DEVELOPMENT OF A LESSON PLAN ON THE TEACHING OF MODULE "WATER CONDUCTIVITY"

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Abstract. The writing of this article is done in light of the need dictated by contemporary developments in the field of chemistry teaching which shape new facts and challenges in the teaching of chemistry and in particular about the subject of "Water Conductivity." The lesson plan created about "Water Conductivity" aims to create a technologically enriched learning environment through the active participation of students in the educational process and through activities. Some of these activities include searching, collecting, selecting, editing, presenting information and exploiting the possibilities and choices offered by the new thematic module. It also seeks to cultivate communication and cooperative skills that upgrade the teaching practices and smooths the difficulties of both understanding and the communication of learning. Besides, with the help of the application form accompanying the teaching, the student is offered a research/interactive teaching tool, easy to use and entertaining while on the other hand the professor is given the chance to integrate the computer into the range of his teaching tools. This specific project aims to improve the learning outcome by facilitating the understanding that enhances interest, using modern computing technology according to the basic principles of pedagogical science.

Keywords: lesson plan; water conductivity; Bloom's taxonomy; water; environmental education

Introduction

The lesson plans are a modern teaching method, the implementation of which converges many components. It is a didactic approach that is co-transformed by the professor and his students (Chrysafidis, 1996). With this method, it is possible to introduce into the pedagogical process issues related to the cognitive object, through a connection of knowledge, which is often absent from the classical shielding of each science in specific contexts, whose birth point is to be found in the past and the use of which was designed to opti-

mize her study. Through a lesson plan it is possible to achieve the linking of knowledge (Morin, 1999), the approach of contemporary social issues and the sensitization of the students to the 'human condition' ("condition humaine") which Edgar Morin regards as one of the basic parameters of education. Also, through the lesson plans, it is possible to achieve students' awareness on issues related to ecological problem-solving on a global scale, since modern ecological issues often have an impact on a global basis (Morin, 2000). Furthermore, there is a growing need to link knowledge to each other as well as to the social reality in which the students live (Morin, 2014).

Electrical conductivity or otherwise specific water conductance is the measure of the ability of water to allow the passage of electricity. It is related to the concentration of ionized substances in water, which is a polar solvent. The parameter of conductivity belongs to the electrochemical techniques of analysis.

The conductivity of a conductive material (solid, liquid or solution) is the inversely proportional to resistance R (1).

$$G=1/R \quad (1)$$

Where R is the resistance (expressed in Ω (ohm) and G the conductivity expressed in S (Siemens)). Previously the Siemens unit was written both ohm^{-1} or mho (Castellan, 1983; Mortimer, 2008).

The conductivity of a solution is measured by immersing into it a system of two chemically inert electrodes (usually Pt), which have an area of A cm^2 and are at a fixed and determined distance of 1 cm apart. The two electrode system is the conductivity cell (Fig. 1).

Previously, the resistance (and hence the conductivity) of the solution between the two electrodes of the conductive cell was measured with the help of a Wheatstone bridge powered by alternating voltage (Fig. 2).

Due to the acoustic frequency of the applied voltage, the detection of the balance point of the bridge was done with simple headphones. Today, the measurement is also based on the use of the conductive cell (which is integrated into the electrode of the conductivity meter). However, conductivity measurement is nowadays easier, with the help of a simple electrical circuit and displaying the measured conductivity value on the liquid crystal display.

