UNIVERSITY OF CRETE, COMPUTER SCIENCE DEPARTMET

"Enhancing Learning Management Systems (LMS) with the use of Web Technologies"

Master Thesis

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Enhancing Learning Management Systems (LMS) with the use of Web Technologies

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Master's Thesis

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Abstract

By using Learning Management Systems (LMS), educators are able to create numerous resources expressed by various technological tools (HTML pages, quizzes, forums, wikis etc.). In this manner, the student is supported throughout the educational process. The students in their turn interact with these resources, by experiencing an enriched learning process. However, the LMSs do not provide adaptivity or guidance to the students' choices. As a result the students use their own criteria to choose between large collections of resources. This usually leads to frustration, and wrong choices, as the students' abilities are not taken into serious consideration.

This master thesis focuses on Information and Communication Technologies (ICT) in Education. More specifically, it proposes a way to enhance the Moodle LMS's functionality by providing more adaptivity. Our ultimate goal is to improve the situation described above. For this purpose, we have designed a user-friendly interface through which the educator can dynamically develop a knowledge base (in the form of an Ontology) of the learning objectives of the e-course's resources.

Although the Moodle LMS already supports a mechanism for tagging its resources, this particular proposal extends this functionality, by adding "hierarchical" information. That means that by using the interface the educator adds to the system the knowledge that the learning objectives of «Resource 1», are prerequisite knowledge for understanding the learning objectives of «Resource 2». By offering that knowledge to the system, a rule-based agent observes the student's actions and makes personalized suggestions, concerning navigation, or further actions. Finally, the proposed approach can be extended to different LMSs as Web Services were used for the creation of the above functionalities. By implementing the above features, we achieve the enhancement and extension of Moodle LMS's adaptive functionality.

Supervisor: Dimitrios Plexousakis

Professor

Ενίσχυση των Συστημάτων Διαχείρισης Ηλεκτρονικής Μάθησης (ΣΔΜ) με τη χρήση Ηλεκτρονικών Υπηρεσιών

Μαριγιάννα Σκουραδάκη

Μεταπτυχιακή Εργασία

Τμήμα Επιστήμης Υπολογιστών, Πανεπιστήμιο Κρήτης

Περίληψη

Χρησιμοποιώντας Συστήματα Διαχείρισης Μάθησης (ΣΔΜ) οι εκπαιδευτικοί εμπλουτίζουν την εκπαιδευτική διαδικασία, με τη δημιουργία ποικιλόμορφου ηλεκτρονικού υλικού (στατικές σελίδες HTML, δραστηριότητες, forums, wikis κτλ.). Με αυτό τον τρόπο αυξάνεται η διαδραστική και συνεργατική φύση της εκπαίδευσης, προσφέροντας στους μαθητές μία διαφορετική εμπειρία στην ηλεκτρονική μάθηση. Αν και οι δυνατότητες που προσφέρουν τα ΣΔΜ σε εκπαιδευτικούς και μαθητές είναι σημαντικές, ωστόσο παρατηρείται μειωμένη υποστήριξη λειτουργιών προσαρμοστικότητας στις ενέργειες του μαθητή. Ως αποτέλεσμα οι μαθητές χρησιμοποιούν τα δικά τους κριτήρια για να επιλέξουν το ηλεκτρονικό υλικό με το οποίο θα αλληλεπιδράσουν. Αυτό πολλές φορές οδηγεί σε λανθασμένες επιλογές, και συναίσθημα απογοήτευσης, και αποπροσανατολισμού αφού οι ικανότητες του μαθητή, και το πρόγραμμα σπουδών δεν λαμβάνονται σοβαρά υπόψη.

Το θέμα της παρούσας μελέτης αποτελεί η εφαρμογή των ΤΠΕ (Τεχνολογιών της Πληροφορίας και Επικοινωνίας) στην εκπαίδευση. Αναλυτικότερα, προτείνεται ο εμπλουτισμός της λειτουργικότητας του ΣΔΜ Moodle με την παροχή λειτουργιών προσαρμοστικότητας. Για το σκοπό αυτό, παρέχεται στον εκπαιδευτικό η κατάλληλη διεπαφή, μέσω της οποίας δημιουργείται δυναμικά μια βάση γνώσης (Οντολογία), που περιγράφει τους παιδαγωγικούς στόχους και έννοιες (σημασιολογική επισήμανση) του ηλεκτρονικού υλικού.

Αν και το Moodle διαθέτει μηχανισμό σημασιολογικής επισήμανσης του ηλεκτρονικού υλικού, στην παρούσα πρόταση προσθέτουμε τη λειτουργία της «ιεραρχίας». Με τη λειτουργία της «ιεραρχίας» παρέχεται η δυνατότητα στον εκπαιδευτικό να καθορίζει ότι οι εκπαιδευτικοί στόχοι της «Πηγής 1» είναι προαπαιτούμενη γνώση για την κατανόηση των εκπαιδευτικών στόχων της «Πηγής 2». Προσφέροντας αυτή τη γνώση στο σύστημα, καταφέρνουμε να παρακολουθούμε τις ενέργειες του μαθητή και να δίνουμε μια σειρά από εξατομικευμένες προτάσεις, σχετικά με τη πλοήγησή του στο υλικό καθώς και τις μελλοντικές του επιλογές στην αλληλεπίδραση με το σύστημα. Η λειτουργικότητα αυτή θα είναι δυνατό να επεκταθεί και σε διαφορετικές πλατφόρμες ηλεκτρονικής μάθησης, αφού δημιουργείται με τεχνολογίες Ηλεκτρονικών Υπηρεσιών. Με την υλοποίηση των παραπάνω δυνατοτήτων επιτυγχάνεται η επεκτασιμότητα και ο εμπλουτισμός της προσαρμοστικής λειτουργικότητας του ΣΔΜ Moodle.

Επόπτης: Πλεξουσάκης Δημήτριος
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Chapter 1

1 Introduction

1.1 Describing the Objectives

Over the last decades, technology has swiftly evolved by changing in terms of complexity and variety [17]. The 21st century is characterized by the widespread and global adaptation of Internet based technologies. The technology we meet includes the generic use of multifunctional cell phones capable of taking digital photographs and exchanging e-mails and more specialized use of ingestible radio transmitters and fluorescent quantum dots for medical diagnosis and treatment [85]. At the same time, Educational Technologies are gaining an equally noteworthy positioning in the field [17]. Current Educational Technologies have emerged from the evolution of the Web as a "system" of information sharing, interoperability, user-centered design and collaboration. They are also characterized by an increased quantity of material produced by students [92]. Many new and promising technologies, like gaming, social web and mobile technologies, are nowadays seen to take part in the educational process [99]. This technological integration into education seems to have a positive impact as it is proven that young people are highly attracted to using them [22], [98].

Despite the wide variety of technological options that can be applied in the educational process [17] most technological applications follow a unique model for interacting with their users. The model assumes similar user abilities, preferences and characteristics, by expressing the notion of «one-size fits all» [23], [4]. In an era where modern learning theories embrace heterogeneous classrooms, technology should also lead in the same direction. However, it is claimed that current Learning Management Systems (LMSs) lack adaptive features [23].

This need became a motivation for this master thesis that aims to enhance Moodle LMS platforms with adaptive features. The main deficiency that was identified and needs to be improved is the fact that students can navigate freely to Moodle LMS learning objects. Although non-linear access is basic for e-learning technologies, this freedom can also have a negative impact on learning, as flexibility also increases complexity [27]. Accessing information in the students' preferred way might not include taking into consideration their learning styles and levels of knowledge. Our goal would be to maintain students' freedom in choosing resources non-linearly, but supporting them with adaptive features in order to lead to more appropriate and conscious choices.

In order to successfully reach our goal we exploited the state-of-the-art technologies, merged them with emerging educational technologies and developed a solution with respect to emerging learning theories. More specifically, by following the suggestions of the modern learning theories, we have developed a complete solution that uses Moodle LMS, for storing content rich in e-learning 2.0 elements. For using valid and qualitative content, we have used the learning material of Greek Secondary School Mathematics (1^{st} grade) as it is presented in the digital book of Mathematics published by the Hellenic Ministry of Education and Religious Affairs, Culture and Sports.

Our second and more imperative goal was to enhance Moodle LMS with adaptive features. We have therefore used Semantic Web, Web Services, and Rule-Based Reasoning technologies to achieve this goal.

This research study describes the theoretical framework that was used as a basis for this project and the methodology followed in the project's implementation. The next section outlines this study's structure in more detail.

1.2 Organization of this thesis

In this master thesis we have implemented adaptive features to enhance the Moodle LMS platform. The study is organized as follows:

Chapter 2 is a theoretical documentation of our study. We first make an introduction to fundamental learning theories that frame this project. Then we make a detailed overview of the emerging educational technologies, in order to explain our later decisions. Lastly, we introduce the state-of-the-art technologies that were used for this project's implementation.

Chapter 3 describes the study's methodology. The related work that was done in the same vein is examined and decisions are explained. In this chapter, we attempt to explain how the notions that were introduced earlier were combined into a unique system. We define the system’s requirements and give an outline of the process that we have followed during the development process.

Chapter 4 gives the technical details. This chapter is an inner view of the system’s architecture. We explain each component separately, in terms of architecture, functionality and implementation details. We also explain technical decisions that needed to be taken during development.

Chapter 5 focuses on the system’s demonstration and on its evaluation. We demonstrate the system’s features and functionalities through screenshots. Then, we make a qualitative system evaluation and define the criteria that could be used on future evaluations.

Chapter 6 makes a quick overview and refers to future extensions and work that can be done on this project.

Chapter 2

2 Background

2.1 Learning Theories

2.1.1 Introduction

This section focuses on giving an overview of the existing learning theories. As our purpose is to develop a complete solution for a Mathematics e-course, the theories are analyzed with respect to this field. More particularly, behaviorism, and constructivism were chosen for analysis. Both of these approaches are considered to be classical in the field of education and comprise the basis of further theories and approaches such as behaviorist- analytical theory, social constructivism, radical constructivism, socio-cultural theory, socio-cognitive theory etc. Therefore, despite the fact that we focus on Mathematics, it is highly recommended that the principles be followed on the design of any e-learning system.

The learning theories were progressively developed through time. Behaviorism was first developed in the 19th century while constructivism was developed in the second half of the 20th century and was followed by the elimination of the appliance of behaviorist practices. Within the framework of the proposals for the updating of school mathematics, teaching actions connected to the emotional sector are emphasized. Such features are interest, self-esteem, curiosity, adhesion and comprehension of the meaning of mathematics [62]. The instruction is based on the development and observation of both cognitive and emotional factors [62]. Emotional factors became part of the educational plans after the elimination of the behaviorist theory. Despite the trend towards constructivism and social constructivism that are analyzed below, it should be emphasized that behaviorist principles have still not been fully eradicated from education. That is because it provides some useful principles in the educational plans that are considered to be essential and effective.

In this study, the approaches are presented in chronological order. In that way, the reader will more easily comprehend the differences that led to the institution of constructivism and social learning. It is important to notice that the theories have a very deep background that was developed, amended, modified and commented on by numerous researchers throughout the years. However, under the circumstances that this study is made, the limited time and word allowance, it would be impossible to attempt a profound analysis. For that reason, the most important principles, strengths and limitations were chosen to be presented according to the literature review that was made for the study.

At that point, and before processing to a more detailed presentation, it is considered essential to mention that the purpose of this chapter is neither to criticize nor to choose the best approach. On the contrary, we aim to guide the reader towards a holistic point of view and comprehension of the theoretical principles that framed this project.

2.1.2 Behaviorist Approach

Behaviorism is one of the most basic psychological approaches that were developed throughout the years. Many psychologists (Pavlov, Watson, Guthrie, Thorndike, Skinner, Hull, Gagne, Miller, Maltzman, Tolman etc.) have been trying to define, extend or amend the concept. Therefore it is impossible to give a rigorous definition that will include all the expressed opinions. The differences between definitions are mostly based on further studies at a philosophical level. However, it is considered that these analyses do not correspond to the purposes of this study.

Behaviorism thrived in the early 90's. It supports that learning is a consequence of modified behaviors which are evoked by external conditions. Behaviorist approaches of teaching focus on the manipulation of these conditions [26]. As far as the instruction of mathematics is concerned, the behaviorist teaching style underlines practices that are centered on rote learning, memorization of formulae, single solutions, and persistence in drill and practice. Teaching is conceptualized as a way to enunciate objectives, providing the means to accomplish them, using repetitive drill and practice techniques for skill acquisition [49].

Drill and practice could be characterized as the pure implementation of behaviorism in mathematics. The technique has been highly criticized through the years. However, there is a mismatch between what the researchers say, and what is eventually applied in the classroom. According to a research study [48], many more than half of the teachers (~0.79860 of the taken sample) “strongly” insisted that drill and practice is one of the best ways to learn mathematics.

The combination of the drill and practice method and educational software is a matter frequently appearing in bibliography. Drill and practice with software has been studied since the early 80’s, when the computers were firstly introduced in classes [100]. Drill and practice combined with software is usually chosen by the teachers as it gives a direct evaluation and it is adaptable to the child’s needs [93]. Moreover, it is stated that drill and practice software assist children in the development of their abilities in skills like counting and sorting.

In general, behaviorism has been used in the instruction of mathematics for many years and is still being used due to the impressive improvements observed in the skill of automaticity in the performance of mathematical operations. However, this method has been questioned many times by researchers. Many limitations have been noted and are worth being mentioned.

One of the basic recognized and frequently mentioned limitations in drill and practice theory is that it is not effective in teaching more complex mathematical facts. According to the method, every complex fact is a sum of simple states, the comprehension of which will lead to the comprehension of the more complex ones. It is questionable though, that a new theorem, or the solution of an innovative problem, could be analyzed into oversimplified steps. As a result, it is commonly accepted that the behaviorist approach acts as a barrier to the development of higher mathematical thinking. Characteristically, Gerber [34] says that drill and practice of single digit addition does not lead to a better implementation of multi - digit problems. Considering what has been mentioned above, one would agree that the drill and practice method is more appropriate for learning basic math facts [40], [34].

It is also observed that the drill and practice technique should be used only for practicing already acquired facts and not for introducing new ones [40],[34]. This assumption is also much associated to the usage of drill and practice software in the teaching of mathematics. Drill and practice gaming software has been proved to be more effective for practicing procedures with which students are familiar [40],[34], thus it is recommended that it be used as an additional rather than a startup activity

[74]. Teachers should also be aware of the fact that practicing incorrect answers may cause negative results, therefore, it is recommended that drill and practice techniques and especially software will give immediate answer feedback [40],[34].

As mentioned above the continuous practice of incorrect answers may lead to negative results. Therefore, there is the imperative need for an immediate answer feedback. However, the use of an immediate feedback is not as positive an action as one may think. It is proven that mathematics anxiety is directly associated with mathematics achievement [51], [84], [36]. What is more, many researchers have found that low achievers in mathematics are usually overwhelmed by feelings of mathematics anxiety [77], [66]. It is a reasonable consequence of the above facts that if we give continuous negative feedback to a low achiever in tasks that he completes incorrectly, it will have undesirable results on the student's psychology and achievement.

2.1.3 Constructivist Approach

Constructivism is one of the most widespread teaching approaches. Piaget's classical concept mostly focuses on the child's psychological development. The theory relies on the concept that discovery is the basis of learning:

"To understand is to discover, or reconstruct by rediscovery, and such conditions must be complied with if in the future individuals are to be formed who are capable of production and creativity and not simply repetition"[75, pp. 20].

This claim supports that during their development children accept ideas and later discard them as wrong. Consequently, understanding is built up through continuous activities of participation and involvement.

A particularly interesting branch of constructivism, with wide appliance in mathematics, is social constructivism. According to social constructivism mathematics does not pre-exist, but is constructed by the individual. Therefore, a social framework is considered to be playing a primary role in the creation of mathematics. Social constructivism presents mathematical knowledge as a social construction. According to Ernest [29] the reasons are threefold:

- *"The basis of mathematical knowledge is linguistic knowledge, convention and rules, and language is a social construction.*

- *Interpersonal social processes are required to turn an individual's subjective mathematical knowledge, after publication, into accepted objective mathematical knowledge.*
- *Objectivity itself will be understood to be social*."

As social constructivism concentrates on the creation of mathematical knowledge, it also succeeds in relating objective and subjective knowledge in a complementary way. As far as the teaching of mathematics is concerned, the principles of social constructivism may be summed up into the following:

- Mathematical knowledge is constructed.
- Students have their own perceptions about mathematics which cannot easily be changed.

As mentioned above, constructivism and social constructivism are both widely spread approaches in teaching. What makes their appliance so popular is that underling specific principles have been proved to be very effective to children's development.

It is noticeable that in the framework of social constructivism, all the approaches should have the task of students discussing and interacting with each other in terms of investigation and experimentation. As students comprise a heterogeneous group, each student would contribute to the team in a different way. It is also of great value for the students to realize that others have the same problems as they do [103]. These cooperative groups contribute to that by consequently decreasing math anxiety, and increasing self -esteem.

According to a Simon and Shifter research study [86], constructivist approaches help students on cognitive, affective, and social levels. Noticeable is their claim that after constructivist approaches, children showed a better corporation with each other, listened more carefully, respected their classmates' ideas, and depended more on one another and less on the teacher.

As constructivism was an innovative trend at the time that it was publicized, it received harsh reviews. There is an attempt to show that most known limitations that are considered to lie in the constructivist methods.

According to constructivist methods of teaching, there is not a straightforward relationship between the procedure of teaching and learning, as the knowledge is not transferred forward from the teacher to students. As a result the students cannot know what the teacher thinks and vice versa [15]. This might cause problems because it is not always ascertained that the students correctly received the transmitted information. On the other side, the teacher, cannot be sure that students have understood what he has taught.

One more limitation appearing in social constructivism approaches is the diversity among students. Although that element was previously described as one of the biggest strengths of constructivism, it may cause some barriers. It is usual, and partly essential and non- exceptive, that students in a class have different cognitive levels as well as different abilities to participate in specific tasks that are designed through the constructivist model. According to Bishop [15], the processes that are followed can be effective only if every student has the same cognitive level and the same frequency of development otherwise, the model cannot be applied. This might lead to the teacher being confronted with certain obstacles, as it is not possible, nor desirable to have a "homogenous" class in levels of understanding and cognition.

Even if constructivism has some difficulties in appliance, we should keep in mind that it is recognized as one of the most used approaches in the teaching of mathematics. It has been reasonably suggested that the teacher should be aware of both the strengths and limitations and selectively choose the elements that best suit his class variables, while minimizing the pre-mentioned difficulties.

2.2 Emerging Technologies in Education

2.2.1 Introduction

During the last decades learning technologies have followed a fast evolution line by changing their nature in terms of complexity and variety [17]. Although a detailed overview of the educational technologies history is out with the purposes of this research a short description of the educational technologies' generations will be given in this section. Nipper [65] recognized three generations of distance learning technologies that took place after World War II. The first generation was based on printed material that was delivered by the postal service. The second generation included multimedia packages (audio tape, video tape etc.), and the third generation was characterized by a blend of broadcast media and teleconferences (audio conference, videoconference etc.). Though it should be mentioned here that second and third generation technologies were used in a combined way.

Nowadays, in the 21st century, with the widespread and global adaptation of Internet based technologies, technology in education has acquired an even more noteworthy role in the field [17]. This expansion is described by Taylor [92] who added three more generations of educational technology to Nipper's [65] work. The fourth and fifth generations are based on the fact that the application of technology was shifted from distance learning solely to mainstream education. More particularly, the fifth generation highlights the extended use of online learning. Lastly comes the sixth generation, the one that we are experiencing now, which has emerged from the web evolution as a "system" of information sharing, interoperability, user-centered design, and collaboration. The sixth generation is characterized by an increased quantity of material that is produced by students.

Taylor [92] categorizes these generations according to the following variables: flexibility in time, place and pace, highly refined materials usage, advanced interactive delivery and, he adds, the parameter of advanced interactive environment for the sixth generation.

The above parameters are considered existent in every online learning environment, regardless if they exist to a smaller or greater degree. To deliver the above features to the user, different technology types and media are used, with both hardware and software tools necessary. Hardware tools are such as interactive whiteboards, smart tables, handheld technologies, tangible objects etc, while software tools are computer-supported collaborative learning systems, learning management systems, simulation modeling tools, online repositories of learning content and scientific data, educational games, web 2.0 social applications, 3D virtual reality, media- rich interactions , social software, media – rich content etc [17], [35].

As it is easily observed when developing an e-learning system, that one has to choose from among a wide variety of technologies. The technologies that were chosen for this project were: Rich Media Content (interactive multimedia), Web 2.0 / ELearning 2.0 Technologies, Learning Management Systems (LMS), and Adaptive

Hypermedia. For the better documentation of our decisions the strengths and limitations of each technology are described further in the following sections.

2.2.2 Interactive Multimedia

According to Andrews [3] rich media technologies are defined as follows:

> *"Rich media technologies are commonly defined as technologies that enable users to engage in interactive communication, with the ability to see, hear and interact with multiple communication streams synchronously or access them asynchronously. Rich media technologies are also characterized by their ability to support non-verbal communication such as body language and verbal inflection (p. 36)."*

Multimedia fall into different types: graphics, photography, text, audio (sound effects, music, voice over etc.), video and animation, and are nowadays delivered through almost any device that can be connected to the web [25]. Multimedia applications can be used individually as a powerful communication medium as well as a combination of media types for an even more engaging and dynamic result [3], [25].

