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Review

The First EU Science Olympiad (EUSO): a model for science education

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In April 2003 the first European Science Olympiad took place in Dublin City University in Ireland. In this competition second level students were asked to carry out a number of tasks involving biology, physics and chemistry. Students had qualified initially in competitions in one of these subjects and were organised into integrated teams which worked together to complete the tasks. This paper examines the background to the competition, describes aspects of the biological input in developing the tasks and discusses the value of the approach and its potential benefits in improving both interest levels in science and the quality of science education.
Key words: European Science; Olympiad; Education; Enzymes.

Introduction

There are many science competitions around the world but the aim that they all share is to provide an opportunity to encourage students to learn about science. Many of these are knowledge-based while others focus mainly on the students carrying out a research project and presenting their findings which are then assessed. The European Science Olympiad (EUSO) arose mainly from involvement with the International Science Olympiads (ISO), now very well-established international competitions for secondary school students. The International Physics Olympiad was first held in Warsaw in 1967, the International Chemistry Olympiad in Prague in 1968 and the International Biology Olympiad (IBO) in 1990 in Olomouc. These individual subject competitions take place every year at different venues around the world. They all consist of a theoretical and an experimental part. The host country is responsible for developing both the theoretical and practical components of the respective competitions. These are then presented to the international jury consisting of members from all full participating countries and the scientific committee that developed the tasks, who agree the final version to be used in the competition. There are clearly defined regulations and syllabi for each subject. The participants compete and are graded as individuals.

The International Biology Olympiad seeks not only to stimulate interest in science but also to foster greater understanding of curricula and approaches used in teaching biological sciences throughout the world (*www.kbinirsnb.be/ibo/ibo.htm*).

A very important aspect of all these Olympiads is that while they encourage excellence through competition, they also strongly embrace the Olympic ideal of enhancing international goodwill between nations through personal contacts and increased understanding of the diversity of cultures and traditions – using science as the catalyst (*http://olympiads.win.tue.nl/icho/index.html*).

European Science Olympiad (EUSO)

The EUSO is a team competition for EU second level school science students who are 16 years of age or younger on the December 31st prior to the competition (the original age limit was 17 years). The constitution, aims and objectives of the EUSO organisation are described in detail elsewhere (*www.euso.dcu.ie*) but an overview will be given here. The EUSO programme has several clearly defined aims. These are to:

- challenge and stimulate gifted science students to develop their talents through science
- promote science as a career
- demonstrate the interdisciplinary nature of scientific endeavour
- demonstrate the role of teamwork in solving scientific problems
- stimulate interactions between students and between teachers in European countries
- offer the opportunity to compare the syllabuses and educational trends in science education within the EU member states, which could help to improve science education at national and European levels.

The original concept of EUSO was devised by Michael Cotter, Director of the Irish Science Olympiad, to complement the existing national and international Science Olympiads in terms of student age, scientific content, competition dates and format of examinations and assessment. He drew up a draft constitution and an outline of a format for EUSO was presented to the then Irish Minister for Science and Technology, Noel Tracey, in 1998, who was extremely enthusiastic about the idea. He took the concept to a meeting of EU Education and Science Ministers in Brussels where it received support from many countries

In 2001, representatives from Belgium, Germany, Greece, Ireland, Luxembourg and Spain set the guidelines for the competition following consultations with members of the staff at DCU who agreed to stage the first competition in Dublin in April 2003. It was agreed that EUSO would be a multidisciplinary approach involving teams consisting of three members with one 'specialist' from biology, one from chemistry and one from physics.

The competition would consist of scientifically integrated tasks and there would be no prescribed syllabus; the subject matter would be based on material that should be generally covered in the science syllabuses of European educational systems. Emphasis would be placed on scientific approaches and understanding rather than on the ability to regurgitate information. Operationally, it was decided to give the competing countries some information regarding possible subject matter for the tasks a few weeks before the start of the first contest.

