Chemistry is All Around Network

Workshop on "Successful Experiences and Good Practices in Chemistry Teaching"
Athens, Greece, 15 March 2014

Minutes

Participants

The workshop was coordinated by the Project manager Dr. Dionysios Koulougliotis. In total, the following 15 people participated in the workshop:

1. Niki Rapti (Teacher) from 5th Geniko Lykeio Petroupolis
2. Katerina Paschalidou (Scientific Expert) from University of Athens
3. Dimitrios Nikolopoulos (Scientific Expert) from TEI of Piraues.
4. Vasiliki Gkitzia (Teacher) from 2nd Experimental Gymnasium of Athens
5. Margarita Fytrou (Teacher) from 2nd General Lyceum of St. Dimitrios
6. Kalliopi Papatheodosiou (Teacher) from 2nd General Lyceum of St. Dimitrios
7. Theodoros Vachliotis (Teacher) from 3rd Lykeio Amarousiou Attikis
8. Konstantinos Kordatos (Scientific Expert) from National Technical University of Athens
9. Effimia Ireiotou (Scientific Expert) from TEI of Ionian Islands
10. Anastasia Mylona (Teacher) from 2nd Experimental Lyceum of Athens
11. Panagiotis Charizanos (Teacher) from Primary (Elementary) School of Mastro
12. Ioannis Sanakis (Scientific Expert) from NCSR "DEMOKRITOS"
13. Christodoulos Makedonas (Teacher) from Model Lyceum of Evangelical School of Smyrna
14. Katerina Salta (Teacher) from 2nd Experimental Lyceum of Athens
15. Dionysios Koulougliotis (Manager, Scientific Expert and ex-teacher) TEI of Ionian Islands

Minutes

<u>9.30 – 9.45</u>

The participants were welcomed to the workshop by the project manager (Dr. Koulougliotis) and subsequently they were asked to divide into groups of 3-4 people each so that each group contains one or two scientific experts. The following four groups were made: Group 1 containing participants 1 - 4 of the above list, Group 2 containing participants 5 - 8 of the above list, Group 3 containing participants 9 - 11 of the above list and Group 4 containing participants 12 – 14 of the above list. Subsequently, the project manager made a short presentation of the so far achieved results in the project and the agenda of the meeting was adopted by all participants.

<u>9.45 – 10.45 (1st Session)</u>

In this part of the workshop, there was a discussion on the topic: "What constitutes a successful experience in teaching chemistry?" based a) on the personal experiences and opinions of the participants and b) on the information provided by the Papers and Publications related to "Successful Experiences" in the project database. A few explanations were given by the workshop coordinator on the aims and scope of this session. Subsequently, participants were given a specific
amount of time (ca 20 minutes) to freely interact with the other members of their group and discuss the specific topic of this first session. At the end of this free interaction, each group was asked to present the main

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conclusions of their in-between discussion via one spokesperson for a maximum period of 10 minutes. These presentations were taped and the project manager interacted with the

group spokesperson during each presentation in order to bring out more information and provoke more in-depth discussion. Here are the main conclusions reached by each separate group:

a) Group 1:

The group initially discussed the issue of how the findings of scientific research can be connected with the teaching practice. It is important that the student is convinced that engaging in chemistry (and science) learning can be a rewarding experience and teachers have to make an effort to provide the reasons on why one should try and study chemistry. In this way, positive attitudes towards chemistry can be created.

Special emphasis was given on how scientific knowledge can be connected with everyday life experiences as well as in the issue of interdisciplinarity between science-related fields such as physics, chemistry and biology. The research advancements and mode of thinking and analysis in one of these fields very often influences and interacts with the other fields.

In regard with the papers/publications/teaching resources of the project database, the discussion mainly involved the following: i) A Spanish publication which is related with a teaching approach of the phenomena of fluorescence and phosphorescence. There were positive comments on the described approach which makes use of simple diagrams and pictures in order to approach two difficult and complex phenomena without involving quantum mechanics and strict mathematical formalism. ii) The publication named STEP (Czech Republic) which describes nine activities aiming at popularization of science. The group mentioned that such activities are very useful because they help students of all ages (from primary school to university) to avoid rote learning and achieve more meaningful learning by trying to understand the reasons for learning something.

Based on personal experience, the group made a special note on the teaching resource “Chemical Compound of the month” (Greece) which provides the teacher with a lot of material and interesting information on a specific chemical compound and can help the teacher to organize a lesson which attracts students’ attention and brings out the several possible applications of chemistry in different aspects of human life.