The pedagogical advantage of multimedia use in education is unquestionable. It mostly lies in the fact that they enable the interactive potential of the computer via the presentation impact of images, sound and animations [24]. More particularly, their nature allows the usage of more than one human sense during the interaction, which is educationally valuable [79]. Additionally images and other multimedia elements on a text- based screen can be of relief to the eye, thus making the experience more pleasant, enforce the engagement, and provide better concept representation [21], [79].

However as with any technology, multimedia could also not be used without taking the tradeoffs into consideration. Multimedia requires powerful computer systems, a resource which a considerable percentage of the users are unable to access. Therefore, the usage of multimedia is made sparingly by the software developers who also have to consider the high cost and developing time required for effective multimedia. Lastly, multimedia requires a minimum level of computer literacy for both the student and the teacher. The students may need extra software configuration in order to be able to access the multimedia, while teachers should be trained to produce courseware or packages and this may end up being a complicated process [79].

2.2.3 Web 2.0 and e-Learning 2.0

The term "Web 2.0" is closely associated to Tim O' Reilly [67] who was the first to introduce it as:

> *The era when people have come to realize that it's not the software that enables the web that matters as much as the services that are delivered over the web.*

And later on [68] he suggested that:

> *Web 2.0 is all about harnessing collective intelligence [68 pp. 3].*

Although the term "Web 2.0" is used widely, it is still difficult to find a unique definition that describes it with precision [12], [32]. However, in order to help the reader conceptualize what Web 2.0 is, we quote the initial list of tools that comprised Web 2.0 [67]:

Web 1.0	Web 2.0
DoubleClick	Google AdSense
Ofoto	Flickr
Akamai	BitTorrent
mp3.com	Napster
Britannica Online	Wikipedia
personal websites	blogging
evite	upcoming.org and EVDB
domain name speculation	search engine optimization
page views	cost per click
screen scraping	web services
publishing	participation
content management systems	wikis
directories (taxonomy)	tagging ("folksonomy")
stickiness	syndication

TABLE 1: INITIAL DESCRIPTION OF WEB 2.0

In general, Web 2.0 is considered to be a "second generation" of the World Wide Web technologies and applications, where more creative learning approaches, embedded in computer games, 3D simulations, virtual realities and other immersive environments such as multimedia applications, visual and audio tools, immersive environments and serious games, and mobile learning devices address different sensory channels, supply more engaging learning opportunities and support individualized learning opportunities with the help of synchronous or asynchronous tools [17], [32]. The applicability of Web 2.0 tools in the educational process has lead to the creation of “e-learning 2.0” [12], [32]. The term “e-learning 2.0” is also used to describe the combination of Web 2.0 tools with the Semantic Web (or Web 3.0) [17], [19] which means that along with Web 2.0 tools in education we should use:

> *a common framework that allows data to be shared and reused across applications, enterprise and community boundaries [101].*

In this paper the term e-learning 2.0 is used to describe the combination of Web 2.0 and Semantic Web as it is considered to be more representative of the current situation.

The positive impact of e-learning 2.0 in education is multidimensional. Ohler [69] and Redecker et al. [80] recognize technological, pedagogical and organizational innovations that have originated from the use of social computing.

The technological innovation occurs by: making learning content more accessible and available, providing new ways to disseminate, acquire and manage knowledge; making possible the production of dynamic learning resources as well as environments of high quality and interoperability; integrating learning in more engaging and activating multimedia environments; taking into account the individual learner’s preferences and consequently enforcing individualized learning; and supplying learners and teachers with multilateral tools for knowledge exchange and collaboration, by overcoming the limitations of face-to-face instruction. This new collaborative and personalized nature that eLearning 2.0 attached to education is recognized by Redecker et al. [80] as the pedagogical innovation of eLearning 2.0. Technological and educational innovations also lead to an organizational innovation such as new policies that need to be implemented in order to apply the tools effectively. More particularly, it is all the actions an institution has to make in order to ensure that the chosen technologies and methods are qualitative; social computing tools are accessible to every member of the educational process and everyone is encouraged to seize the new opportunities.

It is important here to highlight that the eLearning 2.0 innovations also comply with the European Education and Training policies which are: enhancing innovation and creativity, improving the quality and efficiency of provision and outcomes, making lifelong learning and mobility a reality, and promoting equity and active citizenship [30] as this enforces its position as a suitable technology to be part of the educational process.

Although eLearning 2.0 seems to be a powerful and promising technology it has only been a very short time in education, that means there is little formal appliance and quantitative research [32], [80]. Despite that, there are already some recognized challenges and barriers that we still need to overcome in order to use eLearning 2.0 more efficiently, and urge its full deployment by more institutions. Redecker et al. [80] recognize the following factors that make institutions more reluctant in integrating social computing tools in the educational process: staff uncertainty about ICT usage and basic digital skills, safety, security, identity, trust and reliability issues. On the one hand, Redecker et al. [80] study the weaknesses of eLearning 2.0 from an institutional perspective; on the other hand, Exter et al. [32] examine the eLearning weaknesses with respect to the learner's perspective. In this research study, the following issues are spotted: students are sometimes unwilling to edit, comment or delete peer work; students need clearly defined guidance and protocols; students may have poor past experience and fear, or find themselves unprepared for authoring and group work experience. Finally all writers agree that the usage of eLearning 2.0 tools leads to the re-evaluation of the teachers' role by transforming them into guides and mentors, as well as the institution's role of making them knowledge providers. This is a big challenge for the existing structures so it is emphasized in the literature that the usage of these tools should be done after policies planning, matched tool design and task authenticity in order to serve high qualitative pedagogical purposes [32], [80].

2.2.4 Learning Management Systems

The learning management systems (LMS) category includes platforms that are met by a variety of names including virtual learning environments, course management systems and collaborative learning environments. In this research study, the term LMS is preferred as CMS might also mean content management system. The primary purpose of LMSs was to enable students to interact with content, fellow students, and faculty through a unique Website. However, nowadays, we find LMSs to have extended their functionality by transforming themselves into a powerful tool [17]. Mohawk College [53] suggested that an

> *L.M.S. can be broadly described as a web-accessible platform for the 'anytime' delivery, tracking and management of education and training. L.M.Ss are essentially software running on dedicated hardware (p. 5).*

Currently, there are many LMSs available: Blackboard ™, FirstClass ™, Moodle ™, Lotus Learning Space ™ (Naidu, 2003) ATutor ™, Dokeos ™, Olat ™ (Aydin & Tirkes, 2010), Elgg™ some of which are commercial while others are open source. Each one of these LMS platform varies in capabilities and features. In general, LMS is not considered as a single technology, but as a collection of technological tools, with various roles in teaching and learning [17]. So LMS is a convenient tool to use when trying to combine and integrate technologies. More particularly, in the eLearning 2.0 era we see LMS systems move towards their transformation into Personal Learning Environments (PLE's) [90]. PLEs systems are collections of various eLearning 2.0 tools, social characteristics and existing LMS modules within which the learner to take over their own learning [95]. The transformation of LMSs towards PLE's is the first step of PLEs consolidation, and many famous LMSs as Moodle, Sakai, Elgg, etc. can already be considered PLEs [90].

This transformation is also obvious from the newer literature concerning descriptions of LMSs features. For example, American Society of Training and Development (ASTD) [83], a robust LMS should have at least the following features:

- Centralize and automate administration
- Offer self-service and self-guided services (such as learner self-registration for courses)
- Rapidly assemble and deliver learning content;
- Consolidate training initiatives on a scalable Web-based platform
- Support portability and standards, such as sharable content object reference model (SCORM); instructional management system (IMS), learning object metadata (LOM), and

- Personalize content and enable knowledge reuse.

And although the above are minimum requirements, Caladine [17] and Monarch Media Inc. [54] recognize that current enterprise-grade LMS solutions include more functionality that usually include:

- Content management features that provide control over the storage, aggregation, retrieval, and delivery of learning materials.
- Rebranding and customization options;
- User management tools allowing administrators to categorize users and assign them to roles and groups, and match learners or groups of learners to courses
- Features of assessment, grading and tracking;
- Email, wikis, discussion boards, chat and other collaboration tools;
- Reporting and analytics about system and course usage, learner progress, assessment results, and more; and
- Security features limiting access to authorized people and roles.

Over viewing the above, it is easy to conclude that LMS make learning and teaching quicker, easier and less expensive, by providing a learner – centered environment.

However, the usage of LMSs has resulted in a difficulty in keeping up with the occurring changes in the roles of teachers, students, parents and technology. Therefore, systemic, careful training is needed in order to help everyone engage with the new circumstances that have resulted in educational transformations [81]. In a research study that was carried out by Malaya & Poophons [52] it was argued that this training cost, along with costs for hardware, software and staffing that are needed for the transformation per se may be relatively high. Additionally, the research shows that LMSs are generally thought to be prone to hacking and viruses. These facts lead some groups to be more reluctant in LMS adoption. So despite their wide appliance LMSs still have space for improvement in terms of policies and technical issues.

2.2.5 Adaptive Hypermedia

It is commonly accepted, that a classroom consists of students with different learning styles, abilities, characteristics and needs. Taking this fact into consideration, we respectively expect an LMS system to be used by users with various characteristics. However, most LMSs are still following the «one-size-fits-all» model which pre-assumes a unique model of users. This lack of adaptivity is not appropriate for such a heterogeneous environment as a classroom [4], [23]. Therefore, adaptive functionality was set as a primary goal for this project. The LMSs to support adaptive functionalities are considered to comprise the next generation of LMSs [23].

More particularly, according to Paramythis and Loidl-Reisigner [71], an e-learning system is considered to be adaptive if it is capable of:

> *Monitoring the activities of its users; interpreting these on the basis of domain-specific models; inferring user requirements and preferences out of the interpreted activities, appropriately representing these in associated models; and, finally, acting upon the available knowledge on its users and the subject matter at hand, to dynamically facilitate the learning process. [71, pp.182]*.

Annan [4] recognizes two techniques an adaptive web based system might use: *adaptive presentation* and *adaptive navigation*. In *adaptive presentation* the system adapts the presentation of information to the user's characteristics and preferences. For example, extra details might be hidden from novice users, or information can be presented differently with different text size or media types. In the case of *adaptive navigation* the system tends to guide the user towards exploring the required information. This means that the functionalities of enabling, disabling, showing, hiding, annotating or removing links are applied when it is considered appropriate according to the user's activities and features. In a broad sense, these techniques can be narrowed down to the two forms of adaptation: adaptability and adaptivity. The adaptability allows users to actively interact with a system and customize it, with user-driven configurations of content presentation, navigation features and functionalities. The adaptivity is the capacity of a system for automatic adaptation to users' needs based on user's preferences, behavior and trails [91].

Adaptive Hypermedia Systems (AHS) is not a unique -separate- category of e-learning tools. On the contrary, it is a set of suggested techniques that would increase existing tools' usability, and an alternative solution to fighting the "one size fits them all" problem. According to Ayersman and Minden [9], AHS is the most appropriate way to combine various parameters including the users' learning and cognitive style. By using AHS, information can be presented in the most convenient ways for the user (right difficulty level, right medium etc.), at the most appropriate moment (when the users have the necessary foreknowledge) [16]. These valuable features of AHSs come with the string attached that the authors need to do the appropriate configurations to the system. Therefore, appropriate support shall be given to the authors in order to enable them to produce many versions of the resources (so that the system will decide which version to present to the user); offer the way to describe dependencies between concepts, and the relationship between concepts and content (*domain model)* [16].

AHSs give the learners the freedom to navigate through an environment within a guided framework, ensuring that the material is always relevant, and comprehensive. However, in order to make that happen, the system needs to be supported by the appropriate tools and configurations, which might end up being time – consuming. AHS is not a not a unique -separate- category of e-learning tools. On the contrary, it is a set of suggested techniques that, with the right usage would increase existing tools' usability. Their valuable impact makes them the next generation of e-learning tools, therefore it is crucial to keep adaptive principles in mind when building an e-learning environment.

2.3 State-of-Art Information Technologies

2.3.1 Introduction

In the previous sections we have discussed the theoretical framework that surrounds this project, as well as the technological tools that were chosen in order to support the environment. This section focuses on the project's technical parts. It analyzes the emerging technologies (Semantic Web, Web Services, and Rule-Based Contextual Reasoning) that were exploited for implementing the initial idea. These technologies constitute the core of our system, and are the key factor for combining all the necessary components and leading them to function as a united entity. Therefore, the need to research them and make the most convenient decisions is imperative.

2.3.2 Semantic Web

"The Semantic Web is an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation." [13].

Semantic Web provides a wide range of tools to describe and annotate resources with standardized ways that are comprehensible to computers [38]. Technologies that enable us to describe richer integration and interoperability of data are: eXtensible Markup Language (XML) [102], Resource Description Framework (RDF) [78], Web Ontology Language (OWL) [70] and many other technologies included in the W3C technology stack. In this project we have chosen to RDF to express the necessary concepts, terms, and relationships of our knowledge domain. This choice was made as XML does not support inheritance properties "subClassOf", while OWL supports much more functionalities than these needed.

By using these technologies we are able to store information on the Web in various resources (e.g. documents), annotation of resources (e.g. RDF annotations of the documents), meta-data files (like RDF descriptions) or in ontologies. Based on information described by Semantic Web one is able to produce new functionalities that result from the relationship between information sources [38]. It is obvious that Semantic Web extends web's functionality in ways that would not otherwise be existent. It facilitates efficient content search, and specific – information retrieval has become more precise [10].

Concerning e-learning requirements, Semantic Web is a promising approach as it can support semantic querying and conceptual navigation of learning resources [5]. Antoniou and Van Hamerlen [5] recognize three types of knowledge (ontologies) that emerge in an e-learning environment: content, pedagogy, and structure.

The content ontology which describes the basic concepts that lay in an e-course, as well as some relationship between these concepts. An example of content ontology applied on a mathematics e-course might be Algebra "isPartOf" Mathematics.

The pedagogy ontology basically describes the types of the resources such as: exercise, solution, tutorial etc.

Structural ontology contains hierarchical information that is expressed by relations like: “hasPart”, “isPartOf” etc.

In order to describe e-learning ontologies in a standardized way The RDF bindings such as IEEE Learning Object Metadata (LOM) (IEEE, 2011), and Dublin Core (National Information Standards Organization & American National Standards Institute, 2001) have emerged. Although these standards are useful, they are solely based on meta-data (XML-like approaches) which makes their semantics ambiguous. That means that it is difficult to handle ontologies described by different authors automatically [5].

On top of e-learning standards, Shareable Content Object Reference Model (SCORM) [11] was developed. SCORM is a collection of HTML, JavaScript, and multimedia files [59] that can also be annotated with metadata. It is of high interest that SCORM 2004 introduced the idea of “sequencing”. “Sequencing” is a set of rules applied to specify the order in which the learner will interact with the learning objects [41]. Although this idea might have been particularly helpful to this project, the use of learning object standards was omitted as the supported semantic annotations were considered very general for this project’s needs. As a consequence, the use of SCORM objects was omitted too. Moreover, one of the most pertinent reasons for rejecting the use of SCORM objects was the fact Moodle is handling SCORMs as a third- party entity [59]. This leads to the loss of many Moodle functionalities, like “User- tracking”, which was of high importance to this project. Therefore, Moodle discourages its users to author SCORM objects, and this project kept in line with this suggestion. Despite our decision, we should mention that it is not impossible that LOM meta-data info or SCORM objects be added in the future in terms of this project’s extension.

In order to support the decision to develop our own semantic-annotations, the need arose to choose a Semantic Web Framework. Semantic Frameworks provide Java APIs used to extract information from and write to RDF graphs. Some of the mostly used frameworks are Sesame, Jena , JRDF, and SWKM model. This project’s implementation in Java was based on the SWKM model. The model was chosen as it provides a wide range of functionalities through a well-defined API. Furthermore, the SWKM project was developed by the Information Systems Laboratory, of ICS-forth, which is the laboratory that also supports this project. Thus, it was considered that we could achieve better support and integration by using this model.

2.3.3 Web Services

Web Services are a new buzz word in the field of Computer Science. What makes them so special? Why enterprises are inclined to refractor their architecture to be “service-oriented”? In an oversimplified description one could say that Web Services are mostly one more technology that enables the development of client – server applications. To give a more accurate definition Web Services are:

> *“a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically WSDL). Other systems interact with the Web service in a manner prescribed by its description using SOAP messages, typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards.” [96]*.

What makes them so special? Web Services differ from the rest of the distributed computed technologies in the following ways: they are platform and language independent as they rely on standard XML languages; and they use HTTP protocols for transmitting their messages (gives them a great advantage towards proxies and firewalls) [89].

Web services are separated in two major categories:

- ***“REST-compliant Web services,*** in which the primary purpose of the service is to manipulate XML representations of Web resources using a uniform set of "stateless" operations; and
- ***Arbitrary Web services,*** in which the service may expose an arbitrary set of operations” [96] .

The following picture shows each category’s architecture:

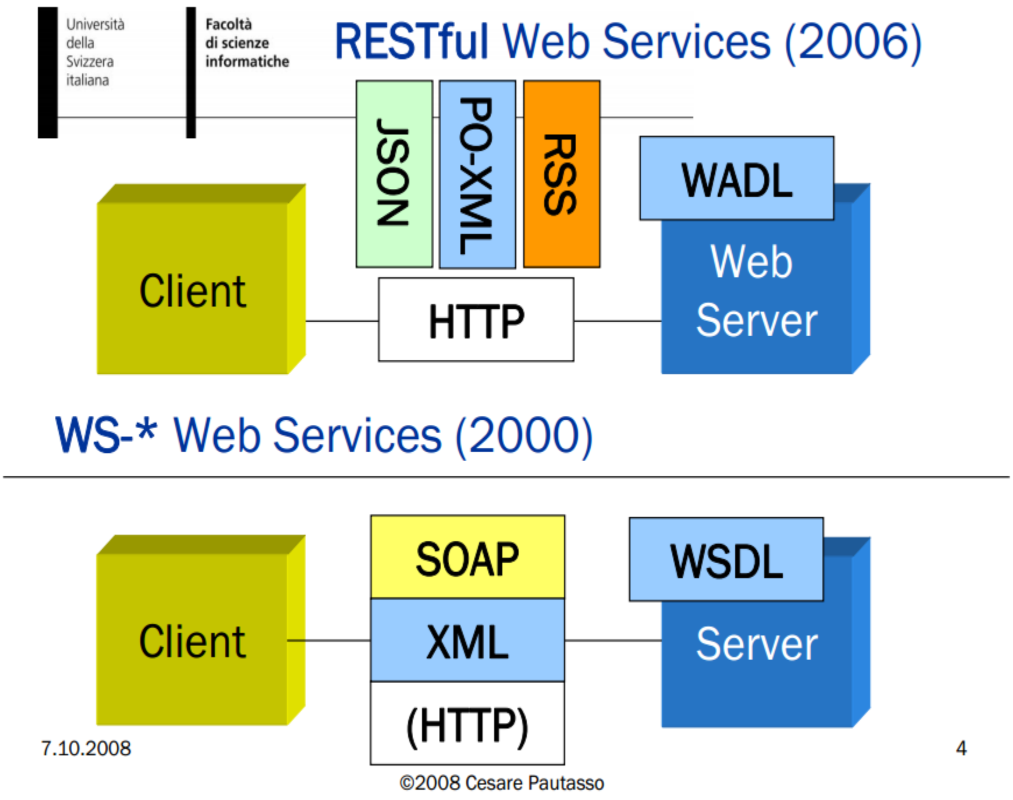

FIGURE 1: WEB SERVICES ARCHITECTHRES [18].

Concerning their dominant characteristics, RESTFul Services support limited usage of bandwidth and resources, stateless operations, and ability to cache. On the other hand, SOAP Services are underpinned by asynchronous processing and invocation, formal contracts that need to be exposed and exchanged before interactions, and stateful operations [18]. RESTFul Services' noteworthy simplicity has had a big impact on the Web and the gradual displacement of the SOAP, and WSDL-based, interface design [82]. The functionality that RESTFul web services offer was considered adequate for supporting this project, as it mostly needed GET methods. This fact, in combination with the RESTFul Services' lightness and simplicity were the dominant reasons for selecting them.

Web services use URIs to identify resources and Web protocols (such as HTTP and SOAP 1.2) and XML data formats for messaging [96]. As shown in Figure 1. RESTFul Web Services rely on XML, JSON and RSS (XML specification) for data transfer. XML and JSON are equally dominant, and supported by Web Technologies. They can both be easily handled, by API's, are supported by most languages, and are usually legible to man. JSON is mostly used for the representation of non – recurrent presentation while XML is more verbose and slow. In this project we have represented the transferred data with JSON objects. This decision was mostly a natural consequence of the fact that some of the needed information had already been represented in JSON objects, so it would have been time-consuming and inappropriate to rewrite it to XML representations.

