ACHIEVING EFFECTIVE TEACHING OF MODULE "CHEMICAL KINETICS – CHEMICAL EQUILIBRIUM" WITH THE AID OF AN INTEGRATED WEBSITE

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Abstract. A website has been created, which seeks to bring out the ways in which is possible, a pedagogic technique, based on exploiting the Internet, to achieve the "higher" learning goal, namely the cultivating of critical thinking. It contains chapters with the theoretical material on "Chemical Kinetics-Chemical Equilibrium" and related subunits. They have the appropriate theory and examples that the student should study before proceeding with the questions to check for understanding and the proposed exercises. It addresses the students in order to help them move away from the classical method of learning from the book and on the other hand to help them experiment with the use of the computer, in order to turn the lesson more attractive to all of them. Except for the creation of the website and its structure, various online tools are presented for its implementation. The goal was for the students to understand the theoretical framework that covers the concepts of "Chemical Kinetics-Chemical Equilibrium", to have their active participation and to maintain their interest during the teaching of the subunits undiminished.

Keywords: teaching; internet; website; chemical kinetics; chemical equilibrium

Introduction

The exploitation and use of new technologies are an essential part of the modern world, making necessary the parallel adaptation of the educational process to the new conditions of reality. School, as an organic part of society, must conform with it, having as a consequence the introduction and at the same time, exploitation of new technologies in the educational environment. It is an imperative need and necessary condition for the school to successfully meet the modern requirements of education and training.

New technologies consist the modern capital, the most basic tool of economic production activity, while on the other hand, they form the basis upon which scientific production and communication activity evolves (Kaplan, 2004). ICTs

are characterized by the constant interaction and interdependence of the various media. The adjective "new" signifies the intersection with traditional technologies, which have as a characteristic the development and improvement of each separate means without necessarily being relevant to the rest. A common element of all new technologies is the electronic revolution, in which from the simple reproduction of image and sound has come to television, video and a combination of images of a various nature, such as "real" images and computer images, which can be integrated in every kind of text and sound (Mikre, 2011). New technologies include the management and presentation of any kind of information (hypermedia), its transmission (networks) and the exchange – question and answer – of information provided by the interaction through the internet (Dabbagh, 2005).

The use and exploitation of the ICTs are highlighted as necessary by the professors and at the same time as an integral part of the priority of every candidate or active professor who wants to consider him- or herself pedagogically trained. The various computer education applications are explicitly or implicitly based on psycho-pedagogical theories and theories of learning, namely they are directly related to teaching and learning. In other cases they give emphasis to the improvement of the quality of teaching, namely they are related to the professor and school knowledge and in other cases they focus their attention on the way students construct their knowledge, meaning they concern the student as an active subject who, through the use of the application, builds his or her knowledge (Khine, 2013; Tyner, 2014; Lê&Lê, 2007; Komis&Mikropoulos, 2001; Beldarrain, 2014; Shiratuddin&Landoni, 2002).

The traditional educational approaches, according to which the student remained a passive recipient of information, have been widely criticized. The approach that puts the student at the center of interest through the application of Knowledge Construction Theories has shown to create conditions for more effective learning than other approaches (Shiratuddin&Landoni, 2002; Eskelinen, &Haapasalo, 2007; Goh et al., 2005; Kundi& Nawaz, 2010). Research in the domain of Knowledge Construction Theories has shown that information that is simply transmitted by a knowledge carrier is not integrated into the recipient's previous knowledge structures and is often only approached by using standardized tests and exams (Richardson, 1997). Notwithstanding the foregoing, Goh (Goh et al., 2005) argue that modern teaching planning incorporates both approaches, especially in complex learning processes.

Professors, in combination with a good knowledge of this teaching tool (Flanagan &Shoffner, 2013), should make a careful planning, that defines the framework of teamwork, support, point out the use of learning strategies and apply educational processes that involve students in self-reflection, self-evaluation and collaboration. In addition, flexibility and the design of diversified

assignments are also prerequisites for all students to experience the joy of creativity and feel confidence (Yang, 2009).