The group discussed also the issue of the analogy at which theory and practice should be mixed in order to render success to the teaching approach. It was pointed out that there is no unique answer to this question and different mixtures should be tested.

In the question “How can a teacher know whether his/her teaching approach has been successful?” the group referred to the following: i) Close observation of students’ behaviour. Are they attending or they seem to have lost their concentration?. ii) Student performance in tests and quizzes. During evaluation, the teacher should always take into account that students often have difficulties in expressing themselves either orally or in writing even when they are asked to give a qualitative description/explanation and also that they face problems when they are asked to do mathematical calculations and/or use chemical symbols and equations.

b) Group 2

The group agrees with the opinions expressed by the first group and adds the following elements to the discussion:

It is important that the lesson starts with some short activity which will attract students’ attention and trigger motivation to learn. This can be a short story, a reference to a recent research finding, a quick live experiment, and/or a phenomenon from everyday life reality. After that, one should enter the theoretical part and try and discuss the possible explanations of the observed phenomenon.

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The “success” of the teaching approach should be evaluated via students’ interest and performance in tests and quizzes. The fact that students show enhanced interest does not guarantee that they have also understood the material taught.
The in-group discussion involved an Irish publication entitled “Engaging first year science students through a multidisciplinary approach” by McLoughlin and Finlayson, in which the elements of multi-disciplinarity (physics, chemistry, biology) and cooperation provided overall a successful teaching approach. In addition, the group also referred to the Spanish publication related with an interdisciplinary teaching approach for teaching the phenomena of fluorescence and phosporescence in three educational levels which seemed to give good results especially among primary school students. In this work, the teaching strategy focused on a different element each time; experiental learning (primary school) – experimentation (secondary school) – research project (tertiary education).

c) Group 3

In addition to what the first two groups referred to, the group wishes to point out the following: One teaching experience can be named successful if we, as teachers, get out of class and feel that strong interaction took place in-between students and between the students and the teacher. We need to be in a position to say that during and after the end of the teaching session the students have been put in a position of asking questions to themselves and in this way they have been mobilized to start thinking, they have got motivated to learn more and sooner or later they have developed some small or larger interests related to chemistry. Thus it is possible that positive attitudes are growing as time goes by and as a result the possibilities for successful teaching experiences increase.
Special emphasis has to be given to the good organization and preparation of the teaching process, for example via the use of worksheets that make students work in small groups. Finally, specific roles have to be assigned to the members of the group thus allowing students to co-operate and bring out their potential (what they personally have to offer).

d) Group 4

The group members agree with what previously noted that a successful teaching experience is one that has the following characteristics: it is well organized, it excites students’ curiosity, and it is internally evaluated and receives feedback in order to improve further. It is important that the students are involved in practical activities (lab). In primary school, pupils should be put in a position to observe, report, make hypothesis. It is also important that all students are involved in doing something.
A large part of the discussion was devoted to the cooperative teaching approach. There was disagreement among the group members on whether this approach can actually be implemented in a way that it can be successful. The group members reported personal successful teaching experiences by using this method but a lot of discussion was made on the circumstances under which this approach can be successful. The main cause for the fact that this approach does not easily succeed in Greek classrooms is related with the issue that there is a lack of culture of working as member of a team in our society. There is lack of team spirit and team effort and this is a social characteristic evident among all educational levels. Additional difficulties of the cooperative teaching approach are the following: it requires a lot of time and specific spatial arrangement of the class.
Personal experience has shown that the cooperative approach is implemented successfully if the students who constitute the team know each other well for a long time and they have developed friendship over the years. In that case, it is possible for the better student to “accept” to help the

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weaker student to learn as well. If the team members do not know each other well, usually the good students are not eager in helping the weaker ones.
Several combinations of team structures have been tested: mixed (good and weaker students), only good students, and only mediocre/weaker students. The most successful team as far as cooperation is concerned seemed to be the team which consisted of mediocre/weaker students. This team managed to perform very successful experiments, however the students had trouble in explaining the results. The team composed solely of good students did not function well; they used to fight easily with each other.

