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Inspiring Students' Enthusiasm with the Help of Educational Videos for the More Effective Teaching of "Chemical Kinetics and Chemical Equilibrium"

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Abstract

Modern educational reality commandeers the use of Information and Communication Technologies during the teaching process in order to exploit the opportunities offered by the Internet and open-source software in education.
In this paper are presented some video recorded educational experiments for the teaching of "Chemical Kinetics-Chemical Equilibrium". Students will be able to "see" real phenomena through these videos, even in a directed way, which in turn will contribute to the discovery of the chemical equations and laws of Chemical Kinetics by them. The idea of this paper was caused by the need to create an activity that approaches chemistry and, more specifically, the module of "Chemical Kinetics-Chemical Equilibrium" holistically and not just as one more course. The purpose is the projection of the experiments so as to trigger a constructive discussion concerning their content, among students, while at the same time to help them discover new knowledge, the beauty of chemistry and its existence in a variety of forms and expressions of everyday life.
The conclusion of this research is the fact that the development of innovative learning activities within the framework of the teaching of "Chemical Kinetics-Chemical Equilibrium" thematic module is imperative for exploring environments that can be exploited appropriately for the easier acquisition of knowledge. Also, the concepts of interactivity and interaction in collaborative contexts with the use of visual information can mobilize and offer more cognitive abilities in comparison to conventional methods.

Keywords: Chemical Kinetics; teaching; self-evaluation; educational videos; Chemical Equilibrium.

1. Introduction

Teaching with the means of Computers can serve fundamental purposes and goals of modern teaching, contributing to the development of social skills that are precious assets, necessary for the citizen of modern, globalized multicultural society. Modern teaching is aimed both at developing critical thinking and at constructing the consciousness of democratic citizens who recognize their identity and understand the diversity in the modern world. The multiperspective approach of events through sources, which are not considered as evidence of the past, supports the supervisory and experiential nature of teaching and contributes to the development of empathy among students.

In terms of teaching methodology, to the achievement of the above mentioned goals contribute the modern collaborative and experiential learning techniques (brainstorming, case study, simulation, field research, interview with specialists [1-4] They reinforce the motivation for learning and at the same time they can activate the educational potential of the classroom, which exhibits a wide range of diversities as to their type of intelligence [1] but also their learning needs.

Video recorded educational experiments are of particular interest because the existence of a variety of digital materials such as figures, sounds and videos, that are available on the internet, allow professors a new pedagogical approach. An approach that visualizes, through color figures and sounds, difficult to understand points of a distant and perhaps not very readable chapter of the school handbook. This approach is based on the logic of mixing the various media in order to produce multimedia presentations (mashups). Based on the logic of Web 2.0, professors can create digital texts, such as digital compositions consisting of spoken and written language, music, static and animated images. This is important because it allows the professor to combine existing material to create the new one by adapting it to the needs of his/her audience. At a first step, the professor has the ability to meet his/her teaching needs and also to support his/her teaching with a video. It substantially creates a fuller and more multimodal presentation. In this case, the professor does not reproduce a digital text developed by someone else for him/her. Instead, the professor produces a digital text

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giving the emphasis he/she wishes to the subject under consideration that best serves his/her teaching plan.

The choice of the “Chemical Kinetics-Chemical Equilibrium” module was based on the fact that it covers a significant part of the curriculum of the school Chemistry Course, in the past and more specifically of the Chemistry course of the second grade of Lyceum and afterwards, of the third grade of Lyceum in the sciences orientation group. It presents several learning difficulties regarding the differentiation of the reaction rate and the rate of product formation or the rate of consumption of reactants. The rapid changes and the abundance of factors affecting a chemical reaction make it prohibitive to perform classical laboratory exercises in a Lyceum Chemistry laboratory [5].

In the course of the module of “Chemical Kinetics-Chemical Equilibrium”, graphs are used. The use of graphs brings difficulties to students (a fact that follows them to tertiary education), these difficulties concern the handling of graphical representations for studying, forecasting and extraction of quantitative and qualitative conclusions. Special emphasis should be placed on the educating but also the teaching contribution of the experiment in the teaching of the two modules (“Chemical Kinetics-Chemical Equilibrium”), but the combination of the limited time for the experiments and the inability to process the results of the classical experimental method, makes the use of video recorded educational experiments an innovation of particular importance in achieving educational goals.

2. Material and method

The starting point for the design and creation of the video recorded educational experiment was the realization of the misunderstandings that arise during the teaching of the chapter “Chemical Kinetics-Chemical Equilibrium”.

The main source of the problem is that the appropriate methods for teaching the course have not been secured. Of the number of factors that may be responsible for the ineffective teaching of the course the following are noted: 1) The old-fashioned way of delivering the course, with the absence of technology and adherence to the traditional school handbook. 2) The monotonous and unilateral approach to the subject, as the teaching is not adjusted to the interests and the daily routine of the students, so as to motivate them towards active participation within the theoretical approach of the course.

