], ActiveMath [26].

2.1.2. Adaptive Systems Tools

MEDEA [9] is an open learning platform with a student model composed of a Student Knowledge Model (which represents what the student knows about the subject) and a Student Attitude Model (which represents other student features that are relevant for the instructional process). It has also an Instructional Planner module that provides guidance during the learning process, defining which knowledge unit should be selected next, and how to present the selected knowledge. MEDEA offers curriculum sequencing, teaching task selection and student model management. MEDEA does not provide group interaction or adaptation in any way. The MEDEA research group is planning to explore how to apply automated reasoning techniques to use the log files to improve the system's behavior.

AHA! [5] is an open source general-purpose adaptive hypermedia system, through which very different adaptive applications can be created. AHA! Uses three types of information: the domain model (DM), the adaptation model (AM) and the user model (UM). The domain model (DM) contains a conceptual description of the application's content using concepts and concept relationships. The adaptation model (AM) is what drives the adaptation engine and consists of adaptation rules that are actually event-condition-action rules. Adaptation is provided by using link adaptation and annotation, adaptive presentation, style adaptation, and other adaptation techniques. The user model (UM), consists of a set of concepts with attributes (and attribute values) specific to each user. AHA! has not been used for multi-user adaptation. At the moment it is only possible to read and write your own user model. Another constraint is that the layout is determined entirely by the author.

The Adaptive Courseware Environment (ACE) [11] is a WWW-based tutoring framework that combines methods of knowledge representation, instructional planning, and adaptive media generation to deliver individualized courseware via the WWW. The domain model describes the concepts of the domain and their interrelations and dependencies, the pedagogical model contains pedagogical strategies and diagnostic knowledge and the learner model stores the preferred settings of a learner, the domain concepts a learner worked on, and the interface components used by the learner. ACE supports adaptive curriculum sequencing and adaptive navigation support. Currently, ACE is not an authoring environment for adaptive educational hypermedia yet, and is domain specific. In addition it does not offer Diagnostic modules or domain entities to support further adaptation.

GRACILE [12] is a learning environment based on software agents, integrating speech technologies and natural language processing. A learner model is used to maintain a learning plan based on the capabilities and the interests of the individual learner and her/his peers in the community. Different types of agents are implemented to help with the learning process (domain agent, mediator agent, information agent, interface agent). GRACILE offers collaboration by facilitating interaction of student agents and teacher agents. It presents a model of a second language learning environment and is domain specific.

2.2 Collaborative Learning Environments

> "In classrooms that adopt the collaborative knowledge building approach, the basic job to be done shifts from learning to the construction of collective knowledge. The nature of the work is essentially the same as that of a professional research group, with the students being the principal doers of the work. Thus, in the ideal case, there is a complete shift from students as clients to students as participants in a learning organization." [13]

Roles in education have changed. Instructors have moved from being deliverers of the knowledge, to being facilitators of the learning activity [14]. Students have become more active by learning from each other, solving their problems, learning about collaboration, and learning the appropriate use of the technology in their own context.

2.2.1. Computer Supported Collaborative Learning

In Computer Supported Collaborative Learning (CSCL) [16] teamwork and Interaction with resources, instructors, and peers are vital to a successful environment. But one of the biggest obstacles to incorporating CSCL techniques into teaching may be the prospect of the educator giving up the responsibility and control over learning and moving it to the student. Educators shift from being the deliverers of knowledge to facilitators of the learning activity.

Another major obstacle when integrating CSCL techniques in the learning strategy is that some students may experience difficulties in communicating with people they are not acquainted with. One factor that may compound these difficulties is the lack of visual contact and body language. By allowing students to bind into groups and to collaborate to achieve a specific objective, the students are responsible for one another's learning as well as their own. In fact, studies have shown that students' motivation increases when they feel challenged and that they perform at a higher level when they work in groups [17].

2.2.2. Collaborative Learning Tools

Computer Supported Intentional Learning (CSILE) [16,18,19], uses new technologies to support decentralized forms of discourse and knowledge building within a discipline. CSILE is an asynchronous discourse tool that supports knowledge building by providing thinking-type labels, scaffolding of notes, and different views of notes. The software provides knowledge building support both in the creation of these notes and in the ways they are displayed, linked, and made objects of further work. CSILE has demonstrated how such technology produces positive effects in learning. However, CSILE does not support link or presentation adaptation for these notes.

CaMILE [20] offers a collaborative environment in which participants can share their ideas through the use of notes. Students in CaMILE can classify their interactions and change accessibility privileges to their notes. CaMILE was designed to (1) facilitate the sharing of text and media in an asynchronous collaboration and (2) provide scaffolding through software to facilitate the activity of and learning about collaboration.

Training and Resources for Assembling Interactive Learning Systems (TRAILS) [21] integrates three learning technologies: Perceptual Agents, Collaborative Workspaces, and Digital Libraries. Each student interacts with his own agent while solving problems or acquiring new curricular concepts. Agents communicate with each other and can collect and organize data across the class for the professor. Instead of the teacher sending responses directly to his/her students, the teacher could send "encourage/correct" responses to the students' trough the student agents. The teacher is able to connect students were it makes sense for one to help another.

KOLUMBUS [23] is a system that combines the integrated presentation of material and annotation by allowing the upload of material by all users and by letting the users to annotate existing annotations provided by other users. KOLUMBUS integrates the following functions related to the four main phases of the learning process: teacher prepares the material, students are introduced to the material and prepare a text based on individual research, then they exchange their contributions with other students, and finally they exchange question and answers, developing a discussion thread or conducting a negotiation to find a consensus over the material they read.

COLER [24] is a learning environment in which the facilitator can interact with remote students while being assisted by a computer coach that facilitates effective collaborative learning interactions. The collaboration coach has to monitor the student's activities and the team activities, encouraging interactions that influence individual learning and the development of collaborative skills. Students must solve problems first alone and then in a group. The COLER research group is considering investigating the use of a single global coach endowed with the ability to inspect all students' private workspaces as well as the shared workspace. Such a coach would be able to identify conflicts between solutions in private workspaces and encourage the students to share the relevant part of their solutions, thereby creating conflict opportunities for collaborative learning.

CA-OLE combines adaptation and collaborative techniques in one online learning environment, getting advantages of the two technologies. CA-OLE is not domain specific allowing for the creation of any educational material. It also allows for students to collaborate within a group assigned by the system, ensuring students with similar characteristics will be able to interact with each other.

CHAPTER 3

CA-OLE APPROACH

3.1 General Overview

3.1.1. Virtual Learning Environment (VLE)

The CA-OLE idea started from the Virtual Learning Environment (VLE), a learning tool created as a common effort between the Social Work department and the Computer Science department at UTA. VLE was developed to evaluate the impact of distance education and the use of online tools on the Social Work department at UTA. The objective was to evaluate and measure which learning techniques worked well in delivering a specific outcome from the exercise and to learn how to evaluate both the design and effects of a virtual learning community.

VLE (Virtual Learning Environment) supports students working in a learning activity by offering learning spaces in which they can acquire knowledge about listening skills. The main point of the exercise is to get the highest score possible by correctly identifying as many skills as possible while playing a video for as many times as he/she can on a 30 minutes period. Listening skills are provided on the screen (left and right columns) and positive and negative audio feedback is given, depending on whether the student correctly identified these skills. Different Experts were asked to identify the missing skills at different stages of the video. Then, if the student identifies a listening skill on a given time frame on the video, the system verifies if the user correctly identified the skill on the given time frame defined by the experts. If so, it will play then the Positive Feedback sound, indicating the skill was correctly identified. If not, it will play then the Negative Feedback sound, indicating the skill was not correctly identified. Figure 3.1 shows the main screen of VLE, where

Figure 3.1 VLE (Virtual Learning Environment) main screen

Fig 3.2 shows how the student can personalize the screen at different stages during the game session. This provides study data to measure how each of these options impact the learning activities and the knowledge acquired by the student. The student is able to personalize his/her screen by changing different interface attributes, such as background color, border color, and button color. He/she is also able to determine what kind of feedback wants at the end of each game (score only, score and positive feedback, score and negative critique, score and comparative feedback). Besides, the student can choose whether to hide or to display his/her "Score" and the

"Remaining Time" for the game session. The objective with this approach was to leave the personalization up to the student, and evaluate if changing the appearance of the user interface will help or not the learning experience for a given students. Also, compare between students that personalized their screen against those who did not and see differences on the knowledge acquired.