11.00 – 12.45 (2nd Session)

In this part of the workshop, the aim was to have an open discussion and exchange of experiences and opinions on the testing in real classrooms of specific teaching resources available in the "Teaching Resources" section of the project portal. In addition, the participants were given the opportunity to make personal presentations of the teaching resource they tested to the other participants. This part of the workshop was conducted with simultaneous participation of all 15 participants as one single group. The project manager had the additional responsibility to lead the discussion in order to keep it organized and for facilitating the taping procedure. Here are the main conclusions reached by the group discussion and presentations:

The first teaching resource that was presented to the participants was "ChemSketch" which was tested by the teacher C. Makedonas. "ChemSketch" is a very nice and freely available program for drawing structures of chemical compounds. The teacher created a team of 20 students in 1st grade of upper secondary school and used the teaching resource in a teaching session which lasted 4 hours in total. He made use of the computer room and each student had his/her own computer terminal. He prepared a worksheet which he used during class. The worksheet involved mainly stereochemistry of organic molecules and nomenclature. The students' attitudes were evaluated by handing out a questionnaire before and after the teaching session. Students' opinions were overall positive. They found this software very useful and expressed their willingness to also use at home. However, in the question "Would you like to be taught more often via such type of activities?" their answers were surprisingly, almost unanimously, negative. Even though they are willing to use this software at home in their free time, in class they seem to prefer to be taught the material that is necessary for the final exam (which involves questions also from a Bank), which is important for their entrance in tertiary education institutions.
Personal experience shows that students have the same attitude also towards laboratory exercises, ie they like getting involved in experimentation, however they consider it as "wasted time" and they would rather "learn" and "see" more chemical reactions in paper. According to the recently applied legislation regarding the New School, students are expected to be examined also in questions related with laboratory techniques. It is thus expected that students will be more motivated to take the lab work more seriously.
Specific details were given on how the resource was used. There was a lot of discussion on the importance and necessity for students to learn stereochemistry in order to be able to really understand how chemical reactivity takes place.

The second teaching resource that was presented to the participants was "BBC School Science" which was tested by the teacher K. Salta. The resource was tested at students of 2nd year of upper secondary school, and more specifically the teacher made use of the units related with fuels and polymers at GCSE level. There was no special selection procedure for the participating students. Testing took place in two classes containing ca 25 students each.

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The students initially watched the available video, subsequently there was some discussion on the English terminology and then they watched the video a second time.
Finally, evaluation of the learning outcomes took place by doing the interactive tests available by the resource and also via more classical methods (using the blackboard, short quizzes, etc). The learning outcomes have been very good and the whole experience has been evaluated as quite successful. It is interesting to note that in general the foreign language did not seem to be a barrier for the students, who on average were rather intrigued by the possibility of mastering English terminology. The videos contain graphics and music which attract students' attention. The chemistry topic is presented in the form of story-telling and it seems that the information sinks in. All students, even the ones who have already decided not to follow the science track in the 3rd (and final) year of upper secondary school, have been very attentive and were able to perform quite well in the evaluation quizzes that followed.
Some of the videos involved interesting information on practical applications (for example in relation with the different types of plastics) and the students asked to watch specific parts more than twice in order to understand better the new provided knowledge which they considered very useful.
Some students got interested in engaging themselves in further research in topics related with environmental pollution, recycling, and new polymers and subsequently present their work to their classmates, thus acting like teachers themselves. In this way, the testing of the teaching resources, somehow initiated a chain-reaction and more ideas were brought out and put into action.
The teacher pointed out that one of the reasons that the testing was so successful is related to the fact that it was done within the frame of a chemistry course in which the final grade does not practically affect their cumulative score for entering tertiary education. In a class where the chemistry course taught plays a role for their future career, the students are reluctant in getting involved in alternative teaching approaches because they feel that they will not learn what is needed in order to perform well in the final exam.

Subsequently, a third teacher (N. Rapti) made reference to the use of hands-on models (plastic building blocks etc) in order to help students understand the differences in scales as one passes from one to two to three dimensions, as well as the differences in orders of magnitude. Even students in upper secondary school need this type of experiential teaching approach.
She then went on to refer to the application of a module of the ICT-based teaching resource "Phet" which is related with stoichiometry of chemical reactions. A worksheet was prepared by the teacher separately and teaching was done in front of the computer (one student per terminal). This is a teaching approach via which one succeeds to make students understand chemistry concepts such as the excess amount of reactant. It is applied to all students of an average class which is usually comprised of 20-25 people. Students are urged to perform the Phet simulation also at home. In the end, a homework assignment is given which involves mainly examples from real life situations (analogies) in order to help students understand the stoichiometric concepts in larger depth. Personal experience (and research findings as well) shows that the use of analogies from everyday life problems/situations does not make it easier for the students to solve problems via the use of simple mathematical calculations. Actually it is often more difficult to use math to tackle real life problems. However, the analogies add variety to the lesson and attract students' interest. Students like them a lot.