The visualization of phenomena is an essential part of Physical Sciences (PS) learning, while at the same time the display of phenomena in a typical teaching process, often aims at the connection of students' mental images to the corresponding principles of Chemistry that govern the respective phenomena. Demonstrations not only allow students to understand how some phenomena are evolving but at the same time provide them with a visual link of the movements with their more abstract descriptions, which traditional lectures usually consider sufficient (Robert et al., 1990). Often, however, the teaching of Physical Sciences (PS) in secondary education is negotiating phenomena that are developing in too short time periods. Consequently, the simple demonstration of these movements can be seen as unable to provide meaningful help in their understanding, as their rapid development does not allow students to create the necessary mental connections between the visual stimulus and the principles that describe it (Beichner, 1995). Thus, even if the presentation of similar movements occurs during the teaching process, students are not in a position to obtain a clear sequence of successive "snapshots" of the movements, and therefore fail to distinguish the finer points of its evolution.

The ability of the use of diagrams may be an important step towards the acquiring of skills in the domain of solving Physical Sciences (PS) problems in general (Brungard & Zollman, 1995). It seems that a significant difference that the experts (scientists) present in comparison to the non-specialists (students) concerning the Physical Sciences (PS) problem management is in their ability to construct and represent physical phenomena using their respective scientific representations (figures, tables, diagrams) (Beichner, 1994). Thus, from the moment that the teaching role of graphic representations is deemed so important, research in the domain of Physical Sciences teaching tried to explore both students' abilities in relation to the use, interpretation and making of kinematics diagrams, as well as the difficulties faced by students concerning these issues (Leinhardt et al., 1990; Thorton et al., 1990).

The Internet is a very important technological innovation of the 20th century in the domain of communication. It is a communicative revolution, while at the same time it constitutes the backbone of global PC-based communication (Kamio, 1997). It is a substantial source of information, knowledge and communication, while at the same time, since its appearance to this day, it has not left any of the aspects of human life unaffected. At the same time, every new technological change brings about significant changes in the way people work and live (Tyner, 2014). Undoubtedly, New Technologies by penetrating all domains of human activity could not leave education unaffected, through which they have made a significant contribution to the teaching of courses at every

level (Atkinson, 1968; Suppes & Morningstar, 1968; Frear & Hirschbuhl, 1999; Kapa, 1999; Mioduser et al., 2000), but have also changed the way of accessing, retrieval and processing of information and communication of all involved parties in the educational process (Livingstone &Bober, 2005).

However, usually technological changes create a conflict with the teaching staff (Kelly et al., 1985) since among the factors necessary for the introduction of any change in education systems, is primarily underlined by the teacher's readiness to adopt and apply innovation in the learning process (Fullan, 1991; Brummelhuis, 1995; Galligan, 1995; Robinson 1997). Surveys reveal an inability of the professors to exploit and effectively use the potential offered by New Technologies (Fisher, 1991; Byard, 1995; Makrakis, 1997; Dawes, 1999) due to their negative attitude or inadequate training (Stein, 2005), deficiencies in technical support and software suitable for each class (Pelgrum, 2001; Jimoyiannis & Komis, 2007; Kalogiannakis & Papadakis, 2007) inadequate Internet access (Kalogiannakis, 2004), the lack of professors' knowledge and skills to integrate Information and Communications Technology (ICT) into the teaching process or the lack of qualified staff to support professors (Cuban, 2001; Law et al., 2008). At the same time, the training of teachers in New Technologies is considered essential in order to acquire skills that will allow their use in the teaching process (Haugland, 2000; Williams et al., 2000; Salguero, 2017; Galanouli et al., 2004).

The reason for the creation of the website responds to the desire of existence of a way of using the computer in teaching, in order to attract the student's interest by escaping the routine while facilitating the work of the professor. The purpose of these experiments is, to make students active and participatory in the learning process, to perceive the nature and functioning of science. Science does not concern only some geniuses, but all people, who should realize that the effort intended to achieve knowledge does not begin and end on rote memorize of the contents of a book but it is a continuous effort that takes place in an environment that includes their classmates, professors, books, computers software and the laboratory.

Methodology

The software used in the creation of the web page, of images (chemical compounds), of interactive exercises and the editing of the video recorded experiments, are as follows: (i) Adobe Dreamweaver CS3; (ii) Hyper Text Markup Language (HTML); (iii) JavaScript; (iv) Cascading Style Sheets (CSS); (v) Adobe Photoshop CS3; (vi) J mol; (vii) Hot Potatoes version 6.0, Half Baked Software Inc; (viii) Chem. Bioffice 2008; (ix) Flash.

