PUBLIC AND STUDENT AWARENESS OF SCIENCE: RECREATIONAL SCIENCE AS A CATALYST

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Abstract

When discussing the traditional and new missions of higher education (1996 Report to UNESCO of the International Commission on Education for the 21st Century) Jacques Delors stated that "Excessive attraction to social sciences has broken equilibrium of available graduates for workforce, thus causing doubts of graduates and employers on the quality of knowledge provided by higher education".

Likewise, when discussing the progress of science and technology, the 1998 UNESCO World Conference on Higher Education concluded that "Another challenge concerts the latest advancements of Science, the *sine qua non* of sustainable development"; and that “with Information Technology, the unavoidable invasion of virtual reality has increased the distance between industrial and developing countries".

Recreational Science has a long tradition all over the Educational World; it aims to show the basic aspects of Science, aims to entertain, and aims to induce thinking. Until a few years ago, this field of knowledge consisted of a few books, a few kits and other classical (yet innovative) ways to popularize the knowledge of Nature and the laws governing it.

In Spain, the interest for recreational science has increased in the last years. First, new recreational books are being published and found in bookstores. Second the number of Science-related museums and exhibits is increasing. And third, new television shows are produced and new short science-based, superficial sketches are found in variety programs. However, actual programs in Spanish television dealing seriously with Science are scarce.

Recreational Science, especially that related to physical phenomena like light or motion, is generally found at Science Museums because special equipment is required. On the contrary, Science related mathematics, quizzes and puzzles use to gather into books, e.g. the extensive collections by Martin Gardner.

However, lately Science podcasts have entered the field of science communication. Not only traditional science journals and television channels are providing audio and video podcasts, but new websites deal exclusively with science podcasts, in particular on Recreational Science.

In this communication we discuss the above mentioned trends and show our experience in the last two years in participating at Science Fairs and university-sponsored events to attract students to science and technology careers. We show a combination of real examples (e.g., mathemagic), imagination, use of information technology, and use of social networks,

We present as well an experience on designing a computational, interactive tool to promote chemistry among high school, prospective students using computers ("Dancing with Bionanomolecules").

Like the concepts related to Web 2.0, it has been already proposed that a new framework for communication of science is emerging, i.e., Science Communication 2.0, where people and institutions develop new innovative ways to explain science topics to diverse publics – and where Recreational Science is likely to play a leading role.

Introduction

When discussing the traditional and new missions of higher education [1] (1996 Report to UNESCO of the International Commission on Education for the 21st Century) Jacques Delors stated that "Excessive attraction to social sciences has broken equilibrium of available graduates for workforce, thus causing doubts of graduates and employers on the quality of knowledge provided by higher education".

Likewise, when discussing the progress of science and technology, the 1998 UNESCO World Conference on Higher Education concluded`[2] that "Another challenge concerts the latest advancements of Science, the *sine qua non* of sustainable development"; and that “with Information Technology, the unavoidable invasion of virtual reality has increased the distance between industrial and developing countries".

Lately, there has been a growing concern about the lack of physical science, mathematics and engineering students, in such a way that governments, namely those of Germany, France or Italy, have undergone special programs to attract and lure students. That situation has arrived already to Spain, which has seen a steadily decline in the number of students in engineering and chemistry, where classrooms were full ten years ago and are half-empty nowadays.

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Recreational science as a catalyst to student attraction to science careers: some experiences

The authors, who belong to *InnoCiència*, a Digital Science Communication Group, have emphasized in the last year the importance of recreational science as a way to attract high-school students to Science careers, especially Chemistry. This discipline has seen a decline in enrollment in all universities, especially in the smaller ones in Spain.

In this communication we will describe roughly some of the recreational science activities where authors have been involved. We hope that our experience is useful to others.

Chemical magic. 25/4/2007

Magic is paramount to human mind. It has attracted interest of people since ancient times, and is still matter of interest to most people. Nowadays magic is found every now and them in TV shows, not only by itself, by connected to recreational science. Fortunately, magic understood as a recreational and communication tool is increasing its public awareness; however, some segments of population still see it as an esoteric, pseudo- and nonscientic, irrational aspect of life. Indeed, we deal only with illusionism, the art of deception, the art of doing seemingly impossible things by normal, rational ways alone.

On April 2007 Josep Duran and Miquel Duran conducted a lecture to Chemistry students of the University of Girona, on Magic and Chemistry. First, an introduction to Recreational Science and Recreational Chemistry was given, and second, an actual performance by depicting a middle-age magician was conducted. Magic games and tricks involved well-known experiments in recreational chemistry and chemical magic.

This lecture was well rated by attendants, which belonged especially to first- and second-year chemical students.