Figure 3.2 Personalize screen

The student can also ask for help if needed at any time during the game. Help is provided on the form of expert, previous player advice, video transcript, game instructions, lessons on listening (text and audio formats) and overview of skills. The objective here was to evaluate how often the students used the help provided, as well as the kind of help that was preferred (audio, text, etc). In addition, we wanted to evaluate how well the students that used help did compared to the ones that did not use it.

Session information is logged in order to keep track of any interaction or personalization the student selected when using VLE. For example, the system will record if the student asked for help, what kind of help was requested, and the exact time when this happened. It also registers if any interface personalization was selected, when it was selected and what was the option chosen. Also, for every Listening Skill identified the exact "video" time will be logged and whether if the answer was right or wrong.

In order to evaluate VLE, a pre-test was given to the students to assess their current knowledge of listening skills and attitude towards technology. A post-test was provided after students took the exercise to evaluate their satisfaction with the VLE environment and to re-measured knowledge of listening skills and attitude towards technology. All the students (7) improved their knowledge when the Post-Test was evaluated. They also improved on the number of listening skills identified the last time they run the game compared to the first time they played it. The study was done with a small sample (8 students) which did not allow getting a verifiable analysis. VLE experiments also showed that allowing the student to customize and adapt the system to their needs improved their overall performance during the learning experience.

Using these experimental results as a baseline, CA-OLE conceptual design was defined, by proposing a system that integrates two major technologies: adaptive systems and collaborative tools.

3.1.2. Conceptual Design

Adaptive systems have evolved and now are divided into adaptive hypermedia, adaptive information filtering, intelligent monitoring, intelligent collaborative learning and intelligent tutoring [7]. The focus of CA-OLE has been directed at adaptive hypermedia and intelligent collaborative learning. Adaptive hypermedia because it includes strategies for adaptive presentation and content. Intelligent collaborative learning because it contains techniques for adaptive group formation.

Collaborative tools allow for group interaction and teamwork. There are two types of collaborative tools: asynchronous and synchronous. Synchronous collaborative tools allow users to interact at the same place at the same time, for example: chat rooms, whiteboards, instant messaging systems, and others. Asynchronous collaborative tools allow users to interact at the same place at a different time, for example: emails, discussion boards, forums, and others. The focus on CA-OLE has been directed to asynchronous collaborative tools where students can interact with peers within the same group, allowing the creation of individual and group knowledge.

CA-OLE combines different components to create the proposed collaborative and adaptive learning environment. These components are: CA-OLE controller, an adaptive framework, an asynchronous collaborative tool, and a group formation system. The CA-OLE controller handles the overlay model that controls and integrates the adaptive system, the collaborative tool, and the group formation system. The adaptive framework handles the adaptive content and presentation layer by adjusting the learning material presented to the student based on their individual performance. The asynchronous collaborative tool allows for the students to interact with other members of their group by sharing comments or questions about the materials they are reviewing. The group formation system determines the student's next group he/she will be interacting with based on his/her evaluation results.

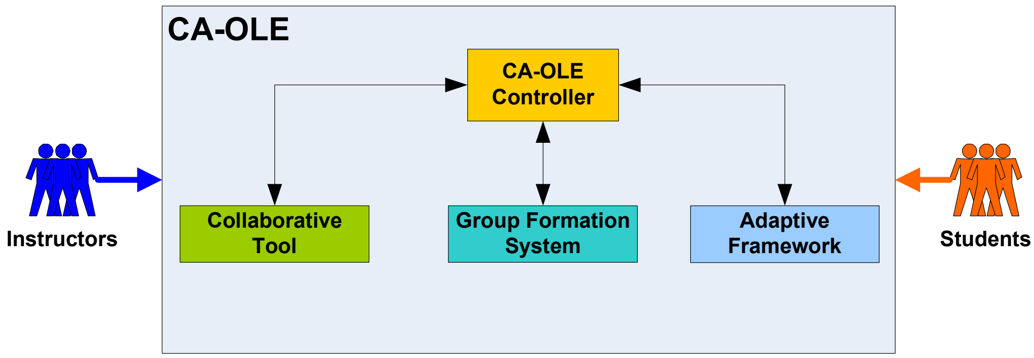

Figure 3.3 CA-OLE Components

Figure 3.3 shows how these four components interact to create the proposed functionality. The CA-OLE controller integrates the other three components and provides the graphical interface for the students. Within the adaptive framework, learning materials are created, concept hierarchies are defined, and adaptation rules are defined. Based on these rules and the concept relationships, the learning material is presented to the student and his/her model is created. The group formation system analyzes the student's model to determine the best group for her/him for a given lesson. The collaborative tool allows the student to interact with peers assigned to his/her same group. Individual knowledge is built by the student's interaction with the learning material. Group knowledge is built by the collaboration between peers within the groups created.

By integrating adaptive systems and collaborative tools, CA-OLE offers an innovative learning environment where instructors and students interact and play different roles. It allows instructors to create lesson materials, define concept hierarchies, and specify adaptation rules. It allows students' to review lesson materials, collaborate with peers and evaluate their performance. The controller component manages the interactions between these actors and CA-OLE.

In the following sections these components as well as the interaction with instructors and students are explained.

3.2 CA-OLE Components

3.2.1. CA-OLE Controller

The CA-OLE controller handles the overlay model that controls and integrates the adaptive system, the collaborative tool, and the group formation system components. It also provides the interface for the instructor lesson setup and students learning material review.

3.2.1.1 Instructors Interaction

The instructor compounds his/her learning material into Lessons. Each lesson is then sub-divided into sections in order to present the student with more specific topics. Lessons are created from basic to advance. Sections are created following the same strategy. The idea behind this approach is to ensure lessons will follow the traditional method used on face-to-face courses. Based on students' performance indicators CA-OLE allows them to advance or not to the next section or lesson. The system ensures they will not progress to more complex concepts if they have not acquired the required understanding of the more basic topics. In order to assess if the student can or not move to the next section or lesson, different parameters can be evaluated and different actions can be taken based on their values. By looking at the student's score after a test is taken, it can be inferred how much he learned about the concepts presented. By looking at the correct and incorrect answers we can specifically know concepts he needs to work on. By looking at the time it took the student to finish the section and the number of times a given test was taken, we can infer if he/she read thoroughly the material or if he/she just did a quick overview and see if luck had anything to do with his/her performance. By comparing the student with other team members we can assess his position within the group. All these parameters are collected and can be evaluated by the system.

Sections in CA-OLE are modeled using the adaptive framework. Using *domain models* instructors create graphs where interrelations and a hierarchy among concepts are defined. These graphs represent the concept structure and the knowledge the students are going to acquire by reviewing the given section.

In addition, instructors create tests to evaluate a student's performance in every section. Tests are created based on the concept graph defined by the instructor, and the purpose of using them is to evaluate how much the students learn when reviewing the learning material.

Another component instructors help to define are group formation rules. By having adaptive group assignment students may be interacting with a different team during the learning activity. Group creation can be done in many different ways and based on different approaches. Groups can be created by categorizing students with similar knowledge level under the same group, or by grouping advanced and beginners within the same group. CA-OLE allows for individual and collaborative interaction, and then having groups that share similar characteristics increases the opportunities for cooperation, and at the same time it allows the student to keep his/her own pace when learning.

Another important issue regarding adaptive group formation is at what time, during the learning activity the groups are going to be re-assigned. One option can be right after a section is successfully completed and the student is ready to move to the next one. Or after a lesson is successfully completed by the student and he/she is ready to move to the next lesson. Or after a test is completed, no matter if the student moves to the next section or not. For CA-OLE, we have decided to re-assign groups after each lesson is successfully completed because it provides a clean cut when changing from one topic to the next one, more data related to the students is collected, and it allows for more opportunities for collaboration within the existing group.

Also, when reassigning groups it is important to define if all students need to finish a section or lesson at the same time or not. Because of the conceptual design we have put in place, evaluating one student at the time gives more flexibility since students can still learn at their own pace, while interacting with groups. If a student finishes a lesson quickly, he/she does not have to wait for everybody else on the classroom to finish, he can continue working and learning his/her material and continue collaborating with his/her team. By doing this, adding and dropping people from a group happens dynamically, and then special attention should be given at the group size, since a student can move to a new group all by him/herself. For the purpose of the prototype implementation, we are not constraining group size in any way and group sizes can vary from group to group.