Adobe Dreamweaver: Dreamweaver is a powerful design application which offers all the tools we need to get professional quality results. Dreamweaver,

version CS3, support technologies like spry framework for Ajax which includes JavaScript, CSS, and HTML for building interactive user interfaces (Lowery, 2007).

HTML is the acronym for Hyper Text Markup Language and is based on SGML, the Standard Generalized Markup Language, which is a much larger document processing system. HTML defines a set of common styles for Web pages, such as titles, headings, paragraphs, lists, and tables. It also sets character styles, such as boldface and code sections. Each item has a name and is contained within two angle brackets, <> symbols, called tags. When creating a Web page with HTML, we basically give titles to the various elements of the web page with these tags. Browsers, along with their ability to retrieve web pages from the Web, also act as HTML formatters. When reading a web page written in HTML in a browser, the browser reads (interprets) the HTML tags and formats the text and images on the screen (Aronson, 2010).

JavaScript is a scripting language used to add effects and interactivity to websites and is competing with the VBScript programming language. It was created by Netscape and its original name was Live Script. The JavaScript code is written in plain text (ASCII format) and is embedded within the HTML code, while it can be executed immediately or when an event occurs. JavaScript compilation in not needed, as long as the browser supports JavaScript. JavaScript (JS) is a lightweight, interpreted, programming language with first-class functions. JavaScript can function as both a procedural and an object-oriented language. Most well-known as the scripting language for Web pages (Crockford, 2008).

Cascading Style Sheets (CSS) constitute a great tool to change the look and layout of web pages. Cascading Style Sheets is a style sheet language used to describe the presentation of a document written in HTML. Understanding CSS requires some basic HTML experience. CSS does not need a web page editor, such as FrontPage, Dream Weaver or even Word, except for a simple text editor, such as Windows Notepad (York, 2006).

Adobe's Photoshop program is a state-of-the-art when it comes to photo-based bitmap handling. The Adobe Photoshop CS3, which is a versatile image-editing application that is capable of adjusting the look and feel of photos, was used to fix photos in our work. It contains two tool groups one for painting and one for image editing. The editing of an image in Photoshop can result in its sharpening to correct its in-focus range, in its blurring in its background, changing its brightness and contrast, or replacing one color with another. A piece of an image can even be detached as well as copied, changed in its size, and generally be processed as deemed necessary (Faulkner &Walthers von Alten, 2007).

Jmol is an open-source Java viewer for three-dimensional chemical structures, with features for chemicals, materials and biomolecules. It is designed as

a component that can be used as a standalone application, as an object within the context of a web page, or as a display sub-system within a more complicated software package. It supports many file types (pdb, cif, mol, cml), while applets can be embedded in web pages. It offers the dynamic visualization of internal motion and deformation of molecular structures. It allows the motion and rotation of molecules for the better understanding of their structure. The atoms that make up the molecules are displayed in their own distinctive colors so they can stand out. The user is free to manipulate the molecular models, rotate them, move them, and increase or decrease their size to better understand the structure and dynamic nature of symmetry processes and the normal vibrational motions of molecules (Herráez, 2008).

Hot Potatoes was created by the Research and Development team at the University of Victoria Humanities Computing and Media Centre. It is a program that allows you to make six different types of self-test exercises. It is free of charge for non-profit educational users who make their exercises available on the web. The exercises are websites that use XHTML 1.1 for the display and JavaScript (ECMA Script) for the interactivity. These basic W3C templates are supported by all good modern browsers. Authoring tools can also handle Unicode, so exercises can be created in any language, or in a language mix. All that needs to be done is insert the data, such as text, questions, answers and so forth, and the programs will create the web pages. The programs are designed in a way that almost every part of the web pages can be modified, so that when a person has knowledge of HTML or JavaScript, he/she can make almost any change he/she desires in the way the exercises work or intervene in formatting the web pages (Arneil & Holmes, 1999).

Chem Bio Office 2008 is a powerful suite of software which includes many applications and databases with the aim to aid chemists and biologists in managing and visualizing their data from the paper to the computer screen. It is a powerful software package for creating chemical compounds, especially organic, three – dimensional models, reactions, mechanisms, copy - paste sequences at Microsoft Office (Gunda, 2007).