According to bibliographical references concerning the module “Chemical Kinetics-Chemical Equilibrium”, problems concerning the understanding are according to Nahum and Barker [5-6] both the transition and the approach materials and phenomena of the macroscom to the microcosm. According to Brooks [7], the problem is the instant-fast reaction. Students have the illusion that almost every chemical reaction takes place instantly. This illusion results from the examples of high school chemistry as well as from the reactions that professors often use, in order to save time, which have very high speeds. The mechanism of a reaction can cause some problems. These problems are the result of the absence of "pictures" concerning the reaction kinetics. Consequently, students are unable to understand that some steps of a chemical reaction play a decisive role in the reaction rate, while others do not. [8]. Misunderstandings that concern “Chemical Kinetics-Chemical Equilibrium” are due to the fact that both professors and some books tend to confuse the two concepts, something that has as a consequence the enhancing of alternative views for students. Thermodynamics is expressed through an equilibrium constant and is about whether a reaction will take place, while kinetics are expressed by the rate of the reaction, and hence the rate at which the reaction will take place [9].

Given the pedagogic design, the relevant material was collected from various sources (global web, documentary) and the script was recorded. This was followed by the processing of the unedited digital material gathered to fit it into the final video. This material was edited with image editing programs such as GIMP, audio editing program, such as Audacity and video editing program, such as Blender. For the experiments, simple materials of everyday use were selected, as described, in order to connect knowledge with everyday experience. Video recorded educational experiments have a catalytic role in the approach of the experiential dimension of experimental learning.

The creation of the final video encountered a variety of difficulties, both in the design and technical parts. The technical difficulties for the creation of the video recorded educational experiment were related to the familiarization with various software, such as software concerning the recording, editing and mixing of audio, editing a video, as well as blending the individual elements of the video.

3. Results and discussion

In the present paper, video recorded educational experiments are suggested and presented accompanied by text, figures, video and audio, and the procedures for performing the experiment are presented step by step. The experimental study of the phenomenon of “Chemical Kinetics-Chemical Equilibrium” is of particular interest with the contribution of the use of the computer. An important advantage for the study of the phenomenon is the ability to temporarily stop the video recorded educational experiment to give the necessary explanations of the phenomenon and then to repeat exactly the same movement.

3.1 Catalytic decomposition of hydrogen peroxide (H_2O_2) by potassium iodide (KI)

The first experiment is the catalytic decomposition of hydrogen peroxide (H_2O_2) by potassium iodide (KI). The reagents to be used are: hydrogen peroxide solution H_2O_2 10%w/v, KI 0.1M potassium iodide solution and commercially available liquid soap. The experimental procedure is as follows: initially, in a volumetric cylinder are placed about 100ml of hydrogen peroxide solution H_2O_2 10%w/v. A small amount of commercial liquid soap is then added and at the last step of the experimental procedure, the catalyst is added, which is none other than the potassium iodide solution KI 0.1M. Strong foaming is observed to generate from the solution.

The reaction is carried out as follows (1):

$$2H_2O_2\,(aq) \longrightarrow 2H_2O(l) + O_2(g) \qquad (1)$$

During the reaction, water ($H_2O(l)$) and oxygen ($O_2(g)$) are produced by the decomposition of hydrogen peroxide. This catalyst-free decomposition is not readily accomplished; therefore, potassium iodide was added as the catalyst. It is noted that by adding a catalyst, the reaction rate increases. The soap that has been added facilitates foaming and creates bubbles, in which oxygen is bound. For this reason, impressive foam is created, which is also called Elephant Toothpaste (Fig. 1.).

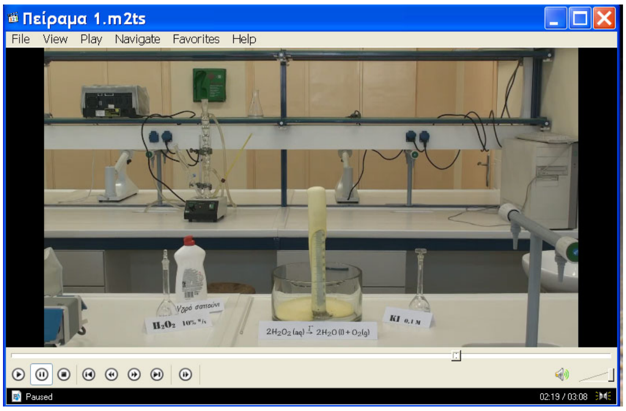

Fig. 1. Production of elephant toothpaste.

3.2 Catalytic decomposition of hydrogen peroxide (H_2O_2) by yeast

The second experiment is the catalytic decomposition of hydrogen peroxide (H_2O_2) by yeast. The reagents to be used are the hydrogen peroxide solution (H_2O_2) 10%w/v, bakery yeast, as well as commercial liquid soap.

