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Using ITC in scientific teaching

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Abstract

The paper is a study in the usage of modern IT in interdisciplinary teaching of notions featured in the physics and chemistry curriculum. It encompasses specifically the study of „THE IDEAL GAS LAWS" and their real life applications, as well as „WATER ELECTROLYSIS" (8th and 10th grades respectively).
The crucial teaching-learning-evaluation chain of a lesson is comparatively analyzed within the „traditional" and „modern" lessons respectively, the last one making use of didactical means such as:
• interactive sequences of the „Elements of thermodynamics and molecular physics" educational software, which is part of the AEL platform, a SIVECO Romania product;
• virtual physics lab – the web-site http://www.jersey.waregon.edu

Keywords: modern education, creativity, e-learning, interdisciplinary, interactivity.

Introduction

Globalization, the new technologies and demographic development mean important changes. A solution to this problem is "life-time learning" according to Jan Figel, European Council for education, culture and multi-linguism.

The challenges of the 21st century: continuous training, "life-time learning", the introduction of IT in all fields, human communication, tolerance and free access to knowledge, cultural and scientific values of mankind teachers' special qualities, their readiness to take part in the professional and social education of youth.

The permanent redefinition of educational quality, the efficiency of the educational process, European integration, the quality of the lesson turned into added plus value represent features of an open, dynamic and democratic society which we want to become.

The efforts of the managing team are steadily directed towards the fulfilling of our VISION, namely training our graduates as people with flexible thinking, with all round knowledge in addition to their specialty, like to develop their creative potentiality in any field.

Our MISSION combines the material and human resources of our whole team for the meeting of the following objectives:

- the use of education in lesson as well in all educational activities;
- the encouragement of COMPETITION, HIGH ACHIVEMENT, SCHOOL PROGRESS, the improvement of the curriculum and the setting up of optional courses likely to learn to individual training and stimulation of values.

Our MISSION is carried out through:

- human resources: teachers, the managing team, pupils, who show their dynamic attitude in the educational process;
- the material stimulation of students' and teachers' high achievements through prizes and trips abroad financed by sponsors.

The objectives of the ICT implementation strategy at "Tudor Vianu" National High school of Information Technology

• Student centered teaching – an essential objective in making a performing educational system

The specialized literature, the experience gained during the design and the implementation of interactive lessons places the student in the centre of the teaching – examination process.

• What is student-centered education?

The pupil is encouraged to create, understand and connect all of his/her newly acquired knowledge. [1] Students will be more motivated to learn when they have direct contact with international content. Pupils won't learn information by heart, instead they'll understand and practice anything they learn as 'co-creators' in the teaching – examination process. [1]

• What are the benefits of student-centered education?

The student doesn't directly receive raw information; instead he experiences it through didactic activities created by the teacher. The pupil is implicated in the process with his own efforts. The "student-centered teaching" is the attribute for success in the student-teacher team.

• How do we create student-centered teaching?

The teacher leads the teaching-examination process, designs the layout of the lesson thus helping the student to 'learn how to learn'.

• What are the steps needed to accomplish this kind of lessons?

The teaching-examination process needs to be accomplished by the student-teacher team, needs to be active and each didactic activity needs to be authentic, specific and oriented towards applications that will attract the student.

If applied to exact sciences, the student-centered teaching has pointed out the usage of teacher designed "lessons plans", depending on the type of lessons. The didactic strategy consists in teaching the subject in a logical way so that the student is "guided" through heuristic conversation by the teacher. The questions address the whole class and the students, alone or in groups, search for the answer (this is the road towards teaching and applying the "student-centered lesson" model).

Modern teaching puts the student in the center of the educational process that is designed, applied and analyzed by the teacher.

Self-evaluation will determine the teacher to choose the best strategy for the future, depending on each class, group or student's capabilities. The modern didactic designing will stimulate the student-teacher team to efficiently solve the work tasks creatively. Therefore, during the "Oxygen" lesson that takes place in the 8th grade the pupils could rigorously understand the physical and chemical phenomena they encounter during direct or virtual lessons, depending on the location where the lesson takes place.