The local scientific committee developed two experimental tasks, keeping in mind the limitations of the competition, the age of the students and the need to encapsulate the following elements:

- the experiments should not incorporate any materials or samples that might impinge on the cultures, religions or sensitivities of the competitors, the latter being of particular importance in relation to biological specimens
- the students should be challenged by the tasks, but the competition should be an enjoyable experience
- the competition should not require vast amounts of knowledge but should centre on understanding and the application of scientific principles. In biological competitions there can be considerable diversity in the flora and fauna of different regions and this can pose problems if not taken into consideration
- the experimental tasks should be related to the students' experience, regardless of scientific background, and should be scientific phenomena of relevance to modern living
- the participants would have the opportunity to use modern equipment, thus giving them a flavour of a career as a researcher in science. While they might not have had exposure to the particular piece of equipment beforehand, this would be overcome by giving them all pre-competition training on site, making them fully aware of all health and safety aspects of the tasks and providing well-trained demonstrators who would help with the use of particular items but would not aid the students in the tasks
- it should be feasible for all participants to get experimental results which would then be graded on the quality of the data and their ability to correctly interpret the experimental findings. This should prevent the frustration and disappointment that can occur if students are unable to do any of the experiments, which in our experience can occur in some science competitions: such incidents have the effect of discouraging students from pursuing science in the future
- while the tasks demanded that certain results be generated, they were designed to allow flexibility so that students could exercise their originality in the choice of approach adopted
- it was felt there should be a construction element in at least one of the tasks as this would engage the team and would illustrate the importance of the experimental design set-up
- the multi-task nature of the experiments should challenge the team to work successfully together in order to complete all elements efficiently within the timeframe available. This would illustrate the importance and benefit of teamwork in solving scientific problems.

Philosophy and Implementation

The philosophy of the competition was to promote and encourage a multidisciplinary involving biology, chemistry and physics. There were a number of practical considerations that pre-determined the nature of the tasks undertaken, the most important of which was that the answers must be alphabetic, numerical, graphical, illustrative or a box tick. The answers had to be language-independent to ensure that the scientific committee could apply the same conditions when assessing the answer booklet from each country. Each task was designed so that a team could achieve a number of milestones or stage results. In addition, each task must be achievable in a four hour period, be based on well-characterised and well-documented processes and the tasks assigned must a have clear and unambiguous result.

Experiment I, *Photosynthesis*, had a strong physics/chemistry emphasis while Experiment II, *Properties of Proteins*, had a greater emphasis on biology/chemistry. In Experiment I and to a lesser extent Experiment II, an element of construction was introduced. Task B of Experiment I required the students to construct the Graetzel cell, while Task B of Experiment II required the students to set up the apparatus to monitor the renaturation of casein, which included the alignment of a light source and light probe. Sufficient text with suitable diagrams was supplied to assist students with the practical set-ups. However, in keeping with the philosophy of the competition the students were encouraged to use their own initiative in so far as this did not compromise their safety.

Once the developmental work was carried out, it was necessary to decide on the layout of each experiment so that the final procedures could be drafted. Each experiment was divided into three tasks as follows:

Experiment I: Photosynthesis.
Task A: Chlorophyll extraction
Task B: Nanocrystalline Solar Cell
Task C: Photochemical Reduction

Experiment II: Properties of Proteins
Task A: Introduction to the Beer-Lambert Law
Task B: Renaturing Casein
Task C: Enzyme Activity

A general introduction was given with each task, followed by the details of the actual experiment. Many versions of the experiments were drafted and re-drafted before the final documents were prepared for translation into the language of each of the competing countries. This was a difficult challenge for the scientific committee, as the language used had to be as unambiguous as possible so as not to complicate the translation process.

Experiment I was described in a previous publication (van Kampen *et al*, 2004). Experiment II was based on an experiment described previously (www.accessexcellence.org/AE/1995/masterman_biochemistry.html) and also on other practicals that we have used in the School of Biotechnology at DCU. These are well-tested experiments that, if performed correctly, will certainly yield results. However, they also offer considerable scope in relation to the set-up of equipment (Task A), the generation of good quality data, the handling and interpretation of this data and the appropriate selection of controls and blanks. In addition, they test the manipulative and technical skills of the students.

From the biology perspective we wished to use modern biochemical techniques and equipment that are quantitative in nature and are related to the types of experiments that are performed by professional biologists in an academic or industrial setting. It was felt that such an approach would be more stimulating and would encompass more chemical and physical principles, again highlighting the integrated nature of science. This would also be more exciting and demanding for students than traditional observational and recording approaches.