Before closing this section, it is imperative to mention that as with any technology, Web Services also have their limitations. Firstly there is an “efficiency – portability” trade-off. Whereas Web Services offer maximum portability, the transmission of all data in XML decreases efficiency. Thus, web services are not used by time-critical applications. Secondly, there is a lack of versatility which is however showing improvement over time [89]. Despite their disadvantages, Web Services’ contribution to cross-platform portability was vital for the implementation of this project as Moodle (PHP based project) needed to be combined with Semantic Web Frameworks (SWKM) that are mostly found to work robustly on Java platforms.

2.3.4 Rule Based Contextual Reasoning in Ambient Intelligence

The concept of Ambient Intelligence provides a vision whereby our everyday life will be surrounded by information devices integrated into people’s everyday life. Intelligent interfaces are expected to become more prominent by opening new directions for information society [42], [43]. In order to achieve that, there is a trend towards increasing capabilities, autonomy, intelligence, and complexity of the systems, moving from traditional computing to the vision of Ambient Intelligence (AmI).

The AmI is based on pervasive computing, ubiquitous computing, profiling practices, context awareness, and human-centered interaction design and is basically expressed by systems with the following characteristics:

- embedded: support the integration of many network devices
- context aware: the users and their situational context is recognizable by the system
- personalized: the system corresponds to the user’s needs
- adaptive: the system changes with respect to the user

- anticipatory: the system anticipates the users' desires without obvious actions [1]:

That means that when using an AmI system, the users are performing actions, in response to which the system reacts in an intelligent way. This can be done in two ways: the system reacts to context changes and generates plans or predicts the user's needs and adapts to them [72].

The ultimate goal of pervasive applications is to provide the most appropriate information concerning a set of variables (users, time, place, devices). In order to achieve that, the system must be in the position of "understanding" its surroundings, in terms of physical resources (i.e. devices), the user's characteristics model (i.e. interests, needs, capabilities), as well as the user's actions model (i.e. tasks, activities). All this information can be expressed under the notion of context [14].

Bikakis et al. [17] argue that in order to make the system context aware and able to make decision, one should use reasoning. The writers examine the cases on which reasoning is useful to a context-aware system. In many cases, reasoning is used for handling information imperfections, and ensures the system's robust functioning. Finally, the writers argue, that reasoning also plays the role of a decision making mechanism. Changes on set of context information trigger a collection of decision rules that lead the system to change its behavior.

Reasoning in our system was based on the RETE algorithm [33], implemented through JESS rules.

Chapter 3

3 Methodology

3.1 Introduction

It is clear that current technologies offer a wide variety of options which can be chosen for application in the educational process. The teacher, or designer who is called to choose among these technologies, should be aware of their nature in order to use them appropriately and match them to learning activities [17]. As described earlier in this research study, our primary goal is to provide a complete solution for the mathematics e-course. It is important to highlight that this initiative does not intend to replace the teacher, as ICT should always have a complementary role in education, and never substitute the teacher's role [94]. On the contrary, it intends to demonstrate a viable case of a complete e-course solution. This research has a dual purpose: firstly, we urge the teachers to understand the matters that should be analyzed before using e-learning tools, and to adopt any of the design suggestions that they consider appropriate. Secondly, we demonstrate the ways in which the emerging technologies can expand current functionalities, combine existing tools and increase their usability and efficiency.

So this research is not narrowed down to a single scientific field. Its value lies and needs to be investigated in the effort to frame the solution with a set of interdisciplinary principles and tools. For these purposes this chapter focuses on the components that were analyzed in the background chapter. It explains how each one of these components was combined and contributes to the development of a coherent solution that exploits each component to a maximum. Moreover, it analyzes the development process that was followed for this system implementation. The system's technical details are given in the following sections.

3.2 Related Work

3.2.1 Moodle and Adaptivity

Moodle has taken some steps towards adaptive features. More particularly, when in adaptive mode, Moodle questions can adapt themselves to the student's answers, by giving them some hints and prompting to try again [60]. As Moodle questions are a small component of this large – scale system, there have been more efforts to make Moodle more adaptive as an entity.

Despotovic-Zrakic et al. [23] have attempted to make Moodle more adaptive, by developing a method of creating adaptive e-courses. In this research they used three e-courses with emphasis on different learning characteristics. For example, course 1 emphasized multimedia resources and team work, while course 2 emphasized written materials and team work. The researchers used data mining tools to define students' dominant characteristics in their learning style, and then assigned the students to the corresponding course. The research showed improvements in learning when using adaptive e-courses.

Skouradaki et al. [87] also describe an effort to create an adaptive e-course on Moodle that targets Greek language learning. This research's adaptivity basically relies on the student's age and knowledge level. By selecting an appropriate path at the beginning of the course, the student is led to the corresponding e-course material. Navigation features are also presented in the Moodle quiz component. Technically, the adaptation methods of this e-course are implemented in a static way of predefined urls.

3.2.2 Moodle Tags

Moodle tags were initially based on tagging blog entries during the creation of a new entry. Tags can be added, removed, or edited by the author of an entry. Each tag is presented as a clickable link at the bottom of the published blog entries, this link leads to a page that shows the related tags, recent blog entries, and users tag with specific tags. Users can be assigned to tags via their "interests" described in their profile. Moodle 2.0 extended tagging to courses and questions [55]. Moodle Tags were not used as we wanted to focus on Moodle resources: quizzes, HTML pages, forums etc.

3.2.3 ConTag Moodle Plugin Work

Elmadani et al. [28] have introduced a new Moodle plug-in, "ConTag" that implements concept tagging. The concept provides a mechanism for creation, editing, and application of concept tags to the courses content (resources). The meta-data are stored in SQL databases. Among a range of tagging mechanisms: FreeTag [50] Semantic Hacker API [6] , AlchemyAPI [2] we have chosen to use "ConTag" plug-in as the base of our project. "ConTag" plug-in was already integrated in Moodle, and offered a relatively good amount of useful functionalities to start with.

3.3 Putting it all together

Everything starts from the learning theories that were analyzed in the previous chapter, behaviorism, constructivism, and social constructivism. The learning theories should be mirrored by the environment in the ways that the student interacts with it. Consequently, the learning theories are expressed through the content and the types of the resources that are presented to the student. The content that we used is presented in the digital book of Mathematics published by the Hellenic Ministry of Education and Religious Affairs, Culture and Sports.

This choice of content was made as the Ministry's printed book is considered to present approved educational material of the highest quality. The material is developed by qualified scientists, and it is considered to express the emerging learning theories. Despite the high quality of the printed book's content, the digital book's presentation leaves room for improvement. Although the enriched edition of the digital book offers some virtual experiments, the book is mostly a faithful representation of the school book. It lacks interactive, collaborative features and e-learning 2.0 elements. It lacks interactive, collaborative features and e-learning 2.0 elements. We therefore considered it necessary to adapt the book's content differently with respect to the new learning theories and technologies. Harper et al. [37] argue that learning material should be created with respect to the emerging learning theories for an effective and efficient use. Behaviorist learning theory and constructivist learning theories are the theories that conquer the computer-based instruction. Instructional design models give helpful guidelines for creating learning material that comprises the learning theories [37].

Gagne et al. [47] have proposed one of the most widely known models for instructional design. IEEE.org suggests that this model should be followed when developing learning material. The model is expressed in terms of nine types of instructional events. The events are shown briefly in Figure 2:

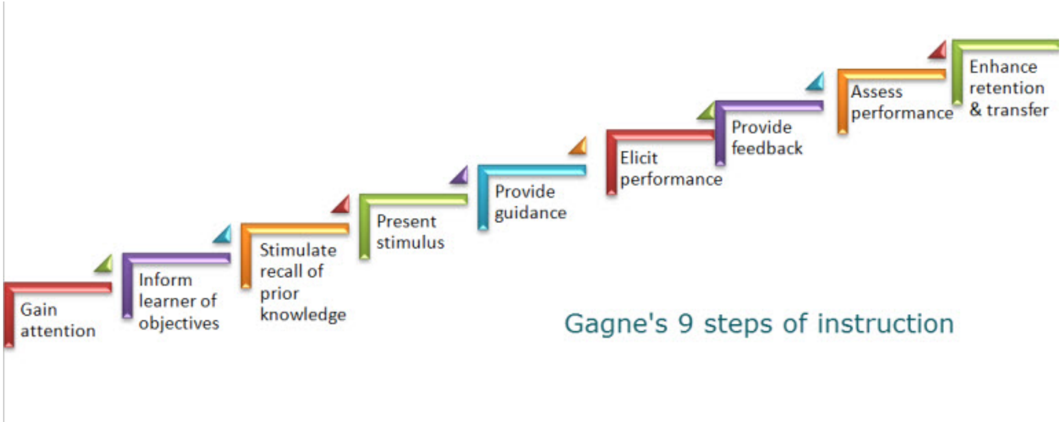

FIGURE 2: GAGNE'S 9 STEPS OF INSTRUCTION [47].

Below we explain how these events were applied to the development of the material:

a) **Gain the learner's attention**: e-learning 2.0 tools natively raise the learner's interest. It is proven that young people are highly attracted in using them [22], [98].

b) **Inform the learner of the lesson objective:** This principle was initially followed as the creation of the material was based on the Ministry's official e-book.

c) **Stimulate recall of prior knowledge:** This principle was initially followed as the creation of the material was based Ministry's official e-book. We enhance this principle with the adaptive navigation features that are described later in this paper.

d) **Present stimuli with distinctive features to aid in perception:** Multimedia and interactive activities will be used in the environment. The usage of multimedia lies in the fact that they enable the interactive potential of the computer via the presentation impact of images, sound and animations [24]. More particularly, their nature allows the usage of more than one human sense during the interaction, which is educationally valuable [79]. Additionally images and other multimedia elements on a text- based screen can relieve the eye, thus making the experience more pleasant, enforce the engagement, and provide better concept representation [21], [79].

e) **Guide learning to promote semantic encoding*:*** This principle was initially followed as the creation of the material was based Ministry's official e-book.

f) **Elicit performance,**

g) **Provide informative feedback,**

h) **Assess performance,**

Interactive elements such as quizzes and collaborative activities help to following the principles f, g and h. We also enhance the environment to these directions with the adaptive navigation and suggestion features that are described later in this paper.

i) **Enhance retention and learning transfer:** This principle was initially followed as the creation of the material was based Ministry's official e-book. We enhance this principle with the adaptive navigation and suggestion features that are described later in this paper.

The learning content that was developed was chosen to be brought to the user through an LMS system. For the development of our system we have chosen the Moodle LMS. Moodle is Open Source, and it comprises a large community of users and developers. The fact that Moodle is Open Source makes it possible to contribute with our own additions to its code. Last but not least, Moodle will save a lot of cost and time for our project as it provides a satisfactory percentage of the needed functionality and already integrates e-learning 2.0 tools that are needed.

Up to this point we have explained how we have exploited the principles of the learning theories and guidelines in order to deliver valuable content to the user. However our work does not stop here. The system's functionalities should be extended in order to exploit the new technologies. In that way we manage to improve the system by providing personalized and adaptive features.

In this particular solution we have focused on extending Moodle LMS with: Adaptive Navigation, Adaptive Suggestions and Completion Tracking.

a) **Adaptive feedback:** The system will make suggestions according to the student's performance and the exercise's semantics. For example, if the student achieves badly, the system will recommend: revising the learning objective's theory, studying more basic learning objectives, practicing with easier exercises, and discussing the problem with their classmates. On the contrary, in the case of a very high performance, the system will suggest helping their classmates on the forum, study resources on more difficult learning objectives, and study with extra-curriculum resources.

b) **Completion Tracking:** Given a good student performance, the system will unhide resources of more difficult learning objectives. Although the student will still be able to access the environment in a non-linear way, there will be some constraints on the resources that the student can access. That way, we let the student discover and take the lead in their learning by guiding them to study learning objectives that are close to their knowledge levels.

c) **Dynamic Navigation:** The student will be able to navigate through the exercises by choosing the difficulty level (easy, medium, and hard), or a random quiz on easier concepts.

A delineation of the above activities' flow is presented in the following images (Figure 3, Figure 4).

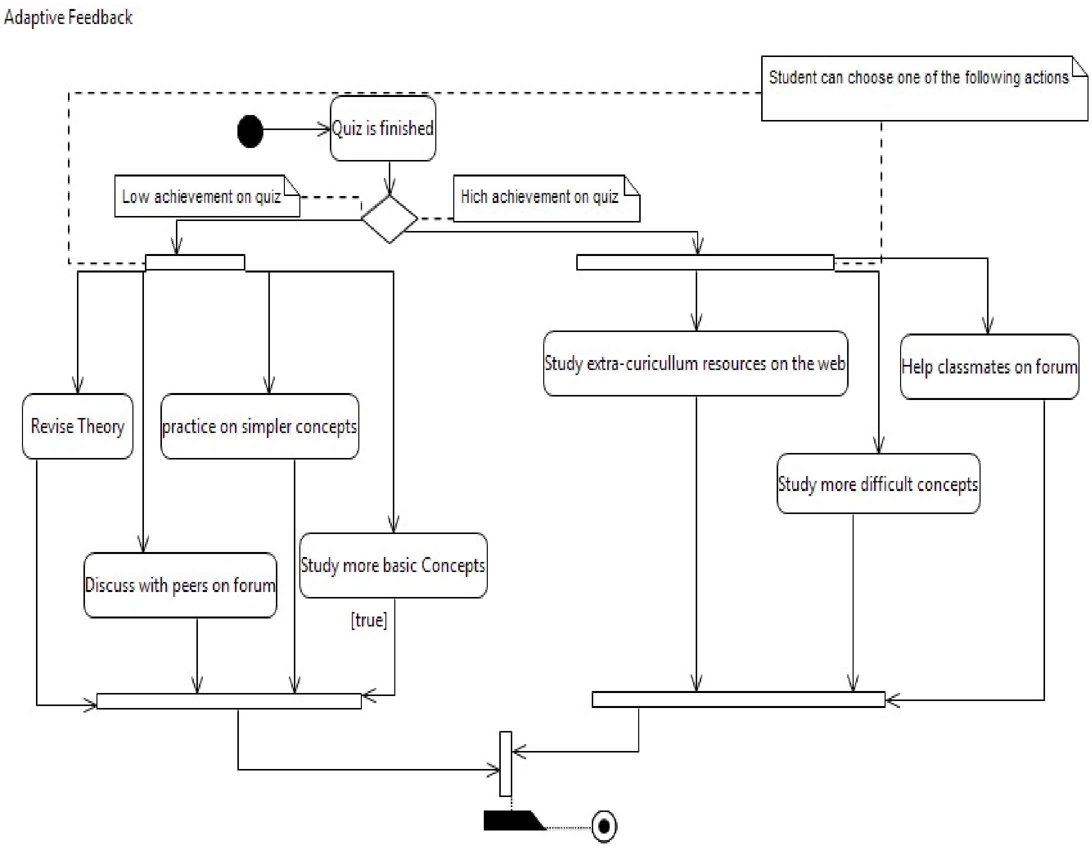

FIGURE 3: ADAPTIVE FEEDBACK ACTIVITY DIAGRAM

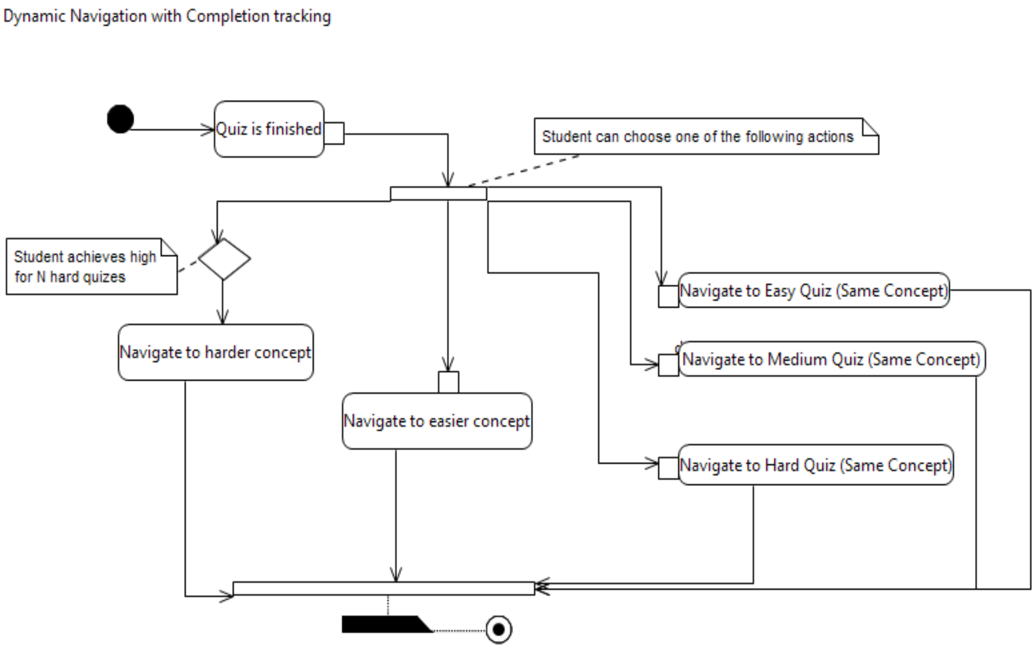

FIGURE 4: DYNAMIC NAVIGATION AND COMPLETION TRACKING ACTIVITY DIAGRAM

As explained previously, these functionalities are based on reasoning and thus context. So, what we needed to do first was to annotate the learning resources in a way by which the system will have the available information for “deciding” on the appropriate changes. For the semantics annotation we have used RDF semantics on the resources. Resources can be any learning material in Moodle such as HTML pages, quizzes, forum etc.

RDF semantics must have a dual role in our system in order to help us accomplish our goals. Firstly, we need a schema that will describe the hierarchical structure of the resources’ semantics. The resources’ semantics are referred to as “Tag” or “Concept” or “Learning Objectives” as they are considered to represent the name of a course’s learning objective. This in order to have the system know that “Tag1” (e.g. “Addition”) is prerequisite knowledge for “Tag2” (e.g. “Multiplication). Although this structure could have been made statically for the demo e-course that we are building, we have decided to provide the user with an interface for making the hierarchical structure dynamic and graphic. This was done for the following reasons: 1) each teacher conceptualizes the course’s learning objectives in a different way, and might need to adjust the hierarchical structure depending on the classroom’s needs; 2) the system is intended to be applied to many different courses of various fields.

By using a user-friendly tree interface the teacher can add, remove, position, and name nodes that represent the course-s semantics. The suggested hierarchical structure is that the semantics of pre-requisite knowledge will be on upper levels of the tree, while nodes that are independently related to each other will be siblings on the tree. In the end we need this hierarchy to be represented through RDF graphs.

From a technical viewpoint, while the tree is formed via the interface, a corresponding JSON is created in the background. When the user presses “Submit Tree”, we need the JSON object to be mapped as an RDF graph that will represent the knowledge in a more meaningful and standard way in terms of semantics. The JSON is represented through jQuery, and is integrated and represented in Moodle, developed in PHP. Nevertheless, as explained earlier, RDF can be handled from JAVA frameworks. In order to bridge this technical gap we have used RESTFul web services. The JSON object is sent through the HTTP protocol to the Web Service which, in its turn parses it in order to map it to an RDF graph. As it will be explained more analytically on the following chapter, the hierarchical structure is presented by the relation “ConceptA”“isSubClassOf”“ConceptB”. The graph also holds information concerning the Concept’s visibility with the property “Concept” “isHiddden” “Boolean”. This RDF graph is also used for the initialization of the users’ models. The users’ model graphs are holding information for each user separately and contribute to the personalization reasoning.

After having the hierarchical information, the system will need the information on the n resources – tags association. In order to make this functionality available to the user, we have used and extended the “ConTag” plug-in that was described in the “Related Work” section. “ConTag” plug-in creates the associations of tags and resources. “ConTag” was extended appropriately in order to be connected to the RDF graphs. A JSON object that holds the SQL table representation is sent with a JSON object to a Web Service that in its turn creates the instances of “Resource” “isTypeOf” “Concept” representations. Moreover, the RDF holds the relation “Resource” “hasDifficulty” “difficulty” that expresses information on the association’s difficulty, and the property “Resource” “hasType” “Literal” which holds information on the resources type (e.g. quiz, page, forum etc.).

At this point we have structured an RDF knowledge base that keeps information on: concepts hierarchy, concept’s visibility, concepts – resources associations, resources difficulty, and resources type. How is this information going to be useful?

In order to provide the functionalities of “Adaptive Navigation”, “Adaptive Suggestions” and “Completion Tracking” the system uses this information for giving the appropriate information to the student selectively. User tracking information, selected from Moodle database tables, are send to web services, that in turn apply logic or JESS rules. The web services’ answers are basically instructions to Moodle on what information to present, and how to adapt itself to the specific user.

3.4 Development Process Overview

Modern software projects require an interdisciplinary cooperation of teams with different expertise and skills that may or may not be related to Information Technologies [45]. This project follows that approach in the degree that it was feasible. As in terms of this research, the writer was responsible for developing the whole solution, we had to get directions from specialists of different scientific fields.