The precision with which the professor sets the operational objectives of the lesson, designs the didactic activities (teacher – student) and interprets the feedback, will influence the "success" of the lack of "success" of the lessons. In comparison, the 'traditional' lesson about "Oxygen" had a success rate of 60%, while the "modern lesson" that determines the student to continuously work for 50 minutes had a spectacular result.

Applying modern didactic strategy, by using the AEL platform, "the didactic project " – THE OXYGEN – makes the pupil capable of communication and permanent collaboration, helps him to consolidate his knowledge by formulating questions or answering the open questions he is asked.

By dealing with the practical activities, explaining the electrolysis phenomenon, the way of obtaining the hydrogen and oxygen from the electrolysis of water, refreshing the knowledge achieved in physics and chemistry, virtually simulating a physical-chemical phenomenon (the electrolysis of bubbly water), outlining all the chemical properties of the oxygen lead to a full participation of the student in the team he works in.

The groups of students, coordinated by teachers, know that during the continuous evaluation (7 minutes), placed at the end of the class, they will obtain spectacular results and so the operational objectives settled by the teacher would be accomplished 99-100%.

These are described in details in the "Oxygen" Didactic Project. The described lesson is based on an extremely well known didactic method, but which has a very poor level of usage and that is "I know – I want to know – what have I learned?"

On the way through the didactic project described above, it is easy to notice:

- The "teacher – students" team is strong and provided with a high level of communication
- The scientific content is carefully selected, is presented in a suggestive way, by making the pupil take part in the rediscovery of every new element of content

The elements of the virtual simulation (the electrolysis of the water, the burning of non-metal substances in oxygen, the oxygen circuit in nature), interactively displayed, transform the student into a “full participant” in the teaching – learning – evaluating process.

By the end of the lesson, both the student and the professor will have known:

- We know/we used to think we know
- What we want to know
- What we have learned

These gaps are filled in by each and every student and this will lead the “teacher – pupils team” to imagine easier the following step.

Throughout the lesson, the persistent interactivity (educational software to student, student to students, student to teacher) will stimulate the pupil for: his imagination (finding real solutions to the presented problems), his level of applying the studied aspects, the development of his possibility to work efficiently, during a certain time limit with a maximum efficiency in the team.

The interdisciplinary study of the thermodynamics – the laws of the ideal gas – studied in chemistry in the 9th grade and in physics in the 10th grade, has highlighted, by using the ICT methods, the necessity of preparing the teachers in the TIC area.

The ability of using ICT, as shown in the Strategy of Lisbon, is seen as a new form of “digital education”, which, together with the classic forms, helps everyone to participate in the society of information. The professor has the role of selecting the digital resources of learning. Therefore, depending on the pupils, he/she can use:

- AEL Laboratory – virtual platform – a closed system available for every school and high school from Romania
- Informative materials created by the teacher
- Digital didactic methods from high-level universities around the world

This way, the present study provides a comparison regarding the use of these learning methods, dedicated to “The laws of the ideal gas”.

The utilization of the AEL virtual platform in the study of the laws of ideal gas has turned to good account:

- A run through scientific notions concerning the isothermal, isobaric and isochoric transformations of an ideal gas
- The student, helped by the teacher, will have a run (according to the didactic project elaborated by the professor) through the virtual didactic activities involved in the making of the virtual experiments, so as, for each and every transformation, the team, consisting of 2-4 pupils, would be able to deduce the laws of the ideal gas (the law of the isothermal transformation T-constant, the law of the isobaric transformation P-constant, the law of the isochoric transformation V-constant)
- The way of learning is chosen by the group of students under the guidance of the teacher. Hence, the didactic activities proposed in the worksheet determine pupils to understand the studied notions, to update the notions studied in physics and chemistry, to put into operation the deduced laws on certain issues.
- The exercises and the applications contained by these methods of study will enable the student to understand the necessity of being aware of these scientific notions (applications in the real life, applications in the industry), leading to the development of his creativity.
- The teacher has the role of coordinating every didactic activity proposed, is active and creative. Thus, he can introduce activities in order to stimulate the children’s imagination, making them consider a lesson as a “quest” for knowing the real world and for improving its quality. In the traditionally built lesson, all the student does is to study the laboratory experiments (the transformations of the ideal gas), without having the chance to concretely complete the experimental determinations in a limited time (a class lasts no more than 50 minutes).
- By adapting the informational support to the operational objectives of the lesson, the “teacher – student team” will obtain an outstanding efficiency. The feedback will emphasize student’s ability to apply and operate with the studied notions.