The teaching resource "Phet" was also discussed by another teacher (A. Mylona), who tested the module on atomic structure. She made use of a worksheet which she had prepared in advance. Students liked it a lot. They understand easily the concept of the ion, the role of the neutrons and the fact that the number of protons is a unique characteristic for each atom.

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The teacher got the impression that teaching atomic structure via “Phet” is more helpful and effective relative to explaining the material by using the blackboard.
The same teacher also referred to her attempt to use some simulation related with Physical Chemistry and more specifically “Virtual Chemistry Experiments” (by David Blauch), which she had found very interesting during her search in the project database. However, when she tried to prepare a worksheet and apply the resource in class, she faced difficulties and realized that in the timeframe available she could not make efficient use of the resource. The simulations she tried out were related with chemical kinetics. She also referred to her effort to teach chemical kinetics via the simulation available in “Phet”. She also seemed to face similar problems in adapting the material in such manner that it would help her explain chemical kinetics concepts more effectively. The discussion that followed pointed out that chemical kinetics is indeed a very difficult chemistry topic which creates problems also to university professors. It is really hard to approach this subject in an “easy” way via simulations.
Finally, the same teacher referred to the testing of the software “Jmol” in a biochemistry class which seemed to work very well. The students like very much watching the models of very large molecules, such as biomolecules. The “Jmol” software shows the stereochemistry between atoms in a much more effective manner relative to the “classical” plastic hands-on models.

Finally, there was a short presentation of the testing of the teaching resource “The Periodic Table of videos” in a one-hour class of 10 students of 2nd grade of upper secondary school. The involved teacher (T. Vachliotis) made use of the videos of two elements, namely helium and carbon. The resource was not connected with the curriculum of the class. The teacher also made some sort of qualitative evaluation, by asking students’ opinions. Some students complained about the use of the English language. In general students found it interesting and they appreciated the fact that they learned interesting additional things that are not available in the textbook.

13.00 – 14.00 (3rd Session)

In this last session, participants were asked to make proposals of good teaching practices and to discuss on the conditions which are required for successful implementation of a novel teaching approach. In addition, participants were asked to make proposals of teaching resources which they will test in their classes in the near future. This session was carried out in a similar way with the first one. The role of the project manager was similar to the one in the first session. Here are the main conclusions reached by each separate group:

a) Group 1

Experimentation in the lab is a good teaching practice, however there are often difficulties during implementation. The curriculum at lower secondary school offers teachers some flexibility which could allow the realization of lab experiments even though the allocated teaching time is generally limited. In upper secondary school, students enter more in the mode of preparation for succeeding in the exams for entering tertiary education institutions and the possibility of connecting theory and practice (via lab work) becomes much more difficult.
Another discussion topic involved the situation at lower secondary school and the difficulties students face in understanding the concept of a particle which is one of the most basic in chemistry. A good teaching practice should aim at connecting the microscopic representations with the macroscopic world and the chemical symbols. In addition, more time should be allocated for chemistry teaching and the material taught (curriculum content) is currently quite inhomogeneous

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(structure and subject wise). This inhomogeneity influences negatively the understanding of chemistry in upper secondary school.
Another good teaching practice is one that involves the appropriate incorporation of modern scientific analytical techniques in school chemistry. The group referred to methods like X-ray diffraction and fluorescence and to the possibility of students to be directly involved with scientific measurements with modern instrumentation by visits to universities and research centers.
The importance of the cooperative teaching approach was finally pointed out and the issue of students getting convinced to work as members of a group was discussed. The chemical analogy of the separate atoms which create molecules has been systematically used by one of the teachers of the group in order to show students the importance of cooperation in achieving a specific target.
Finally, one of the group members has brought out the issue of whether it is possible or advisable to adopt a systematic educational approach in the Greek school. The discussion has brought out interesting issues and ideas and the next logical step is to try and provide a unified aspect, some general guidelines.