The experiments used in the competition were pre-tested on a number of student groups before the competition proper in order to ensure that the level of the material and the timeframe used were reasonable. The tasks involved pH measurements, spectrophotometry and demonstration of the nature, structure and activity of proteins. The proteins selected were casein and the enzyme, alkaline phosphatase (O'Kennedy, 1989; Plummer, 1991; Garret & Grisham, 1995; McKeon *et al*, 1998).

Organisation of the laboratory

A total of 14 teams entered the EUSO competition and each team comprised three students. Initially all the teams were to complete simultaneously each experiment in two four-hour periods over two days. However, it was decided at an early stage to split the teams into two groups of seven teams. This would improve the working environment for the students and also avoid the teams having to share equipment. The lab chosen was equipped with both the appropriate numbers of laboratory benches and fumehoods. Each team was allocated a laboratory bench space of approximately 10 metres that was divided into three separate areas for each task. The UV-visible spectrophotometers (eight in total) were placed on separate stands leaving the laboratory bench space free for the students.

Results of the competition

Teams from Belgium, UK, Germany, Ireland, The Netherlands, Spain and Sweden entered the EUSO competition. The UK, Germany and Ireland entered three teams each. The Netherlands entered two teams and Belgium, Spain and Sweden entered one team each. The teams were assigned a postgraduate student from DCU (from either chemistry, biology and physics) to assist with any problems that might occur during the competition. However, they could not help the competitors with any theoretical aspect of a particular experiment. A safety talk and demonstration of all the equipment to be used in each experiment was given on the evening before each examination.

At the end of each exam, each team had to submit a single answer book including any graphs or spectra that they had generated. The scripts were then marked by the Scientific Committee and by the mentors representing each country. A mediation process was conducted between the scientific committee and mentors where the results and scores were discussed and finalised.

Medals were awarded as follows:

- **Gold medals**: United Kingdom T3 & Netherlands T2
- **Silver medals**: Ireland T3, Germany T3, Ireland T2, Netherlands T1 & United Kingdom T1
- **Bronze medals** (in alphabetical order): Belgium T1, Germany T1, Germany T2, Ireland T1, Spain T1, Sweden Ti and United Kingdom T2.

All teams were awarded medals in keeping with the philosophy of the competition that everyone was a winner and that the true goal of the competition was to encourage and promote science at secondary level, to promote international understanding and to acknowledge the achievement of the participants in representing their respective countries.

Feedback from the participants

The overall feedback both from the team leaders and students indicated that they had found the competition and the interaction with their peers very enjoyable. This was in no small part due to some excellent social events and the inputs of the guides and organisers in creating a supportive and challenging environment. The general view was that the experimental tasks had been demanding but students felt that they could perform most elements. The students felt that they had learned a lot about experimental science. Their involvement in laboratory sessions with a team of other young scientists was a new experience. Almost everyone felt that the competition had created a more positive view of science for the participants. The next EUSO took place in the Netherlands in May 2004 and we look forward to future competitions all over Europe.

Implications for further education

In Dublin City University we have pioneered the development of courses in Ireland that integrate a number of scientific disciplines. For example, our programme in Biotechnology integrates a range of biological subjects with engineering and a smaller business element (O'Kennedy, 1991). In addition, it involves a considerable amount of team project work *e.g.* in Process Biotechnology. Our degree programme in Analytical Science integrates chemical and biological analytical approaches. Recent courses have included Medical Mechanical Engineering which integrates considerable amounts of biology with engineering, Science Education which concentrates on physics and chemistry with a minor biological element and Bioinformatics which integrates computing and biology. All our programmes include periods of industrial or practice placements where the students experience the work situation at first-hand.

Our experience with these programmes and EUSO confirms our belief that science education at all levels would benefit greatly from an integrated approach. In this time of greatly diminished interest in studying science and a possible long-term shortage of scientifically-qualified graduates – with associated implications for research and industrial development – the approach we have described may be valuable. Perhaps, while we all need to ensure the quality of education in our respective speciality areas, the really successful scientists of the future will be capable of successfully integrating a number of scientific disciplines. In the research area this is already bearing fruit as we have recently developed a number of highly integrated research centres such as the National Centre for Sensor Research and the National Institute for Cellular Biotechnology. The key factor that sets these apart is their multidisciplinary nature and this is recognised nationally and internationally as contributing to their long-term success. If this is the type of environment to be found in the future, whether in research or in industry, then educationalists must take this very seriously in developing future approaches and programmes at all levels.

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