Flash is a leading program for creating and editing vector graphics and animation to be used on the Internet. It gives the ability to users to create integrated multimedia presentations and publish them on the Web. Flash contains a work area, the so-called Stage, which works similar to the stage of a theater, namely it has the equipment needed, as well as the actors who will take on roles. All the action of a Flash movie takes place in the Scenery. The files which are created with Flash are called movies and have the .fla extension, while executable Flash files, which will appear embedded in a web page or can run as standalone applications, have the extension .swf (Adobe, 2010).

Results and discussion

The educational material of the Chemistry course, "Chemical Kinetics-Chemical Equilibrium" was developed and is available to students both in .pdf format as well as in the form of web pages. For example, below is a representative image of an internet page on the Collision theory, which falls within the first chapter. Students, with the aid of the website menu, can be easily transferred to the next subunit on the Collision Theory. The website is set by the professor to open in a new window in the browser used by the students (Fig. 1).

Visual representations attract the attention of students and retain their incentive for learning. They substantially provide an additional way of presenting information and encourage the acquisition of knowledge, which students cannot understand directly from the text alone. In particular, visual representations enhance the retention of information obtained from a topic or concept relevant to the subject, improving thus problem-solving and facilitating the integration of new knowledge by linking it to prior knowledge. In the domain of Physical Sciences, visual representations play an important and decisive role in the way of presentation and analysis of physical concepts or processes. In all chapters, there are visual representations such as diagrams, figures of chemical compounds, and representations of three-dimensional molecules. Below are listed representative images of some web pages of the web-based educational material (Fig. 2 – 6).

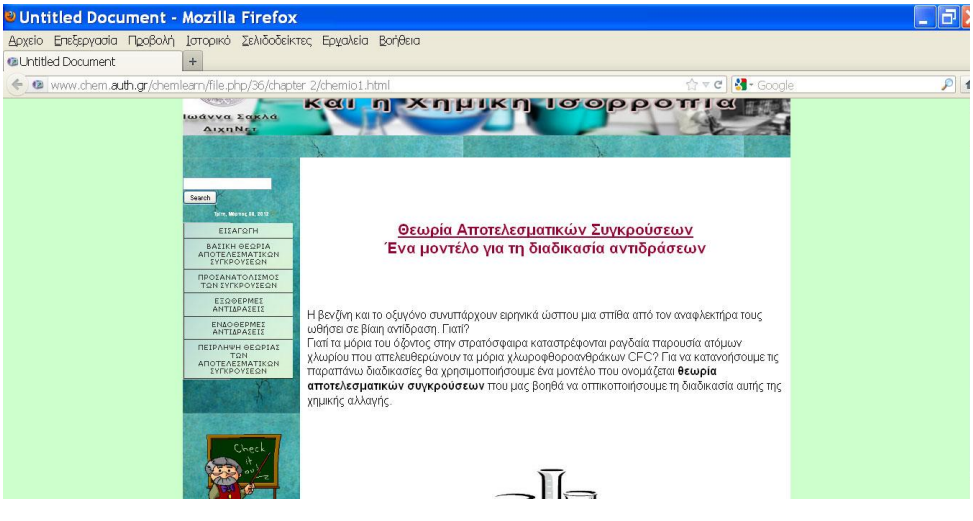
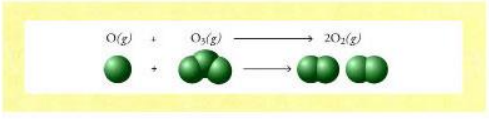
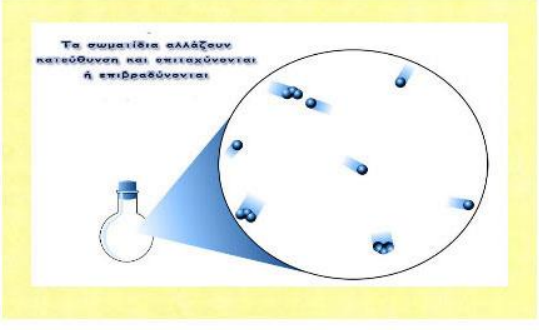


