European Union Science Olympiad

Towards a Multidisciplinary Strategy for Science Education

A thesis presented to Dublin City University for the Degree of Doctor of Philosophy

By

Michael Anthony Cotter, B.A, M.Ed.
School of Education Studies
Dublin City University

Supervisor

Dr. Carmel Mulcahy
School of Education Studies
Dublin City University

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DECLARATION

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Michael Anthony Cotter

ID No.: 93700768

Date: ____ January 2013

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I want to thank my wife Breda, my daughter Maura and my sons Michael and Gerard, who by their example have shown me what is possible.

DEDICATION

To the Memory of my Children’s Grandparents:

Mr. Martin & Mrs. Brigid Cotter
Mr. Tomas & Mrs. Máire O’Sullivan

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ABSTRACT

The European Union Science Olympiad (EUSO) is a unique, multidisciplinary, integrated, Science, practical-based, team competition. It was established to provide young EU students with a platform to display their scientific capabilities.

The concept of the EUSO thus developed from the senior Olympiads which existed at international level at the time. To be accepted by EU Science educators and governments, it would have to mirror these single subject, individual, theory-based Olympiads in several respects and yet be novel in aspects that embody and reflect new ways of teaching and learning.

This thesis tracks the historical growth and success of the EUSO from its establishment in 2003 to the present day. It describes the background and significant difficulties involved in convincing EU Science educators of its merits. The philosophy, rationale, teething problems, evolution, integration and key role of team-work are outlined. The EUSO's contribution to the education system of today and the performance of Irish students in EUSO in comparison with the performance of students from the old and new Europe, are examined.

A crucial element in this success story has been the methodology used in the organisation of the EUSO: Participatory Action Research (PAR). Through this democratic process, participants were released from the constraints of the established Olympiad structures and enabled to function in an environment which allowed them to investigate their own reality in order to change it. Such actions have resulted in the development of a new science Olympiad model, the EUSO model.

The EUSO has worked: 22 countries and 132 students participated in 2012. 906 students have taken part since 2003. The most striking finding in its ten year history, however, is the dominance of the gold and silver medal categories by the former Soviet Bloc countries.

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LIST OF ABBREVIATIONS

AISPC	All Ireland Schools Programming Competition
AR	Action Research
ASTI	Association of Secondary Teachers in Ireland
BERA	British Educational Research Association
CARE	Centre for Applied Research in Education’
CDVEC	City of Dublin Vocational Education Committee
CSI	Crime Scene Investigation
CSO	Central Statistics Office
Cz, Rep.	Czech Republic
DCU	Dublin City University
DES	Department of Education and Skills
DIT	Dublin Institute of Technology
DLVEC	Dun Laoghaire Vocational Education Committee
DNA	deoxyribonucleic acid
EACEA	Education, Audiovisual and Culture Executive Agency
ESTABLISH	European Science and Technology in Action Building Links with Industry, Schools and Home
EU	European Union
EUSO	European Union Science Olympiad
FDR	Franklin D. Roosevelt
FRG	Federal Republic of Germany
GA	General Assembly
GB	Governing Body
GCSE	General Certificate of Secondary Education
GDR	German Democratic Republic
IBO	International Biology Olympiad
IBSE	Inquiry-Based Science Education
IChO	International Chemistry Olympiad
IJSO	International Junior Science Olympiad
IMO	International Mathematics Olympiad

IOI	International Olympiad in Informatics
IPhO	International Physics Olympiad
IrEUSO	Irish European Union Science Olympiad
ISO	Irish Science Olympiad
LMO	Leningrad Mathematical Olympiad
MMO	Moscow Mathematical Olympiad
NCCA	National Council for Curriculum and Assessment
NPADC	National Policy Advisory & Development Committee
OECD	Organisation for Economic Co-operation and Development
PAR	Participatory Action Research
PATS	Positive Attitudes Towards Science
PBL	Problem-Based Learning
PISA	Programme for International Student Assessment
PPR	Progressive Pedagogies Research
QSRLS	Queensland School Reform Longitudinal Study
ROSE	Relevance Of Science Education
RuG	University of Groningen
SEC	State Examinations Commission
SMEC	Science and Mathematics Education Conference
STS	Science -Technology-Society
TCD	Trinity College Dublin
TIMSS	Trends in International Mathematics and Science Study
TLC	Thin Layer Chromatography
TY	Transition Year
UK	United Kingdom
ULB	Université Libre de Bruxelles
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
VEC	Vocational Education Committee
VUB	Vrije Universiteit Brussel