• The study compares and contrasts the results obtained in the continuous evaluations of a “traditional lesson” and those of a lesson in which the ICT methods are used, by focusing on the following issues:
1. the amount of reservation of the scientific concepts
2. the amount of applicability of the studied notions
3. students’ ability to explain the natural phenomena based on the studied laws
4. students’ ability to create and solve and proposed exercises
5. the results obtained in the summative evaluations
6. students’ ability to take part in the improvement of the utilized ICT didactic methods

Table 1: Modern lesson vs. Traditional lesson.

“TRADITIONAL” LESSON (the study of the ideal gas)	ASPECT	“MODERN” LESSON (the study of the ideal gas)
40%	1	80%
35%	2	80%
40%	3	80%
50%	4	90%
grades > 900 40%	5	Grades > 900 90%
-	6	1-2 students propose solutions

National College of Computer Science “Tudor Vianu” educational project: The laws of ideal gas

• Didactic project
Subject: Chemistry 9th grade
Physics 10th grade
Teacher: Silvia Moraru
Topic: The laws of ideal gas
Type of lesson: Acquiring new information and knowledge
Takes place in the chemistry laboratory, physics laboratory, AEL, 2hours
• Reference objectives
At the end of the lesson the student will be able to:
1. To use the terminology and the scientific conventions regarding the ideal gas
2. To lead experimental operations in the laboratory to study the isothermal process and isobaric process.
3. To classify and represent the observation/data resulted after performing the experimental activities (real/virtual)
4. To identify the cases of the transformation of the ideal gas in real life
• Operational objectives
At the end of the lesson the student will be able to:
O1: explain and state the law of the isothermal process
O2: explain and state the law of the isobaric process
O3: explain and enunciate the law of the isochoric process
O4: identify each case in which they should use each transformation (T = ct; P = ct; V = ct) and to solve the proposed problems
O5: to explain the technical applications of this transformation of the ideal gas
O6: to do the experimental activities real/virtual for the three transformations (T = ct; P = ct; V = ct;)
• The development of the lesson:
1. Accomplishing the didactic project
2. Organizing and preparing the class
3. The announcement of the subject
4. The announcement of the wanted effects
5. Preparing the self-evaluating test
6. Preparing the sheet which contains the homework Means

7. The multimedia equipment (PC, Video projector, screen)
8. Educational software
   • Didactic strategies

Didactic methods:
1. Dialogue
2. Explanations
3. Problematization
4. Observing, explaining and analyzing the experiments (real/virtual)
5. Completing the worksheet during the class

Didactic means:
1. The physics /chemistry book
2. The notebooks
3. The worksheet
4. The educational software

For the „Performance team" using the most popular mean of communication „The internet"

For studying this theme „THE LAWS OF THE IDEAL GAS" in the virtual lab.

The basis of this lesson presents:
1. The features of the ideal gas
2. The definition of pressure and the unit of measurement (IS and others)
3. The AVOGADRO law
4. The law of the ideal gas (establishing R)
5. Applications concerning to find out the molecular mass

Presenting the transformation of the ideal gas

Table 2: A lesson plan.

Didactic Event	Activities		Subject of the activities	Evaluation Items – 10 minutes
	Teacher's job	Pupils' job		
	Establishes the schedule of the lesson and builds didactic activities considering the accomplishment of the operational objectives	The student answers to the teacher's questions (having in mind previously acquired knowledge)		
	The teacher prepares the sheet and the test (for realizing the feedback)			
	The teacher leads to achieving the operational objectives O1	The students work individually the didactic activities on the sheet A1a,A1b,A1c,A1d,A1e	M1 AEL M2 AEL	I 1
	O2	A2a,A2b	M3 AEL M9 AEL	I 2
	O3	A3a,a3b,a3c	M11 AEL	
	O4	A4a,A4b		I 3
	O5	A4d		
Measuring performance	Evaluate and comment the answers	Analyze the answers of their colleagues and argue about it		
Accomplishing the transfer	Propose for solving three items*checking two essential objectives)	Analyze the proposed problems and apply the acquired knowledge.		
Students' self evaluation		Correct the mistakes and self-evaluation		
Evaluation of the answers	Focusing the results of the evaluation test	Correct the possible mistakes (the test solved and written on the screen)		
Leading the individual activities	Recommending the homework Recommending to work on a report with the title "Industrial applications of the ideal gas"	Write the teacher's requirements		