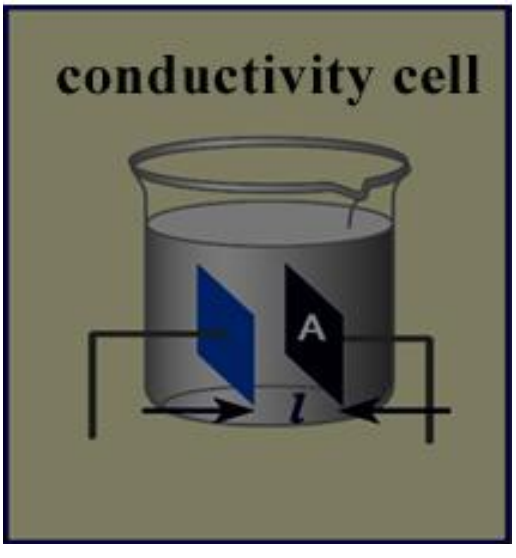

Fig. 1. Conductivity cell

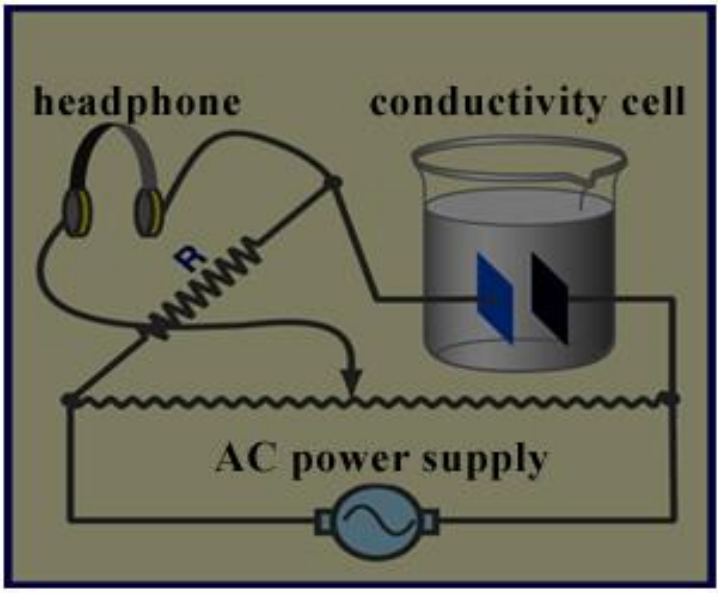

Fig. 2. Wheatstone Bridge and determination of point of balance in the past with the use of headphones

According to the relationship (2):

$$G = \kappa\,(A/l) \qquad (2)$$

If the surface A is known and the distance between the two electrodes, l, the specific conductivity k of the solution is calculated based on the measured resistance.

For each conductivity cell the quotient I/A is called cell constant, denoted by C (or K) and expressed in m^{-1} (in SI), but more commonly in the chemical literature in cm^{-1}.

The unit of measurement of the specific conductivity is in SI system, S/m (Siemens/meter). When the measurement is carried out in dilute aqueous solutions, the specific conductivity is usually expressed in μS/cm (10^{-4} S/m), while for denser solutions in the unit mS/cm (10^{-1} S/m). Moreover, the specific conductivity was expressed in the literature instead of Siemens/ meter in the equivalent mho/meter unit. This way of expression has now been altered by IUPAC.

Pure water is not a good electricity conductor. The distilled water produced in a laboratory has a specific conductance value of 0.5 to 3 μS/cm. However, the specific conductivity of pure water increases very quickly due to the CO_2 dissolution of the atmosphere (Thysiadou, 2015).

Methodology

Objects intended for use during teaching, in a view of more efficient learning, are educational equipment. The use of these objects depends on the nature of the lesson, the potential offered by technology but furthermore on its cost. Alternative supervisory means that can be used in the teaching process are:

– *Blackboard*: this is the oldest, most common, easier and more affordable (cost-effective) tool. This traditional "blackboard" with chalks, has in some cases been replaced by newer versions and writing is nowadays done i.e. with markers but also with whiteboards

– *Illustrations* (printed diagrams, tables, images, photographs, concept map): can be either ready-made or made by the professor himself. They offer a representative and instant presentation in an attractive, compact and clear way

– *Models* (digital material, software): three-dimensional models can be fixed or assembled, depending on the purpose they serve. They help the better understanding of the subject as well as how the components are assembled from the various machines

– *Transparencies*: they are widely used in teaching because they are relatively easy to prepare, easy to use, adjust and change if necessary and combine the benefits of other supervisory means without having their disadvantages

– *Images* (still and moving – video): fixed images are photos, slides and film-strips. Animated images are videos – motion pictures, videotapes that,

when combined with a parallel lecture, offer many advantages in the learning process.

It is of fundamental importance to define the objectives and goals of a program as this is what sets the frameworks that guide all decisions and actions in the program. The difficulty of a professor lies in formulating and setting down the desired results of his teaching. This difficulty arises from the fact that the professor needs to clarify the meaning of both "educational objectives" and "educational goals" in order to set both objectives and goals which are to be realized and understood.[1)]

Educational objectives

Educational objectives are long-term and general. They are the framework in which the professor will create (Marcinkowski et al., 1994) concerning what will be implemented in the teaching program. They are mostly in complete accordance with major reference documents and declarations (Hungerford & Peyton, 1994). Therefore, these are difficult to use in the process of preparation of teaching.

Educational goal

Educational goals are considered essential to obtain educational achievements and are the intermediate steps that need to be implemented. They refer to how classroom teaching will be organized, what the students should learn and what level they will reach at the end of the lesson. Their goal is to achieve the desired educational objectives. Many times the educational goals in bibliographic references are called educational results or performance goals. The way of action of both the lesson designers and the lesson performers as well as of the students derives from the goals set (Kraft & Kielsmeier, 1995). They are the reference point between all the interactions that can take place within a project, that is, between the lesson designer, the professors and the students.