Figure 1.A representative figure of a web page



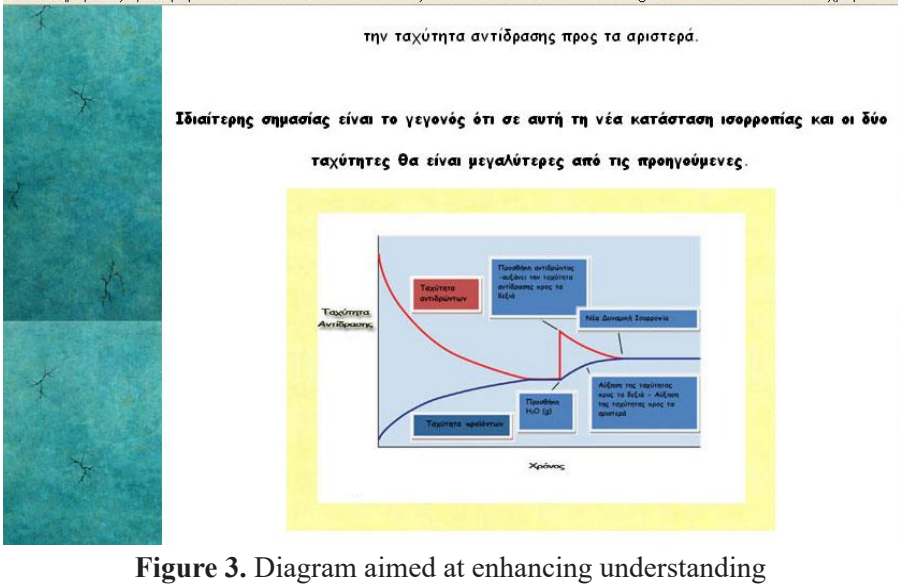
Σχήμα 1. Αντίδραση ενός ατόμου οξυγόνου με ένα μόριο όζοντος

Κάποιες από τις συγκρούσεις μεταξύ των ατόμων του οξυγόνου και των μορίων του όζοντος οδηγούν στη δημιουργία μορίων οξυγόνου ενώ άλλες όχι. Για να καταλάβουμε το λόγο για τον οποίο κάποιες συγκρούσεις είναι επιτυχείς ενώ άλλες δεν είναι πρέπει να εξετάσουμε τα γεγονότα που λαμβάνουν χώρα κατά τη διαδικασία της αντίδρασης.



Σχήμα 2. Μόρια όζοντος O3 και άτομα οξυγόνου O.

Figure 2. Visualization of molecules and reactions



την ταχύτητα αντίδρασης προς τα αριστερά.

Ιδιαίτερης σημασίας είναι το γεγονός ότι σε αυτή τη νέα κατάσταση ισορροπίας και οι δύο ταχύτητες θα είναι μεγαλύτερες από τις προηγούμενες.

Figure 3. Diagram aimed at enhancing understanding

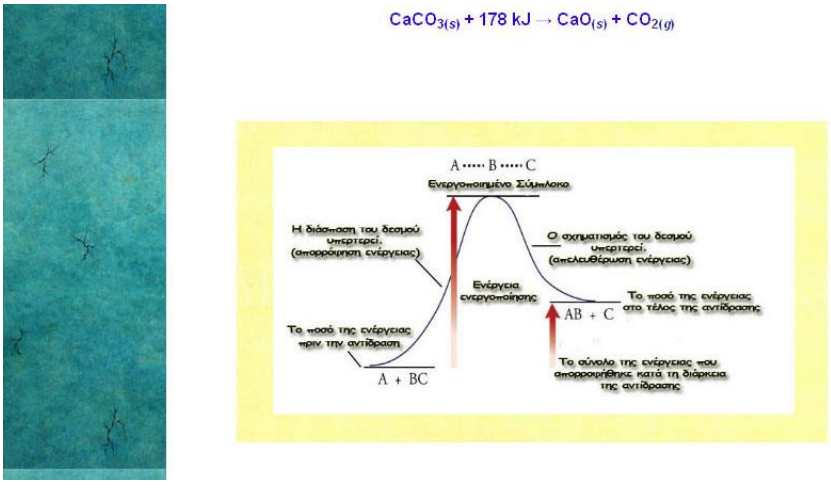


Figure 4. Diagram which attributes to the structuring of new knowledge

The three-dimensional visualization of molecular structures, as well as the dynamic visualization of internal movement and deformation of molecular structures, enables students to move and rotate the structure of molecules in order to achieve a complete understanding of their structure (Fig. 5).