Comments to book "Ciencia Recreativa" by Josep Estalella

In the early years of the 20th century, Josep Estalella, a high school teacher in the

Institute of Girona, the only institution allowed to teach high school at that moment, wrote a book on Recreational Science (Ciencia Recreativa). 70 years later, a few University professors have gathered to comment on the experiments and recreations of Prof. Estalella. The comments, presented in February 2008 in Girona as a book complementing the reedition of the original one, have tried to assess the suitability of ideas by Estalella when considered in the world of

education and science of the early years of the new century. M..D and J.D, in particular, have contributed to comments on mathematical games and recreations, and on chemical experiments. Indeed, nomenclature has evolved, and availability of reactants is nowadays much scarcer. Safety issued are also much tougher now.

Researchers' Night, 28/9/2007

The InnoCiència group collaborated Researcher's Night in the University of Girona by maintaining a blog and a twitter, and by showing the importance of computational chemistry to visitors and participants.

J.D. and M.D. performed a magic show dealing with transformation of wine into water, soda, and other beverages. In the figure at right, J.D. is dressed as a middle-age magician and performs transformation of wine.

Science Week, 15-17/11/2007

In November 2007, Science Week had a special occasion in the University of Girona. During three days, an exhibit was organized in the very City center, where visitors could easily reach about 40 booths ranging from geology to psychology, and from robotics to printing and humanities.

The Department of Chemistry of the University of Girona set up a booth where a few experiments were conducted: petrification of a flower, balloon expansion through liquid nitrogen, and other nice and atractive experiments.

The InnoCiència group, within the Institute of Computational Chemistry booth, joined forces with a local store on Recreation Toys and Games, and presented an exhibit which contained the computer activity "Dancing with Bionanomolecules", Molecular Origami (picture left), molecular models involving fullerenes and nanotubes, and a computational experience on Atomospheric Chemistry. Moreover, a blog and a twitter were mainatined durint the three days of the exhibit.

Furthermore, M.D. and J.D. performed magic on stage. In front of a variety of middle- and high-shool audiences, they transformed water into a variety of beverages, and conducted superconducting experiments. Moreover, M.D. carried out some mathematical games using cards and allowing students to play an active role.

Interestingly, attraction for the various items in the booth varied with the type of visitors. High-school students were mostly attracted by the variety of gadgets and games provided by the local store. Mind-boggling games became a key aspect of the booth, despite the short amount of time students had (they had to visit ca. 40 booths and attend one show within one hour period).

In the right picture, M.D. performs card magic.

We were mostly surprised, however, by the success of molecular origami, especially among middle- and elementary-school students. Molecular origami, like molecular ballooning, pursues bulding molecular models with paper, starting from small square pieces which much be folded suitably. Molecular ballooning, which requires long, magician-type balloons, is much harder and carries two problems: balloons explode, and they lose pressure with time. On the contrary, molecular origami ir really fun, it can be taken away by visitors, it can be easilly multicolored, and can be painted if desired.

Modeling molecules with paper seems also to be more effective that modeling molecules with usual ball-and-stick sets. The hands-on experience of building a molecular system with paper parts is more emotional that just watching a nanotube of fullerene system, despite its size and interest in nanotechnology. The appeal of chemistry is not immediate, but molecular modeling with origami helps indeed.

Expojove 2008 and Open Day 2008 - a local Girona exhibit for high school students and University of Girona's open day to high school students and their parents. During these two opportunities (22-25/1/08 and 25/4/08, respectively), one of us (J.D.) performed spectacular chemical experiments, like adding Mentos to a one-liter Coca-Cola bottle, where a nice fountain arises for a few seconds. Likewise, freezing flowers and rubber balloons brings about appealing experiments. In both cases visitors are not limited to science-interested students.

On UdG's Open Day 2008 we went beyond building molecules with paper (molecular origami) – one of us (C.B.) built up a fullerene molecule using 90 long balloons (see figure above). This was one of the key attractions to our booth.

In the picture above, J.D. (dressed as a magician) performing in front of a high-school audience at Expojove Girona on January 2008.

On chemical magic

This area, in the interfase of Chemistry and Illusionism, is performed by only few people usually arising from the teaching sector. Actually, chemical magic is not fun in itself, as mathematical magic may be – the latter is easily related to mental magic, so its performances are much more impressive. Chemical magic, if not complemented by normal magic tricks, is rather unimpressive.

Transforming wine into water and back into wine, or changing the color of a coin, is not really attractive to an audience as other magic shows may be.

However, chemical magic is rare nowadays, so it is kind of a novelty to students used to watch magic shows in a theatre or in television. It is an ancient kind of deception that magicians do not use much.

Finally, one must recall that chemical magic is slightly dangerous. Real stage magic is safe, but chemical magic carries intrinsic danger. This issue has changed in the last decades - safety regulations prevent many of the chemical magic tricks existing in the scarce literature, so the actual appel of chemical magic is limited. Many classical chemical magic games involve fire, so they cannot be performed. Others involve acids, so care must be taken especially in front of kids. In any case, for students interested in Science and for chemistry students already in the University, chemical magic may help in ther motivation to understand and realize the inner secrets of chemistry.