The project has a timeline that is divided into six phases that may be repeated appropriately:

1. *Preparing the environment, and importing the content, resources, graphic, sound files, and quizzes:* The content was available to us with the digital book of Mathematics. We needed to map the book's exercises to Moodle interactive activities. This was done with the corporation of the Mathematicians of the "Peiramatiko Gymnasio"(Experimental Junior High School) of Heraklion and the directions of specialists in "Instructional Design". We needed to extend Moodle functionalities by adding plug-ins in order to cover all the specified requirements. The resources when then added to Moodle were:
2. *Alterations on content:* When the content is inserted into the system, we have the specialist review it and suggest alterations
3. *Apply alterations to content:* We apply the alterations to content. Steps 1 to 3 may be repeated sometimes until the content is ready. However, this procedure stops when specific deadlines are met.
4. *Design the new features:* The ideas of the new features are designed with the corporation of specialists in "Information Technologies". Then, they are discussed with mathematicians and specialists of instructional design. The final requirements are defined by the summary of the above procedure.
5. *Implement the new features:* The new features are implemented with the directions of specialists in "Information Technologies".
6. *Feedback from teachers:* When the first beta edition is ready, it is presented to mathematicians and specialists in instructional design. In order to make the process more efficient, we have distributed a "Teachers Guide" which is shown in Appendix A. The adjustment of their suggestions leads in repeating steps 5 and 6 sometimes until certain deadlines are met.
7. *Release beta edition & final edition of the project:* When the final alterations are finished, the first beta edition will be released.

Figure 5 shows an activity diagram of the development process described above.

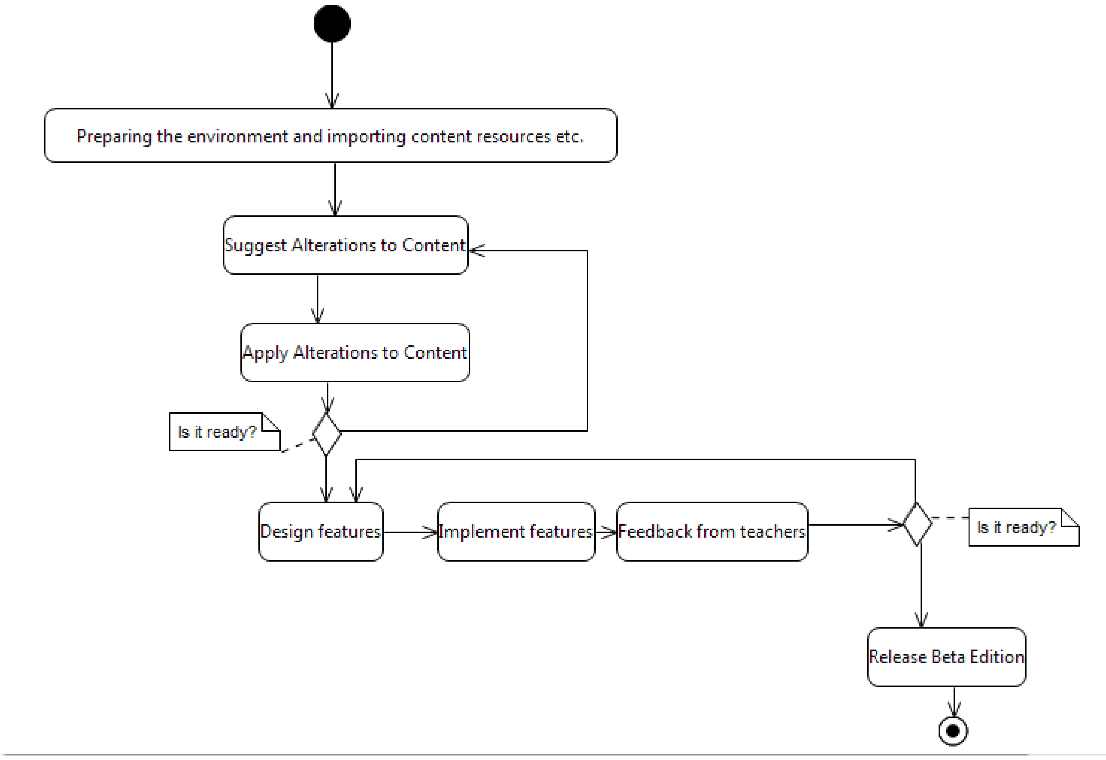

FIGURE 5: DEVELOPMENT PROCESS ACTIVITY DIAGRAM

Up to this chapter we have discussed the consistency and application of the principles and components that were analyzed in “Background”, as well as the development process that was followed during this system’s implementation. In the following section, we are going to make a more analytical overview of the system’s technical details.

Chapter 4

4 Platform Design and Development

4.1 Introduction

This chapter describes the decisions that were made during the implementation of the system components, and gives specific technical details. More specifically, it is organized as follows: first we make an overview of the system architecture and technical requirements. Then we give a short description of the steps that were followed during the system's development. After that, follow subsections that describe each component separately. The components described are: the "ConTag" plug-in by explaining its initial structure, the extensions that were made on it for fulfilling this project's needs, and its interaction with the rest of the components; the "ConTag Dynamic Navigation" and "«ConTag Dynamic Suggestion»" plug-ins by presenting their internal structure, along with the ways that the plug-ins interact with the rest of the components; the implemented Web Services by giving technical details, such as the needed URL parameters, and their main functionalities; the RDF databases by giving sample schemas, and describing the key points of the semantics representations; and lastly the Rule Based Agent by explaining the model and rules that were implemented for it.

4.2 System Architecture overview

This section intends to give to the reader an outline of the system architecture. Figure 6 is a UML component diagram that shows the system's components, and the links that connect them.

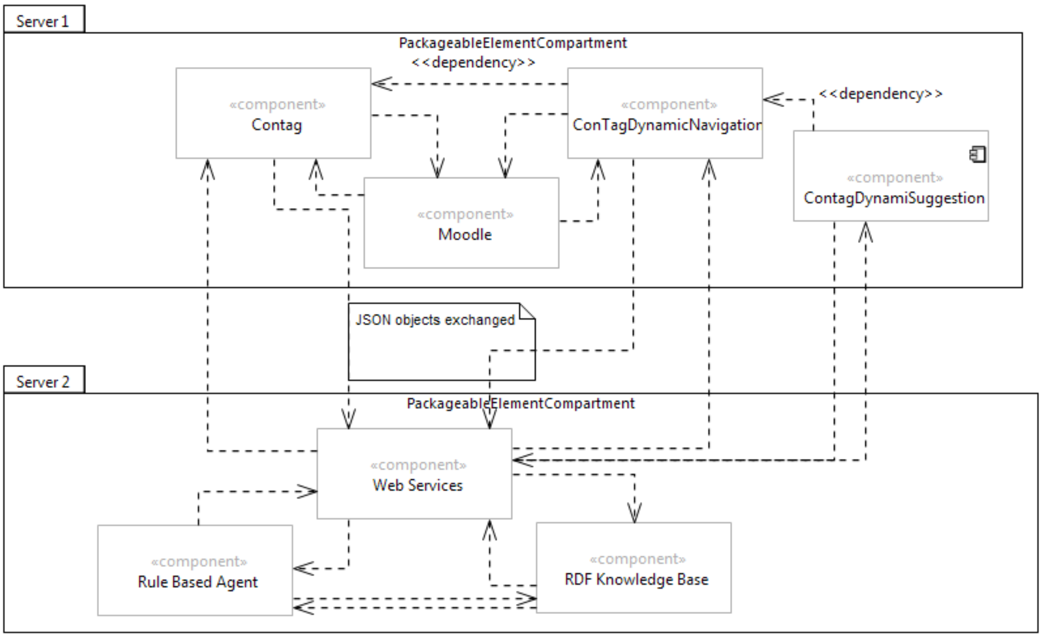

FIGURE 6: SYSTEM COMPONENTS

The above image divides the project in two packages, as we basically speak of two entirely different projects: "Moodle installation" and "Web Services project". The two projects are even installed on separate Web Servers. "ConTag" plug–in and "Quiz" component are parts of "Moodle", while "Web Services", "Rule Based Agent" and "RDF Knowledge Base" are parts of the "Web Services project". "ConTag", "ConTag Dynamic Navigation", and "ConTag Dynamic Suggestion" plug-ins call the needed Web Services. The plug-ins transfer data to the Web Services through JSON objects. As it will be seen later, the JSON objects sometimes hold more information than needed. This decision was made as it for reducing the complexity of parsing and changing the JSON objects before sending them. The Web Service finally "gets" specific fields of the JSON objects which is a O(1) procedure. Depending on the case, the Web Services will query or modify the Knowledge Base straightforward, or start the Rule Based Agent (Rules Engine), to do it. The Web Service's reply is fnally returned to the caller plug-in.

Concerning the technical details: Web Services were deployed on an Ubuntu 12.04 Server, of two CPU, 10GB disk space, 4096MB Memory. For deploying the Web Services we needed to install Apache Tomcat 7.0.26 and JVM version: 1.6.0_27-b27 of Sun Microsystems. Moodle 2.3.6+ (Build: 20130510) was installed on a Server

Ubuntu 12.04 of two CPU, 10GB disk space, 1024MB Memory. For running Moodle we needed to install: Apache 2.2.22, PHP 5.3.10, and SQL 5.5.31. We should point out that according to Moodle Requirements (MoodleDocs, 2013c) this server supports the usage of 10 to 20 concurrent users in Moodle. Both servers are virtual machines that were supported by "okeanos IAAS". The technical details of the rest of the components are analyzed in detail in the following subsections.

4.3 Moodle plug-ins

Customizations on Moodle code can be made by either changing the core code, or by developing a new plug-in. Our inexperience in Moodle development, and strict time limits, led to the decision that developing a new plug-in (block) would be the most convenient solution. This choice will help to present our ideas to the users, and have our code tested and evaluated without changing the Moodle code straight away.

4.3.1 ConTag plug-in

"ConTag" plug-in offers functionalities of adding, modifying, deleting and associating tags. It also offers navigation features where resources are presented grouped by concept. "ConTag" plug-in expresses meta-data in SQL tables. However, hierarchical information cannot be efficiently expressed by SQL. Therefore, it was essential to add RDF graphs to our Knowledge Base. The extension of "ConTag" plug-in was therefore necessary. It was made by both adding a new UI component and extending the API. The UI component that we added is a Hierarchical Dynamic Tree implemented by jQuery easy-UI. Through this component the user gives to the system the hierarchical information on which the RDF graph will be based on. The extensions on the API were made for enabling Web Services calls that eventually create RDF knowledge base. Figure 7 is a UML diagram that shows how the extended "ConTag" plug-in architecture is formed.

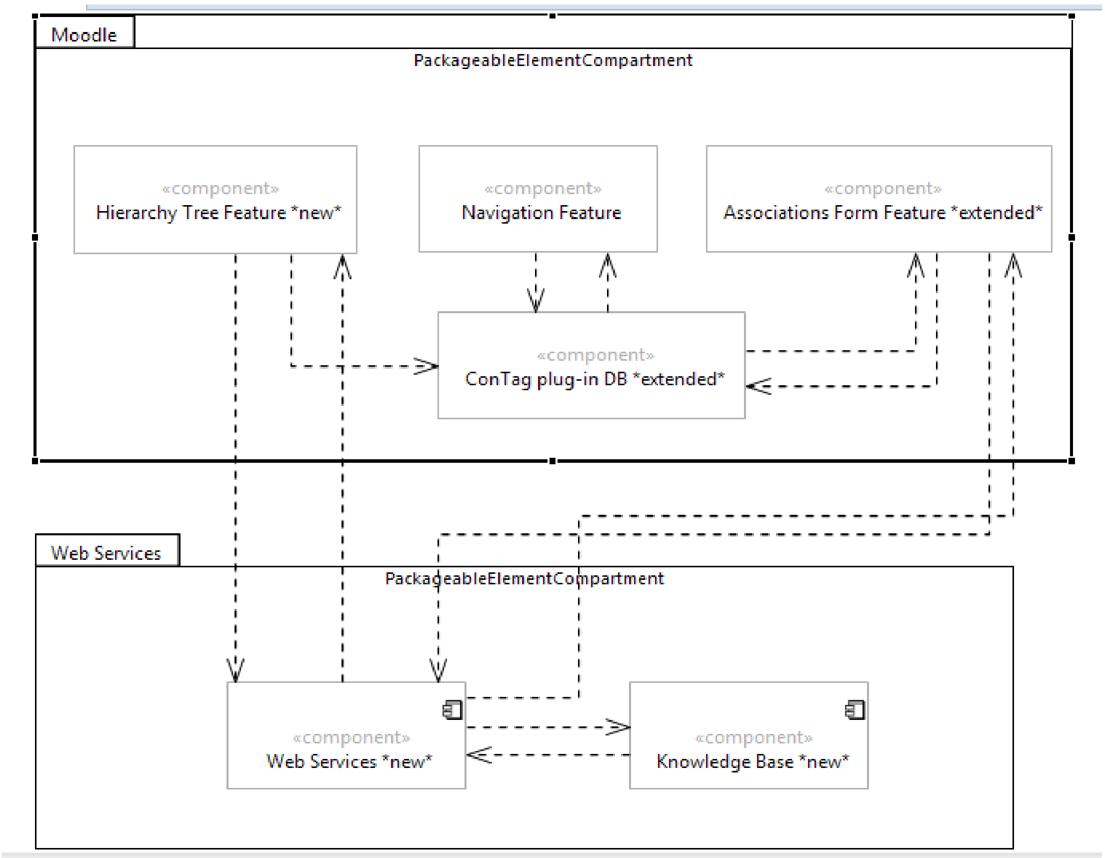

FIGURE 7: CONTAG PLUG-IN EXTENDED ARCHITECTURE

As seen in the picture the components attached were: Web Services, Knowledge Base, and Hierarchy Tree Feature. Moreover, the "ConTag" plug-in, and the Association Forms component are marked as extensions. The new components make queries and Modify "ConTag" database. More particularly, the extension we did was to add information of the tree_node_id on "ConTag" database. This field marks the association between the hierarchy tree nodes and the tags. The Hierarchy Tree extension and the Association Form extension make the appropriate Web Service calls. Web Services create and modify the database and return the required data.

4.3.2 "ConTag Dynamic Navigation" plug-in

"ConTag Dynamic Navigation" plug-in is implemented as a Moodle block plug-in, that requires the "ConTag" plug-in. It implements "Dynamic Navigation" and "Completion Tracking" features. For the "Completion Tracking" feature we have used Moodle "Groups and Groupings" API [58]. Moodle uses groups and groupings in order to enable and disable resources to specifics groups of users. In order to achieve that, the user-groups, are associated with groupings. A user, in a group can only see a resource of a grouping if and only if its group is assigned to that grouping. The way that groups and groupings help completion tracking works as follows:

1. Resources are assigned to groupings corresponsive to their associations (each resource can have many associations but Moodle only permits the assignment of one grouping per resource).
2. User groups are created in "1-1" relation to groupings.
3. Groups are associated with their corresponsive groupings.
4. Each user is assigned to the group of the resources that should be visible to them.
5. When a user moves to the next knowledge level, he is automatically assigned to this group. This way the resources of the following level are enabled.

This architecture described above is shown in figure 8:

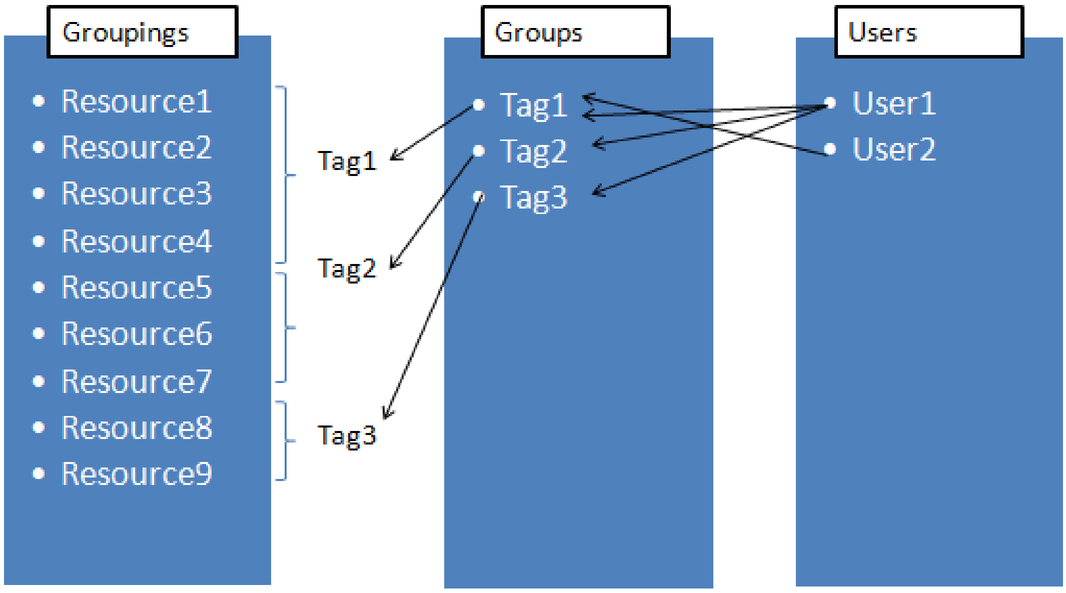

FIGURE 8: MOODLE GROUPS AND GROUPINGS ARCHITECTURE

Explaining figure 8, *User1* can see resources of *Tag1*, *Tag2*, and *Tag3* as he belongs to groups of *Tag1*, *Tag2*, and *Tag3*, while *User2* can only see resources of *Tag1*, as it is the only group he belongs to. So "Completion Tracking" basically is based on the user's assignment to new groups. The limitation of this method is that we have only one grouping per resources, as Moodle API supports it this way. So if *Resource1* is associated with two learning objectives (e.g. *tag1* and its descendant *tag2*) and the grouping is made according to *tag2*, then it will only be available when the user unlocks *tag2*, while we would have wanted it to be open in *tag1* too. A solution to this is that the teacher will make some extra administrative effort. The teacher must check the groupings of a resource, and make sure that the upper level concepts are applied for grouping.

The rest of the plug-in basically works with the appliance of selective queries to the RDF knowledge database. Specifically the “Completion Tracking” feature makes queries that are driven by a Rule Based Agent. The agent’s logic is triggered by user-tracking related data that come from Moodle. Lastly, the plug-in is also connected to the RDF knowledge base with Web Services. Figure 9 is a UML diagram that shows how the plug-in components work.

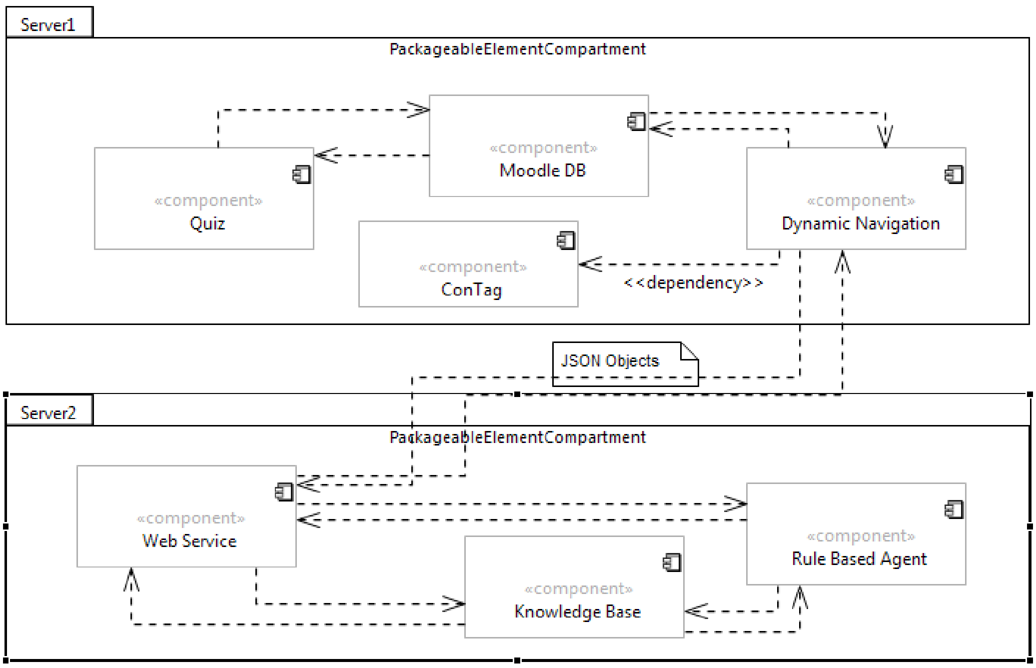

FIGURE 9: CONTAG DYNAMIC NAVIGATION COMPONENT DIAGRAM

“ConTag Dynamic Navigation” block’s instances can be installed on Moodle Quiz instances. The “ConTag Dynamic Navigation” created JSON objects, that are basically data selected from Moodle Database. Then the JSON objects are sent to appropriate Web Service. In their turn the Web Services call the Rule-Based Agent which interacts with the Knowledge Database and makes decisions depending on the rules invoked. The data are returned to the Web Service, and finally to the "ConTag Dynamic Navigation" plug-in as a JSON object. The "ConTag Dynamic Navigation" formats the results to HTML in order to present them in a human – friendly way.

4.3.3 *"ConTag Dynamic Suggestion" plug-in*

"ConTag Dynamic Suggestion" plug-in is implemented as a Moodle block plug-in that requires both "ConTag" plug-in and "ConTag Dynamic Navigation" plug-ins. It implements the "Dynamic Suggestion" feature. It is the appliance of selective queries to the RDF knowledge database driven by the Rule-Based Agent. The agent's logic is triggered by user-tracking related data selected from Moodle. The agent's rules form suggestion phrases that correspond to the student's achievements. The plug-in is connected to the RDF Knowledge Base with Web Services. Figure 10 is a UML diagram that shows how the plug-ins components work.