Chapter 1

Introduction

1.1 The Focus

This is primarily a practice-focused research thesis on a progressive version of Science Education with historical, social and political dimensions. It tracks the development and organisation of a unique Science competition for sixteen year old students, the European Union Science Olympiad (EUSO) from its conception to the end of its tenth year. The original idea, which was the brainchild of the researcher, has over time, resulted in the growth of an initiative which is currently embraced by students, teachers and mentors across the EU. The motivation for establishing the EUSO was to develop, organise and maintain over an extended period of time a Science competition which would develop “Team Science Tasks” that would integrate Science, be problem-based, be connected to the real world and involve the construction of knowledge, higher-order thinking, alternative solutions, depth of knowledge and sophisticated communication between the team members.

The concept of competition and/or examination generates mixed feelings among students and teachers alike but also has the effect of focusing minds, setting goals and identifying benchmarks. Efforts are usually rewarded and standards achieved. Olympiads have an additional feature in that the participants have not only already achieved success and recognition but also have the potential to represent their countries at International level.

The EUSO was designed to fill a gap in the Science Olympiad landscape, whilst simultaneously functioning as a stimulus for increased interest in and enjoyment of scientific phenomena at a critical period in students' education. The specific factors which resulted in its foundation and uniqueness include the following:

- the discovery that the members of an Irish team competing at an International Olympiad in Informatics (IOI) were in fact also in competition with each other.
- the poor performance of Irish students at the International Biology, Chemistry and Physics Olympiads.
- the reality that taking part in Olympiads is about winning medals.
- the decrease in the number of male Science teachers across the EU.
- the sharp decrease in the number of female Chemistry and/or Physics students worldwide.

An additional factor was the gradual realisation on the part of the researcher that, while daunting, a less ambitious project had the potential to fail. In this regard, it had been his initial intention to simply develop an activity for Transition Year (TY) or "Gap Year" Irish students, albeit again with a view to prolonging Irish student participation in school Science on completion of the Junior Cycle. On reflection, the decision to establish the EUSO instead has elevated the debate to a global level and facilitated universal awareness of the issues facing Science and Scientists.

The success of the EUSO is due in large part to the approach adopted by all involved in its development. The methodology used was Participatory Action Research (PAR) which is characterised by a commitment to openness, transparency, equality, respect, collaboration and communicative action. Throughout the whole process the EUSO members were consulted and their views taken. It is a story of patience, perseverance, tolerance and achievement. It is the story of an adventure which began in Ireland 1993 when Irish students first participated in the International Olympiad in Informatics (IOI) in Mendoza, Argentina and which, following many stops along the way, continued in Vilnius, Lithuania in 2012. The context within which this Olympiad developed and the historical record are a significant dimension of this research.

This story may serve as a road-map for others wishing to enhance the educational journeys of students and wondering which routes to follow as part of their quest.

Another such road-map or framework which provides an intellectually challenging environment is articulated by Hayes et al. in Teachers & Schooling – Making a Difference (2006). They call the framework *"Progressive Pedagogies, Assessment and Performance"* (p. 22-23). Many of the dimensions and elements of Productive Assessment and Performance aptly describe the features and components of the EUSO Tasks. These include, the *Intellectual Quality Dimension*: - problematic knowledge, construction of knowledge and consideration of alternatives, higher-order thinking, depth of knowledge and understanding, disciplinary content and processes and substantive conversation. In the *Connectedness Dimension*: - problems connected to the real world beyond the classroom and school are embarked upon, knowledge is integrated, and links made to background knowledge. In the *Supportive Classroom Environment: -* the EUSO has a supportive laboratory setting where intellectually demanding tasks are solved by team of three students at their own pace and in their own way.