On mathematical magic

Our experience has shown that the pursue of science careers is quite effective with mathematical magic. Straightforward magic tricks, which may be quite difficult to guess by the audience, are related to mentallism and stay for long time in the memories of the public. There is a wealthy of literature related to mathematical magic (or mathemagics) which allows for automatic of semiautomatic games and which may be then explained because the trick involved is not actually a trick, but a procedure, yet still being a secret. In a mathematical magic trick, as in usual magic performances, technique may account for 10% of the show, with the other 90% being patter.

Mathemagic allows also for collective participation. We have performed in front of young and adult audiences and realized that some mental games and some tricks involving paper and pencil allow all attendants to participate actively. Furthermore, is paper is used, they can keep it and take it home, so the importance of the game and its outcome is magnified with time.

Mathematical diversions and magic tricks are a good way to attract students to mathematics and thus to science and technology. For middle-school students, it is a nice way to break the barrier that prevents them to enjoy mathematics and abstraction. For high-school students, the difficulty of algebra involved in some tricks and the fun of actually understand the inner work of tricks makes them think that mathematics are not that difficult.

Stereochemistry, for instance, was shown at SW07 and UdG's Open Day on April 2008 by cutting one apple into two congruent parts as described by Martin Gardner in one of his books [3]. Cutting an apple in half in such a way, which reminds in 3D of the Yin-Yang bisection of a 2D circle, can be done in two ways, where one is a mirror image of the other (they are enatiomeric).

The chemistry of ordinary things

A new area has recently emerged which brings about an innovative way to increase attraction to science, especially to chemistry: gastronomy. A kitchen contains two chemically meaningful sets: cleaning items like soap, detergent or bleach, and food processing – vinegar, eggs, flour, salt. In other words, a kitchen has a rather dangerous chemical part, and another fun, rewarding, tasteful part.

The huge impact of modern gastronomy in society has caused wide interest in gastronomy. Moreover, the emerging discipline of molecular gastronomy (even though not very molecular actually) is popularized by top-ranked restaurants. The use of liquid nitrogen to prepare on-the-spot ice creams with new flavours is nowadays commonplace.

The impact of gastronomy allows thus to carry out some chemistry-related experiments involving ordinary things found in a kitchen. Cooking is fun, especially if the result, e.g.., pastries or omelettes, can be eaten safely.

When people realize that cooking involves some kind of chemistry (and physics) and even mathematics, their attitude for science improves. Gastronomy is a fancy subject, so the knowledge of its chemical basics has a positive, psychological impact on students.

Last but not least: art and science

We would like to stress also the importance of emotions for the public perception of science. The number of artistic pieces involving science aspects is not very large but not at all meaningless.

For instance, recently a biophysicist has designed necklaces where the name of a person is spelled with aminoacid molecular models instead of actual letters; the aminoacid letter representation is used instead.

Protein sculptures have also been designed. This kind of artwork may help in promoting interest in biochemistry and even teach some concepts related to (oligo-)peptides and DNA. This gives rise to another, amazing world of science, that of molecular biology and biological chemistry.

Conclusion

In this communication we will have shown our experience in participating at Science Fairs and university-sponsored events to attract students to science and technology careers. We have commented real examples (e.g., mathemagic) and its outcome,

A new well-known term involving information technology is Web 2.0, We think that a new framework for communication of science is emerging; we might name it Science Communication 2.0, where people and institutions develop new innovative ways to explain science topics to diverse publics – and where Recreational Science is likely to play a leading role.

All in all, we have dealt in this communication with emotions. Even better – we have dealt with the introduction of students to imagination. Recreational science involves some kind of imagination. Experiments themselves are not powerful enough to encourage students to Science. But recreational experiments allow them to imagine what Science might be. Fun and rewarding, and a catalyst. Yet we must remember always that somewhat difficult.

Blogs on this

Some aspects and examples mentioned in this communication can be found in our website [4]. Moreover, M.D. has a blog [5] commenting regularly on these issues; more information can be found there. L.G. in turn carries two different blogs [6], one related to high school science and another on chemistry-related information.

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[3] "Fractal Music, Hypercards and more…", chapter 8, by Martin Gardner, Freeman, New York, 1992.

[4] http://innociencia.net (accessed 4/5/2008)

[5] Blog *Edunomia* by M.D., http://edunomia.net (accessed 4/5/2008)

[6] Blogs by L.G. (a) "*ReAcCIONa*", http://quimics.wordpress.com, and
(b) "*El Kid Científic*", http://elkidcientific.wordpress.com (both accessed 4/5/2008)

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