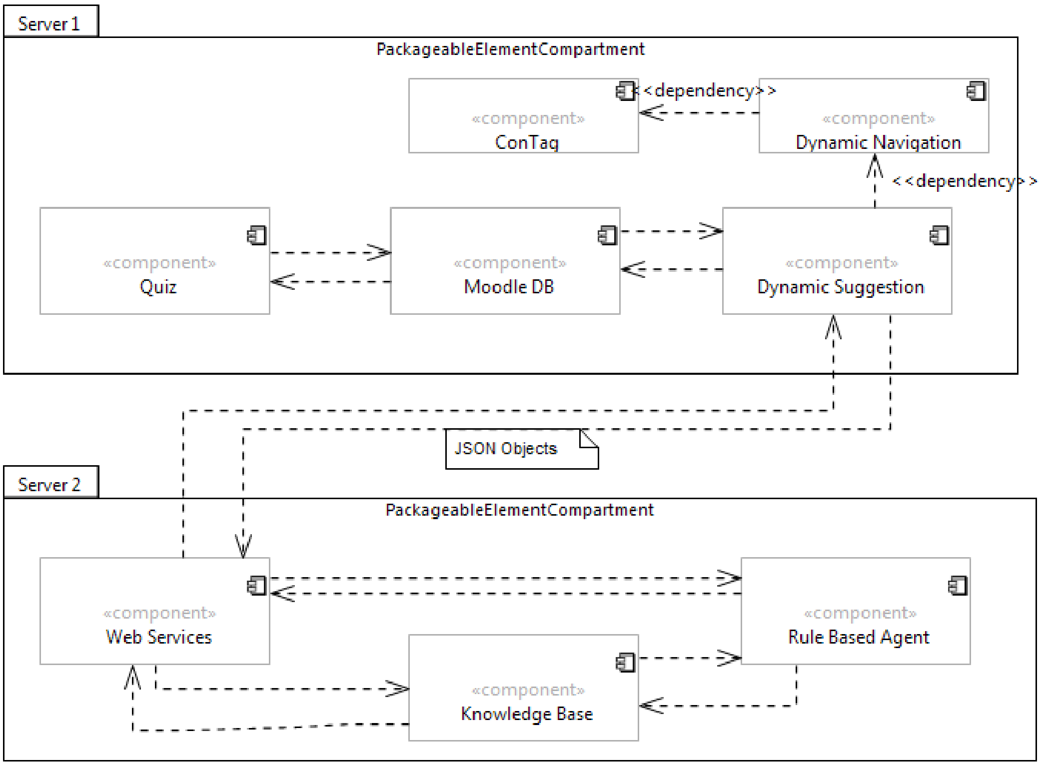

FIGURE 10: CONTAG DYNAMIC SUGGESTION COMPONENT DIAGRAM

"ConTag Dynamic Suggestion" block instances can be installed on Moodle Quiz instances. The "ConTag Dynamic Suggestion" creates JSON objects, that are basically data selected from Moodle Database. Then the JSON objects are sent to the appropriate Web Service. In their turn the Web Services call the Rule Based Agent which interacts with the Knowledge Database and makes decisions depending on the rules invoked. The results are returned to the Web Service, and finally to the "ConTag Dynamic Suggestion" plug-in as JSON object. The "ConTag Dynamic Suggestion" will format the results to HTML in order to present them in a human – friendly way.

4.4 Web Services

Web Services are the components that connect Moodle with the RDF Knowledge Base. The data transferred from Moodle to Web Services are represented in JSON objects. Web Services handle JSON objects with the org.codehaus.jettison.json Java package. The following subsections describe the Web Services implementation in detail.

4.4.1 Create Ontology

This Web Service is responsible for mapping the JSON object of the ConTag Hierarchy Tree to an RDF Schema. According to the firstly created RDF Schema the service makes copies that initialize the User Models Knowledge Base. The Web Service is called with the following path:

```
@Path("/createontology/{url}/{courseId}/{treeJsonStr}/{usersJsonStr}")
```

Where *url* is a String of the Moodle site's URL written in a normalized way (without special characters), the *courseId* is an integer of the Moodle course's id, *treeJsonStr* is the JSON string that represents the Hierarchy Tree of ConTag plug-in and *usersJsonStr* is a JSON string that describes the users that are enrolled to the Moodle course. The Web Service returns the root tree node's immediate associates. The JSON strings are formatted as shown in Figure 11 and Figure 12. The JSON strings are presented along their corresponding JSON trees.

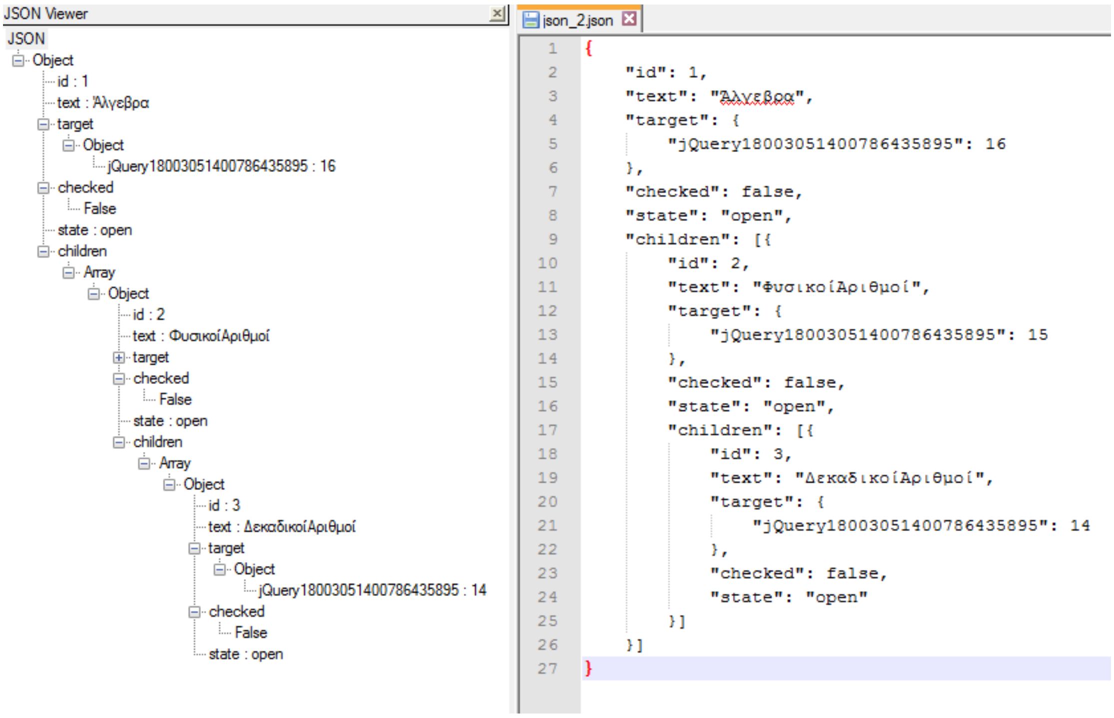

FIGURE 11: HIERARCHY TREE JSON REPRESENTATION

In the above picture we see that every node is presented as a block. The block contains many details that are automatically written from the jQuery easy-UI tree. A node might have children that are presented as nested blocks. The information that is mostly used in the Web Service is the *id* field that presents the *tree_node_id*, and children hierarchies to create the RDF graphs.

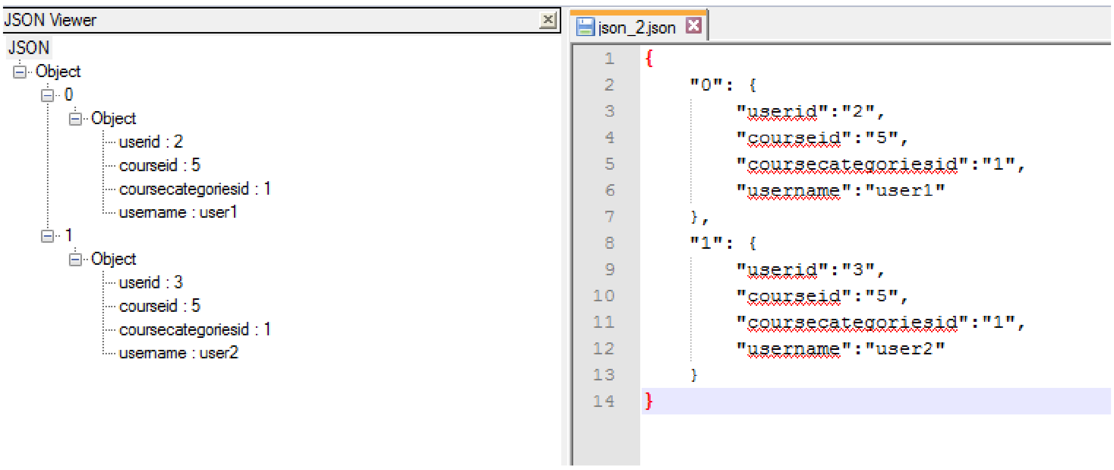

FIGURE 12: USERS DATA JSON REPRESENTATION

This figure shows the user information that is passed with the JSON object. Each node represents a user. The fields *userid*, *courseid*, *coursecategoriesid*, *username* correspond to Moodle DB fields. Nodes indexes are increasing from 0 and created automatically.

4.5 Create Instances

This Web Service maps relations of "*Resource associatedWith Concept*" described in ConTag SQL table to RDF graph. The Web Service is called with the following path:

@Path("/createinstances/{url}/{courseId}/{instancesJsonStr}")

Where *url* is a String of the Moodle site's URL written in a normalized way (without special characters), the *courseId* is an interger of the Moodle course's id, and *instancesJsonStr* is the JSON string that represents the association relations. The Web Service returns *true* or *false*, upon success or failure. Figure 13 shows the format of the *instancesJsonStr*.

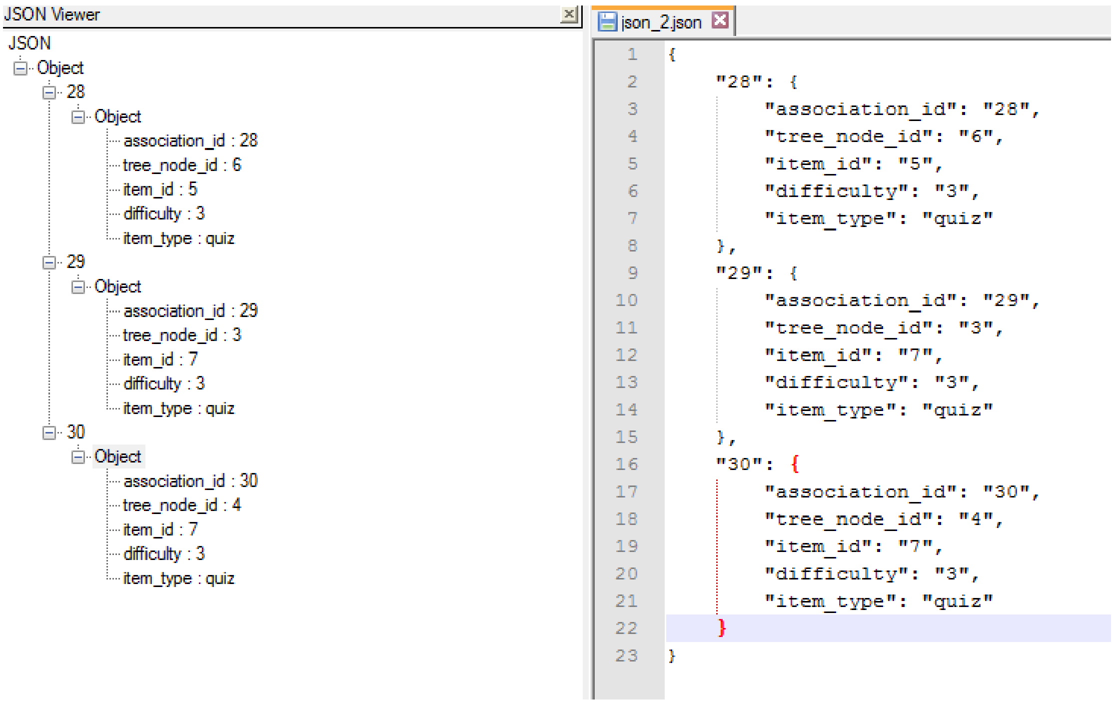

FIGURE 13: ASSOCIATIVE RELATIONS INSTANCES REPRESENTATION

This JSON object has one node for each association relationship. The fields correspond to Moodle DB fields. The index of each node is the same as the *association_id* and it is calculated automatically by Moodle DB queries results.

4.5.1 *Write To JSON*

This Web Service writes JSON data to a file. The implementation of this Web Service was necessary, JSON files are kept in the Tomcat Web Server and the only way to access them is through a Web Service. The Web Service is called with the following path:

```
@Path("/writetojson/{url}/{courseId}/{contentJsonStr}")
```

Where *url* is a String of the Moodle site's URL written in a normalized way (without special characters), the *courseId* is an integer of the Moodle course's id, and *contentJsonStr* is the JSON string with the content that we need to write to the JSON object and it might have any format. The Web Service returns *true* or *false*, upon success or failure.

4.5.2 *Adaptive Suggestions*

The Web Service is dynamically creates the "Dynamic Suggestion" phrases that are presented to the student. The Web Service returns the visible concept ids that are retracted from the RDF Knowledge Base. The Web Service is called with the following path:

```
@Path("/getvisiblequiztags/{url}/{courseId}/{userId}/{statisticsJsonStr}")
```

Where *url* is a String of the Moodle site's URL written in a normalized way (without special characters), the *courseId* is an integer of the Moodle course's id, and *statisticsJsonStr* is the JSON string with information of the user's achievement on a Moodle Quiz or a specific concept. The Web Service returns the suggestive phrases as calculated from the Rule-Based Agent. Figure 14 shows the format of the statisticsJsonStr.

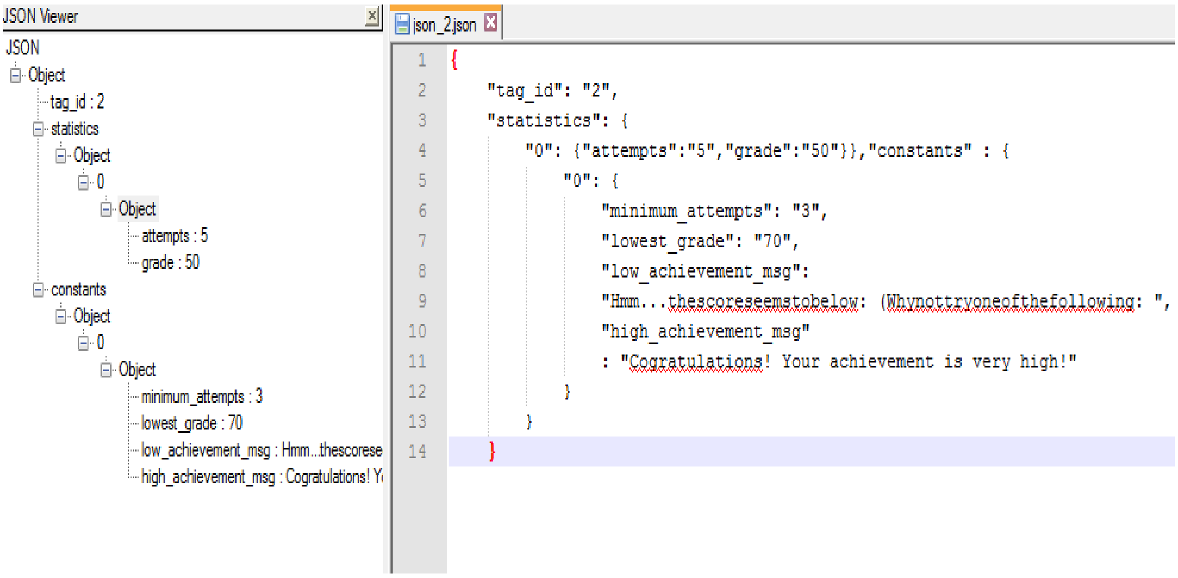

FIGURE 14: USER ACHIEVEMENTS AND CONFIGURATION CONSTANTS JSON REPRESENTATION FOR ADAPTIVE SUGGESTIONS

This JSON object is separated into two main fields. The fist field *tag_id* indicates the id of the tag that we will be examining. This id is basically the same as the *tree_node_id*. The second field is the *statistics* field, which stores constants that came from the plug-in instance’s configuration options. The *minimum_attempts* field indicates how many attempts a user has to make on a quiz or concept before the suggestions rule is triggered. The *lowest_grade* field indicates the threshold that will define if the student is low or high achiever. Lastly *low_achievement_msg* and *high_achievement_msg* contain the messages that the teacher has chosen to be displayed to the user depending on their achievements.

4.5.3 Completion Tracking

This Web Service implements the “Completion Tracking” feature. It is called with the following path:

```
@Path("/completiontracking/{url}/{courseId}/{userId}/{statisticsJsonStr}")
```

Where *url* is a String of the Moodle site’s URL written in a normalized way (without special characters), the *courseId* is an integer of the Moodle course’s id, the *userId* is an integer that stores the id of a specific Moodle user, and *statisticsJsonStr* is the JSON string with information of the user’s achievement on Moodle quizzes on a specific concept. If a student achieves above the predefined threshold, and s/he opens a next concept the Web Service returns the new concept's id, or NULL otherwise. The decision on whether the student can change level is made by the Rule-Based Agent. Figure 15 shows the format of the *statisticsJsonStr*.

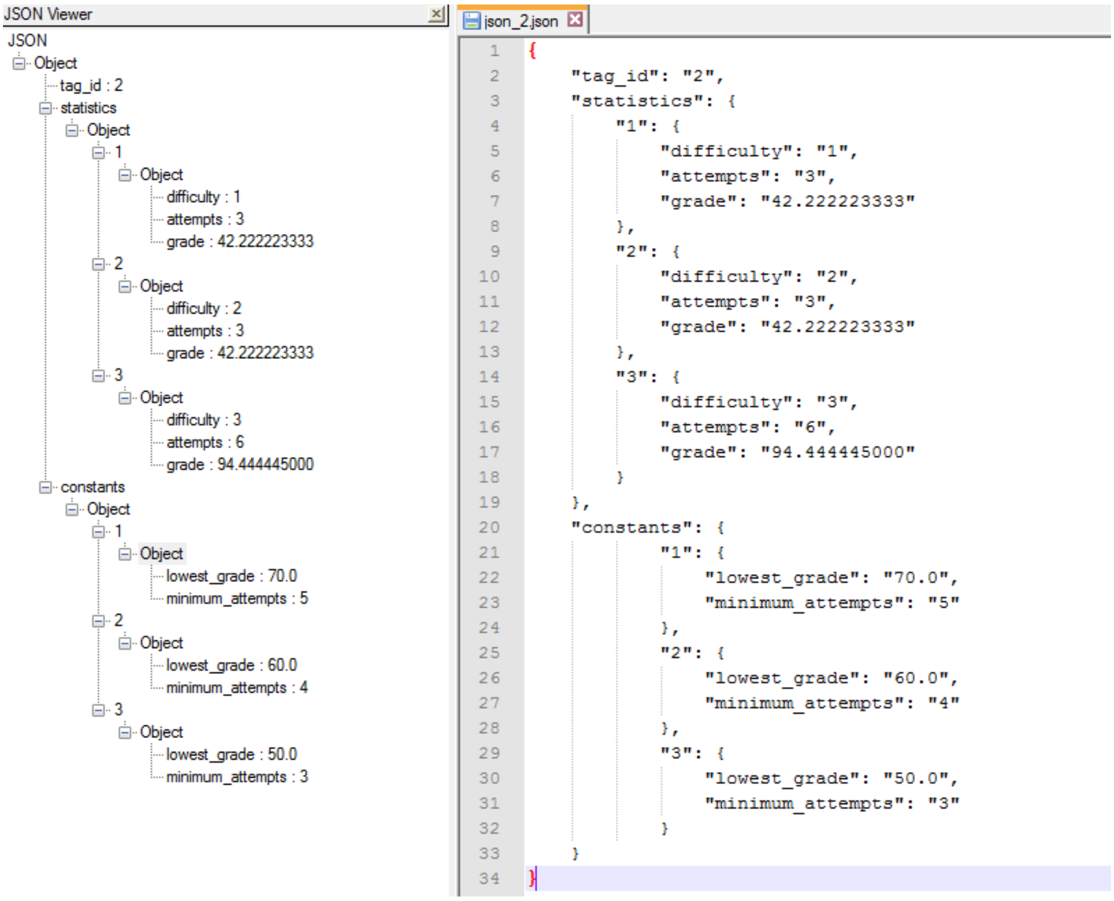

FIGURE 15: USER ACHIEVEMENTS AND CONFIGURATION CONSTANTS JSON REPRESENTATION FOR COMPLETION TRACKING

This JSON object is separated into three main fields. The fist field *tag_id* indicates the id of the tag that we will be examining. *Tag_id* basically holds the same value as the *tree_node_id*. The second field is *statistics*, which are the student's achievements and attempts as they were fetched from Moodle User-Tracking DB tables. As observed every node contains the difficulty level, to which it is connected; the student's *attempts*, for the specific concept and difficulty; and the user's average *grade* for this concept, difficulty level. Lastly, the *constants* field, stores constants that come from the plug-in instance's configuration options. The *minimum_attempts* field indicates how many attempts a user has to make on each difficulty level before the completion tracking rule is triggered. The *lowest_grade* field is the minimum grade that would make the user change level for each difficulty. The node indexes "*1*","*2*","*3*" in both *constants* and statistics fields correspond to enumerations of the difficulty levels, *"easy"*, *"medium"* ,*"hard"* respectively.