1.2 Biographical Note

The researcher qualified as a primary school teacher in 1969 having completed a two-year teaching diploma programme in the all-male, Catholic, St. Patrick's Teacher Training College in Dublin. He was awarded a scholarship to St. Mary's Catholic College in Twickenham, London in 1970 to pursue a three year degree course (BA) in

Education and Physical Education. In 1978 he was conferred with a Master in Education degree (M.Ed) by Trinity College, Dublin (TCD). His has taught at both primary and secondary levels. He has also lectured in three Teacher Education Colleges in Dublin and in the School of Education Studies at Dublin City University (DCU).

In 1985 he entered the political world as a candidate in the Local Government Elections in Blackrock, Dublin which resulted in him becoming a member of the City of Dublin Vocational Education Committee (CDVEC), the Dun Laoghaire Vocational Education Committee (DLVEC) and Chairman of the Governing Body of the Dublin Institute of Technology (DIT). Over the next ten years he worked in a voluntary capacity for a political party as a researcher and report writer dealing with primary and secondary education, primarily but also with the social issues of the day. In 1987 he was appointed by the Minister for Education to the Primary Education Review Body which radically changed primary education in Ireland and in 1997 he was appointed Chairman of the National Policy Advisory & Development Committee (NPADC) which managed the introduction of Information Technology into Irish first and second level schools.

In 1993 he founded the All Ireland Schools Programming Competition (AISPC) which began Ireland's participation in the International Olympiad in Informatics (IOI). The holding of an All Ireland competition for second level students was a conscious political statement by the researcher and unique in Ireland at the time. He followed this in 1995 by founding the All Ireland Schools Chemistry Competition and selected a team of four students from both jurisdictions to represent Ireland at the International Chemistry Olympiad (IChO). In 1997 he founded the All Ireland Schools Biology and Physics Competitions and selected teams of four students from both jurisdictions to represent Ireland at the International Biology

Olympiad (IBO) and the International Physics Olympiad (IPhO). In 1998 he amalgamated all four All Ireland Competitions into a single competition, with four Science sections, which he named the Irish Science Olympiad (ISO).

The establishment of the Science Olympiads in Ireland was a deliberate political act, on the part of the researcher, which reflected his view that male and female Irish students of all social, political, religious, ethnic and other backgrounds should have the opportunity to represent Ireland at the International Science Olympiads. The establishment of the Olympiads also called on him to use his political skills to get Government Departments in two jurisdictions, Universities, administrators, schools, teachers and academics in four disciplines to work together for the benefit of the students.

From the beginning the researcher became conscious of the limitations of the International Olympiads and was determined to establish a Science Olympiad which would challenge educators to develop Science Tasks for students, the completion of which would result in what Hayes et al (2006) would later call “Productive Performance”. The journey also involved implementation of and adherence to the democratic process.

The researcher is not a scientist or a Science teacher. The motivation for establishing the European Union Science Olympiad (EUSO) is described in detail on page 9.

1.3 The Concept

The researcher recalls that as he contemplated the concept of a new vision for a Science competition for young EU students, a line from the poem ‘An Essay on Criticism’ by Alexander Pope (1688-1744) immediately came to mind:.

> ‘Be not the first by whom the new are try'd.
> ‘nor yet the last to lay the old aside’.
> (Pope. 1711)

He ignored this first piece of good advice but paid more attention to the second line from the famous heroic couplet: A new Science Olympiad would be established that would contribute to a context-based, multidisciplinary, integrated, experimental curriculum for Science Education. It would be novel in many aspects but not so totally new as to alienate completely the target audience, namely, the European Governments EU team leaders and mentors of the International Biology, Chemistry and Physics Olympiad delegations. They were already, for many years, familiar with, attached to and somewhat satisfied with the structure, format and terminology of these International Science Olympiads. Some disquiet had been perceived with the seemingly built-in unfairness or imbalance in favour of bigger countries and the bias against female students, especially in Physics. The researcher would not totally *‘lay the old aside’* by including and incorporating aspects of these well-established Olympiads, such as the vocabulary used, overall culture, management and structure. Through on-going discussion and debate, new ideas would be introduced and maybe accepted by all the stakeholders.

What became an EU-wide Science Olympiad had originally been envisioned as a local Irish Science initiative for Transition Year (TY) students, the primary purpose of which was to help stem the tide of decline in participation in Chemistry and Physics Education, particularly in relation to girls. Ireland had participated in five International Olympiads from 1988, but participation had not helped to promote Science in Irish schools.