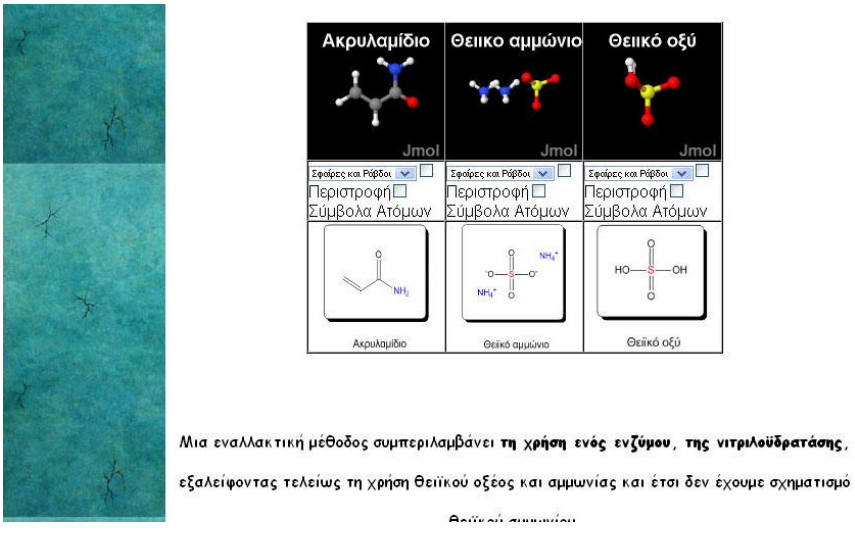


Figure 5. Three-dimensional visualization of molecular structures

Figure 6. Shockwave file

A shockwave file was created, which illustrates the energy changes in the exothermic reaction between buoyancy of methane (CH_4) and oxygen (O_2) in relation to the time. This diagram facilitates the learning and understanding of exothermic reactions by the students because the theory is being visualized (Fig. 6).

The website created included both online educational material with the experimental processes (Fig. 7) as well as videos showing the corresponding experiments (Fig. 8). Students see the theory turning into practice, and there is a specific subunit in the experiment chapters, where safety rules in a chemical laboratory are described.

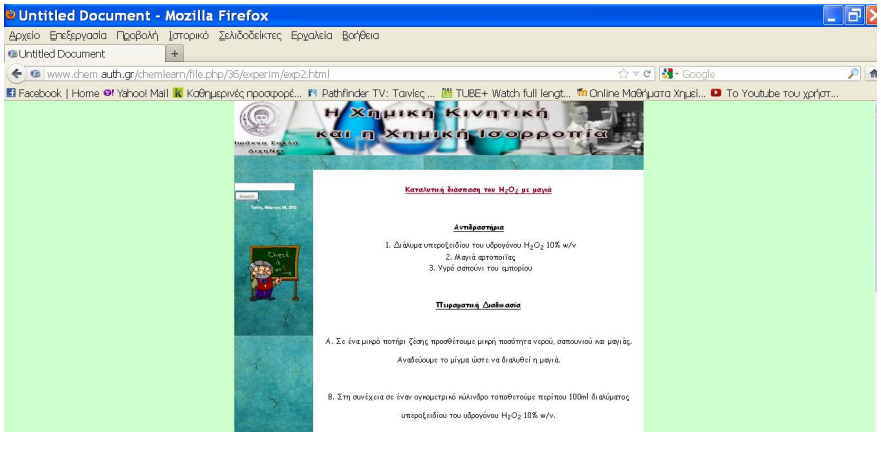


Figure 7. Online educational material

Many students are not familiar with the modern way of learning, with the use of the internet, so it was considered necessary to have the notes of each chapter of the course in the .pdf format in the online educational material (Fig. 9). Among the printable notes can be found the theory of each unit of the chapter, in which there are visual representations, such as diagrams, images of chemical compounds and reactions.