The experimental procedure is as follows: A small amount of water, soap and yeast is added to a small glass beaker. The mixture is stirred so as to dissolve the yeast. Then, in a volumetric cylinder are placed about 100ml of hydrogen peroxide solution (H_2O_2) 10%w/v and finally, the above mixture is placed in the volumetric cylinder with hydrogen peroxide. An eruption of intense foaming is observed in the solution.

The reaction that occurs during the experimental procedure is as follows (2):

$$2H_2O_{2(aq)} \xrightarrow{\text{yeast}} 2H_2O_{(l)} + O_{2(g)} \quad (2)$$

During the reaction, water ($H_2O_{(l)}$) and oxygen ($O_{2(g)}$), are produced by the decomposition of hydrogen peroxide. This decomposition without a catalyst is not easy, so baking yeast, which is a kind of fungus, was added as a catalyst. The soap that has been added facilitates foaming and creates bubbles in which oxygen is bound. For this reason, impressive foam is created, which is also called elephant toothpaste. It is therefore concluded that the added catalyst increases the rate of the above reaction (Fig. 2.).

3.3 Effect of temperature on the reaction rate between copper sulfate ($CuSO_4$) and iron (Fe).

The next experiment is about the effect of temperature on the reaction rate between copper sulfate and iron. The necessary reagents are copper sulfate solution ($CuSO_4$) 0.1M and iron filings (Fe) or an iron nail.

The experimental procedure is as follows: initially in two test tubes is shared a small amount of 0.1M copper sulfate solution ($CuSO_4$) and then a small amount of iron (Fe) filings is added to both test tubes. The reaction in the first test tube proceeds at ambient temperature, while the second test tube is heated using a blowtorch or a portable camping stove.

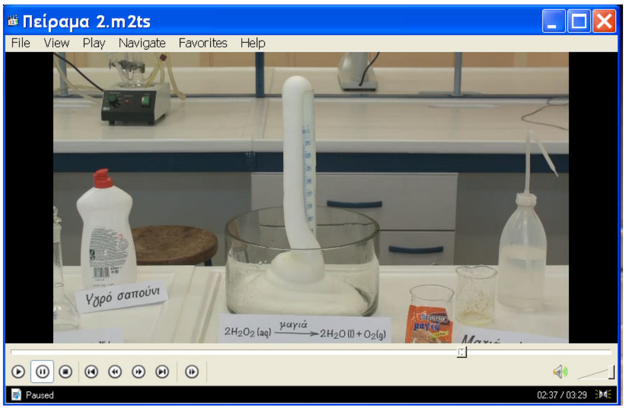

Fig. 2. Production of elephant toothpaste.

The heated solution is observed to change color faster than the solution at ambient temperature. The heated solution obtained a green color turning from the initial blue, while the iron filings were reddish-colored.

The reaction is as follows (3):

$$Fe + CuSO_4 \rightarrow FeSO_4 + Cu. \quad (3)$$

The solution was colored green from initially being blue because iron sulfate (FeSO4), was produced which is green. The iron filings were colored red due to the produced copper (Cu) which is red. The rate of reaction in the heated tube is greater because the increase in temperature causes greater mobility of the reactants' structural particles, thereby is increases the effective impact between them. It is therefore concluded, that the increase in temperature causes an increase in the reaction rate (Fig. 3.).

Fig. 3. Production of iron ammonium sulfate.

3.4 The reaction of potassium permanganate ($KMnO_4$) with glycerol

The next experiment is the reaction of potassium permanganate ($KMnO_4$) with glycerol. The reagents to be used are powdered potassium permanganate ($KMnO_4$), potassium permanganate ($KMnO_4$) in the form of crystals as well as glycerol.

The experimental procedure to be followed is: Firstly in two petri dishes are placed a small amount of potassium permanganate in the form of powder and in the form of crystals, are placed respectively. Then, with the aid of a pipette, a drop of glycerol is simultaneously added to the two petri dishes on the potassium permanganate ($KMnO_4$) (Fig. 4.). The creation of a flame is observed.

The reaction is as follows (4):

$$14KMnO_4 + 4C_3H_5(OH)_3 \longrightarrow 7K_2CO_3 + 7MnO_3 + 5CO_2 + 16CO_2 \quad (4)$$

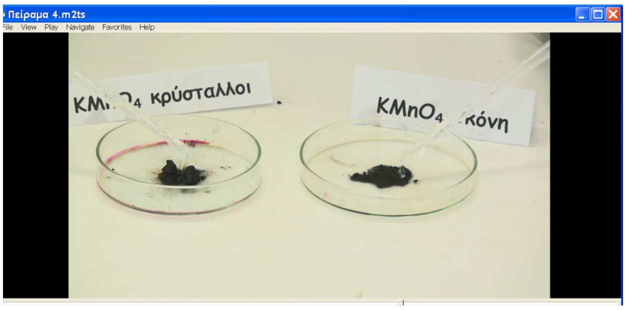

Fig. 4. Simultaneous addition of glycerol.