The researcher cannot precisely recall when the idea of a European Union Science Olympiad (EUSO) first came into his consciousness. He is in no doubt, however, but that it became crystallized for him following his attendance at and his experience of organising Ireland's participation in the 6th IOI, which was held in Haninge, Sweden from July 3rd to 10th, 1994. At this event, he met and spoke with the then President of the IOI, Dr. Yngve Lindberg (1900-1966) and with the Chairman of the Scientific Committee for IOI 1994, Dr. Håkan Strömberg. Through these, he was enabled to make contact with persons involved in the International Biology Olympiad (IBO), the International Chemistry Olympiad (IChO) and the International Physics Olympiad (IPhO). As a result, the researcher organised Ireland's initial participation, as an observer, in the 27th IChO which took place in Beijing, China from July 12th to 20th, 1995; in the 8th IBO which took place in Ashgabat, Turkmenistan from July 13th to 20th, 1997 and in the 28th IPhO which took place in Sudbury, Ontario, Canada from July 13th to 21st, 1997.

It could be perceived as presumptuous of the researcher to expect that a newcomer to these Olympiads would effect fundamental changes in the short term. He believed that leading by example was the best solution and looked at the possibility of constructing a new vision for an Olympiad, which would be unique, appeal to EU Governments, Universities and Mentors and develop team Science Tasks that would be: intellectually challenging, support cooperation, collaboration and teamwork, integrated, and connect Science across the disciplines, problem-based, relevant and connected to the real world. It would engage all the team members in the task, be self-directed in terms of pace, direction and outcomes, support and value all students' efforts, minimise high-stakes assessment and involve the students in the construction of knowledge, higher-order thinking, alternative solutions and strategies, depth of knowledge and understanding, manipulation of information & ideas and sophisticated

& substantive communication between the team member and thus answer some of the questions that were raised. It would also provide younger EU students with a platform to display their scientific capabilities. The design of a methodology that would support such a large-scale venture was the next step in the process. In order to arrive at a suitable approach it was important to examine a number of issues.

1.4 The Beginning

Ireland had been participating in the International Mathematics Olympiad (IMO) since 1988, the IOI since 1993, the International Chemistry Olympiad (IChO) since 1997, the International Biology Olympiad (IBO) since 1998, and the International Physics Olympiad (IPhO) also since 1998; yet, with one exception, the researcher noted that Irish students had achieved limited success in the medal stakes. The exception in this regard related to the IOI.

In the early years, Irish students' success stories emanated from the IOI. On closer examination, it became evident that this was due, primarily, to the establishment of a junior section in the Irish Informatics Olympiad and to the setting up of online computer programming clubs and training programmes. As a result, Ireland was awarded a silver medal at IOI 1997 due to Eóin Curran's performance and a gold medal at IOI 2003 due to Martin Orr's performance. These results suggested that Ireland's performance at other Olympiads could be enhanced through early intervention.

An additional observation on the part of the researcher was that participation in the International Science Olympiads had done little to promote Science in Irish schools. In this instance, the factors having the potential to contribute to such a scenario included the reality that a majority of students make the decision to drop certain Science subjects, in particular Chemistry and Physics, after the Junior Certificate Examinations and that all students competing in such Olympiads have completed the Senior Cycle prior to taking part. Thus, if students' participation in school Science was to be prolonged and their performance at International Olympiads enhanced, an intervention at Transition Year (TY) was required.

The sanctioning by the Department of Education and Skills (DES) of a TY between the Junior and Senior Cycles had occurred in 1994 (Circulars M31/93 and M47/93). This year is the first year of a three-year Senior Cycle. It is a ''Gap Year'', during which students pursue activities that interest them and which may have little or nothing to do with the school syllabus. The TY mission is to:-

> ''*promote the personal, social, educational and vocational development of pupils and to prepare them for their role as autonomous, participative, and responsible members of society*'', (DES. 1994/95)

Activities undertaken often include participating in the ''*Gaisce Awards*'' which 'contribute to the development of all young people through the achievement of personal challenges' (Gaisce. 1985) spending of a period of time in another country for the purpose of learning its language and experiencing its culture; partaking in school productions such as musicals and plays and carrying out of work experience.