In order to allow for the adaptive group formation features explained above, a dynamic evaluation of individual student's performance during a lesson and his/her interaction with other peers is needed. Individual performance can be evaluated based on different parameters and data collected during student interaction. By looking at the different scores the student got on the tests, we can compare his/her performance with other team members and evaluate the best group he/she will fit in. By looking at the time it took the student to finish a lesson, we can evaluate and assign him/her to a group where members have similar learning pace. By looking at the collaboration module, we can evaluate how students interact, what kind of interaction they have and how much they do it. For example, a student that asks too many questions will fit better with students that provide answers, a student that shares a lot of comments is better of interacting with students that interacts a lot as well. Another option to assess group assignment, is by doing a *team evaluation* that includes how the perception of your team members was, how your interaction during the activity was, and any other important factors that may affect group performance. The way these all these different parameters are evaluated, can vary from topic to topic, or instructor to instructor, therefore, we are allowing the instructor to create a baseline for group creation that is then evaluated by CA-OLE to determine whether or not a student should move to a different group or not. These adaptive group formation rules are accessible by the instructor for him/her to modify them whenever is necessary. Instructor interaction overview is displayed on Figure 3.4.

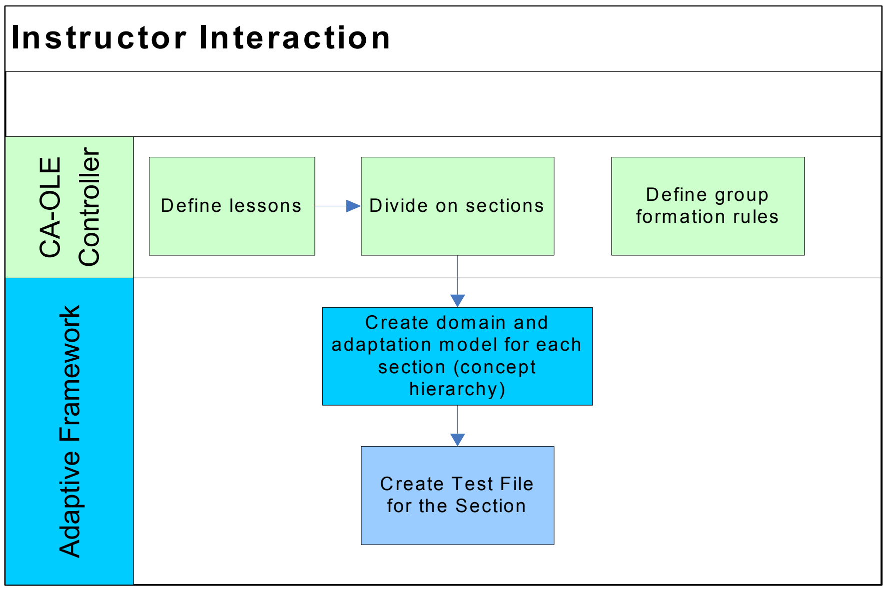

Figure 3.4 Instructor Interaction

3.2.1.2 Student Interaction

Having asynchronous collaboration as well as persistent data related to lessons, sections, tests, and user performance allows students to proceed at their own pace and study the material at their own rhythm. They can exit a lesson and go back and finish it later if needed.

Student interaction with the different components integrated in CA-OLE is seamless and transparent. CA-OLE will validate the student *user model* and performance data in order to present the student with the right lesson or section. The adaptive framework presents the learning material according to this data as well, and by modifying it according to the adaptation rules defined by the instructor. The objective here is to adapt the interface and content presented to the student based on his/her own situation.

A student starts by logging in ti CA-OLE and by taking a first assessment test where initial data is collected. This data is used by CA-OLE to determine the best group association for this student. Group assignment can be done by evaluating different parameters recorded by the system, like score, time, personal values, collaboration logs, and others explained on the previous section. For the purpose of this prototype we are using score and time as a baseline to categorize a student.

The system then takes the student to the appropriate lesson. By continuing with the given lesson link, CA-OLE presents the student with the next section he/she needs to review within the lesson. Figure 3.5. shows an example of a section when is presented to the student.

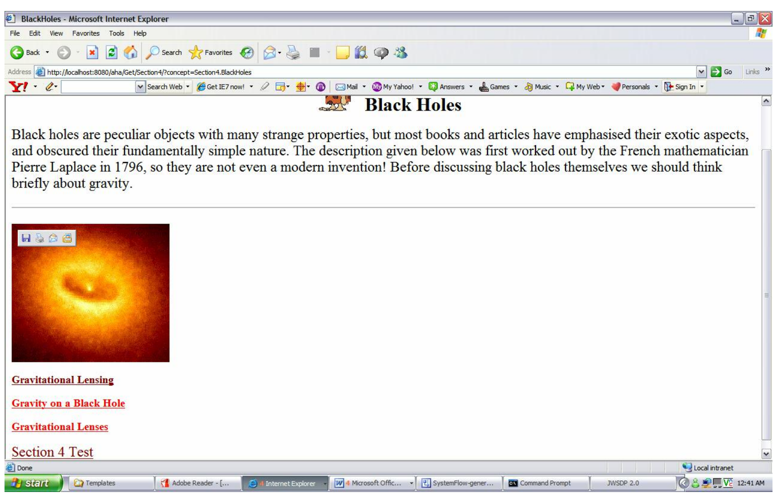

Figure 3.5 CA-OLE - Sections

Section content is presented to the student as it was specified by the instructor in the *domain model*. Conditional fragments and objects are either displayed or hidden depending on the student's *user model.* Once the student is done with the section, he/she takes a test prepared by the instructor to evaluate his/her knowledge about the concepts reviewed. Figure 3.6 shows the test being presented to the student.

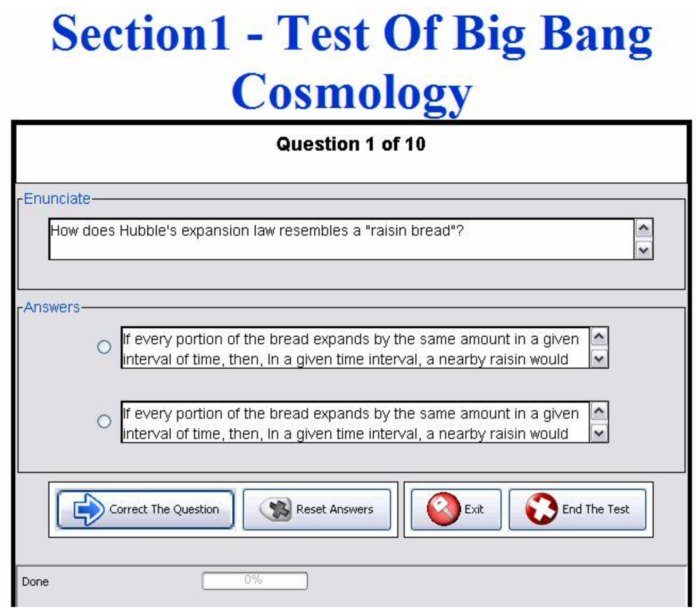

Figure 3.6 Test Evaluation

The test contains questions and possible answers related to the concepts examined on the section just visited. At the end of the test a final score is calculated based on the individual student's performance, which may or may not be displayed to the student depending on the user model and the instructor's choice. CA-OLE evaluates the student's performance on the test and if it is considered acceptable (greater than baseline score) the student is allowed to move to the next section. If not, the student goes back to the same section but only the concepts were he/she missed are presented. Figure 3.7 shows how the screen looks if the student just started the "Black Holes" section and how concepts are presented to him/her.

