Chemistry Education in Italy: Focus on ICT Resources to Enhance Students' Motivation

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Abstract

In Italy, among the scientific fields, chemistry is identified as an exemplary case study as it is recognised as one of the most difficult subjects. In order to enhance chemistry education, a key objective, is to motivate students, to raise their interest in science subjects, thus making their learning process more effective. For this purpose, the Government has taken a number of actions, with particular attention to the use of information technologies as educational tool for the new generations, those of 'digital natives'. The paper presents the first step of a research aiming at evaluating the utility of carefully selected ICT teaching resources on chemistry learning and students' motivation

1. Science education: national scenario

Improving science education has been high on the political agenda of many European countries since the end of the 1990s and a great number of programmes and projects have been set up to address this issue [1]. One of the key objectives has been to encourage more students to study science.

In Italy, unfortunately, promoting science is not a national priority, therefore an overall national strategy for science education cannot be claimed. Nevertheless, specific policies and local strategies have been developed to try to improve pupil and student interest in science.

In particular, worth to be mentioned are projects as 'Scientific Degree Plan' or 'Teaching Experimental Sciences' characterized by joint-efforts between schools and partners from higher education or from outside the education sector, that have been put in place by the Ministry of Education (MIUR).

Different reasons can be mentioned as the driving force for developing the above actions to improve science education, but the most meaningful are:

- declining interest in science studies and related professions;
- demand for qualified researchers and technicians;
- unsatisfactory results in national and international surveys (i.e. INVALSI surveys [2], PISA 2006 [3]);
- bad image of science in citizen's mind.

The latter have been evidenced by national and international surveys, researches and documents published by experts in the field of education, national reports, discussions with teachers and former students; an exhaustive database of related documents has been produced and uploaded on the portal of the project 'Chemistry Is All Around Us' [4] funded by the European Commission (March 2010-February 2011).

Among the scientific disciplines, chemistry is the less appreciated, being considered difficult and abstract by most of the students, but also by adults. For this reason, the Italian Chemical Society, the most important association of chemists at national level, has always been focused in the effort of improve the image of chemistry and its teaching, collaborating with schools and government institutions.

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2. Students' motivation

As above mentioned, a key objective to enhance science education, is to motivate students, to raise their interest in science subjects, thus making their learning process more effective. That is particularly difficult when the discipline considered is chemistry. In fact:
- the difficulty in the comprehension of the microscopic (abstract) level,
- the use of not adequate text books,
- the lack of experimental activities,
- the insufficient allocated teaching time,
- the low skills of teachers,

make chemistry a subject often rejected by students.

Two main national projects are currently devoted to enhance student's scientific literacy as well as teachers skills, involving.

The national project 'Teaching Experimental Sciences' (ISS) [5] is addressed to primary and the first two years of lower secondary school. One of the objectives of the plan is to support the training of teachers, organized in communities of practice and supported by local presidia; teachers, after proper training, can develop and promote experiences and formal and informal training in science, towards colleagues. The ultimate goal of the initiative is to raise the scientific literacy level of Italian students.

The national project 'Scientific Degree Plan' (PLS) [6] started in 2005 as an answer to the dramatic drop of matriculation to scientific degree courses (Chemistry, Mathematics, Physics, Material Science), registered in our Country. It has been realized all over Italy and it consists of initiatives oriented to arouse interest for science in students from secondary schools. It is directed at both teachers and students and aims to build a bridge between school and university. It consists of many different initiatives, like seminars, laboratories, etc. to be held at school, as well as at university. The main goal of the project is to promote the study of scientific disciplines. Tools to reach the goals described are: to increase the diffusion of scientific culture in the secondary school and to start a process of refresher courses for teachers. The main idea driving the project is the need to the direct involvement of students in laboratory activities as a tool to increase their scientific knowledge.

Both of these projects point to the collaboration between teachers and higher education representatives, but, above all, between teachers and students, to improve mutual communication by developing a shared language and tools able to arouse interest.

Experimental activities are teaching resources very appreciated and considered efficacious to gain students involvement in chemistry lessons. That is of course true, because experimental activities make students protagonists together with their teachers and manage to show the concrete aspect of chemistry and its inextricable link with everyday life, moreover adding a pinch of spectacular, a pupil-friendly ingredient. But they are not sufficient if the objective is to improve motivation.

At this point it is useful to clarify the meaning of the word 'motivation', that is far from obvious and the latter cannot be used as synonymous of enthusiasm or, even worse, enjoyment.

Enthusiasm and enjoyment are certainly immediate and evident moods that seem to make chemistry more friendly and even easier but their effect do not lasts long because they are based on surprise and charm of novelty.

Motivation is more difficult to be obtained and is the result of a long and hard work, but is long-lasting and self-sustaining. In order to motivate pupils it is necessary to make them protagonist of the teaching-learning process, in a join- effort teacher-student that will develop full comprehension of topics, but also awareness and desire to learn. Thus, a motivated student is a person who derives satisfaction in facing and overcoming the challenges he encounters during his training.