1.5 Motivation for Establishing the EUSO

In light of his initial observations as outlined above, the researcher consulted the literature in order to extend his knowledge of the situation in relation to Science in other countries. He discovered that much of the documentation emanating from the EU and elsewhere

(EACEA report on Key Data on Education in Europe, 2009; European Commission Report on Science Education, 2007: Nuffield Foundation Report on Science Education in Europe, 2008; OECD - PISA report on Competencies in Science, 2009) signalled a consensus regarding the features of Science Education that member countries had in common. These included:

- decline in the numbers studying Science in secondary schools
- sharp decline in the numbers studying Chemistry and Physics
- steep decline in the number of girls studying Chemistry and Physics
- lack of interest among students in school Science
- poor attitude towards Science and Scientists
- shortage of suitably qualified Science teachers, particularly in Chemistry and Physics
- ineffectual teaching of Science
- single subject Science curricula
- lack of integration in school Science
- lack of experiments / practicals in school Science
- shortage of university Science graduates

He also conducted a detailed examination of the results of all International Science Olympiads with a view to establishing the trends, if any, that could be discerned across competitions and countries. This exercise revealed that Germany and the Soviet Bloc countries, e.g. Hungary, Bulgaria, Estonia, the Czech Republic and Slovakia, frequently featured in the gold medal category; that the UK, the Netherlands and Italy featured regularly in the silver medal category, and that certain other EU countries, including Ireland, tended to figure mostly in the bronze category if at all.

Given the generally negative findings regarding school Science and Irelands' performance at International Olympiads, the idea of an All Ireland Junior Science Olympiad to be held in TY began to emerge. It was envisaged that it could function both as a mechanism to increase participation in Science and as a platform to train Irish students for the International/Senior Olympiads and thus facilitate enhanced performances at those events. After some deliberation, however, the researcher concluded that its timing, while having the potential to influence the participation rates of students in Science, would militate against its use as a training platform for the International/Senior Olympiads given the three year lead-in time to these for such students. Hence the realisation of a need for a more immediate goal and the birth of the concept of an EU Olympiad in Biology, Chemistry and Physics for TY students.

1.6 Research Proposition

Having determined that the establishment of an EU Science Olympiad (EUSO) had much to recommend it, the researcher through additional examination of the relevant literature and following discussions with colleagues, discovered a general consensus across governments and among educators that, despite the lack of interest in the discipline, Science should be taught in schools. Moreover, a fundamental concern shared by all the stakeholders was why so many were turning their backs on Science Education and at a relatively early age. In these circumstances, an initiative designed to stimulate interest in and enthusiasm for school Science among TY students, while also challenging them at an International level, seemed timely. The question for the researcher, however, was ‘could it be accomplished?’

Having reflected upon the issues and consulted with a range of professionals in the area, the researcher decided that the following was the question that needed to be addressed.

Can a Science competition be developed, organised, maintained and monitored over an extended period of time by the researcher, which will appeal to EU governments, universities, mentors and EU students, particularly girls, which will develop team Science Tasks that integrate the Sciences, are problem-based and connected to the real world, involve the construction of knowledge, higher–order thinking, alternative solutions, depth of knowledge and sophisticated communication between the team members and contribute to stemming the tide of decline in interest in school Science across the EU ?

This same question is the focus of this research thesis. In attempting to provide the response to this question, the present study and historical account will, it is hoped, make a significant contribution to Science Education within the EU and facilitate the exposure of substantial numbers of students to stimulating scientific phenomena and experiences at an International level.

1.7 Theoretical Framework

The researcher was fully aware that that his personal perspectives and preconceptions would have a bearing on the research process and his approach to answering the research question. In this regard he realised that he subscribes to the view that the kind of knowledge that is valid and satisfactory is that which is created through the subject's interactions with the world. However, subjects construct their own meaning in different ways and experience the world from different perspectives. Such a constructivist stance calls for an interpretivist approach to knowledge creation. In interpretivism, the *'world is interpreted through the classification schemas of the mind'* (Gray 2006 p. 20); the emphasis is on understanding the real workings behind 'reality'. For the researcher, attempts to understand this reality were grounded in people's experiences of that reality. The task was to explore people's multiple perspectives in the natural settings.