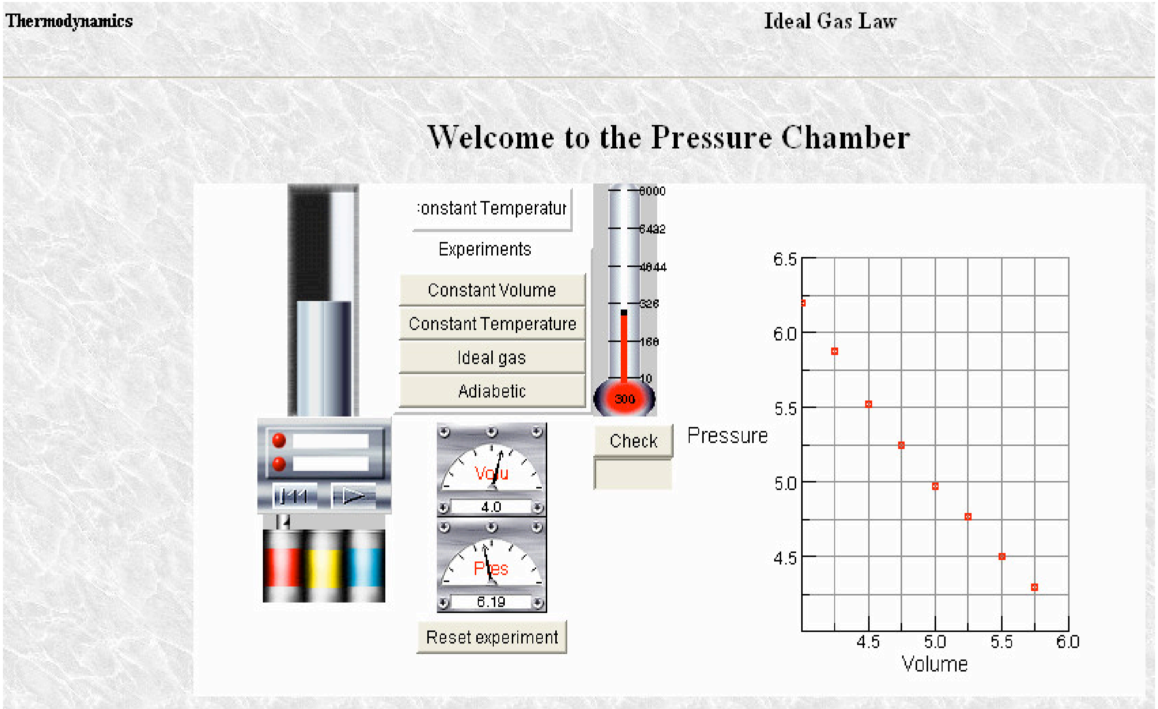
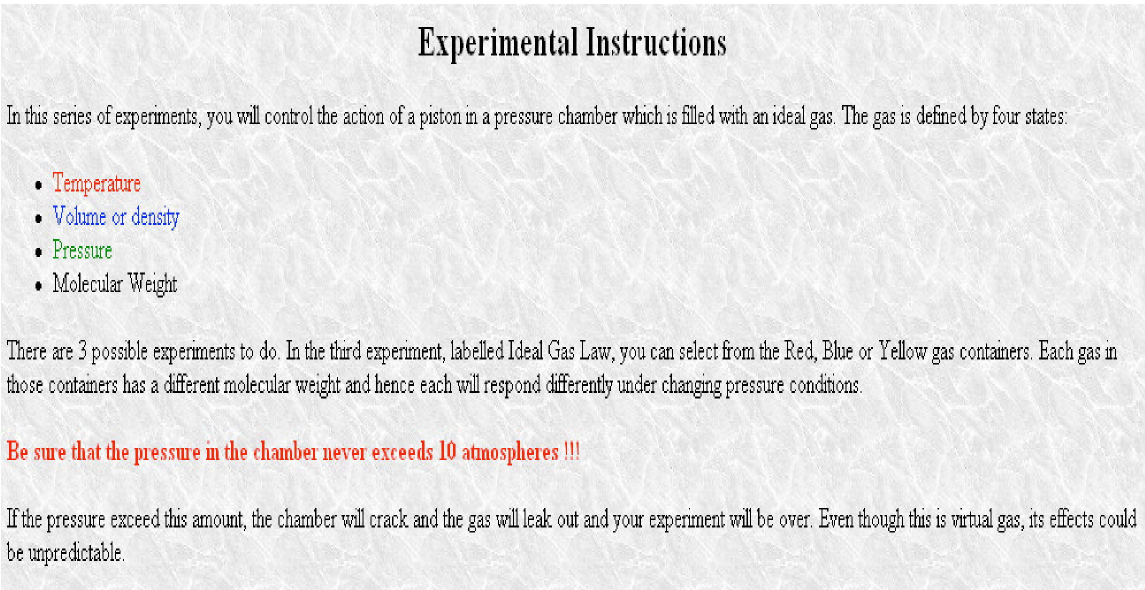