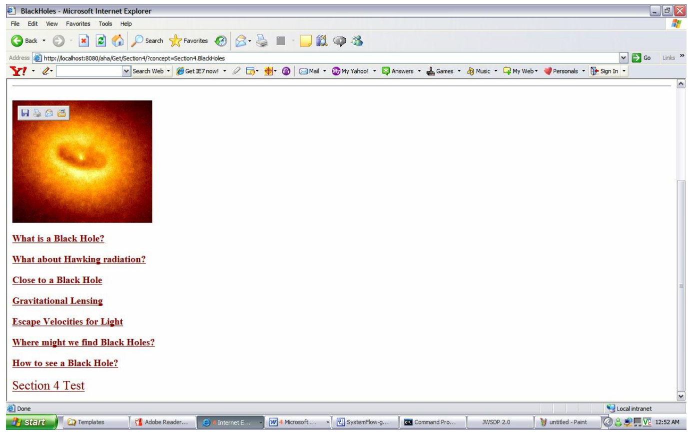

Figure 3.7 Section presenting links prior evaluation

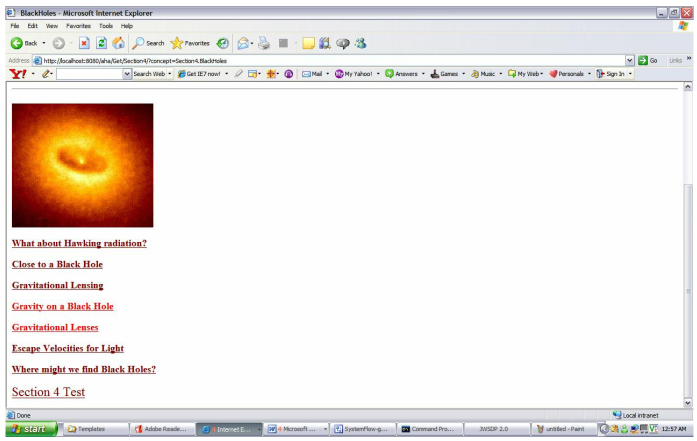

Figure 3.8 Section after evaluation score not acceptable

On the other hand, Figure 3.8 shows how the screen looks after the student has been evaluated and has missed the acceptable score. As shown on the figure, extra links related to the concepts he/she failed during the evaluation are presented, and links to the concepts he/she passed are not displayed anymore.

This process continues until the student is ready to move to the next lesson. Moving successfully to the next lesson can be based on different parameters: score, time, personal values, correct or incorrect answers, and student's comparison. For the purpose of this prototype we are basing this on score and time.

The group assignment is re-evaluated every time a student is ready to move to the next lesson. This re-assignment can be based on different attributes like score, time team evaluation, collaboration style, and other values collected during the interaction. For the purpose of this prototype, CA-OLE verifies overall student performance (score and time) on the previous lesson, and based on this data it assigns a group.

Student collaboration can be performed asynchronously by using tools like forums, thread messages and email. Or it can be performed synchronously by using tools like chats and whiteboards. For the purpose of this prototype we are using asynchronous tools by posting messages on a forum where students can only collaborate with other students assigned to the same group. Student interaction is shown on Figure 3.9.

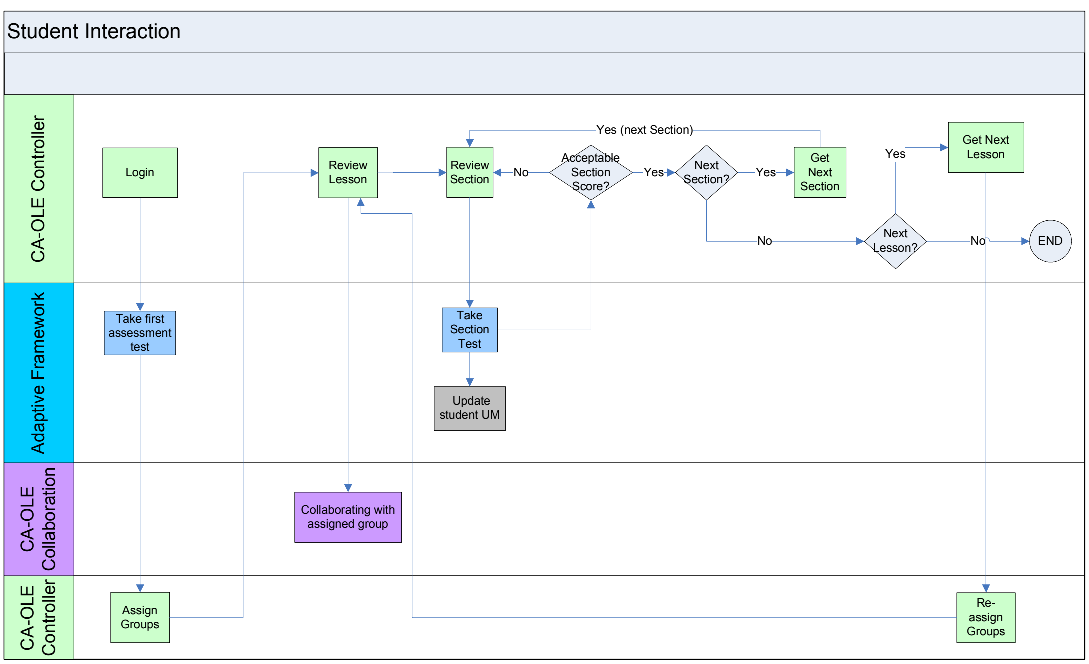

Figure 3.9 Student interaction

3.2.2. Adaptive Framework

The adaptive component handles the adaptive content and presentation layer by adjusting the learning material presented to the student based on their individual performance. For CA-OLE functionality we need to provide adaptation in a flexible way so the instructor can be able to create the concept hierarchies for the learning material he wants to provide his/her students, no mater the domain where he/she is working on.

Instructors can also define *adaptation rules* within the adaptive component, which modify content or presentation based on events and conditions. By using adaptation rules, the instructor is allowed to model each individual section and define its behavior. These adaptation rules allow him/her to specify condition rules for the concepts he/she wants to present to the student. The instructors need to be able to define which concepts will be presented to the student and under which circumstances. Therefore, adaptation rules need to be linked somehow to the concepts created for a given lesson. For example, the instructor might decide to present *algebra* example 3 and 4 only if the student already reviewed example 1 and 2 and still did not understand the *algebra* concept clearly. Or, instructors can make a concept *suitable* for a student, only if he already acquired the knowledge required for more basic concepts. They can do this by defining an adaptation rule that checks for the *knowledge* value for the student, and updates the *suitable* value accordingly. The student will see this concept with a different link color and annotation.

The adaptation module should control whether or not the student moves to the next lesson or to the next section. . In order to assess if the student can or not move to the next section or lesson, different parameters can be evaluated and different actions can be taken based on their values. By looking at the student's score after a test is taken, it can be inferred how much he learned about the concepts presented. By looking at the correct and incorrect answers we can specifically know concepts he needs to work on. By looking at the time it took the student to finish the section and the number of times a given test was taken, we can infer if he/she read thoroughly the material or if he/she just did a quick overview and see if luck had anything to do with his/her performance. By comparing the student with other team members we can assess his position within the group. All these parameters are collected and can be evaluated by the system.

By looking at these requirements, the adaptive component needs to make use of adaptive hypermedia and/or intelligent group formation techniques, since those are the two adaptive system areas we wanted to concentrate on. Adaptive hypermedia techniques focus on adaptive presentation and content. While intelligent group formation techniques focus on adaptive group formation.

Now the question was to develop an adaptive component from the beginning or to evaluate if any existing adaptive framework could be used. Different adaptive systems and frameworks were evaluated and reviewed in order to assess our requirements. From the systems evaluated, we decided to use AHA! (Adaptive Hypermedia Architecture), an open source framework developed at the Eindhoven

University of Technology. AHA! makes use of adaptive hypermedia techniques, allowing for presentation and content adaptation. It is an open source project, provides a web-based adaptive engine, uses standard java-servlet and xml technology, and is not domain specific allowing for general purpose user model. However, AHA! has not been used for multi-user adaptation and does not allow group formation or collaboration. Since AHA! provides most of the adaptation functionality required and allows for a framework that can be easily integrated with other applications in case customizations are needed, we have decided to use it and let CA-OLE components to handle group creation and asynchronous collaboration between students (see sections 3.3. and 3.4.).

AHA! has been successfully used in other applications such as to create on-line adaptive courses, to perform research into data mining on log information for browsing, and as a vehicle for students to develop adaptive documents. AHA! has been used in many different countries, including US, Spain, Italy, Brazil, India, etc

The following sections explain how CA-OLE uses some of the available features in the AHA! framework.

3.2.2.1 Domain Model / Adaptation Model

The combined *domain and adaptation model* DM/AM consists of a model of the *conceptual* structure of the application, and the *adaptation rules*. DM/AM in combination with the User Model (UM) are used to decide which application file to retrieve upon a request from the user.

The instructor creates the DM by creating a new application within AHA!. The domain model consists of a “concept hierarchy” (see Figure 3.10) were the teacher specifies concepts hierarchy he/she considers relevant to be acquired by the student for the given application. Each concept can be linked to an XHTML page that will be displayed to the students with information related to that concept.