1.8 Research Methodology

In attempting to address the research question, as presented above, the researcher was mindful of the fact that his chosen methodology should align with his epistemological stance and theoretical perspective, i.e. constructivism and interpretivism, respectively. In this regard, the postmodernist approach to knowledge creation promoted by Action Research (AR) was considered appropriate. AR enables the researcher to:

> *'Develop a context in which individuals and groups with divergent perceptions and interpretations can formulate a construction of their situation that makes sense to them all – a joint construction'* (Stringer, 1999, p. 45).

Moreover, given the nature of the EUSO project, that AR is

> *'a participatory, democratic process concerned with developing practical knowledge in the pursuit of worthwhile human purposes'* (Reason and Bradbury, 2006. p. 1).

marked it out as especially apt. For the researcher, the particular AR model chosen, namely Kemmis and McTaggart's (2003) Participatory Action Research (PAR), was selected due its primary focus: authentic participation. In addition, the emphasis on investigation of actual practices and the concentration on transformation of practitioners' practices in an egalitarian manner enabled adoption of PAR as the model most likely to have the capacity to handle the variety of challenges that the EUSO concept would inevitably generate.

However PAR does not cover all aspects of this research. Like any research paradigm it has its drawbacks and limitations. The historical aspect of the EUSO is a crucial aspect and a vital component of the narrative, which PAR does not cover. Chapter 2 (The Context) explains the context and the environment in which the EUSO developed and which helped shape the final outcome. Without the "Irish" dimension the EUSO could not have been developed.

1.9 Ethical and Political Considerations

The researcher's direct involvement in the IBO, IChO, IPhO and the IOI gave him a unique insight into their structures, organisation and management and gave him access to a wide range of influential people who gave him their views on aspects of the events and the profile a new Olympiad might adopt. This raised ethical issues around privileged information and how it might be used. However the researcher was open and not clandestine or covert in any way and as many opinions as possible were sought. Cooperation and collaboration were ensured and dissenting opinions were listened to. Gray (2006) citing Badger (2000) suggests that

> *"At least superficially Action Research seems to pose few ethical dilemmas because it is based on a philosophy of collaboration for the mutual benefit of the researchers and participants" (p.388).*

While Action research is not a "smash and grab" approach to research or what Lather (1986) calls *"rape research"* (p. 261), it requires negotiated access, confidentially and the right to withdraw. Nothing was taken for granted and as Mumford (2001, cited in Gray 2006, p. 390) suggested the participants agreed the final report and continue to be involved in its evolution.

1.10 Thesis Outline

This thesis is divided into seven Chapters. In the Introduction above the focus of the research and the motivation for establishing the

EUSO as a progressive, integrated, Science, team-based competition, involving the construction of knowledge and the use of higher-order thinking are outlined. The function of the EUSO in filling a gap in the Science Olympiad landscape while stimulating interest in and enjoyment of scientific phenomena is described. The involvement of the Science Olympiad community within the EU in a democratic and egalitarian manner through PAR is highlighted. The researcher's background in education and politics helps to clarify why the EUSO was conceived in Ireland and why it developed as it did from the concept of a local event to an EU wide one. The research question, which anchors the entire study, is presented. The theoretical framework is constructivist / interpretivist while the research methodology is primarily PAR and includes an historical account of the development and execution of the EUSO.

Chapter 2 puts the EUSO in context and highlights some of the issues that led to the establishment of the EUSO and which may still exist today. The Irish Education system and in particular the Science Education system in Irish secondary schools during the lifetime of the EUSO forms the backdrop and explains the environment that instigated and motivated the establishment of the EUSO which differs fundamentally in many respects from the existing Science Olympiads. The popularity of science at the Junior Cycle among all students to the virtual collapse of Chemistry and Physics participation particularly among girls at the Senior Cycle is highlighted and comparisons made with other EU countries. Ireland's participation at the EUSO, the team selection process, the gender and school background of the team members and the ranking achieved provides the opportunity to compare Irish students with their cohort in the rest of the EU in this very limited area of schooling, while at the same time indicating where progressive approaches to Science education might be beneficial to Ireland and the rest of the EU