Figure 1: Educational software for the isothermal process.



Experimental Instructions

In this series of experiments, you will control the action of a piston in a pressure chamber which is filled with an ideal gas. The gas is defined by four states:

- Temperature
- Volume or density
- Pressure
- Molecular Weight

There are 3 possible experiments to do. In the third experiment, labelled Ideal Gas Law, you can select from the Red, Blue or Yellow gas containers. Each gas in those containers has a different molecular weight and hence each will respond differently under changing pressure conditions.

Be sure that the pressure in the chamber never exceeds 10 atmospheres !!!

If the pressure exceed this amount, the chamber will crack and the gas will leak out and your experiment will be over. Even though this is virtual gas, its effects could be unpredictable.

Figure 2: Usage instructions for the educational software.

Gas Laws

Gases behave differently from the other two commonly studied states of matter, solids and liquids, so we have different methods for treating and understanding how gases behave under certain conditions. Gases, unlike solids and liquids, have neither fixed volume nor shape. They are molded entirely by the container in which they are held. We have three variables by which we measure gases: pressure, volume, and temperature. Pressure is measured as force per area. The standard SI unit for pressure is the pascal (Pa). However atmospheres (atm) and several other units are commonly used. The table below shows the conversions between these units.

Units of Pressure	
1 pascal (Pa)	$1\ N*m^{-2} = 1\ kg*m^{-1}*s^{-2}$
1 atmosphere (atm)	$1.01325*10^5$ Pa
1 atmosphere (atm)	760 torr
1 bar	10^5 Pa

Volume is related between all gases by **Avogadro's hypothesis**, which states: Equal volumes of gases at the same temperature and pressure contain equal numbers of molecules. From this, we derive the molar volume of a gas (volume/moles of gas). This value, at 1 atm, and 0° C is shown below.

Figure 3: An example of how can one calculate the molar volume.

Volume is related between all gases by **Avogadro's hypothesis**, which states: Equal volumes of gases at the same temperature and pressure contain equal numbers of molecules. From this, we derive the molar volume of a gas (volume/moles of gas). This value, at 1 atm, and 0° C is shown below.

$$\overline{V} = \frac{V}{n} = 22.4 \text{ L at } 0\,^\circ\text{C and } 1 \text{ atm}$$

Where:

V bar=molar volume, in liters, the volume that one mole of gas occupies under those conditions
V=volume in liters
n=moles of gas

An equation that chemists call the **Ideal Gas Law**, shown below, relates the volume, temperature, and pressure of a gas, considering the amount of gas present.

$$PV = nRT$$

Where:

P=pressure in atm
T=temperature in Kelvins
R is the *molar gas constant*, where R=0.082058 $L*atm*mol^{-1}*K^{-1}$.