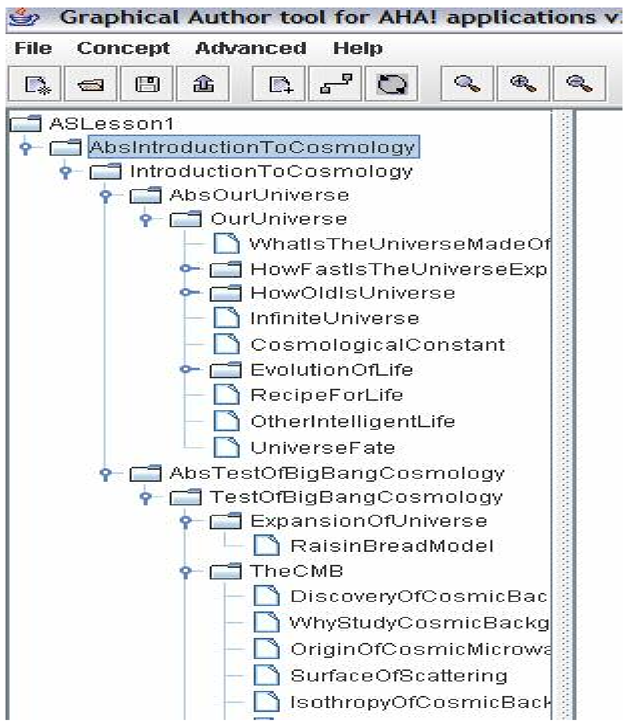

Figure 3.10 AHA! Domain Model – Concept Graph Definition

AHA! creates the AM for the concepts entered by the Instructor on the DM based on the hierarchy of concepts. The instructor can change these adaptation rules to control what concepts will be shown to the students and under which conditions. The instructor selects which information fragments or objects to include in pages and under which conditions.

The *adaptation model* allows the instructor to specify the rules that adapt the content and presentation depending student interaction with the system and on the triggers related to the DM attributes explained above. See Figure 3.11 for an example of the *adaptation model* from the instructor's perspective.

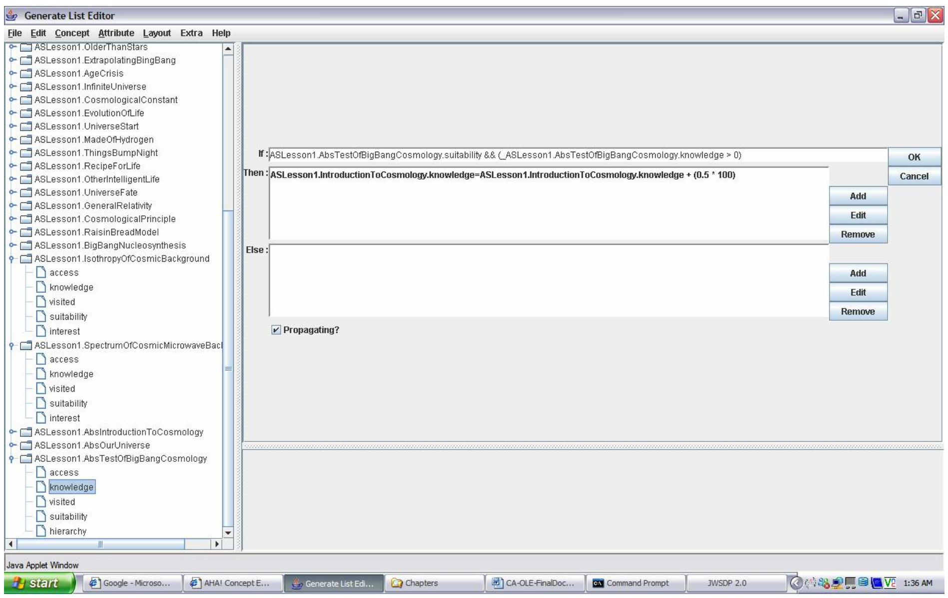

Figure 3.11 AHA! Adaptation model – rules and attributes definition

Different attributes are associated with each concept, and the instructor can specify how these attributes will be modified during student interaction and how the system will adapt accordingly by using the adaptation rules. One of the attributes is *knowledge,* and standard AHA! functionality assumes student acquired knowledge if he/she visited the page. Then, every time the student visits a page AHA! will add the concept to the user model list, mark it as visited and check on the adaptation rule engine for the knowledge value that needs to be updated. It will also update the whole knowledge value for the application depending on the parent-children adaptation rule defined. However, we believe even though a student visits a page, it does not mean he/she read through the material and understood the concepts presented. We have modified this functionality and allow for knowledge updates only when the student has taken the test and we have evaluated how much they really learned.

AHA Standard functionality allows also for a form where the student can give a percentage or value for each concept knowledge value. The form will present the student with a concept and then, the student needs to specify how much he thinks he knows that concept. Instead of doing this, we are using a Pre-Test that will evaluate with questions/answers how much does the student really know, nor what he/she thinks he/she knows.

Another feature provided by AHA! is the use of *personal values.* Personal values allow for the student to determine certain attribute values about himself/herself. Standard AHA! functionality allows the students to provide this information only at the beginning of the interaction, but student beliefs or interests can change from topic to topic, or they can change with time. Our evaluations done on VLE we have concluded that by allowing the student to specify personal values during interaction according to his/her specific interest at the time, can help with the learning experience. Then we think we can use *personal values* within other components defined on CA-OLE and allow the students to modify these values at any time during the learning activity. Depending on values collected by CA-OLE, the system can also update some of these values. For example, based on how much the student contribute during a given lesson, how much he collaborated on the forum, CA-OLE can update this values. So, it is not only students' perception, but also how the system evaluates the student performance and interaction.

3.2.2.2 User Model

As the user is interacting with the application a *user model* (UM) is used and constantly updated. The UM includes data related to the user individual knowledge for a given section as well as the knowledge for a specific concept. The UM in combination with DM/AM is used to decide which application file or "page" to retrieve upon a request from the user and which objects to conditionally include in that page.

Each student interacting with the system has his/her own user model. This information is used by CA-OLE to evaluate whether or not the user should move to the next Section or Lesson. This information is used as well to determine how to categorize students into groups so they can get the most out of the collaboration capabilities.

3.2.2.3 Adaptive Presentation

Conditional objects are fragments of learning material or concept pages that are presented to the student only if a certain condition is fulfilled. For example, a student that understands a given concept might not need extra data related to it, while a student that has problems understanding the concept might need some additional material or examples. Providing more information allows the student to go deep into the topic and get more understanding about it. An example of conditional objects will be:

```
<if expr="ASLesson1.OriginOfCosmicMicrowaveBackground.knowledge !=
100">
<block>
<h4><a
href="http://localhost:8080/aha/ASLesson1/xml/OriginOfCosmicMicrowaveB
ackground.xhtml">The Origin of the Cosmic Microwave
Background</a></h4>
```

```
</block></if>
```

For the student a conditional object is transparent since his/her performance will dictate whether or not a given object is displayed. When the student is interacting with CA-OLE, he/she will either be able to see the conditional object learning material or not. Figure 3.12 shows what the student will be seeing on the screen if the condition above is not true, if the student has not yet acquired the required knowledge about Cosmic Microwave Background.

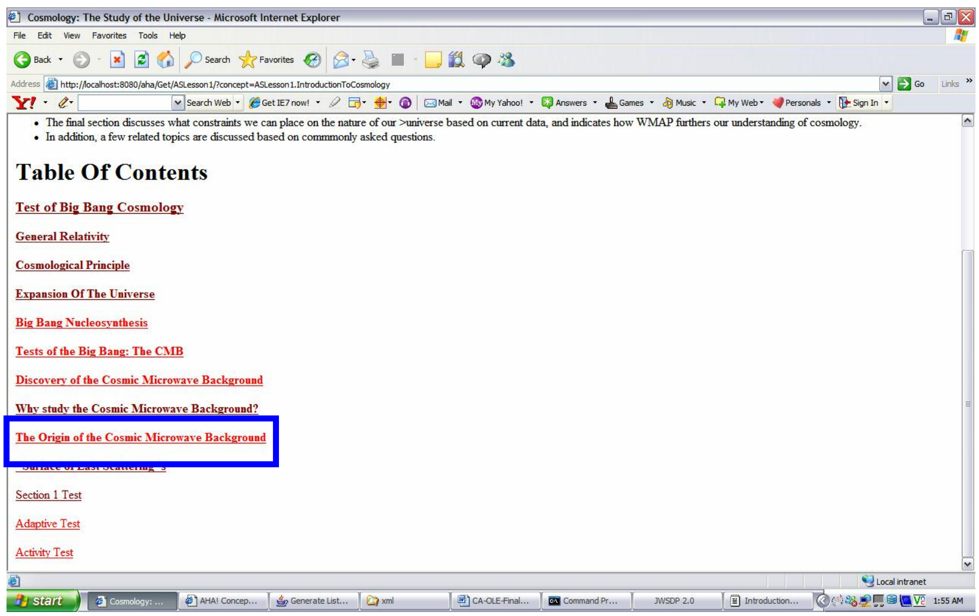

Figure 3.12 AHA! Conditional Objects

The *link anchor adaptation* functionality typically uses three colors, named *good*, *neutral* and *bad.* These colors are used as a reference so the student can have an idea of which concepts to go to first according to the concepts he has previously visited or acquired knowledge about. Figure 3.12 shows the different on colors when the student is reviewing the learning material.