Conclusions

The selection of the website in the learning process has successfully utilized the familiarization of students with the use of computers by integrating the website into an organized learning environment, approaching thus, the purpose of their education in modern Information and Communication Technologies. The lesson gained greater interest, enhanced the creativity of the students, their active participation, it developed skills necessary in a modern school and work environment, improved student-student and teacher-student relationships, adapting to the particularities of each student. The nature of the teaching of the Chemistry course through this specific teaching intervention has been substantially modified in many points. The knowledge of the new thematic module of "Chemical Kinetics-Chemical Equilibrium" was not plainly transferred, but it was built into a collaborative framework, rich in digital stimuli/resources. At the same time, new knowledge was co-built within the class. The learning process got distance from book-centered and teacher-centered, namely professor-centered, approaches and transferred to a student-centered scheme where research, argumentation and collective action skills were cultivated.

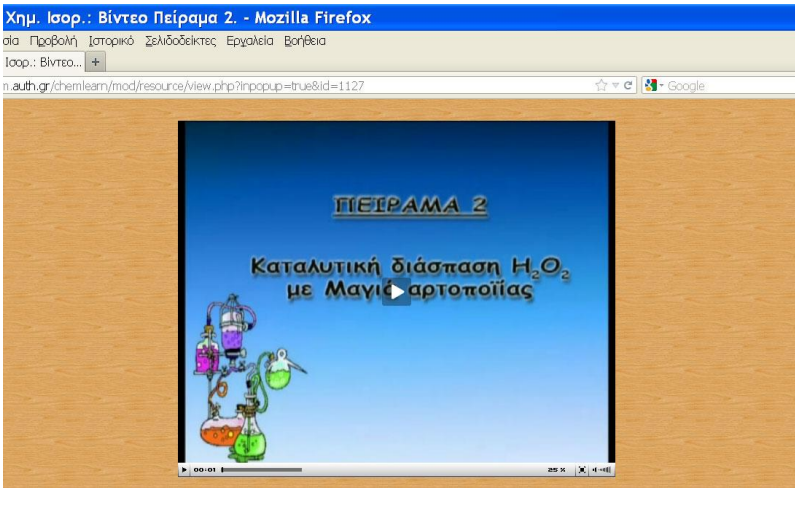


Figure 8. Video of the experimental procedure

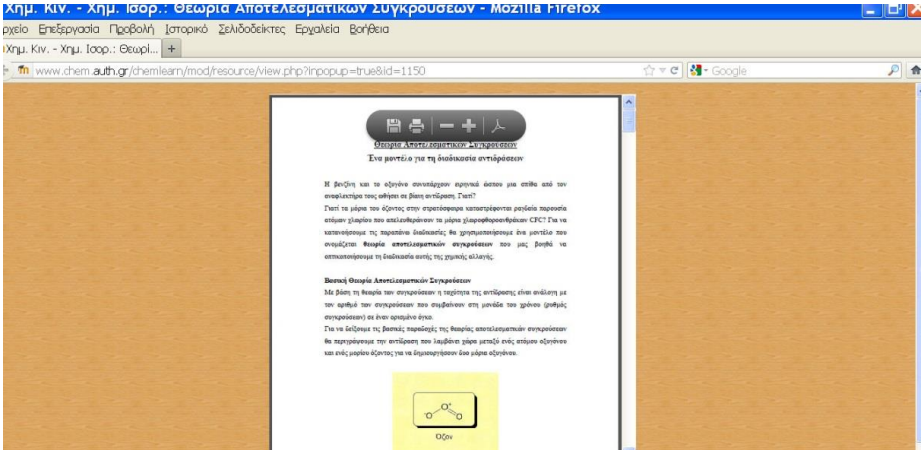


Figure 9. Notes of the theoretical part of the lesson in .pdf format

The creation of visualizations is important because it makes 'visible' the world, a representation of which, high school students and future university students are called to make mentally, something that is impossible to perceive with any of their senses. The success of the integration of Information and Communication Technologies into education requires qualified professors with special skills in choosing the appropriate methods of integrating ICT into the learning process. In order to make this introduction of innovative teaching and learning tool in education as effective and smooth as possible. The designation of computers and, in particular, of the Internet as a "cognitive tool" and the recognition of its contribution to promoting student's critical competence is a powerful incentive to identify their possible interactions. Conclusively, particular emphasis is placed on highlighting the assumption that our students are able to "learn" meaningfully when engaged willingly to carry out a learning activity that is valuable and meaningful to them. The bibliography highlights that unfortunately students do not consistently use the required "Vocabulary" of graphic representations and often exhibit significant difficulties and misconceptions when asked to manage graphical representations (McDermott et al., 1987). It is the fact that has been confirmed by this survey.

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