International Conference

Successful Educational Experiences and Didactic Guidelines in Science Teaching

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"Successful Experiences in Chemistry Teaching: Has Chemistry Education Research common ground with Greek school practice?"

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Some history …

The Chemistry is All Around Network aims at stimulating the interest of students towards the study of chemistry

Students' Motivation – Teacher Training – Successful Experiences and Good Practices
National Workshops

Students' Motivation (1st year)

What do Greek teachers and experts believe on

What motivates students to learn chemistry?

Extrinsic motivation – Interest – Self regulation – Self efficacy – Teachers' expectations

Which factors influence students' motivation?

Curriculum design – Teacher – Family

Parallel research is needed on the perceptions of students in order to have a complete picture of the motivation map

Some history …

Students' Motivation (1st and 2nd year)

So, which are the actual motivational constructs of the Greek students?

- Adapted the Science Motivation Questionnaire II (SMQ II) for application into a different cultural context (Greece), a different age group (secondary school students) and with a focus on chemistry learning.
- Investigated Greek secondary school students' motivation to learn chemistry for the first time. Sample of 330 secondary school students (163 boys - 167 girls) of which 146 in lower secondary school (14-15 y) and 184 in upper secondary school (16-17 y).
- Confirmatory factor analysis provided evidence for the validity of Greek CMQ-II.

- **Girls showed higher self-determination** relative to the boys irrespective of age group.
- **Girls in lower secondary school had higher career and intrinsic motivation** relative to the boys of the same age group.
- Age-based comparisons showed that **lower secondary school students had higher grade motivation** relative to upper secondary school students.
- Overall, **low absolute scores for career motivation**

Some history …

Teacher training (2nd year)

Teachers' personal experiences in relation with their pre-service and in-service training

A series of **factors** influencing (positively or negatively) the effectiveness of teacher training programs were identified

Major obstacles for the implementation of novel teaching approaches

Anchoring of upper secondary school to the National exams for entering tertiary education institutions

Closed curriculum and **student evaluation method** which are imposed horizontally in all secondary schools of the country

Lack of basic equipment from the large majority of science laboratories of public schools

These obstacles are related with structural characteristics of the Greek educational system – The implementation of a teacher training program is inhibited.

Proposals on different aspects of teacher training

Content – Type – Responsibility

Successful Experiences and Good Practices

Objectives of final study

1. Short summary of educational research related with the effects of different instructional strategies on student learning

   Focus on the two most common settings for school instruction—the classroom and the laboratory.

2. Explore the degree of adoption of these strategies by Greek teachers via analysis of the content of a workshop carried out with the participation of 15 persons.

Research on successful instructional strategies

- Persistent concerns that school chemistry courses are not providing students with high-quality learning experiences and not attracting and retaining students in science and chemistry fields
- Chemistry education research on measuring the impact of instructional strategies on student learning and understanding

- Majority of studies consistently support the view of adopting various student-centered approaches to classroom instruction can improve students' learning relative to lectures that do not include student participation

- Interactive lecture demonstrations as a strategy for encouraging student participation

  Students who were allowed to work in small groups to make predictions about lecture demonstrations showed significant improvements on tests over students who merely observed demonstrations (Cooperative-based demonstration assessment)

Research on successful instructional strategies

- Research has shown that transformed courses which incorporate in-class activities where students collaborate with each other (peer discussion) improve student performance on in-class concept questions.

- Collaborative group testing has been shown to improve student retention of content knowledge

- Mixed research evidence for widely used technologies such as animations . Research demonstrates that how technology is used matters more than simply using technology. Instructors must be aware of the conditions that support the effective use of technology and incorporate it into their lessons with clear learning goals in mind

Research on successful instructional strategies

- Well-designed laboratory instruction can help students to develop different competences (experimental design, argumentation, formulation of scientific questions)
- However, laboratories that are designed primarily to reinforce lecture material do not necessarily deepen students' understanding of the concepts covered in lecture.
- A review of more than 20 years of research on laboratory instruction found "sparse data from carefully designed and conducted studies" to support the widely held belief that laboratory learning is essential for understanding science (*Hofstein and Lunetta, 2004*)
- Laboratory instruction styles: deductive ("explain, then experiment") to inductive ("experiment, then explain"). "Inquiry" often synonymous with inductive experiments. However, not so many laboratory manuals (commercially available or not) that self-identify as "inquiry" score very high on Lederman's rubric of scientific inquiry.
- Emerging research evidence suggests that students in an open-ended problem based laboratory format improve their problem solving skills [14].

Methodology

Participants (N = 15)

- 1 primary school teacher and 8 secondary school chemistry teachers
- 6 scientific experts from 5 different Institutions
- Four groups of 3-4 persons each
- Each group containing at least one scientific expert

Workshop activities

Participation of all groups in three activities

- Participants were given a specific amount of time (ca 20 minutes) to freely interact with the other members of their group and discuss the topic of the activity.
- At the end of this free interaction, each group was asked to present the summary of their in-between discussion via one spokesperson for a maximum period of 10 minutes.
- The spokespersons' talks were taped and transcribed.
- Content analysis

Methodology

Activity 1

What are the characteristics of a successful experience in chemistry teaching?