The first taxonomy of educational objectives, which is widely known and accepted, was determined by Benjamin Bloom (Bloom et al., 1956) and his colleagues in the 1960s. It focuses on three domains that often extend along one another. It is the cognitive, affective and psychomotor domain.

The goals of the cognitive domain include both the mental skills and abilities that the student will acquire at the end of the teaching. They relate to the long-term development of cognitive skills that students will obtain to 'learn how to learn' with a future purpose of being able to meet the challenges that will exist in the modern world as active citizens of the society in which they live. The verbs used to define cognitive goals are at the beginning of the sentence and are in active voice.

The goals of the affective domain concern both the behaviour and the habits, interests, values and beliefs that the student can adapt after the end of his train-

ing. The absence of a reference to the fact that it is a very difficult and complex process to evaluate emotional goals would be a serious omission, because of the tools used – the materials used (tests, questionnaires, etc.) are designed for the cognitive domain (Lahiry et al., 1988). Changes in students' behaviour can be perceived through long-term observation so as to see whether both attitudes and behaviours of students have been modified and whether they are compatible with the principles that sustainable development requires.

The goals of the psychomotor domain were initially related to the improvement of motor skills. These goals in the domain were ultimately aimed at acquiring technical skills that will be useful for the student not only during learning but also for the subsequent course that he will make in his life.

The classification of the cognitive domain objectives is shown in the figure below (Fig. 3). The vertical classification of the six different structured levels was carried out using as a criterion the complexity and the pedagogical importance of each of them.

The level of application could be characterized as one of the most important levels of the teaching process. There are numerous and distinct ways in which the application of new knowledge can be achieved. Some of them are the application of new knowledge in similar but also in new situations as well as its connection with completely different situations. It would be essential to omit reference to the value of individual applications, such as in situations when the students solve an exercise, matching exercises or crosswords and the professor walks through the room giving valuable advice as well as controlling the outcome of the whole process.

Evaluation levels seeks to assess the skills acquired by students and to identify their weaknesses and abilities with the ultimate goal of identifying the effectiveness of the educational process and, at the same time, its imperfections in order to improve it.

The motivation that triggered this research was the student misconceptions about drinking water quality assessment parameters. The multimedia material is addressed to the secondary and tertiary education students and aims at a deeper understanding of this thematic module because each student has its own characteristics (profile, learning styles, previous background). These particular features are very useful to provide the student with the most appropriate learning pathway to achieve his learning outcomes (Garrido & Onaindia, 2013; Papanikolaoum et al., 2002). An example of the pedagogical sections and the methodology used in the template lesson plan is presented in Table 1. They refer to the proposed methodology, interactive discussions, demonstration of competencies, case study analysis, presentations and evaluation.

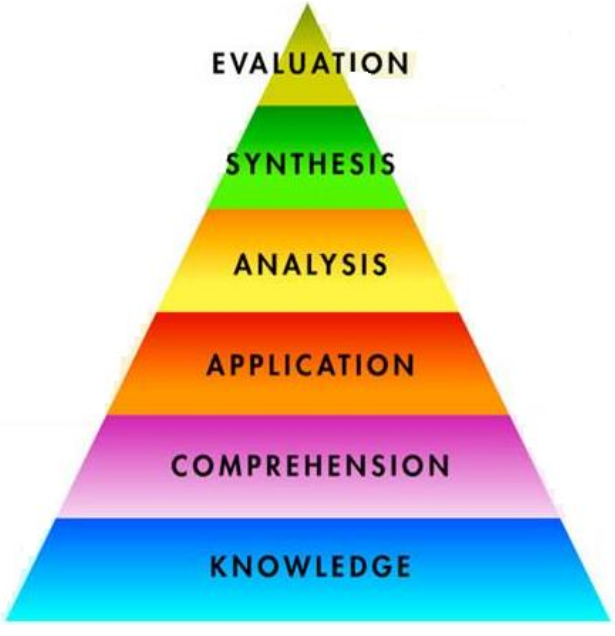

Fig. 3. Bloom's taxonomy of educational objectives

A basic concern of professors when organizing a lesson plan is to develop student skills. An important role in this method is the development of decision-making, critical thinking, problem - solving, creativity as well as the development of metacognitive skills to support personalized learning. In this form of training, students are offered more opportunities to make decisions and more problem – solving conditions are created than by traditional teaching. For example, students could be given the freedom to decide on the type and amount of content of information they would like to include in their work or on how to conduct a specific survey. At the same time, students are given the opportunity to use their imagination and creativity, since each group can follow its own path to reach the final "product". In addition, students learn how to learn, an element that will help them in lifelong learning and smooth adaptation to their age, which is distinguished by the ever - evolving technology.