Potassium permanganate ($KMnO_4$) is a strong oxidizing agent and glycerol is very easily oxidized, resulting in a redox reaction which is exothermic and flame-induced. It is noted that in the petri dish with the powdered potassium permanganate ($KMnO_4$), the reaction takes place faster (Fig. 5) than in the petri dish with the potassium permanganate ($KMnO_4$) in the form of crystals (Fig. 6). It is therefore readily concluded that the greater the contact surface of a solid reactant, the greater the rate of the reaction with a liquid reactant.

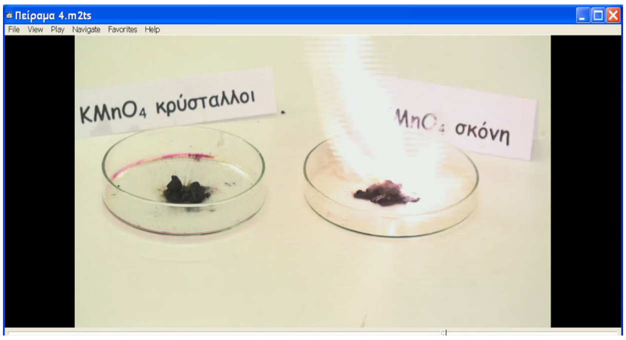

Fig. 5. Creation of flame in the petri dish with $KMnO_4$ in powder form.

Fig. 6. Creation of flame in the petri dish with $KMnO_4$ in the form of crystals.

A questionnaire with 6 questions was answered by undergraduate students from the department of Chemistry of the Aristotle University of Thessaloniki, Greece. The collection of primary material, using the questionnaire method, took place in the period from February 2018 to February 2019. Closed-type questions were selected in order to make it faster to complete and process its data. All questions were scaled questions with a 5-point rating. The scale chosen for this research was the Likert [10-12]. Also, particular attention was given to clarity. The questions were brief and explicit. Negative questions were avoided as they can lead to misunderstanding, in that the negative word may be overlooked and the respondent gives an answer that is contrary to his/her true opinion [10-12]. The results obtained are illustrated in Fig. 7.

Educational material	**1**	The educational material for Chemical Kinetics and Chemical Equilibrium helped you: to understand the definitions.
	2	The educational material for Chemical Kinetics and Chemical Equilibrium helped you: to use the experiments.
	3	Based on the Chemical Kinetics and Chemical Equilibrium educational material, you consider: are necessary for the teaching, the thematic unit Chemical Kinetics and Chemical Equilibrium
Reliability Index Cronbach's Alpha 0,894	**4**	Based on the Chemical Kinetics and Chemical Equilibrium educational material, you estimate that: If this Chemical Kinetics and Chemical Equilibrium educational material is applied universally, there will be a progressive improvement in education quality.
	5	Educational material for Chemical Kinetics and Chemical Equilibrium helped you: to understand the need for a holistic approach to Chemical Kinetics and Chemical Equilibrium.
	6	Chemical Kinetics and Chemical Equilibrium educational material helped you: To take personal action on Chemical Kinetics and Chemical Equilibrium in your everyday life.

Fig. 7. Verifying the reliability of educational material.

To control reliability of the factorial structure, for these thematic units, the Cronbach's Alpha index was calculated, values greater than 0.7 are considered satisfactory [13]. Because Sig is 0.000, the statistical results of the anova analysis (Table 1) are statistically significant. The value of the statistical F indicates the significance of the relations between the variables and the significance of the model, which in this case is high acceptable.

Table 1: Anova analysis

	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	34,638	13	2,664	9,189	,000[b]
	Residual	20,586	71	,290		
	Total	55,224	84			

4. Conclusions

The challenge that education faces on the dawn of the third millennium is the constructive use and integration of new technologies into the educational process. The development of educational material using educational videos and its teaching approach methods through advanced technology applications is indeed an undeniable prospect for education. The educational material developed and the particular teaching methods proposed will be a solid step in this direction.

The objective is the achievement of the individual teaching and pedagogical goals and the increase of the efficiency of the learning process. Moreover, the purpose of the educational research is to transfer the results of the research projects directly and productively to the educational process.

It is considered particularly useful for students to study collaboratively and interdisciplinarily when it comes to the fields of study, as their multiple benefits focus on communication skills, self-reflection on common issues and the interconnection of the knowledge already possessed by each as a separate entity to achieve a common goal. It is important that children learn to collaborate and learn together already in the classrooms to collaborate and learn together, as school is considered the preparatory step of a person in society.

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