Personal experiences and opinions of the participants

Activity 2

Presentation and Discussion on the testing of ICT-based teaching resources available in the CIAAN database

Discussion topics: Resource adaptation, implementation issues, teachers' and students' evaluation of the experience

Activity 3

Transformations needed in traditional instruction and Proposals for good teaching practices

Results and Discussion

Characteristics of a successful chemistry teaching experience

- Well organized
- Excites students' curiosity and keeps them interested but at the same time achieves significant learning outcomes.

  The fact that students show enhanced interest does not guarantee that they have also understood the material taught. Need for evaluation of the teaching practice (students' behavior, performance and opinions)
- Emphasis on how scientific knowledge can be connected with everyday life experiences
- Exploits interdisciplinarity between science-related fields such as physics, chemistry and biology.
- Allows strong interaction in-between students and between the students and the teacher.
- Enables student to master competences in posing questions as well as in searching ways for getting answers.

Results and Discussion

Testing of ICT-based teaching resources in class

- 8 teaching resources: Chemsketch 12 Software, BBC School Science (GCSE level – Units related with fuels and polymers), Phet (applications on stoichiometry, atomic structure, chemical kinetics), Jmol, The Periodic Table of Videos, Chemical Compound of the Month.

- Adaptation issues: need for use of worksheets, English terminology issues (motivating factor in most cases)

- Students' attitudes and learning outcomes: Overall positive feedback - Careful organization of the material may lead to better learning outcomes than the traditional teaching approach.

- However, all teachers agreed that in the grades where the chemistry course taught plays a role for the students' future career, 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.

Results and Discussion

Transformations needed in traditional instruction

- Engaging students in laboratory activities and working in small groups (2-3 people) with pre-assigned specific roles by the teacher

- A lesson introduction like a short activity which will attract students' attention and trigger motivation to learn

- The circumstances under which the cooperative teaching approach can be successful are questionable. A culture of working as a team member must be taught from early schooling and more time needs to be spent in engaging students in cooperative activities during class.

Results and Discussion

Proposals of good teaching practices

- Integration of activities aiming at popularization of chemistry research for achieving more meaningful learning
- Adoption of the cooperative teaching approach, despite its difficulties in implementation
- Targeted use of Information and Communication Technology (ICT) for teaching fundamental chemistry topics such as stereochemistry;
- More emphasis on laboratory work despite existing difficulties

- limited teaching time and infrastructure

- pressure to the teacher for "covering the material"

- students' perception for lab work as a simple game requiring no serious learning effort

- students' interest solely in performing well in the national exams for entering tertiary education institutions

- Appropriate incorporation of chemistry research (eg modern scientific analytical techniques) in school chemistry via interaction with academic institutions and/or chemical industries

Conclusions – Future directions

- Greek secondary chemistry teachers seem to be aware of the student-centered instructional approaches proposed by chemistry education research
- Seem to face several obstacles in practical implementation of these approaches
  (closed curriculum, students' evaluation methods etc)
- Often ignore the circumstances under which these approaches are effective as successful experiences for students' meaningful learning (teacher training issues)
- According to chemistry education literature, the most common strategy for translating chemistry education research into practice has been to develop new teaching approaches and materials, test them via educational research, and then make the most promising ones available to chemistry teachers, primarily through conferences and workshops.
- According to chemistry teachers' self-report data, the evaluation of this process indicates that it has generally been more successful in simply making participants aware of existing research than in convincing participants to adopt new, research based teaching practices

Conclusions – Future directions

- Research suggests that chemistry teachers are unlikely to change their teaching practice without opportunities to reflect on their own teaching practice, compare their practice to research-based, more effective approaches, and become dissatisfied with their own practice.
- Process of conceptual change similar to the process a student needs to go through for developing scientifically correct understanding of natural phenomena

Efforts to translate chemistry education research into practice are more likely to succeed if the following conditions are met:

1) Consistent with research on **motivating** adult learners

2) Include a deliberate focus on changing chemistry teachers' conceptions about teaching and learning

3) Recognize the **cultural** and **organizational** norms of secondary schools

4) Work to address those norms that pose **barriers** to change in teaching practice

Conclusions – Future directions

Promotion of chemistry (science) learning for preparing scientifically literate citizens is a multi-layered, multi-faceted task which involves many "players" (students, teachers, society)

The work done in the three main topics of the "Chemistry is All Around Network" project

- Students' motivation
- Teacher training
- Successful teaching experiences and good practices

tried to take into account this **complex multiplicity** and has produced results that could provide the basis for designing and implementing **more efficient methods for chemistry/science learning** in all educational levels thus accomplishing a high level of **scientific literacy**, one of the most needed competences of today's world.

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