Additionally, of great importance are the opportunities provided not only for individual but also for cooperative work. Lesson plans provide opportunities to promote individuality and co-operation through the various stages and micro-activities that need to be carried out. Simkins et al. (2002) "define collaboration as working together jointly to accomplish a common intellectual goal in a manner superior to what might have been accomplished working alone". Students can work in pairs or

small groups. It may be necessary at some stage of the project to work cooperatively. The objective is to help everyone in such a way that the final work is better than the sum of its parts. Students, while acquiring content knowledge, learn the secrets of working with members of a team, learn to solve problems and make decisions. In addition, students can be asked to assess their progress through specific standards or criteria that will be given to them.

Table 1. Lesson plan for conductivity module

<table>
<tr><td>Lesson</td><td colspan="3">Conductivity Measurement in water</td></tr>
<tr><td>Module Concepts (keywords)</td><td colspan="3">Conductivity.
Conductivity Cell.
Types of electrodes of Conductivity-Meters.</td></tr>
<tr><td rowspan="6">Goals of teaching</td><td colspan="3">Define the conductivity of a water sample.</td></tr>
<tr><td colspan="3">Explain the origin of conductivity.</td></tr>
<tr><td colspan="3">To perform the appropriate experiment to find the conductivity of an unknown sample of water and calculate the conductivity according to experimental results.</td></tr>
<tr><td colspan="3">Compare the results of analyses of different water samples.</td></tr>
<tr><td colspan="3">To combine the different parameters that influenced each sample.</td></tr>
<tr><td colspan="3">To check the water quality concerning the conductivity parameter.</td></tr>
<tr><td colspan="4">Teaching Method - Course description with the corresponding technique and means at each step.</td></tr>
<tr><td colspan="4">Teaching method: Method of concept attainment</td></tr>
<tr><td colspan="2">Course</td><td>Teaching Technique</td><td>Supervisory means</td></tr>
<tr><td>1</td><td>Preparation of a teaching framework. Recall relevant knowledge from students. Lesson objective notification.</td><td>Questions and Answers Dialogue</td><td>PC
Projective
Software
Power Point
Transparencies</td></tr>
</table>

2	Student's contact with lesson content: 1. Conductivity. 2. Conductivity Cell. 3. Types of electrodes of Conductivity-Meters.	Presentation and analysis	PC Projective Software PowerPoint Transparencies video
3	Application An application form is distributed to the students. The professor separates the students into 5 groups, gives them 5 to 7 minutes to answer and follows the professor's conversation with all the students to see if the goals of the teaching have been achieved.	Portfolio	PC Projective Software PowerPoint Transparencies
4	Evaluation An evaluation testing form is being distributed to the students, asking them to answer some questions related to the above-mentioned theory	Evaluation testing form	PC Projective Software PowerPoint Transparencies
5	Feedback A recapitulation of the key points of the above-mentioned theory is done with the detailed presentation of the answers to the questions in the evaluation testing form.	Lecture	PC Projective Software PowerPoint Transparencies
6	An individual activity at home is assigned to the students.	Homework	PC Projective Software PowerPoint Transparencies
Evaluation: Description of the evaluation techniques applied. Students are given an evaluation testing form asking them to answer some questions about the above-mentioned theory.			
Skills development through the description of specific activities			
Cognitive			
With the recall of previous knowledge, questions and answers, new data, the commentaries on figures, the students will get to know the concept of conductivity.			
Affective			
Through dialogue, examples and presentation on figures, students will be sensitized about the value of integrated knowledge for the determination of conductivity. They are satisfied with the fact that they acquire a new knowledge applicable to their science. Finally, they feel a reduction in the anxiety they often have in terms of expressing their thoughts in the presence of their classmates.			
Psychomotor			
With the question – answer method, the students will understand the concepts taught and more specifically the differences between them. They will be able to determine the method of water analysis as well as the units of expression of the results and their classification.			

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The question of evaluation of students learning outcomes is particularly complex in the case of lesson plans. Its purpose is not only to acquire knowledge but also in obtaining skills and competencies, as well as in gaining experience, through which changes in attitudes and behaviours that are much more difficult to measure and find out are to be made.

The objective of the lesson plan is to promote knowledge to students so that by the end of this lesson, they will be able to:

Define "water conductivity".

Explain the origin of "water conductivity".