For this purpose, language used to communicate scientific contents is fundamental. Pupils, especially if kids, encounter difficulty in the study of chemistry because they do not know the scientific language, they cannot understand the texts in which it is presented without suitable mediation and they find difficult to think at a microscopic level. In order to make them capable of read and understand scientific texts, it is necessary to start from their own language and concepts, then build gradually a more complex language together with the knowledge of phenomena, through the implementation of experiences and the reflection on them. Then they will be able to extend their understanding from the macroscopic to the microscopic level.

Innovative tools, increasingly introduced in teaching methodologies, are provided by Information and Communication Technologies (ICT). The Ministry of Education, University and Research (M.I.U.R.)

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encourages the utilization of these technologies, also because they are very familiar to the new generation of pupils, hence called 'digital natives'.

3. ICTs for school education

Widespread use of new technology in schools was introduced by means of the School System Reform in 2003 concerning the 1st cycle of education (primary and lower secondary school). A wide offer of initiatives has had the aim of renewing and enhancing the teaching/learning methodology to better cope with the needs of teachers, students and families. The major initiatives have concerned:
- Supplying schools with multimedia equipment
- Connecting schools to the Internet
- Setting up networks and services
- Training teachers

The Digital School action plan [7] is the main, but not the only one, project adopted by M.I.U.R. to promote the use of ICT in the teaching/learning process. The initiative is developed in two phases: the introduction of Interactive Whiteboards (IWB) in the schools and the development of digital classes [8] – cl@ssi 2.0. (156 classes at lower secondary level monitored in order to evaluate the impact of ICT and the new learning environment on students' performance and skills) [9,10].
INDIRE (National Institute of Documentation, Innovation and Research on Education) has developed a database system which collects resources to be used by teachers. The most meaningful is Gold [11], the database of best practices, including the Learning Objects produced by teachers.

4. ICT teaching resources for chemistry

Unfortunately, the availability of national ICT teaching resources for science, chemistry in particular, is far to be rich. More fruitful is the research of resources for mathematics and much more for humanistic disciplines.
A selection of about 200 ICT resources to teach chemistry (and science) has been carried out for the project "Chemistry Is All Around Network" (CIAA_NET) [12] by eleven Countries, each Country seeking in its national environment. Only 14 of those resources are in Italian.
The ICT education sector in chemistry/science is still at an embryonic stage in our Country: valuable resources are being developed, also thanks to projects funded by M.I.U.R., but they are not yet sufficiently shared, thus difficult to be found.
The main risk, surfing in Internet without appropriate references, is find free but low quality resources, due to the poverty of interactive material or even to the inaccurate/trivial contents.
Many of the interactive resources selected and available on the CIAA_NET portal, as easily usable and scientifically reliable, have the characteristics of ludic approaches, which certainly offer an attractive variant to the classic lesson, but this does not ensure an improvement of learning. The construction of a multimedia resource should, in fact, take into account also the problem-solving aspect of the tutorial, according with what has been said about students' motivation.

5. Evaluation of the impact of ICT teaching resources on pupils

The work-group of the CIAA_NET project, is composed by experts in school education, higher education and teachers' trainers:
Carnasciali Maria Maddalena (University of Genoa and Scientific Coordinator)
Ricco Laura (University of Genoa)
Alloisio Marina (University of Genoa)
Cardinale Anna Maria (University of Genoa)
Campodonico Serena (University of Genoa)
Ghibaudi Elena (University of Turin)
Lotti Antonella (University of Genoa)
Matricardi Giorgio (University of Genoa)
Parmigiani Davide (University of Genoa)
Regis Alberto (University of Turin)
Saiello Silvana (University of Naple)
Bennucci Valter (teacher, classic lyceum)
Bignone Caterina (teacher, primary school)

Caviglia Giuseppina (teacher, primary school)
Lucifredi Enza (teacher, classic lyceum)
Mallarino Barbara (teacher, primary school)
Pitto Anna (teacher, scientific lyceum)
Rametta Marco (teacher, scientific lyceum)
Rebella Ilaria (teacher, primary school)
Zamboni Nadia (teacher, lower secondary school)
Zunino Rosalia (teacher, primary school)

The workgroup started an exploratory study aimed at evaluating the impact of few selected ICT teaching resources on pupils of different ages and schools.

The preliminary step of the research (preliminary testing) was aimed at highlighting the ideas that an interactive resource arouses on students non-used to this kind of scientific tutorial, that is mainly the emotional impact and the instinctive reaction.

The next step will be devoted to investigate on the effect that the same resources will have on learning and motivation, but this will require at least one year of experimentation for result that can be considered reliable.

5.1 Method, instrument and procedure of preliminary testing

The setting is the computer lab and the procedure foresees four steps:

1. At the beginning, the pupils, grouped in pairs, surf the resource (website or simulation) freely and without teacher guidance.
2. Then, the teacher indicates some website sections considered important (e.g. simulation, evaluation test, video, etc.) to be sure that pupils can arise an opinion about them.
3. Finally, pupils surf autonomously again, discussing each over about the website features.
4. At the end they are requested to answer a structured interview focused on the following progressive key points: interesting, learning, interacting, critical thinking [13-16].