Adaptive Presentation standard functionality has been used since it fulfills our needs.

3.2.2.4 Test Module

Test Editor is an AHA! add-on module that allows the instructor to create tests related to the sections he created for a given lesson. Tests are created for given lessons and they can be randomly or sequentially generated based on the concepts to be evaluated.

The instructor can decide to display an introduction to each test as well as performance information at the end of the test. The configuration information interface for this functionality is shown on Figure 3.13. Also, immediate feedback of whether the answer provided by the student is correct or not can be provided. The instructor can decide to limit the time the student has to give an answer for a given question.

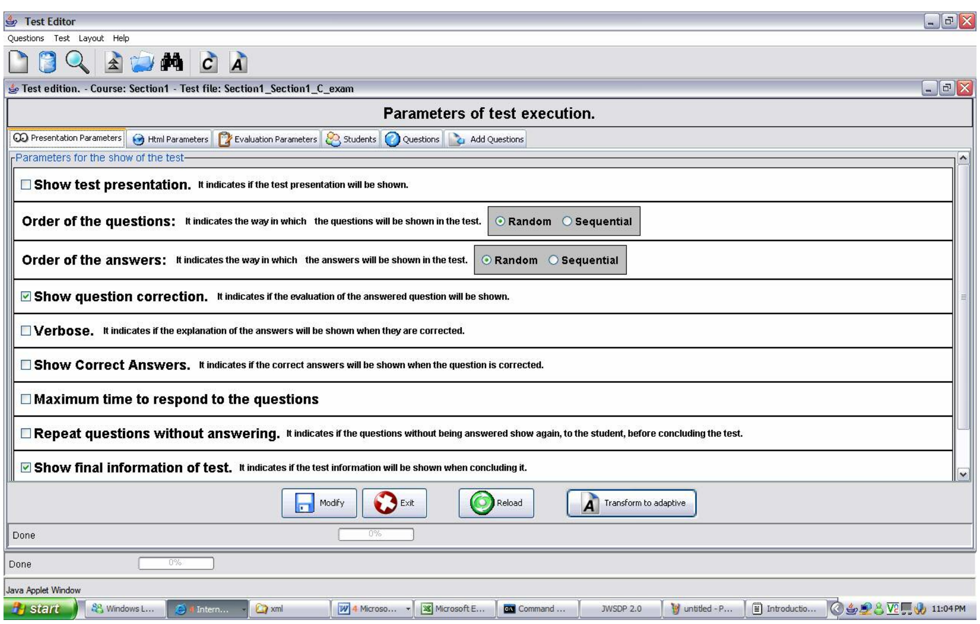

Figure 3.13 Test Editor – Test Creation

For the above configuration the student will see corrections after each question answered, as shown in Figure 3.14. The student also will be shown final information regarding the test, as shown in Figure 3.15.

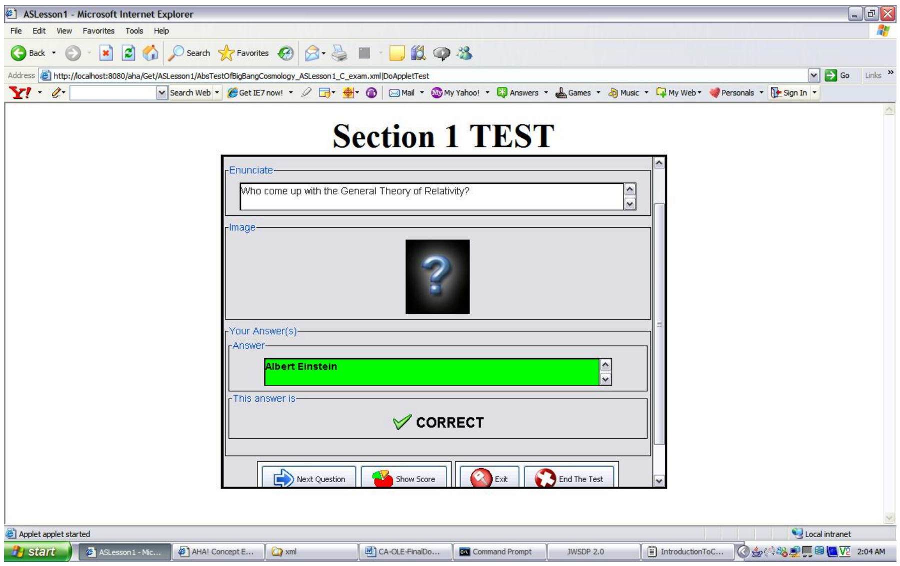

Figure 3.14 Test Editor – student gets feedback on the question he/she just answered

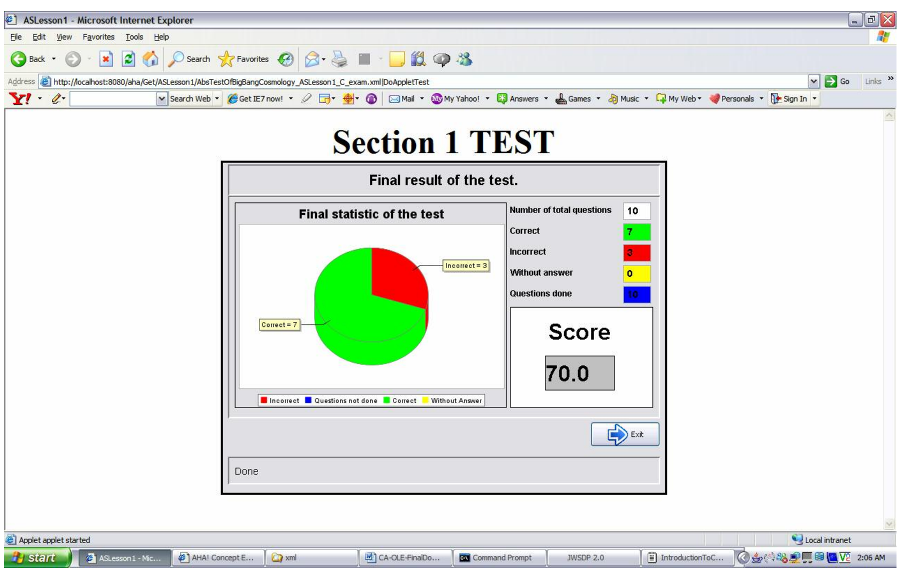

Figure 3.15 Test Editor – final test information shown to the student

Test data is collected for each student, including the number of times he/she took a test within a section, the score per test, time per test, number of correct, incorrect and unanswered questions, etc.

Standard AHA! functionality updates only the overall section knowledge value with the score attained on the respective test. However, individual concept knowledge values are important for our design. We are displaying additional information if the student needs to review again a concept that is not clear for him/her. But if the student understood a concept, there is not point on forcing him/her to review that material again, we want him/her to focus on the concepts he/she is failing on. Therefore, we have modified this standard functionality, by updating individual knowledge values at the end of the test as well. We are doing this by getting the number of correct answers out of all the questions presented to the students for a given concept, and updating the individual concept knowledge value with this data. Then, if the student fails the section test and needs to review the material again, only the concepts he/she failed on are the ones presented. We do this by validating knowledge values and only showing those the student did not learn before.

Tests can be presented more than once to the student in case CA-OLE's evaluation of the student's performance indicates he/she needs to review the material again. Test questions and answers are randomly sequenced to avoid the student memorizing this information. Also, immediate feedback data is not presented to the student to ensure they will not remember correct answers if they need to repeat the test.

3.2.3. Collaborative Tool

Collaborative learning systems offer common virtual spaces where different users can interact. The most important characteristic of collaborative learning is the active role of the learner. Collaborative tools allow for students interaction and cooperation, students are able share their questions about the learning material and help others by answering questions or comments. The CA-OLE learning environment follows this methodology were the instructor acts more like a facilitator, and the student more like a proactive learner. Studies have showed that students' motivation increases when they feel challenged and perform at higher level when they work in groups [17].