b) Group 2

The cooperative teaching approach is also considered important by this group, with emphasis in small groups of 3-4 people. It is preferable that the groups are formed by the teacher so that students of different levels are mixed and teaching effectiveness is increased.
More time should be allocated to lab practice which should be combined with a decrease in the curriculum material. However, there is often lack of laboratory equipment and basic infrastructure. In addition, the currently established educational reforms in upper secondary school drastically increase the pressure to the teacher for “covering the material” and for “preparing students for university entrance exams”. In this way, it becomes practically impossible to involve additional laboratory activities (beyond the ones written in the textbook) or to engage in alternative and novel teaching methods.
The interdisciplinary teaching approach (especially in primary and lower secondary schools) is proposed as a good teaching practice as well. In upper secondary school, there is the need for more specialized knowledge and thus this approach (interdisciplinary) cannot be easily applied.
Finally, the group pointed out the need for incorporating more activities and ICT based resources that involve stereochemistry, because in this way students can drastically improve their level of understanding of chemistry concepts, especially those related with chemical reactivity.

c) Group 3

According to this group’s opinion, it is important that the student realize that via a specific chemistry module, they will be able to understand one specific aspect of the natural world and that it is not possible to put everything under one single theory or explanation. Teachers have to help their students concentrate their interest and their effort in the understanding of the concept under study and at the same time help their students avoid confusion and chaos in their mind. Very often students get overenthusiastic and believe that they can easily approach and explain everything. However, this can lead to the opposite effect , ie. aversion towards science. It has to be clear to the students that knowledge is built slowly and systematically.
A chemistry teacher has the possibility to attract students’ attention and create enthusiasm via live experiments (especially if they are spectacular) but at the same time this can pose a barrier to learning; in fact experience has shown that once students are found in an environment like the lab they tend to just try out things and consider the experience as a game and not as a real class. It is preferable if they work in small groups (2-3 people).

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d) Group 4

The cooperative teaching approach is considered a good teaching practice. It gives the opportunity to the weaker students to learn more effectively and to the stronger students to assimilate in depth their knowledge by helping their classmates to learn.

However there are certain conditions under which it can be successful: The teams have to be made by the teacher, who should also be responsible for assigning specific roles to each student. Students have difficulty in finding their own role in the team. The teacher should reassign roles if the team does not function properly. Kids should be educated from very young age in the culture of cooperation. The teachers themselves have not been educated to function as team members and this is a barrier for implementation of the cooperative teaching approach.

The teachers stated that next year they will incorporate the teaching resource Chemsketch in their classes, in order to give the students the opportunity to grasp the concepts of stereochemistry which are fundamental for understanding chemistry.

Finally, there was presentation and discussion (between all 15 workshop participants) of a proposal of a good teaching practice, already tested by one of the teachers (C. Makedonas). This teaching practice involves the use of a platform of unsynchronized e-learning in order to more effectively teach the chemistry class in 1st grade upper secondary school students. It is a platform similar to Moodle and Blackboard which is called Haiku LMS and it is available freely. The teacher referred to the reasons for choosing this specific platform (user-friendly, nice graphics, different from a typical e-learning academic platform) and the different ways it is put in use (uploading of additional material that is related with the lesson for examples videos and simulations, photos of the experiments of the experiments done in the lab, self-evaluation tests). Students are asked to fill in the quizzes and submit them electronically. The teacher is mostly interested in following students' participation and also in receiving feedback for specific difficulties students may face with the material taught. After the first year of use of the platform, the results in regard with the students of 1st grade of upper secondary school are quite encouraging. Some participation statistics are the following: above 70% of students fill in the quizzes, while "real" participation (not only doing the quiz but also checking out the material, etc.) is ca. 60%. This practice does not work well in the 3rd grade of upper secondary school, because these students are concentrated in performing well the in the national exams for entering tertiary education institutions.

The group also expressed the opinion that for the successful implementation of an alternative/novel teaching approach it is important that students are gradually trained to work with the fashion that is required from the specific approach. For example, the cooperative teaching approach works well if the students are used to working in teams. In this way it is important that students are exposed to this approach as early as the first year of primary school. In regard with the use of the unsynchronized e-learning platform, the teacher involved mentioned that he hopes the students which are now in 1st grade of upper secondary school, will be in a position to accept more easily this alternative teaching technique when they reach 3rd grade because they will have already been exposed in it.

14.00 – 14.30

In this part of the workshop the participants were asked to fill in the portal evaluation questionnaires. Some general concluding remarks were made by the project manager. All the material collected will be used as effectively as possible for the production of the third national report and a paper to be presented in the final project conference in Genoa (October 2014).

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