As first ICT resource, a virtual experiment on viscosity (viscosity explorer 2012 [17]) has been tested on kids attending the fourth year of primary school (24 kids, 9 years old).

The experiment consists in dropping a ball through different liquids (water, oil, honey...) then observing its speed; it is possible to change liquid temperature by heating with a flame or cooling. Two simultaneous droppings are carried out, after choosing the liquid and the temperature, thus comparing viscosities as function of temperature and substance.

5.2 Data analysis

After the experience pupils have been interviewed: the questions and a synthesis of the answers are reported below.

1. Website interest

a. Is the website interesting?

Yes, because it helps to learn – Yes because it teaches interesting things – Yes because it helps to understand science – Yes because it makes you understand because when the ball drops in the honey it goes slower than in another liquid – Yes because we experienced liquids at different temperatures.

b. Which sections are more interesting?

To watch the speed of the ball - Honey, because when it is cool the ball drops slowly, but it is also interesting to watch what happens after changing liquids – Video – Two different substances at different temperature that drop with the same speed – The behaviour of substances at different temperature – The ball dropping – The flame that changes liquid temperature because raises or lowers the ball speed.

c. Which parts (texts, pictures, video, ...) are more interesting?

To change temperature – To change liquids – To drop the ball, because it shows the behaviour of liquids – The experiment is like a game, that makes you learn the behaviour of substances when you change their state – The ball, the flame, the liquids – The reset function, because you can repeat the experiment at different conditions – Oil with oil, or the same liquid at different temperatures, or different liquids at the same temperature.

2. Contents learning

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a. Do the site help you in remembering the contents or it would be similar with a book?
The site is better because it shows the motion, the book shows pictures only – The site helps more because I see images – Books are more accurate – The site helps to remember topics already studied – A book states that liquid viscosity changes when you change temperature but the site shows me that the ball drops slower or faster.
b. Is the website structured in an easy way for your understanding?
Yes because it has many options – Yes because it helps us to understand the behaviour of liquids – Yes because it says what to do – Yes because you can understand well what to do e you can do many things – Yes because of pictures – Yes because it has a few things to do.
c. Which parts (simulation, video, pictures,...) support your learning better?
The ball, because when it drops you understand the behaviour of liquids at different temperatures – The video – Pictures in motion – Liquids – The possibility of select the same temperature but different liquids, thus observing the different speed of the balls – Oil compared with oil at different temperatures.

3. Meaningful interaction

a. Does the website stimulate interaction with your schoolmate?
So and so because they are distracted by the experiments – Yes because it helps us to agree – Only when you have to decide what to change – Yes because we help each over when we decide to change something – Yes because we find it very interesting.
b. Which parts stimulate more discussion with your schoolmate?
The ball, because it drops many times – The video – Chemistry, because there are many substances – To change temperature and substances thus observing differences – The liquids and the temperature – To see oil at 100°C and at 0°C – The ball dropping makes you understand temperature.
c. The discussion has been concentrated on the chemistry topics or not?
Yes – Yes because substances are chemistry – Yes, about liquids and temperature

4. Critical thinking

a. Does the website help you in understanding the real world?
Yes, because it shows the behaviour of substances– Yes, because it deals with things of the world – No – I don't know – Yes, because you discover new things.
b. Which are the parts that suggest you critical issues?
None – Texts, video and pictures – The ball in motion through the liquid – The liquids, because they are different – The video, that makes you discover the behaviour of substances.
c. Do you think that you will be able to explain the chemistry contents better after surfing this website (argumentation)?
Yes – Yes, because now we know more about chemistry and about the behaviour of liquids when temperature changes – Yes, because we learn more things – Yes, because we consulted it with attention.

The first step of individual approach to the resource has been exploratory, but almost all the children discovered what was more interesting in the site, then it has been easy for the teacher to guide them to a functional exploration of the same. At this time, knowledge previously built a school, even long before, emerged.
Children initially were attracted by the 'game' but later a different interest arose. It led them to use the tool to test and study the phenomenon.

6. Conclusions

Finally, we want to indicate some educational suggestions that arise from the first observations:

- how to use an Internet resource? If a teacher uses a digital tool, learning does not improve automatically; it is convenient to identify the most suitable sections so the students can use them, at least initially, with a good guidance by the teachers. In this manner, the students do not surf in a haphazard way [18,19];
- the meaningful discussion among the students does not start immediately; also in this case, the teachers should arrange some leading questions that helps the students in developing critical issues and discussion [20];
- the critical thinking is the most difficult aspect; we should calibrate and modify the research instrument [21];

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- a further key point is related with the teacher education: we should consider the opportunity to educate teachers in using the internet resources in the classroom; it's necessary to identify and underline the crucial sections of the resource (this is both a design activity of the teacher before the experience in the classroom and a discussion activity with the students during the experience in the classroom)

A development point for further studies is as follows: how to create and build new resources in a shared (with the students) and easy way (with applications that also non-expert teachers can use)? Obviously, we should verify these data with a larger number of participants.

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