Student collaboration can be performed synchronously and asynchronously. Synchronous tools allow students to interact at the same time at the same place, for example chats and whiteboards. Asynchronous tools allow students to interact at different time at the same place, for example forums, thread messages and email.

One of the objectives of CA-OLE is to allow students to learn at their own pace and at the same time to be able to collaborate with other members of the group. We want to control students' interaction by making sure they only interact with students that have similar learning styles, therefore students can only interact with other members within the group they have been assigned to.

To support collaboration, CA-OLE can make use of asynchronous and synchronous tools. Asynchronous tools allow students to get answers to their questions right when they asked questions. Synchronous tools allow students to post questions and get back later to see the answer.

CA-OLE prototype tool provides an asynchronous collaborative forum where students can interact with member of their group. Once the group to which a student belongs is assigned, he/she can share questions, answers and ideas with other people within the same group. Students are able to see history of any messages posted before on the forum for the group he is assigned to. CA-OLE Asynchronous forum allows students to post messages and read users responses. Figure 3.16 shows the graphical interface created for CA-OLE Forum.

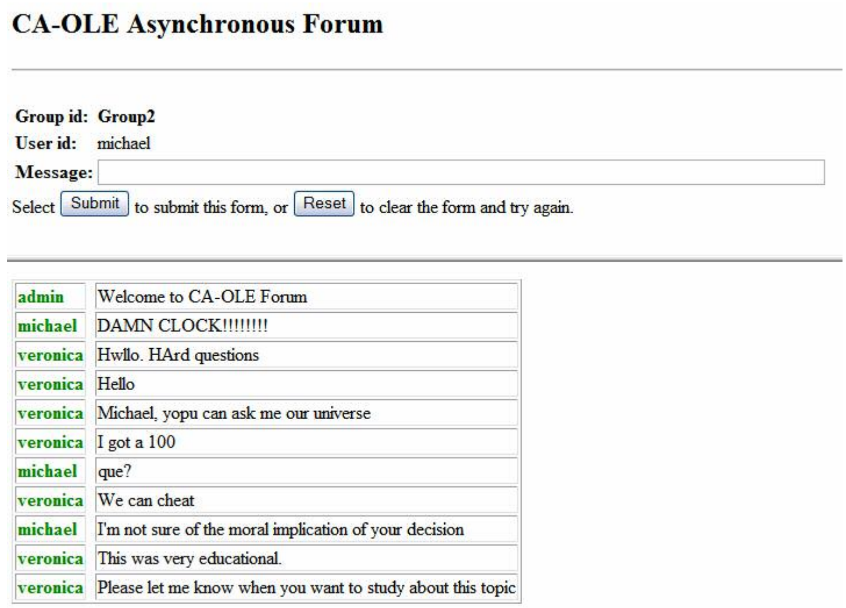

Figure 3.16 CA-OLE Forum

3.2.4. Group Formation System

CA-OLE allows for group formation by placing students with a similar level of knowledge in the same group. When the student logs in the first time, CA-OLE considers the first evaluation assessment to determine the group to which each student is assigned. Students collaborate with peers assigned to the same group. Once a student finishes up a lesson, CA-OLE re-evaluates the group assignment by looking at the student's performance for that lesson. CA-OLE analyzes score and time for each of the tests for each of the sections included in the lesson. A new group may be assigned based on this analysis and this new group is the team the student will be interacting with for the next learning lesson.

By having adaptive group assignment students may be interacting with a different team during the learning activity. Group creation can be done in many different ways and based on different approaches. Groups can be created by categorizing students with similar knowledge level under the same group, or by grouping advanced and beginners within the same group. CA-OLE allows for individual and collaborative interaction, and then having groups that share similar characteristics increases the opportunities for cooperation, and at the same time it allows the student to keep his/her own pace when learning.

By reassigning groups CA-OLE's objective is to increase the collaboration quality and quantity between peers, as well as increase the overall perspective on the learning experience.

Another important issue regarding adaptive group formation is at what time, during the learning activity the groups are going to be re-assigned. One option can be right after a section is successfully completed and the student is ready to move to the next one. Or after a lesson is successfully completed by the student and he/she is ready to move to the next lesson. Or after a test is completed, no matter if the student moves to the next section or not. For CA-OLE, we have decided to re-assign groups after each lesson is successfully completed because it provides a clean cut when changing from one topic to the next one, more data related to the students is collected, and it allows for more opportunities for collaboration within the existing group.

Also, when reassigning groups it is important to define if all students need to finish a section or lesson at the same time or not. Because of the conceptual design we have put in place, evaluating one student at the time gives more flexibility since students can still learn at their own pace, while interacting with groups. If a student finishes a lesson quickly, he/she does not have to wait for everybody else on the classroom to finish, he can continue working and learning his/her material and continue collaborating with his/her team. By doing this, adding and dropping people from a group happens dynamically, and then special attention should be given at the group size, since a student can move to a new group all by him/herself. For the purpose of the prototype implementation, we are not constraining group size in any way and group sizes can vary from group to group.

In order to allow for the adaptive group formation features explained above, a dynamic evaluation of individual student's performance during a lesson and his/her interaction with other peers is needed. Individual performance can be evaluated based on different parameters and data collected during student interaction. By looking at the different scores the student got on the tests, we can compare his/her performance with other team members and evaluate the best group he/she will fit in. By looking at the time it took the student to finish a lesson, we can evaluate and assign him/her to a group where members have similar learning pace. By looking at the collaboration module, we can evaluate how students interact, what kind of interaction they have and how much they do it. For example, a student that asks too many questions will fit better with students that provide answers, a student that shares a lot of comments is better of interacting with students that interacts a lot as well. Another option to assess group assignment, is by doing a *team evaluation* that includes how the perception of your team members was, how your interaction during the activity was, and any other important factors that may affect group performance. The way these all these different parameters are evaluated, can vary from topic to topic, or instructor to instructor, therefore, we are allowing the instructor to create a baseline for group creation that is then evaluated by CA-OLE to determine whether or not a student should move to a different group or not. These adaptive group formation rules are accessible by the instructor for him/her to modify them whenever is necessary.

CHAPTER 4

EXPERIMENTS

4.1 Setup

For evaluation purposes, a prototype tool has been implemented and setup. The objective of this prototype tool is to evaluate CA-OLE's modules and their usability, as well as the impact that adaptation, collaboration and adaptive group formation has on learning activity.

4.1.1 Configuration

For the purpose of this experiment, cosmology lessons have been setup in CA-OLE. Lesson materials have been collected from the NASA and WMAP Science Team website (no copyright restrictions). Two lessons have been utilized: lesson 1 contains sections related to the Big Bang and Our Universe; lesson 2 contains sections related to Gravity and Black Holes. By having two lessons we will be able to evaluate group re-assignment as well as to give opportunity to the students to get used to using the tool.

For each of the sections, a domain model has been setup. By using the adaptive framework, sections have been created and relationship between the concepts defined based on hierarchy (from simple to complex – general to specific). For the purpose of this experiment we decided to use only the “knowledge” value, and omitted attributes like “suitable”, “access” and “interest”. Personal values attributes, likewise, have not been used.

XHTML pages have been created and associated to each of the concepts setup for each different section. Additional learning material has been created for some of these concepts, in order to provide additional information to the student. Conditional objects have been included to control whether or not this additional material is displayed to the users, based on their individual performance. These conditional objects evaluate the student's knowledge value for a given concept in order to determine if the student needs to be presented with extra information.

For each of the sections defined we developed a test scenario in order to evaluate how much the students learn from the material provided. Each test was setup with different parameters to evaluate their impact as well. For this experiment, we have decided to use the following parameters:

- Initial guideline information is provided at the beginning of each test.
- Random questions and answers are used, to avoid the students easily remembering them.
- Question correction is not displayed at the end of each question, to avoid the students remembering correct answers.
- Final information about a student's performance is displayed: score, incorrect answers, correct answers, unanswered questions.
- For two of the sections we use a timer of 1 minute. If, after this time, the student has not answered the question, it will time out and be counted as an unanswered question.

- For one of the sections, we repeat questions that were unanswered until the student answer them all.