4.5.4 Get Easier Concepts

This Web Service returns concepts that are easier than the specified concept. It is called with the following path:

```
@Path("/geteasierconcepts/{url}/{courseId}/{tagId}")
```

Where *url* is a String of the Moodle site's URL written in a normalized way (without special characters), the *courseId* is an integer of the Moodle course's id, and the *tagId* is the id of the tag which's the ancestors we need to get. The Web Service returns the ids of the easier concepts or NULL if there are not any.

4.5.5 Get Visible Quiz Tags

This Web Service searches a specific User Model, and returns the resource id's that should be visible for the specified user.

```
@Path("/getvisiblequiztags/{url}/{courseId}/{userId}/{associationJsonStr}")
```

Where *url* is a String of the Moodle site's URL written in a normalized way (without special characters), the *courseId* is an integer of the Moodle course's id, the *userId* is an integer of the Moodle id of the specific user, and *associationJsonStr* is a JSON that holds information about associations related to tags that are visible to the user. The Web Service returns the ids of the resources or NULL if there are not any. Figure 16 shows the format of the *associationStr*.

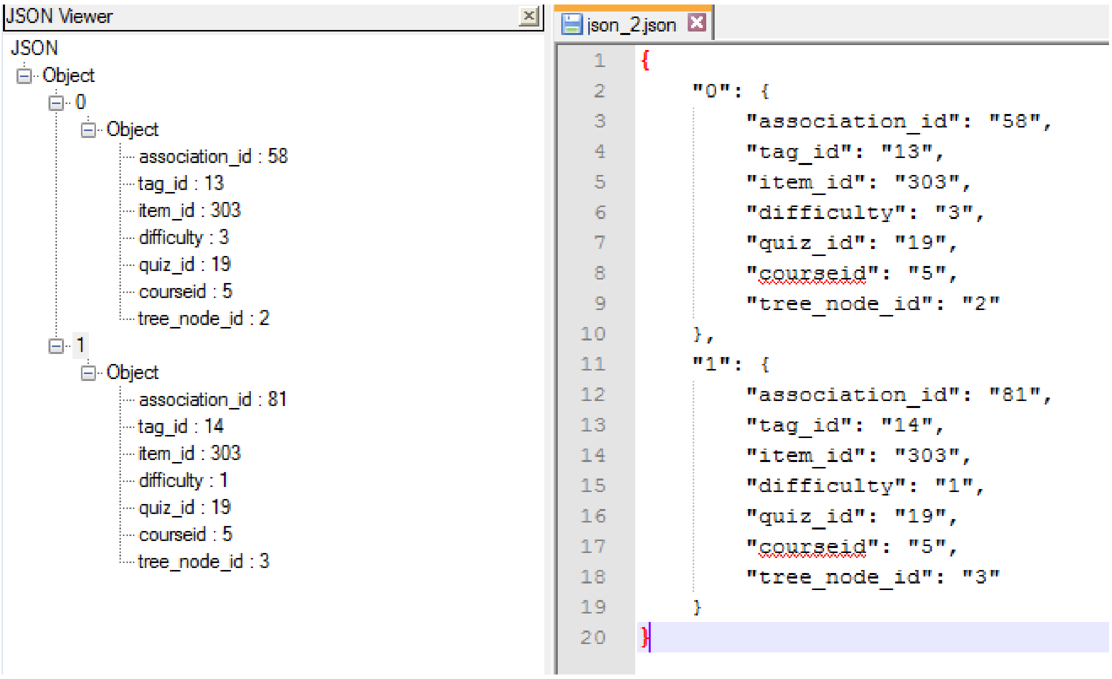

Figure 16: Associations of visible tags JSON representation

This JSON object nodes correspond to association relationships enriched with some extra data. The fields are presented as fetched from Moodle DB field. Each node describes an association (*association_id*) of a concept (*tag_id*) and a resource (*item_id*) as they are presented in "ConTag" DB tables. The field *difficulty* describes the association's difficulty. The field *quiz_id* basically is a second id for *item_id*, and it is created and used by the ConTag plug-in. *Courseid* as the course's id, and *tree_node_id* is the tag's id as presented in the hierarchy graph. The index of each node is increasing starting from 0 and it is calculated automatically.

4.5.6 Get Tags from Difficulty

This Web Service returns the resources that correspond, to a specific concept and a specific difficulty. The Web Service is called with the following path:

```
@Path("/gettagsfromdifficulty/{url}/{courseId}/{jsonStr}")
```

Where *url* is a String of the Moodle site's URL written in a normalized way (without special characters), the *courseId* is an integer of the Moodle course's id, and *jsonStr* the string that holds data for concept and difficulty. The Web Service returns a

JSON string that describes the requested resources. Figure 17 shows the format of the *jsonStr*.

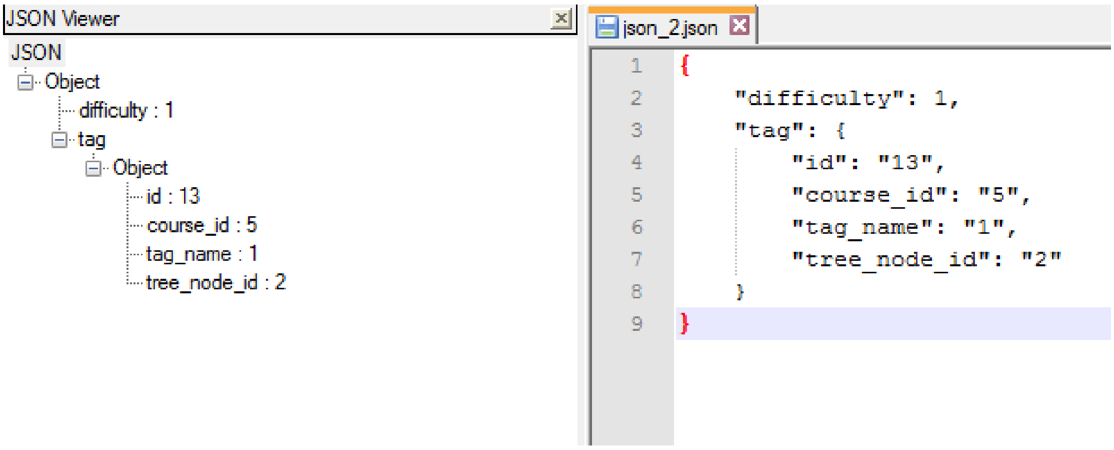

FIGURE 17: RESROURCE INFORMATION JSON REPRESENTATION

This JSON object has two main fields. *Difficulty* field describes the difficulty on which we focus. *Tag* node contains information of: the tag's id in ConTag plug-in, the course's id (*course_id*), the tag's name (*tag_name*), and the tag's id in the hierarchy graph (*tree_node_id*).

4.6 RDF Knowledge Base

The RDF Knowledge Base holds the hierarchical information of the existing concepts, the "*Resource associatedWith Concept*" relations, and User Models. The model is enriched with properties and relations required for the implementation of the necessary functionalities. The RDF Knowledge Base is handled by the SWKM model. The RDF graphs were saved in Turtle format as it is considered to be more close to JSON representations, thus more easily handled and comprehensible. The RDF graphs formats are described in more detail in the following subsections.

4.6.1 RDF Hierarchical Information & User Models

The RDF graph *conceptsRDFSChema.ttl* stores the hierarchy of the concepts with relations "*Concept1 isSubclassOf Concept2*" that are translated to triples as follows:

```
<http://www.ics.forth.gr/ConceptTag#1>

a <http://www.w3.org/2000/01/rdf-schema#Class> ;
```

```
    <http://www.w3.org/2000/01/rdf-schema#subClassOf>
<http://www.ics.forth.gr/ConceptTag#2> ;
```

The root Concept "*isSubClassOf*" Resource expressed by the following triple:

```
    <http://www.ics.forth.gr/ConceptTag#1>                a
<http://www.w3.org/2000/01/rdf-schema#Class> ;

    <http://www.w3.org/2000/01/rdf-schema#subClassOf>
<http://www.w3.org/2000/01/rdf-schema#Resource> ;
```

The property "*Concept isHidden Boolean"* indicates the visibility of a concept and is described from the following schema:

```
    <http://www.ics.forth.gr/isHidden>a
<http://www.w3.org/1999/02/22-rdf-syntax-ns#Property> .

    <http://www.w3.org/2000/01/rdf-schema#Resource>
<http://www.ics.forth.gr/isHidden>
<http://www.w3.org/2000/01/rdf-schema#Literal> .
```

User Models follow the same format, but store different information on the "*isHidden"* property for each individual user. User Model filenames are related to user ids, and stored in directories with unique path for every Moodle course and installation e.g. *rdf/http83212123121moodle/5/ conceptsRDFSChema_2.ttl*.

4.6.2 RDF Association Instances

The RDF graph *conceptsRDFInstances.ttl* stores association relations of "*Resource associatedWith Concept*" in a triple formatted as follows:

```
    <http://www.ics.forth.gr/Resource#2>a
<http://www.ics.forth.gr/ConceptTag#2> ;
```

The graph is enriched with some extra properties. There is the property "*Resource hasType Literal"* that describes the type of a resource and is described by the following schema:

```
    <http://www.ics.forth.gr/hasType>a
<http://www.w3.org/1999/02/22-rdf-syntaxns#Property> .
```

```
        <http://www.w3.org/2000/01/rdf-schema#Class>
    <http://www.ics.forth.gr/hasType>
    <http://www.w3.org/2000/01/rdf-schema#Literal>
```

There are also the properties "*hasEasyDifficulty*", "*hasMediumDifficulty*", "*hasHardDifficulty*":

```
        <http://www.ics.forth.gr/hasEasyDifficulty>a
    <http://www.w3.org/1999/02/22-rdf-syntax-ns#Property> .

        <http://www.ics.forth.gr/hasMediumDifficulty>a
    <http://www.w3.org/1999/02/22-rdf-syntax-ns#Property> .

        <http://www.ics.forth.gr/hasHardDifficulty>a
    <http://www.w3.org/1999/02/22-rdf-syntax-ns#Property> .
```

that describe the difficulty of an association through triples formatted as follows:

```
        <http://www.ics.forth.gr/Resource#25>a
    <http://www.ics.forth.gr/ConceptTag#2> ;

        <http://www.ics.forth.gr/hasMediumDifficulty>
    <http://www.ics.forth.gr/ConceptTag#2> ;
```

4.7 Rule Based Agent

4.7.1 Rules Model

Rules need to be applied to instances of certain classes. These classes constitute the "Rules Model". For this project the implemented classes are: Statistics.java, Attempt.java, and Feedback.java.

Statistics.java is basically a java mapping of the JSON object that is represented on Figure 15.The class parses the JSON object, and creates the instances that hold the student's attempt on each difficulty separately. These instances are instances of Attempt.java and are added to the rules engine.

The class Feedback.java is a mapping of the JSON object represented in Figure 14.The class parses the JSON object, and stores the information in Java, in order to be added and processed by the rules engine.

4.7.2 Rules

Reasoning to our system was based on the RETE algorithm [33], implemented through JESS rules. The Rule Based Agent mostly took decisions on whether:

- *The student changes knowledge level*: Descendant concepts are unhidden. The rule that makes this decision is showed in figure 18.

```
(defrule unhide-next-concept
    (Attempt  (tagId ?tagId)(url ?url) (userId ?userId) (courseId ?courseId) { (grade >= lowestGrade)
    && (attempts >= minimumAttempts)
    &&(difficulty == ?*medium* || difficulty == ?*hard*) })
  =>

    (bind ?o (new OntologyUtilities))
    (bind ?r (call ?o markVisibleResources ?tagId ?url ?courseId ?userId))
    (add ?r)
)
```

FIGURE 18: UNHIDE-NEXT-CONCEPT JESS RULE

This rule takes an instance of Attempt class. There is one instance for every difficulty level that we need to examine. The rule assigns the values *tagId, url, userId,* and *courseId* to slots. Then it checks the condition on whether the student's *grade* is greater or equal to the "threshold" grade (*lowestgrade*), if the student's *attempts* are greater or equal to the "threshold" attempts (*minimum_attempts*), and if the attempt we are checking was made on medium, or hard difficulty quiz. If the conditions is satisfied the rule creates a new OntologiesUtilities instance ?o, and calls *o.markVisibleResources(tagId,url,courseId,userId).* The results of this function are added to the engine and are returned to the Web Service as the engine's response.

- *The student is low-achiever*: The rule that makes this decision is showed in figure 19.

```
; If the student has made many attempts and the grade is still low, then he gets an low-achievements message
; with suggestions
(defrule suggestions-for-low-achievement
    (Feedback (lowAchievementMsg ?msg) )
    (Attempt  (tagId ?tagId)(url ?url) (userId ?userId) (courseId ?courseId) { (grade < lowestGrade)
    && (attempts >= minimumAttempts)
    &&(difficulty == ?*no_difficulty*) })
  =>
    (bind ?o (new OntologyUtilities))
    (bind ?r (call ?o getSuggestions ?tagId ?url ?courseId ?userId ?*low_achievement* ?msg))
    (add ?r)
 )
```

FIGURE 19: SUGGESTIONS-FOR-LOW-ACHIEVEMENT JESS RULE

This rule takes an instance of Attempt class and an instance of Feedback class. The rule assigns the values *msg, tagId, url, userId*, and *courseId* to slots. Then it checks the condition on whether the *grade* is greater than the "threshold" grade (*lowestgrade*), if the *attempts* are greater or equal to the "threshold" attempts (*minimum_attempts*), and difficulty variable is not set which means the engine was started by the "ConTag Dynamic Suggestion" plug-in. If the conditions is satisfied the rule creates new OntologiesUtilities instances "?o" calls *o.getSuggetstions(tagId,url,courseId,userId,*ACHIEVEMENT_CONSTANT_STRING,*msg)*.

The results of this function are added to the engine and are returned to the Web Service as the engine's response.

- *The student is high-achiever*: The rule that makes this decision is showed in figure 20.

```
;If he has achieved a high grade , we ignore the number of attempts he needed to get it.
;The student gets a high-achievement message
(defrule suggestions-for-high-achievement

    (Feedback (highAchievementMsg ?msg) )
    (Attempt  (tagId ?tagId)(url ?url) (userId ?userId) (courseId ?courseId) { (grade >= lowestGrade)
    &&(difficulty == ?*no_difficulty*) })
  =>
    (bind ?o (new OntologyUtilities))
    (bind ?r (call ?o getSuggestions ?tagId ?url ?courseId ?userId ?*high_achievement* ?msg))
    (add ?r)
)
```

FIGURE 20: SUGGESTIONS-FOR-HIGH-ACHIEVEMENT JESS RULE

This rule works the same as the previous one with the following differences: the condition does not contain *minimum_attempts*, as we do not mind giving positive feedback to the user straightaway, and the constants and slots are set to *high_achievement* instead of *low_achievement*.

Chapter 5

5 Evaluation

5.1 Introduction

This chapter focuses on demonstrating the functionalities of the implemented features. For achieving a better comprehension we have used demonstrative screenshots of the system's configuration combined with descriptive explanations. For the system's usage we have assumed a use-case scenario of a student navigating to the system, and demonstrate the adaptive features with screenshots and explanations.

At the end of this chapter we focus on the system's evaluation. Unfortunately, time constraints did not allow as making a quantitative evaluation of the system. Therefore we examine qualitative evaluation criteria in order to locate the project's strengths and limitations, and predict the results of the system's possible future evaluations.

5.2 System Overview

5.2.1 Hierarchical Information

The first step for creating the knowledge base is for the teacher to define new tags and the hierarchy that connects them. This can be done by a user friendly tree interface which is depicted in figure 21:

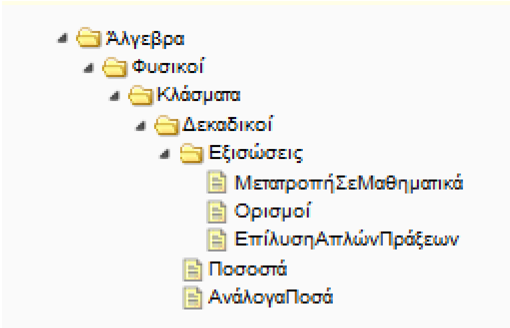

FIGURE 21: CONCEPT TAG HIERARCHY TREE USER INTERFACE

The easier learning objectives should be positioned in higher levels on the tree, while nested nodes indicate learning objectives that their ancestors are prerequisite knowledge. Siblings on the tree indicate learning objectives that are independent with each other.

Through this user interface one can add, remove (Figure 22), rename (Figure 23) or reposition (Figure 24) nodes.

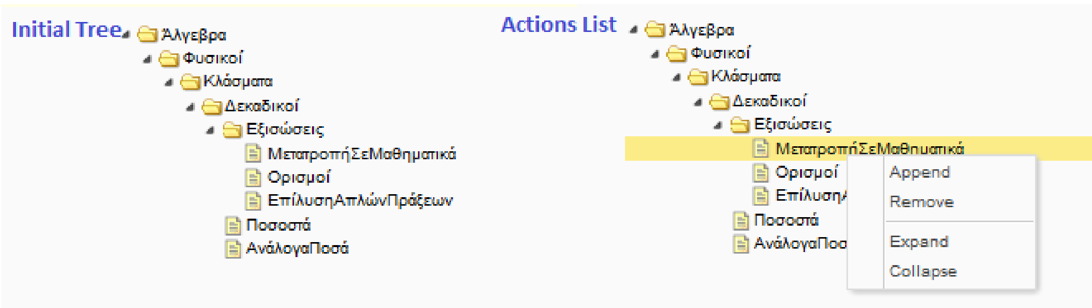

FIGURE 22: CONCEPT TAG HIERARCHY TREE USER INTERFACE MENU

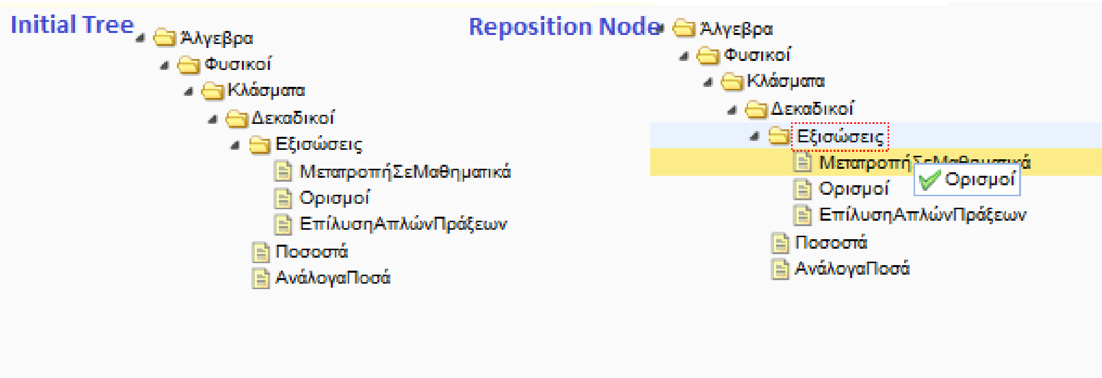

FIGURE 23: CONCEPT TAG HIERARCHY TREE RENAME NODE USER INTERFACE

5.2.2 *Associate the resources*

As soon as the user has created the desired hierarchy tree s/he needs to associate the resources with the predefined tags. This functionality can be found if one navigates to the "*Edit Concept Tags*" link at "ConTag" plug-in. The link leads to the form showed in figure 24:

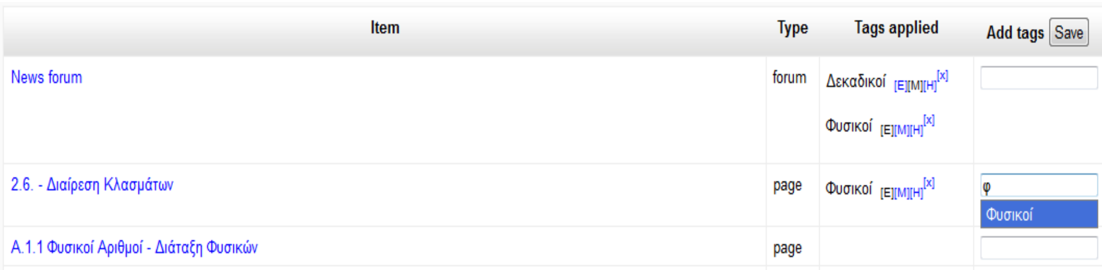

FIGURE 24: USER INTERFACE FOR ASSOCIATING RESOURCES TO CONCEPT TAGS

As seen in the figure 24, the form is divided into four fields. Field "*Item*" shows the name and link of the resource. Field "*Type*" shows the type of the resource such as forum, quiz, page etc. Field "*Tags Applied*" shows the tags that have already been applied to the resource. The label is followed by three links: [E][M][H] stand for Easy, Medium, Hard and can be chosen for defining the associations difficulty. The link [X] is used for deleting the association. Field "*Add Tags*" shows the field in which the teacher types the concept's label. As seen in the picture, the labels of the hierarchy tree can be found as pre-set options on the associations form when the user types the first letters. When the user types a word that is not already defined as a concept in the hierarchy tree the association is created and the label is automatically added in the hierarchy tree under the root element. The user is prompted to go back to the tree and change the position of the label if necessary.