Chapter 3 reviews the limited literature on the history of the International Science Olympiads from the Leningrad Mathematical Olympiad (LMO) in 1934 to the present day Olympiads by using primary sources where possible. Little research has been carried out on the impact of the Olympiads or the role of competitions on science education. Literature on relevant topics raised by the research question such as, why teach Science are explored. The central role of Science Education in the Education systems across the EU is investigated, in particular the perceptible decline in participation in the Senior Cycle of the secondary Education systems in Chemistry and Physics by all students, but especially girls. This has raised concerns about the future supply of well qualified Scientists, Engineers and Science Teachers. This has led to much research on the pivotal role of the teacher, their qualifications and training, the curriculum content of the subjects they teach and the teaching methods that are employed and how this in turn influences the interest and attitude of students. The critical role of assessment is reviewed.

Chapter 4 outlines the Research Methodology chosen. The Epistemological Stance and Theoretical Perspective of the researcher are presented as is the rationale for choosing Participatory Action Research (PAR), because of its aim to transform and to be participatory, practical, collaborative, emancipatory and reflexive. While acknowledging the overarching importance of the PAR approach, the import of the setting and historical account of the EUSO over a ten year period is emphasised. The advancement of the Action Research methodology from the early work of Kurt Lewin (1890-1947) through its many modifications and developments to PAR developed by Kemmis and McTaggart (2003) is described. The challenges faced and overcome, the data collection method of informal and formal meetings, diaries and interviews are graphically presented in five cycles over a five year period. The cyclical nature of the research is further described in the development of the EUSO constitution from 2002-2012

Chapter 5 presents a brief summary of the twenty EUSO Tasks developed over a ten year period 2003–2012. It also serves as a historical record which describes how these unique Team Science Tasks, a central feature of the EUSO were created. As well as each summary it also illustrates how each Task contributes, in its own way, to the concept of "Rich Tasks" in a Progressive version of Science Education. Each task was reviewed to see if it conforms to Progressive Pedagogies. In line with PAR, it describes how the Scientific Committee from the host country chooses the topics and designs the Task before presentation to the mentors at a General Assembly (GA) meeting. All aspects are discussed before finalisation by task designers and mentors in a collaborative manner. The need for future research into the amount of interaction that takes place between team members is alluded to. The elimination of high-stakes assessment is emphasised as a feature of the EUSO in the presentation of the results. This feature developed during the PAR process, by getting the mentors to emancipate themselves from the familiar concept of Olympiads where the emphasis is on winning and not on taking part.

Chapter 6, a natural continuation of the previous chapter, presents the results from the EUSO in two five-year periods because of EU enlargement in 2004 and 2007. This Chapter contributes to the historical record of the EUSO and highlights some of the trends that have developed. It was expected that the former Soviet Bloc countries, because of their success at the International Olympiads would perform well. The interviewing, which was one of the research methods used in PAR was continued to help the researcher comment on the results. In the first five years the former Soviet Block countries featured strongly in the gold and silver medal categories while the early EU members performed well in the silver category and were dominant in the bronze category. In the years 2008-2012 the former Soviet Bloc countries were dominant in the gold and silver categories while the early EU members featured strongly in the bronze category.

Interviews were conducted with the EUSO Country Coordinators from Latvia, Hungary and Estonia to provide the researcher with a clear picture of Science Education in the former Soviet Bloc so as to provide answers to why they had performed so well. EUSO Country Coordinators from Germany were also interviewed because many schools in East Germany are in a transition phase. EUSO Country Coordinators for the Netherlands were also interviewed because that country performs well at the EUSO and other Olympiads. Their contribution to the debate has influenced the Recommendations in Chapter 7.

The final chapter, Conclusions & Recommendations, points to the success of the EUSO as the product of Participatory Action Research (PAR). Ten years of the EUSO has seen the number of participating countries and the numbers of students steadily increase. Ten EU governments have hosted the EUSO between 2003-2012 and the Science Faculties of the Universities in these countries have cooperated to develop 20, integrated, content rich, team science tasks. The ranking of the participating countries has shown domination by former Soviet Bloc countries of the medal table. Finally recommendation including the promotion of an integrated science curriculum and the possibility advanced programmes in science. Areas where additional areas of research might be undertaken are highlighted.