The Ideal Gas Law assumes several factors about the molecules of gas. The volume of the molecules is considered negligible compared to the volume of the container in which they are held. We also assume that gas molecules move randomly, and collide in completely elastic collisions. Attractive and repulsive forces between the molecules are therefore considered negligible.

Example Problem: A gas exerts a pressure of 0.892 atm in a 5.00 L container at 15 degrees Celsius. The density of the gas is 1.22 g/L. What is the molecular weight of the gas?

Figure 4: Some examples of possible problems.

Answer:

$PV = nRT$

$T = 273 + 15 = 288$

$(0.892)(5.00) = n(.0821)(288)$

$n = 0.189$ mol

$\frac{.189 \text{ mol}}{5.00 \text{ L}} x \frac{x \text{ grams}}{1 \text{ mol}} = 122 \text{ g/L}$

x = Molecular Weight = 32.3 g / mol

We can also use the Ideal Gas Law to quantitatively determine how changing the pressure, temperature, volume, and number of moles of substance affects the system. Because the gas constant, R, is the same for all gases in any situation, if you solve for R in the Ideal Gas Law and then set two Gas Laws equal to one another, you have the Combined Gas Law:

$$\frac{P_1 V_1}{n_1 T_1} = \frac{P_2 V_2}{n_2 T_2}$$

Where:

values with a subscript of "1" refer to initial conditions
values with a subscript of "2" refer to final conditions

If you know the initial conditions of a system and want to determine the new pressure after you increase the volume while keeping the numbers of moles and the temperature the same, plug in all of the values you know and then simply solve for the unknown value.

Example Problem: A 25.0 mL sample of gas is enclosed in a flask at 22 degrees Celsius. If the flask was placed in an ice bath at 0 degrees Celsius, what would the new gas volume be if the pressure is held constant?

Answer:

Because the pressure and the number of moles are held constant, we do not need to represent them in the equation because their values will cancel. So the combined gas law equation becomes:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Figure 5: Some examples of possible problems.

$$\frac{25.0 \text{ mL}}{295 \text{ K}} = \frac{V_2}{273 \text{ K}}$$

$V_2 = 23.1$ mL

We can apply the Ideal Gas Law to solve several problems. Thus far, we have considered only gases of one substance, pure gases. We also understand what happens when several substances are mixed in one container. According to Dalton's law of partial pressures, we know that the total pressure exerted on a container by several different gases, is equal to the sum of the pressures exerted on the container by each gas.

$$P_t = P_1 + P_2 + P_3 + ...$$

Where:

P_t=total pressure in atm
P_1=partial pressure, in atm, of gas "1"
P_2=partial pressure, in atm, of gas "2"
and so on

Using the Ideal Gas Law, and comparing the pressure of one gas to the total pressure, we solve for the mole fraction.

$$\frac{P_1}{P_t} = \frac{n_1 RT/V}{n_t RT/V} = \frac{n_1}{n_t} = X_1$$

Where:

X_1=mole fraction of gas "1"

And discover that the partial pressure of each the gas in the mixture is equal to the total pressure multiplied by the mole fraction.

Figure 6: Some examples of possible problems.

Conclusion

School progress must be understood as a possibility to put to very good use the growth of the confidence in ICT usage in education, generally or particularly, in scientific education, through realizing the future benefits of learning-teaching-evaluating resources management, access and storage.

ICT usage in didactic activity should be based upon a real support given to the teacher. It is necessary that in the school should exist a technical support – the virtual laboratory AEL, the "SMART" board, an internet connection and also the capacity of the teacher to use this technology.

Research has imposed a supplementary preparation of the teacher, the creation of necessary work-sheets, the organization of problem types. Hence, the students of the performance group (7 national school Olympiad participants from the 9th grade) have individually run through the informative material (in English), the work files (in Romanian) and the problems proposed in the mentioned site, but also those proposed by their teacher, during a working time of 2 hours.

Traditional didactics involve the student to a much smaller extent, without the feed-back realistically presenting the parameters aimed by the teacher. Meanwhile, modern didactics involve the student-teacher team in equal proportions, the teacher determining the learning conditions, taking into account the collective of students.

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