Perform the appropriate experiment of the "water conductivity" of an unknown sample of water and calculate the conductivity according to the experimental results.

Compare the results of analyses of different water samples.

Combine the different parameters that influenced the sample.

Check the water quality for the "water conductivity" parameter.

The required materials for this lesson plan include an instructor prepared lecture, a pre- and post-lecture quiz and video. The presence of video presentation is particularly effective in the final learning outcome because the student is transferred through it to a virtual lab where the corresponding analysis is carried out. In this way, it is able to accurately identify the experimental equipment that will be needed to carry out the respective experiment as well as the indicative course of its evolution until the final desired result is obtained. The purpose of video viewing as part of the educational process is to investigate and evaluate the first experience of designing the experimental process for students and to identify reactions after the video completion, whether or not there is a desire to conduct the analyzed analysis from the larger percentage of students.

The teaching process is carried out through certain steps which are illustrated in Fig. 4.

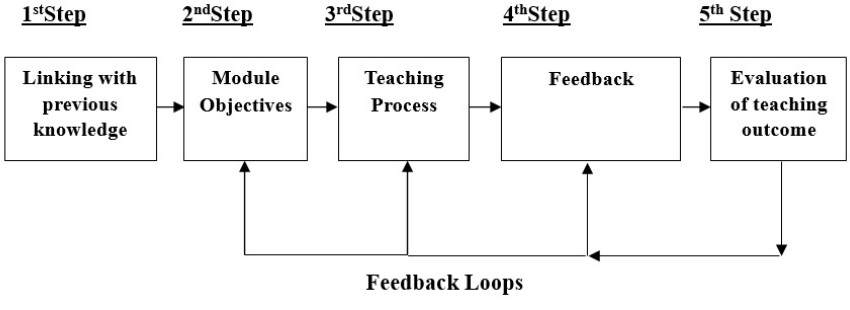

Fig. 4. Progress of the teaching process

During the first step, the cultivation of a positive climate is intended, through the challenge of students' interest and the exploration of their earlier perceptions. The detection of this pre-existing knowledge by professors is achieved by discussing the subject and through images, newspaper or print cuts in paper or electronic form. Through the answers and the views of the students, on the subject, the professor organizes the teaching program to focus on the misconceptions and ideas and the points where the conflicting views of students exist.

In the second step, students are made aware of the goals of the module. The third step in which the teaching process is carried out is followed. Initially there is contact with the data of the module as well as process of the data in order to be able to lead to the extraction of conclusions. The metacognitive step is then followed, which is the step of recapitulating, summarizing, generalizing and finalizing what has been taught in the previous steps.

Lastly, comes the evaluation step. It is the professor's overall evaluation of the performance of his student. The educational evaluation is one of the most important parameters of the educational function. It is a key element in determining the degree of achievement of educational goals and the evaluation of the student's overall progress. It is a means to inform the stakeholders about the feedback of the education system. The most prevalent form of evaluation for natural sciences is written examinations. In recent years, other evaluation techniques (concept maps, synthetic works, oral interviews, portfolio for each student, organizing of experiments) have been applied.

Conclusion

The importance of this study lies in the fact that it sheds light on the important subject of the designing and creating of a lesson structure with the help of a lesson plan. The ultimate goal of a properly and suitably structured lesson plan is the scientific as well as the social improvement of students.

It further focuses on events, settings, conditions that intend to shape the current knowledge level of the student into the desired learning outcome. As well as the ways in which the teaching (individual - collective) is organized in order to achieve the desired result, i.e. the acquisition of new knowledge and at the same time the cultivation of skills.

Besides, the way of teaching is directly related to the science of didactics, because in the course of its progress it follows everything that the didactic prescribes in order to achieve the goals set at the beginning of the teaching. There may be a general didactic framework on which each science is based in order to carry out the transmission of the necessary knowledge, but it is each science that is shaping its own didactic - teaching adapted to its particularities.[2)]

Of high priority is the most important problem in the planning process of the lesson, this of the formulation of goals. On these grounds, professors must provide

specific appropriate goals. Particular attention should also be paid to issues such as how to select appropriate activities for a particular group of students and how to effectively manage time.

All the above have the ultimate objective of acquiring skills concerning the understanding of the theoretical background of the specific parameter of "Water Conductivity", but moreover of the ability to conduct the experimental process using the new technologies in their daily learning life initially and in their life in general.

NOTES

1. https://pjp-eu.coe.int/documents/1017981/1667921/tkit6.pdf/459e262b-11f9-4af8-834f-c10c4cf4d30a
2. http://teiserron.gr/index.php?action=dlattach;topic=10267.0;attach=6251 (in Greek)'

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