Individual performance data is collected for each test taken by the students. However, standard AHA! functionality automatically updates concept knowledge values based only on whether the student visited or not the page, and by just visiting a page it is not clear on whether or not the student understood the concepts presented, thus we think it is important to evaluate if the student read and understood the material presented. To evaluate whether a student has acquired the concept or not, we have created question files per concept in order to assess student's knowledge about that particular concept. Questions were grouped on tests, one test per section, to assess how much the student really learned. Standard AHA! functionality only updates the overall concept value for the section, it does not update any individual concept values. And for us it is important to know whether or not the student understood individual concepts. We modified this functionality by updating individual concepts based on how the student answered the questions related to a given concept. Evaluating how many correct or incorrect answers related to that concept were given, CA-OLE calculates an average score for that particular concept. Based on these individual concept values, conditional objects are used to know exactly what needs to be displayed to the student, and if any additional data related to that concept needs to be presented again.

The overall section knowledge value is used by CA-OLE to determine if the student can move to the next section or needs to review the current section again. For the purpose of this experiment, CA-OLE makes this decision based on student's score on the section test he/she just took. If student's score is less than an acceptable score (defined by the instructor), she/he needs to review the current section again, but now, CA-OLE will present only the concepts she/he failed during the test. CA-OLE determines this by evaluating the individual concept knowledge value and by displaying additional information if needed with the use of conditional objects. CA-OLE does not display any concepts where the knowledge value is greater than an acceptable score, since knowledge has been already acquired. If the student's test score is greater than the acceptable score, then CA-OLE will allow him/her to move to the next section available.

Once the student has successfully finished a lesson, the student can move to the next lesson available and his/her group assignment is evaluated. For the purpose of this experiment, CA-OLE's group re-assignment is based on that student's score and time to complete during the specific lesson. The system gets a student's average score for all the tests he/she took during the given lesson, as well as an average for the time it took him/her to finish these tests. These values are evaluated against the group formation rules specified by the instructor. Group formation rules are specified by the instructor, and for the purpose of this experiment, we only setup two groups: Group1 and Group2, where Group1 configuration is for beginners or students with poorer relative performance and Group2 configuration is for advanced students with relatively good performance. For this experiment, group formation rules are based on score and time, therefore, for each for these groups a set of score and time ranges are defined. Student's time and score averages are compared against these ranges, and depending on the range where the student fits, his/her group is assigned. By following this approach, we are evaluating not only how good did the student perform (score) but also how long it took him to finish tests. For example, a student with a very high score but who finishes a test in 10 seconds might have been lucky and just run through questions without reading them or the material provided. When a student is assigned to a different group, it is because his/her profile better fits the new group and its members, then the collaboration should increase and be more helpful.

For the purpose of this experiment we have created a collaborative forum, on the form of a thread messaging system. There is one forum per group in order to ensure students collaborate only with peers within the same group. Forums allow students to post messages that will be visible to other students assigned to the same group. History is available on the forum, and then a new student joining the group is able to look at any messages posted before he joined the group.

When doing the evaluation, users were provided with a guideline document explaining what CA-OLE is and the different components interacting. They were also explained the objective and the purpose of the test, as well as the application domain selected. CA-OLE was evaluated by approximately 10 people on two different sessions. By the end of the experiment, users were asked to fill a questionnaire to evaluate CA-OLE's main areas of research.

4.1.2 Results

Initial Evaluation results were based on observations, a questionnaire and system collected data.

Students were asked to answer some questions in order to evaluate CA-OLE's different components.

When asked about the learning experience, 10 out of 10 they found the way of presenting materials was effective, CA-OLE was easy to use and overall the activity went really smooth. In addition, the system allowed learning the materials at individual pace, and at the same time, it allowed consulting the group by asking questions. They all considered the knowledge about they have about the concepts presented increased, they learned from the lessons presented by CA-OLE.

In order to measure how much the students learn from the overall learning experience with CA-OLE, we compared student's knowledge at the beginning and at the end of the experiment conducted. The initial knowledge is obtained from the score on the first assessment test. The final knowledge value is obtained from the overall score values the student got when taking the different section tests. From this comparison, we found 10 out of 10 students increased their scores by 22 points on average. With this data we can conclude after the learning experience with CA-OLE, students learned and acquired knowledge about the materials presented, accomplishing one of our objectives, to improve the learning experience.

When asked about how the system adapted according to their individual performance, the 5 students that fail one or more tests during the exercise, agreed CA-OLE provided additional material only on the concepts they needed to review, and it did not display material related to concepts they acquired before. 2 students out of 10 thought it will be good if CA-OLE presented them with help on the form of music, videos or other visual effect tools, this will allow them to adapt the system to their specific learning style.

In order to measure how effective was the adaptation, we reviewed the results from students who repeated a section test more than once, and evaluated if by reading the new material provided by CA-OLE they improved on those specific concepts they failed before. We do this by comparing the answers provided for those concepts on the first test and on the consequent ones, and checking whether or not the answer went from INCORRECT to CORRECT. 5 out of 10 students took a test more than once and needed to review additional material, for a total of 12 cases we evaluated. In 6 of the 12 cases, students answered correctly the questions related to the concepts they failed before. In 5 of the 12 cases, students improved by answering correctly 80-90 percent of the questions they answered incorrect before.

CA-OLE's collaborative forum was not widely used, however it was found helpful and useful by SOME OF the students. One comment written about the forum concept, was that it allowed on-demand interaction by the students. Some possible reasons for students not to use the forum during the exercise can be the fact that they are not used(familiar?) to work and learn with online collaborative tools, and also that the experiment was too small with regard to group size and time, and it did not create the need to interact with other team members. Therefore, although the forum was used by some of the users, a more extensive evaluation needs to be conducted to assess the forum's impact on the learning experience. This also applies for the automatic group formation system impact, since it re-assigned students to a new group in order to allow for more effective collaboration. Without a big enough sample of students interacting, the impact of the new group assignment can not be fully evaluated.

9 out of 10 users reacted positively to the graphical interface presented and they were able to easily interact with the system. Users had different learning styles that influenced the way they navigated through the lessons, but these differences did not change their perception of the learning experience. Although students found CA-OLE user-friendly and easy to use, they would have preferred to have a more detailed guideline at the beginning of the test and improved graphics and design of the learning material. 3 out of 10 students expressed that having some feedback by the end of each question and at the end of each test would have helped them during the learning experience.

CHAPTER 5

CONCLUSIONS AND FUTURE WORK

5.1 Conclusions

This thesis presents CA-OLE, a Collaborative and Adaptive Online Learning Environment. The main contribution of this project is the integration of two major technologies: adaptive systems and collaborative tools, by incorporating four main components: adaptive framework, collaborative asynchronous forum, group formation and a controller component.

CA-OLE adapts presentation and content displayed to the student based on his/her individual situation. It also integrates a collaborative asynchronous forum where students can collaborate with other peers. Additionally, CA-OLE allows for group formation by placing students with similar knowledge level on the same group.

This thesis shows that the adaptation of presentation and content, as well as the collaboration between the different actors improves their learning skills, as well as their knowledge on the concepts presented and evaluated. Also, it shows how by allowing collaboration between students, teamwork and group effort develops and the learning experience improves.

An initial evaluation assessment was completed and results based on observations, a questionnaire and system collected data were gathered. These results shown that student presentation and content successfully adapted based on CA-OLE adaptation rules, collaborative forum was a successful tool for teamwork development, the system allowed learning at individual pace.

5.2 Future Work

Future work for CA-OLE includes improvements on group formation strategy, the use of additional adaptation techniques, and to support other types of collaboration.

One possible enhancement for collaboration tools is to allow for collaborative as well as competitive systems. Collaboration can be between peers within the same group and competition between different groups. Then it can be evaluated if this competition improves students' knowledge and learning experience overall. Additionally, it will be helpful to provide more options for collaboration, with the integration of synchronous tools such like chats or whiteboards.

It will be helpful to include on-demand personalization features, by allowing the students to customize their graphical interface, and by including on-demand help using different media options, like video, audio, graphics, etc. Then it can be evaluated if students improve their knowledge when they select the media help that more fit their learning style and preferences.

In addition, it will be useful to improve the group formation strategy and allow instructors to modify it depending on their specific needs. Future strategies can consider size of the classroom to allow for static or dynamic group size, or consider people with similar scores and personal preferences. Also, another approach for group formation can be based on previous collaboration by evaluating which students used the collaborative tools in a similar way and how compatible they are.

It will be helpful to provide a graphical interface for CA-OLE management and initial setup. As well as a graphical interface to allow the instructor to setup and personalize his/her lessons and sections.

In addition, a more thorough evaluation of the approach with bigger groups is needed in order to refine the tool and identify what other problems can be detected and how the learning experience can be improved. The ongoing evaluation should answer most of these questions if a significant sample (n) can be collected.

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