5.2.3 Configuration options

Before the system is ready for use, the teacher must also configure the "ConTag Dynamic Navigation" block, and the "ConTag Dynamic Suggestion" block. This step could be omitted as the blocks already have default configuration. However, one might want to change the predefined values. The configuration options given in "ConTag Dynamic Navigation block" are shown in figure 25:

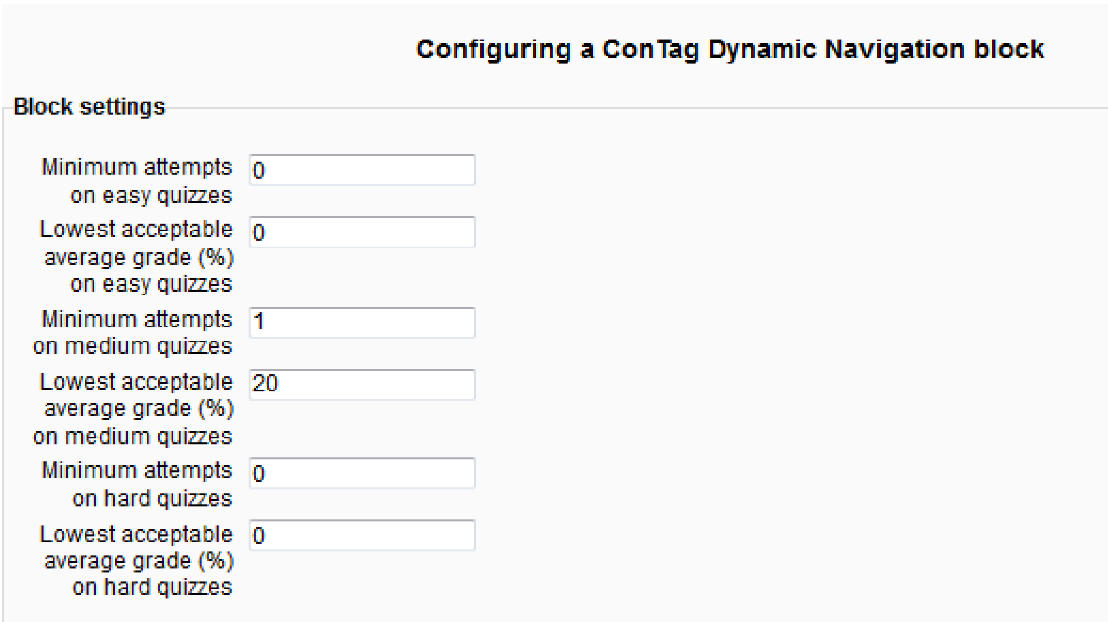

FIGURE 25: CONFIGURATION MENU OF CONTAG DYNAMIC NAVIGATION PLUG-IN

In this picture the user sets the minimum attempts and lowest acceptable average score that will be used as the threshold that changes level to the student's attempt. The values must be submitted for every difficulty level separately.

Figure 26 shows the configuration options available by "ConTag Dynamic Suggestion" block:

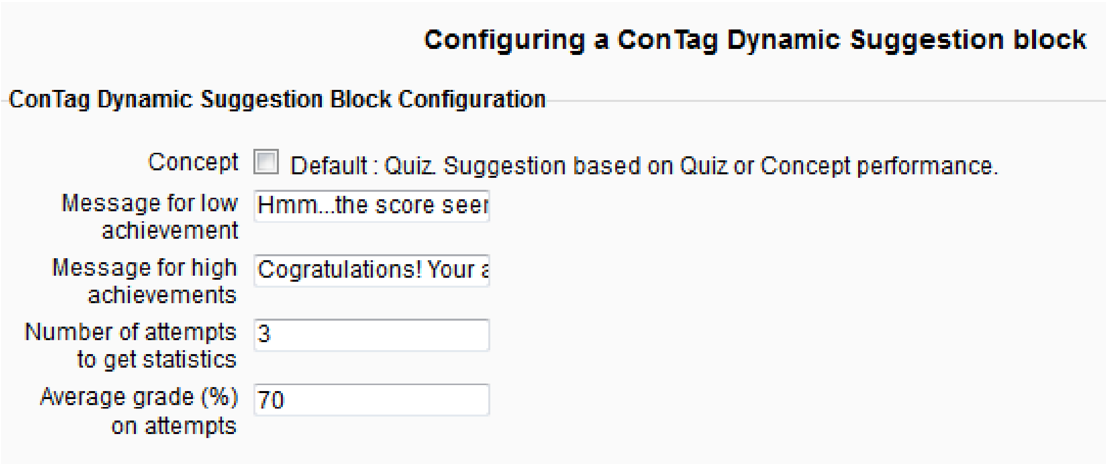

FIGURE 26: CONFIGURATION MENU OF CONTAG DYNAMIC NAVIGATION PLUG-IN

In this form the user can choose whether the suggestions will focus on student's statistics on a quiz, or a concept. Then the user is available to provide a personalized feedback message for the students. This message will be shown as feedback to the student on the suggestion block. Lastly, the user can choose the minimum attempts, and minimum average grade on which the "ConTag Dynamic Suggestion" will start calculate and prompt suggestion messages.

5.2.4 Adaptive functionalities (Use Case Scenario)

In this section we are going to overview the scenario in which a student navigates in quiz activities, and demonstrate how adaptive plug-ins supports the student. It should be pointed out here that for having adaptive features functioning properly, one should be logged in as a student, as Moodle does not maintain grading and user-tracking data for the rest of the roles (Administrator, Teacher etc.)

For demonstrating the use case scenario we make the following hypotheses:

- The Hierarchy Tree is the one shown in figure 21.
- "ConTag Dynamic Navigation" block has been configured as shown in figure 25.
- "ConTag Dynamic Suggestion" block has been configured as shown in figure 26.
- The quiz has concept "*Φυσικοί*"
- The quiz has medium difficulty.
- The student has already made four attempts on the quiz, and the average score was 60%.
- Suggestions are focused on quiz achievements

Relying on these assumptions we expect the following:

- The student will have already unlocked the next concept which is "*Κλάσματα*". That is because we have attempts >= 1 and average score >= 20 on medium difficulty quizzes of "*Φυσικοί*" *tag.*
- The student will get negative feedback. That is because we have attempts >= 3 and average score <70% on this specific quiz.

The system reacts as presented in figure 27:

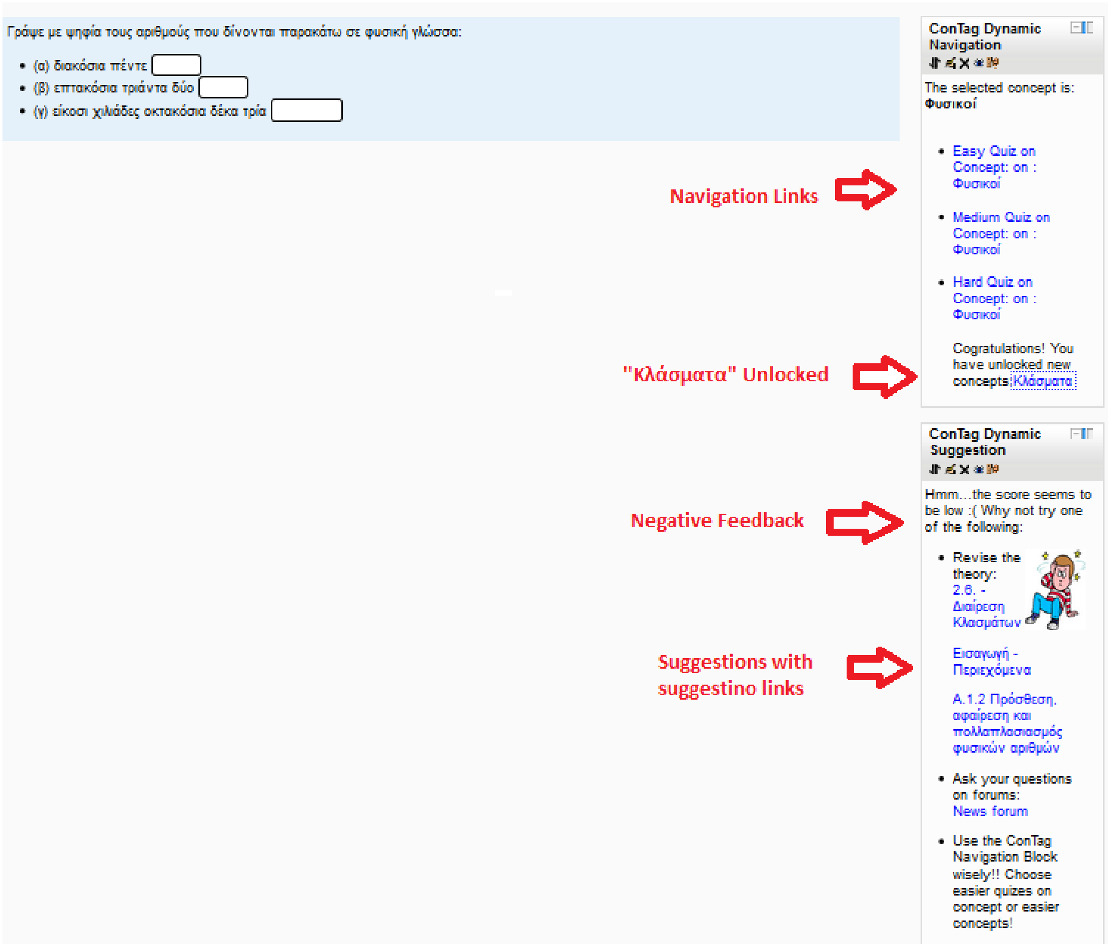

FIGURE 27: ADAPTIVE FEATURES DEMONSTRATION

As we see the student is offered:

- Navigation links to quizzes of same concept but different difficulties
- Prompt that s/he has moved to the next level
- Feedback that s/he did not do well the last time s/he did the quiz
- And the following suggestions with respect to feedback
    - *Revise the theory*, followed by links of corresponding resources

- *Ask questions on forums*, , followed by links of corresponding resources
- *Instruction to navigate to easier concepts from "ConTag Dynamic Navigation block"*

Now let's assume that the student navigates to "*Κλάσματα*" link that is prompted by "ConTag Dynamic Navigation link". That will take the student to a new quiz (random quiz of "*Κλάσματα*") that he has not attempted before. The student sees the screen that is presented in figure 28:

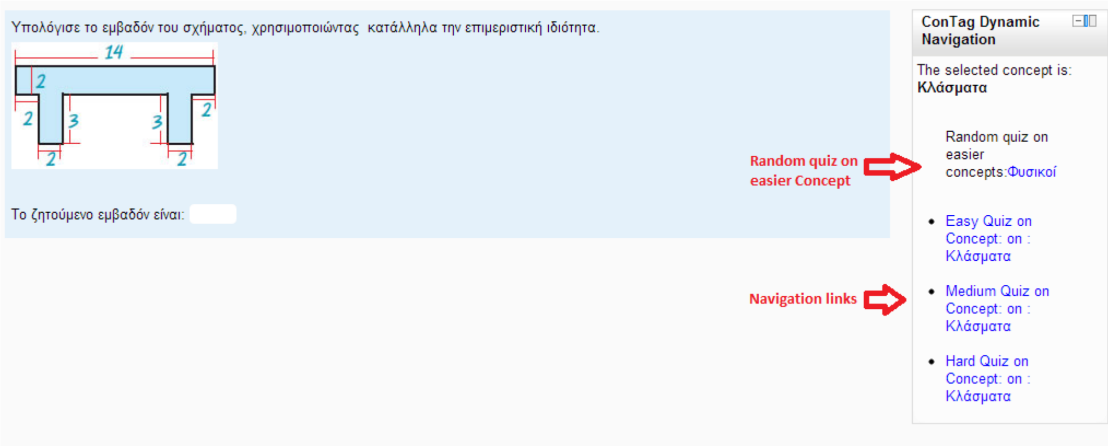

FIGURE 28: ADAPTIVE FEATURES DEMONSTRATION

As we see the student is offered:

- Navigation to random quiz of easier concepts which in this case is "*Φυσικοί*"
- Navigation links to quizzes of same concept but different difficulties
- "ConTag Dynamic Suggestion" does not show any messages as we do not have sufficient data yet.

Let's assume that the user answers correctly. Figure 29 shows the feedback as it is presented to the student:

FIGURE 29:ADAPTIVE FEATURES DEMONSTRATION

As seen above, "ConTag Dynamic Suggestion" displays messages as soon as it has sufficient data. The prompt messages suggest:

- Search extra resources on the web for the concepts label – keyword
- Continue practicing to unlock all concepts

Suggestion on "Help your classmates on forum" is not displayed as it did not find any forum associated with this concept.

5.3 Qualitative Evaluation

It is commonly accepted in the literature that evaluation should be an integral part of each e-learning system [7]. We have therefore considered it of high importance to execute evaluation into our system as well.

Occasionally, literature has suggested a variety of models and frameworks for evaluating e-learning environments, and as one could imagine, it is not possible to include all of them in just one evaluation process. The researchers are called to choose the most appropriate criteria that fit each case and evaluate the system with respect to them [7]. In this chapter we will be focusing to our system's evaluation with respect to pedagogical effectiveness, usability and willingness to adopt Moodle LMS.

In order to do so, we have researched the literature for designing an appropriate method of evaluation. Most of the methods met in the literature propose quantitative research in a plan where student groups use the system and provide data that are analyzed afterwards. The proposed evaluation models are usually limited by the following constraints: time restrictions in school educational programs, school infrastructure, practical difficulties in computer and internet access, and the well established teacher-centered model [76]. In addition to these constraints, we had to deal with strict time limits that made quantitative evaluation infeasible in terms of this project. Consequently, the system's evaluation is made with qualitative criteria. It is mostly our purpose to examine whether certain criteria are met and to define the conditions that it has been suggested be examined if evaluation is to be executed in the future.

Smeets [88] questioned 331 teachers and generalized their answers for setting criteria that indicated pedagogically valuable (reliable) systems:

1. *Stimulating pupils to work autonomously :*
   - ✓ Our system allows autonomous interaction based upon student's preferences and will.
2. *Paying special attention to problem solving strategies;*
   - ✓ The creation of the e-learning material was based on the Ministry's official e-book. The book highlights the theory parts that are considered key points.
3. *Stimulating pupils to discuss the learning content together;*
   - ✓ "ConTag Dynamic Suggestion" feature prompts the students to discuss with each other on the forum.
4. *Stimulating pupils to find out things on their own or together with fellow pupils;*
   - ✓ "ConTag Dynamic Suggestion" feature prompts the students to search learning objectives on the web and discuss with each other on the forum.
5. *Providing additional learning materials or tasks for advanced pupils;*
   - ✓ "ConTag Dynamic Navigation" and "ConTag Dynamic Suggestion" features prompt high achieving students to search learning objectives on the web or continue to more difficult levels.
6. *Providing remediating learning materials or tasks for slower pupils;*

- ✓ “ConTag Dynamic Navigation” and “ConTag Dynamic Suggestion” features prompt low achieving students to practice on easier learning objectives, easier quizzes or revise the theory.

7. *Providing different activities for different pupils;*
   - ✓ The system’s activities are the same for all students. However, our features adapt to the student’s achievements and present the activities in a different sequence that suits the student’s progress.
8. *Providing different learning content for different pupils;*
   - ✓ The system’s content is the same for all students. However our features adapt to the student’s achievements and present the content in a different sequence that suits the student’s progress.
9. *Allowing pupils to choose learning tasks themselves;*
   - ✓ Our system allows autonomous selection of activitiesbased upon student’s preferences and will. The adaptive features ensure that the students will choose from among learning activities that suits their profile.
10. *Allowing pupils to choose learning contents themselves;*
    - ✓ Our system allows autonomous selection of contentbased upon student’s preferences and will. The adaptive features ensure that the students will choose from among learning content that fits their profile.
11. *Using authentic texts;*
    - ✓ The texts are authentic as they are based on the Ministry’s e-book.
12. *Referring to the application of the acquired knowledge and skills outside school;*
    - ✓ The book refers to application cases outside school. Even more, the activities are created in a way that the student can combine mathematical problems with life outside school. For example, a mathematical problem might refer to calculating discounts and final prices while shopping.
13. *Discussing recent events during the lesson;*
    - ✓ The book has activities for discussion in the classroom. These activities were also inserted into the e-learning environment. The teacher can either start a class discussion or exploit the forum feature.

14. Paying special attention to information handling skills.

- ✓ ConTag Dynamic Navigation" and "ConTag Dynamic Suggestion" take the student's achievements into consideration.. This leads to adaptive suggestions if it is concluded that the student does not handle the information properly or, stimulates the students to get occupied with more difficult concepts if they handle information efficiently.

According to the above analysis, it seems like our system fulfills the reliability criteria. So in the case of a quantitative evaluation, it is expected that it will get a high score in reliability.

Katsanos et al. [46] focus on the evaluation in terms of usability. They have created a mapping of the System Usability Scale (SUS) questionnaire [44] to Greek. This is a valuable contribution as SUS is considered to be the most known standard for usability evaluation [46]. The authors use the questionnaire for evaluating an e-learning course in English. Greek students have answered the questionnaire. As our system was also developed with respect to Greek standards it would be interesting to execute a system evaluation with this questionnaire and study the outcomes. The questionnaire is shown in Table 2:

Item	Greek Version of SUS	English Version of SUS
Q1	Νομίζω ότι θα ήθελα να χρησιμοποιώ αυτό το σύστημα Moodle του μαθήματος συχνά.	I think that I would like to use this lesson's Moodle system frequently.
Q2	Βρήκα αυτό το σύστημα Moodle του μαθήματος αδικαιολόγητα περίπλοκο.	I found the lesson's Moodle system unnecessarily complex.
Q3	Σκέφτηκα ότι αυτό το σύστημα Moodle του μαθήματος ήταν εύκολο στη χρήση.	I thought the lesson's Moodle system was easy to use.
Q4	Νομίζω ότι θα χρειαστώ βοήθεια από κάποιον τεχνικό για να είμαι σε θέση να χρησιμοποιήσω αυτό το σύστημα Moodle του μαθήματος.	I think that I would need the support of a technical person to be able to use this lesson's Moodle system.
Q5	Βρήκα τις διάφορες λειτουργίες σε αυτό το σύστημα Moodle του μαθήματος καλά ολοκληρωμένες.	I found the various functions in this lesson's Moodle system were well integrated.
Q6	Σκέφτηκα ότι υπήρχε μεγάλη ασυνέπεια σε αυτό το σύστημα Moodle του μαθήματος.	I thought there was too much inconsistency in this lesson's Moodle system.
Q7	Φαντάζομαι ότι οι περισσότεροι άνθρωποι θα μάθουν να χρησιμοποιούν αυτό το σύστημα Moodle του μαθήματος πολύ γρήγορα.	I would imagine that most people would learn to use this lesson's Moodle system very quickly.
Q8	Βρήκα αυτό το σύστημα Moodle του μαθήματος πολύ περίπλοκο/δύσκολο στη χρήση.	I found the lesson's Moodle system very cumbersome to use.
Q9	Ένιωσα πολύ σίγουρος/η χρησιμοποιώντας αυτό το σύστημα Moodle του μαθήματος.	I felt very confident using the lesson's Moodle system.
Q10	Χρειάστηκε να μάθω πολλά πράγματα πριν να μπορέσω να ξεκινήσω με αυτό το σύστημα Moodle του μαθήματος.	I needed to learn a lot of things before I could get going with this lesson's Moodle system.

TABLE 2: SYSTEM USABILITY SCALE (SUS) QUESTIONNAIRE [46]

Finally, we would recommend an evaluation of the students' acceptance in adopting our system. There are various models that aim to explain the link between user attitudes, perceptions, beliefs and eventual system adoption [76]: Theory of Reasoned Action (TRA), the Theory of Planned Behavior (TPB), and the Technology Acceptance Model (TAM). Of of these models, TAM (Davies, 1986) is the most well-known [76].

Psycharis et al. [76] have carried out particularly interesting research that could be used as a set square in the case of our system's evaluation for a) students' improvement on fundamental issues of mathematics, and b) their attitudes towards the use of Moodle. The writers have executed an evaluation for examining the same things in the field of natural sciences. The methodology that they have followed is described below:

> *(a) The domain of Natural Sciences Teaching and learning:*
>
> > *(a1) Applying strategies to correct students' erroneous perceptions in electric circuits by introducing the appropriate educational activities which should lead to conceptual transformation.*
> > *(a2) Evaluating the efficiency of educational tools with regard to learning objectives.*
>
> *(b) The effectiveness of LMS's use in education:*
>
> > *(b1) Creating, developing and applying an interactive learning environment at school level through the use of the distance learning platform Moodle.*
> > *(b2) Exploring the response model of the LMS, its use and intention of using it.*
> >
> > *(Psycharis et al, 2013)*

Based on TAM model data analysis, the writers conclude that Moodle use is not always popular with students but generally positive attitudes are had towards LMS adoption. Students also seemed highly positive regarding Moodle LMS's collaborative features. Finally, the intervention seemed to have pedagogical value as a certain amount of students had a better perception of natural sciences fundamentals after the system's usage [76]. As our system is much akin to the investigated one, one would predict similar results on a corresponsive evaluation on pedagogical value and usability. However, even the writers [76] stress the need to apply the same methodology in a Mathematics e-course and a Moodle platform with adaptive characteristics. So our system makes a suitable use case for evaluation.

Chapter 5

6 Conclusion

6.1 Conclusions

In this research study we have described a software solution of a learner-centric environment. For purposes of demonstration, the environment uses the learning material of Greek Secondary School Mathematics (1^{st} grade) as it is presented in the digital book of Mathematics published by the Hellenic Ministry of Education and Religious Affairs, Culture and Sports. The e-learning material is expanded in order to exploit the advantages of e-learning 2.0, thus the final environment contains: pages, quizzes, forums, and multimedia elements.

The system uses Moodle LMS for its base. We have focused on expanding the Moodle functionality by creating new features through expanding the plug-in ‘‘ConTag’’ [28]. The features are implemented with the usage of Web Service, Semantic Web, and Rule-Based reasoning technologies. More particularly, our study’s main contribution is that we enable the educator to construct a hierarchical structure of the course’s learning objectives through a user-friendly interface. The system, in turn, will use this hierarchical information in order to provide personalized guidance according to the user’s actions in the system.

The system’s major innovations and advantages are: Dynamic Suggestion, Dynamic Navigation, and Completion – Tracking features. Through Completion Tracking the students can access only resources that fit their knowledge level, while Dynamic Navigation and Dynamic Suggestion instruct the user to navigate consciously through the resources. As the features are implemented with Web Services our system can be applied to other LMSs with small adjustments.

The system’s value does not come attached with one unique factor. For perceiving its value one has to consider it as a full package of innovations that respect a sum of principles. We have developed the content with pedagogical correctness, and have enriched it with emerging educational technologies (multimedia, e-learning 2.0 elements etc.). On top of that, we have enhanced the existing system with adaptive features. The features were implemented by exploiting state-of-art technologies, Web Services, Semantic Web, and Rule-Based content. In that way, we have not only enhanced Moodle LMS by contributing new plug-ins to its community, but also proposed ways to move towards more Service-Oriented Architecture.

The system should be evaluated with respect to its reliability and adoption potentials. We have therefore executed qualitative evaluation, and set the criteria for future evaluations. The system is expected to be highly reliable in terms of pedagogical value as it satisfies the corresponding criteria. However, its adoption potential seems to be low when compared with the results of a similar study. It is therefore suggested that usability and adoption potentials will be further investigated by future evaluations.

6.2 Future Work

Future work related to our system can be done to improve its pedagogy and technicality. In terms of its pedagogy, it is suggested that quantitative evaluation should be executed. Depending on the results and suggestions, a circle of improvements should be applied. Concerning the evaluation sample it is already agreed that it may be used by students of the “Experimental Secondary School of Heraklion” in Crete in order to evaluate it and suggest further changes. It would also be interesting to use our system as input for [76] future evaluations on Mathematics systems, and adaptive features. A comparative study with their first paper [76] would be intriguing.

The system could also be enriched in terms of content. Moodle allows the addition of wikis, mind maps, extra plug-ins and activities that teachers might find useful to add to the e-course.

In terms of technological extensions, more features can be added to the system, and changes must be made to overcome its limitations. We would recommend the following:

- Extend Moodle API so that more than one grouping value can be added to the resources. In that way we will reduce administrative actions demanded by teachers, and increase adaptivity.
- Resources' association to tags is very time consuming for the teacher. A method for initially populating the Resource- Tags associations form based on the resource's "Title" and "Description" would be desired, as it would also increase administrative actions, and make the plug-in more usable.
- The plug-ins' contribution to Moodle community. This action will lead to a code review that will result in code refactoring.

References

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Appendix

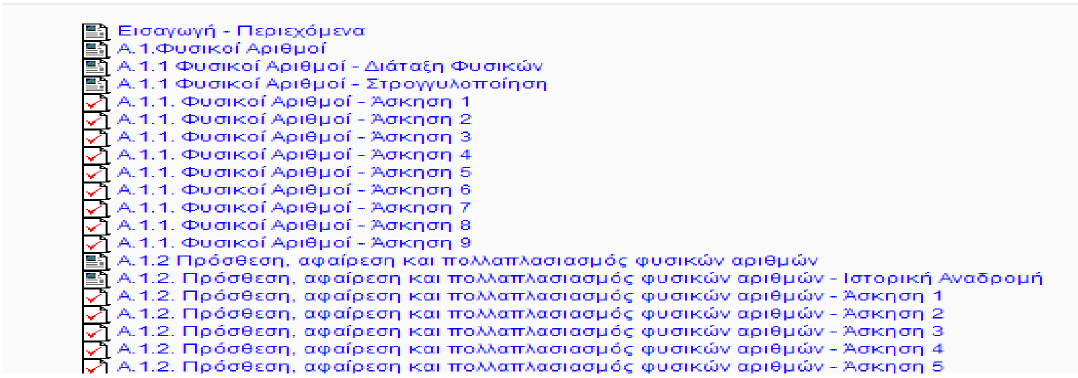
«MOODLE- ΙΕΡΑΡΧΙΣΗ ΣΗΜΑΣΙΟΛΟΓΙΚΩΝ ΕΝΝΟΙΩΝ»

Σημειώνεται ότι το σύστημα είναι υπό κατασκευή οπότε μπορούν να παρατηρηθούν ασυνέπειες στο περιεχόμενο καθώς και τη λειτουργικότητα.

Βήμα 1: Ιεράρχηση εννοιών και αντιστοίχηση εννοιών στις πηγές (υλοποιημένο)

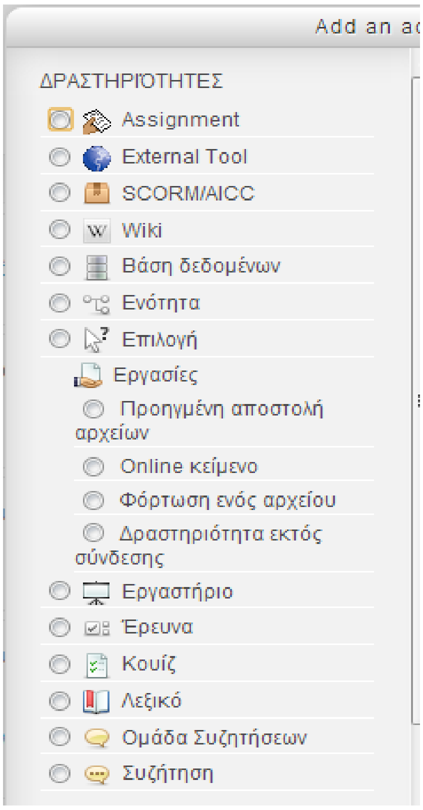
Η εργασία αυτή στοχεύει στην δημιουργία μιας ιεραρχίας εννοιών, για τις παιδαγωγικές πηγές που υπάρχουν σε μία πλατφόρμα ηλεκτρονικής μάθησης. Πιο συγκεκριμένα, για τους σκοπούς αυτής της εργασίας χρησιμοποιείται η πλατφόρμα ηλεκτρονικής μάθησης **Moodle** στην οποία έχει εισαχθεί υλικό της ύλης των μαθηματικών Ά Γυμνασίου, όπως αυτή παρέχεται από το ***«Υπουργείο Παιδείας και Θρησκευμάτων, Πολιτισμού και Αθλητισμού».***

Στην Εικόνα 1 δίνεται μια παρουσίαση της πλατφόρμας με τις πηγές όπως παρουσιάζονται στο χρήστη κατά τη σύνδεσή του στο σύστημα.

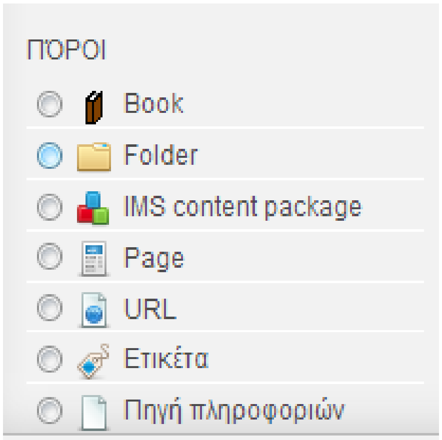


ΕΙΚΟΝΑ 1

Οι πηγές που παρέχει αυτή τη στιγμή το σύστημά μας είναι στατικές διαδικτυακές σελίδες που αναπαριστούν τα τμήματα «Θεωρίας» του σχολικού βιβλίου, διαδραστικές ασκήσεις quiz που αντιστοιχούν σε ασκήσεις του σχολικού βιβλίου, και ενότητες forum. Διευκρινίζεται όμως ότι ο χρήστης – καθηγητής μπορεί να δημιουργήσει πηγές οποιασδήποτε από τις επιτρεπτές μορφές της πλατφόρμας **Moodle** όπως φαίνονται στις Εικόνα 2 και Εικόνα 3.



ΕΙΚΟΝΑ 2



ΕΙΚΟΝΑ 3

Σκοπός της διπλωματικής εργασίας είναι να εισαχθεί «νοημοσύνη» στο σύστημα ώστε να παρέχεται ένα σύνολο λειτουργιών πάνω στις πηγές σύμφωνα με την «έννοια» που αντιπροσωπεύει η κάθε πηγή.

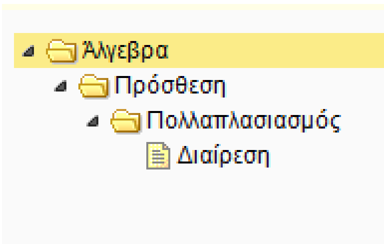
Για παράδειγμα αυτή τη στιγμή η ηλεκτρονική πλατφόρμα παρέχει την περιήγηση του μαθητή στις πηγές σύμφωνα με την κρίση του και τις προτιμήσεις του. Ο μαθητής δηλαδή, θα μπορούσε χωρίς να έχει κατανοήσει σωστά την έννοια της διαίρεσης να μπορεί να συνεχίσει στις ασκήσεις κλασμάτων. Αυτό που περιμένουμε από ένα «έξυπνο» σύστημα είναι να γνωρίζει ότι η έννοια της διαίρεσης προηγείται αυτή των κλασμάτων, οπότε παροτρύνει τον μαθητή, να κατανοήσει τις βασικές έννοιες πριν προχωρήσει, να διαβάσει ξανά τη θεωρία μετά από αποτυχίες στις ασκήσεις κλπ.

Για να το επιτύχουμε αυτό, ο καθηγητής θα πρέπει απαραίτητα να έχει ακολουθήσει κάποια βήματα, ώστε να δίνει στο σύστημα την ιεραρχία των εννοιών, αλλά και να αντιστοιχεί τις πηγές με τις έννοιες που αντιπροσωπεύουν.

Για να γίνουν αυτές οι λειτουργίες παρέχεται στον καθηγητή το μενού που φαίνεται στην εικόνα 4.

ΕΙΚΟΝΑ 4

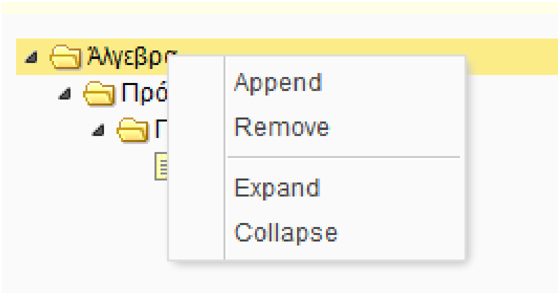
Αρχικά ο καθηγητής θα πρέπει να επιλέξει: « ***Edit Concept Tagging Hierarchy Tree***». Σε αυτή την επιλογή ζητείται από τον καθηγητή να δώσει μια ιεραρχική αναπαράσταση των εννοιών που διδάσκονται στην ύλη του μαθήματος. Οι πιο εύκολες έννοιες πρέπει να είναι υψηλότερα στο δέντρο αναπαράστασης.



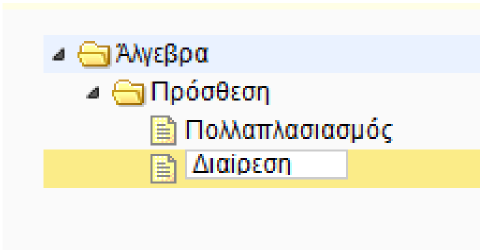
ΕΙΚΟΝΑ 5

Το δέντρο ιεράρχησης εννοιών παρέχει στο χρήστη τις εξής λειτουργίες:

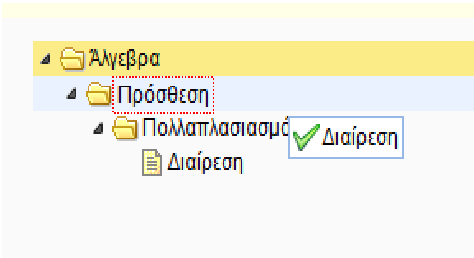
- Με δεξί κλικ πάνω σε κόμβο της επιλογής μας :
    - Εισαγωγή κόμβου (append)
    - Διαγραφή κόμβου (remove)
    - Απόκρυψη κόμβων ενός υπόδεντρου(collapse)
    - Παρουσίαση των κόμβων ενός υπόδεντρου (expand) (Εικόνα 6)
- Με διπλό κλικ πάνω στο όνομα κόμβου
    - Μετονομασία κόμβου (Εικόνα 7)
- «Drag and drop» κόμβου της επιλογής μας
    - Μετακίνηση κόμβου(Εικόνα 8).



Εικόνα 6



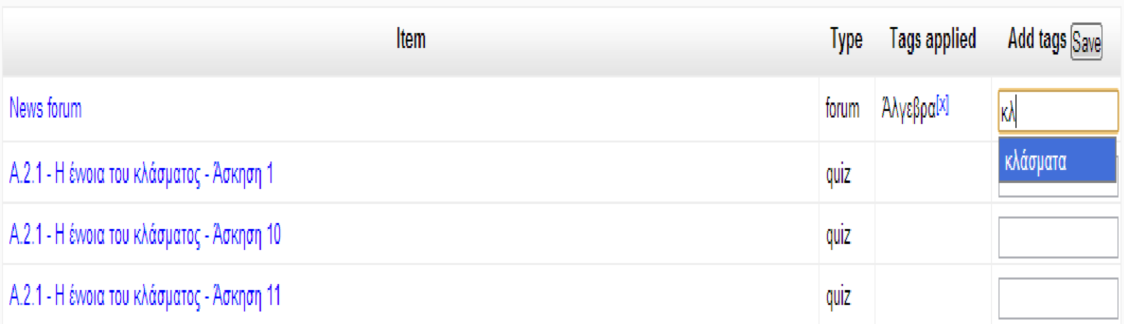
Εικόνα 7



Εικόνα 8

Μόλις ο καθηγητής έχει δημιουργήσει το δέντρο που επιθυμεί επιλέγει το submit, ώστε να καταχωρηθούν οι έννοιες στο σύστημα.

Στη συνέχεια ο καθηγητής θα πρέπει να επιλέξει ***«Edit Concept Tags»*** για να αντιστοιχήσει τις εκπαιδευτικές πηγές του συστήματος με τις έννοιες:



ΕΙΚΟΝΑ 9

Σε αυτή τη φόρμα ο καθηγητής πρέπει να πληκτρολογήσει την έννοια που αντιστοιχεί στην κάθε πηγή. Οι έννοιες που έχουν οριστεί στο δέντρο από το προηγούμενο βήμα, παρουσιάζονται ως προεπιλογή στον καθηγητή και μπορεί να τις επιλέξει. Ωστόσο, εφόσον ο καθηγητής το επιθυμεί μπορεί να πληκτρολογήσει έννοιες που δεν υπάρχουν στο δέντρο ιεραρχιών. Οι έννοιες αυτές εισάγονται στο δέντρο αυτόματα χωρίς πληροφορία για τη θέση τους μέσα στην ιεραρχία. Έτσι ο καθηγητής σε δεύτερη φάση θα πρέπει να καθορίσει την θέση τους στο δέντρο εννοιών όπως παρουσιάζεται παραπάνω.

Δίνεται επίσης η δυνατότητα να διαγραφούν έννοιες που έχουν ήδη συσχετιστεί με πηγές, πατώντας το **Χ** που βρίσκεται δίπλα στην έννοια, στη στήλη «Tags Applied».

Η λειτουργία ***«Navigate by concept tags»*** *δίνεται στο μαθητή και στον καθηγητή. Παρουσιάζει τις πηγές της πλατφόρμας ηλεκτρονικής μάθησης, σε ομάδες σύμφωνα με τις έννοιες που τους έχουν αντιστοιχισθεί.*

Βήμα 2: Προσφερόμενη λειτουργικότητα στον καθηγητή και στο μαθητή που προκύπτει από την ιεράρχηση εννοιών και την αντιστοίχηση των πηγών στις έννοιες . (Προς συζήτηση)

Ο μηχανισμός που περιγράφεται στην παραπάνω ενότητα, θα πρέπει να χρησιμοποιηθεί ώστε να παρέχεται κάποια χρήσιμη λειτουργικότητα στους καθηγητές και στους μαθητές. Η λειτουργικότητα αυτή επιθυμούμε να συμβαδίζει με τις νέες θεωρίες μάθησης. Κάποιες από αυτές τις λειτουργίες μπορεί να είναι οι εξής:

Λειτουργία	Μαθητής	Καθηγητής
1.	Δυναμική ανατροφοδότηση. Προτάσεις σύμφωνα με τις επιδόσεις του μαθητή , και την θέση της άσκησης στην ιεραρχία εννοιών	Θα πρέπει ο καθηγητής να έχει την επιλογή να παραμετροποιεί τη συγκεκριμένη λειτουργία. Π.χ. από πιο ποσοστό και κάτω γίνονται υποδείξεις στο μαθητή για επανάληψη; μετά από πόσες ασκήσεις προτείνουμε να συνεχίσει ο μαθητής το επόμενο κεφάλαιο; **Τι άλλο πιστεύουν οι εκπαιδευτικοί ότι θα ήταν χρήσιμο;**
2.	Πρόσβαση στο υλικό «υπό συνθήκη»(Completion tracking). Δηλαδή η επόμενη ενότητα να «ξεκλειδώνονται» εφόσον ο μαθητής έχει επιτύχει υψηλό ποσοστό , σε πάνω από συγκεκριμένο αριθμό ασκήσεων.	Να μπορεί ο καθηγητής να παραμετροποιεί το ποσοστό επιτυχίας που είναι απαραίτητο καθώς και τον αριθμό ασκήσεων. Να μπορεί επίσης να ενεργοποιεί και απενεργοποιεί την λειτουργία αυτή.
3.	Δυναμική πλοήγηση. Ο μαθητής επιλέγει «ευκολότερη , ίδιας δυσκολίας, η δυσκολότερη» άσκηση και το σύστημα επιλέγει δυναμικά σύμφωνα με την ιεραρχία.	Ενεργοποίηση/ απενεργοποίηση λειτουργίας.
4.		Στατιστικά στοιχεία για τον καθηγητή **(Τι ακριβώς θα ενδιέφερε τους εκπαιδευτικούς; Τι επιλογές – παραμέτρους θα μπορούν να δίνουν ώστε να εμφανίζονται ενδιαφέροντα στατιστικά στοιχεία για τους μαθητές).**

Βήμα 3: Επιπλέον παιδαγωγικές αλλαγές

Άλλες αλλαγές – προσθήκες που έχει προγραμματιστεί να πραγματοποιηθούν στο σύστημα κατόπιν προτάσεων των εκπαιδευτικών, και του επόπτη παιδαγωγικού σχεδιασμού κ. Καλογιαννάκη είναι οι εξής:

- Εμπλουτισμός του υλικού με forum συζητήσεων και συνεργατικών δραστηριοτήτων (wiki, forum), chat, extra activities, νοητικού χάρτη.
- Αναλυτικότερες οδηγίες στις εκφωνήσεις σχετικά με τον τρόπο ολοκλήρωσης της άσκησης π.χ. (πληκτρολογήστε στο πλαίσιο το σωστό αριθμό, drag and drop τη σωστή απάντηση κλπ)
- Να αλλάξουν οι ασκήσεις drag and drop πάνω σε εικόνα ώστε να είναι πιο ευκρινή. Να τοποθετηθεί κόκκινη γραμμή στα σημεία των αξόνων που αντιστοιχεί το τετράγωνο.
- Να αλλάξουν οι ασκήσεις που συμμετέχει ο καθηγητής ώστε να μπορούν να ολοκληρωθούν αυτόνομα από τον μαθητή.

Οι αλλαγές αυτές έχει προγραμματιστεί να γίνουν μετά την υλοποίηση των λειτουργιών που περιγράφονται στο βήμα 2, πριν την παράδοση του τελικού συστήματος.