Chapter 2

The Context

2.1 Introduction

As stated at the outset, this thesis has a historical dimension and the historical setting of this research is a vital component. This chapter sets out the context for the EUSO and it also highlights some of the issues that emerged and still exist today.

The research question asked at the start of this thesis;

> "*can a science competition be developed, organised, maintained and monitored over an extended period of time … …and contribute to stemming the tide of decline in interest in school science across the EU".*

This presupposes that there was a reason for asking the question, that part of the reason was that participation in science education in schools was declining and that there was a catalyst that initiated action to answer it. That catalyst was Ireland's poor performance at International Senior Science Olympiads in Biology (IBO) Chemistry (IChO) Physics, (IPhO) and Informatics (IOI) since 1994, the researcher's involvement in establishing them and the decline in participation in science in the Senior Cycle in Irish schools.

The Irish State Examination system is concerned with national standards in a limited range of subjects, the content of which is prescribed by the State controlled curriculum and Examination system. This is what Connell et al. (1982 cited in Hayes et al. p.8) call *"…the hegemonic or competitive academic curriculum at the core of schooling, and the ways in which it is taught and assessed" (p.8).* While PAR is the overarching philosophical position underpinning the research, without the historical setting in which the EUSO was conceived this story is incomplete. The historical setting, namely Ireland, has many resonances with the rest of the EU and Ireland's performance at the EUSO gives a clearer picture of how the EUSO works in practice.

2.2 Irish Secondary Education System

Unlike at the Senior Science Olympiads, Ireland is represented at the EUSO by students from the Republic of Ireland only. This political decision was taken by the DES because all the funding was provided by the Irish government. The island of Ireland is legislatively divided into two parts. Dublin is the capital of the 26 county Republic of Ireland and Belfast is the capital of the 6 county Northern Ireland. The Irish language is the national language and the first official language and the English language is the second official language of the Republic (Ireland, Official Languages Act, 2003). The Republic of Ireland is a democracy situated on the most westerly side of Europe and a member of the EU since 1973. The 2011 census reveals that the population is 4,588,252 and that the number of students attending primary school is 514,852 and secondary school is 356,107, bringing the first and second level school cohort to 879,959. The number of students attending Irish schools 2010-2011 is shown in Table 2.1.

Table 2.1. Number of Students Attending Irish Schools 2010-2011.
Source: State Examinations Commission (SEC), 2011 and Central Statistics Office (CSO), 2011

First Level	Total	Percent
Primary School	514,852	100
Second Level		
Secondary Schools	186,622	52
Vocational Schools	114,761	32
Community Schools	47,058	13
Comprehensive Schools	7,666	2
	356,107*	
Total		100

** A small number attend private fee paying schools and special schools.*

The second-level school sector consists of secondary, vocational, community and comprehensive schools. All of these schools provide courses prescribed by the DES leading to the Junior Certification Examination after three years and the Leaving Certificate Examination after 5/6 years. Some schools offer a one- year transition programme after the Junior Cycle.

Secondary Schools are privately owned and managed by Boards of Management, Boards of Governors or a single manager and they educate 52% of second level students. 95% of the cost of teachers' salaries is met by the state. These schools, traditionally run by religious orders, provide academic type education but in recent years have also offered technical and practical subjects.

Vocational Schools and Community Colleges, administered by Vocational Education Committees (VECs) educate 32% of all second level students. Initially, these schools developed the manual skills of students and prepared young people for trades. Nowadays the full range of second-level courses is available.

Comprehensive Schools and Community Schools, managed by Boards of Management, cater for 15% of the cohort. They combine academic and vocational subjects in a wide curriculum and are funded by the DES.

The Irish second level school system can therefore be categorized into two main groups: Secondary Schools which are privately owned and managed, catering for 53% of students and Vocational Schools & Community Colleges, Comprehensive Schools and Community Schools which are financed by the DES and cater for 32% of students. A number of students attend Special Schools for students with disabilities who cannot be accommodated in the other schools. A very small number of private colleges, funded by student fees, also exist.

2.3 Junior Cycle

Approximately 55,000 students, 50% male and 50% female, sit the annual Junior Certificate Examination. This is held in June at the end of the three- year Junior Cycle and covers a range of subjects including Science. In the past ten years the number of students has fluctuated by approximately 4,000, with the number of males slightly higher than the number of females.

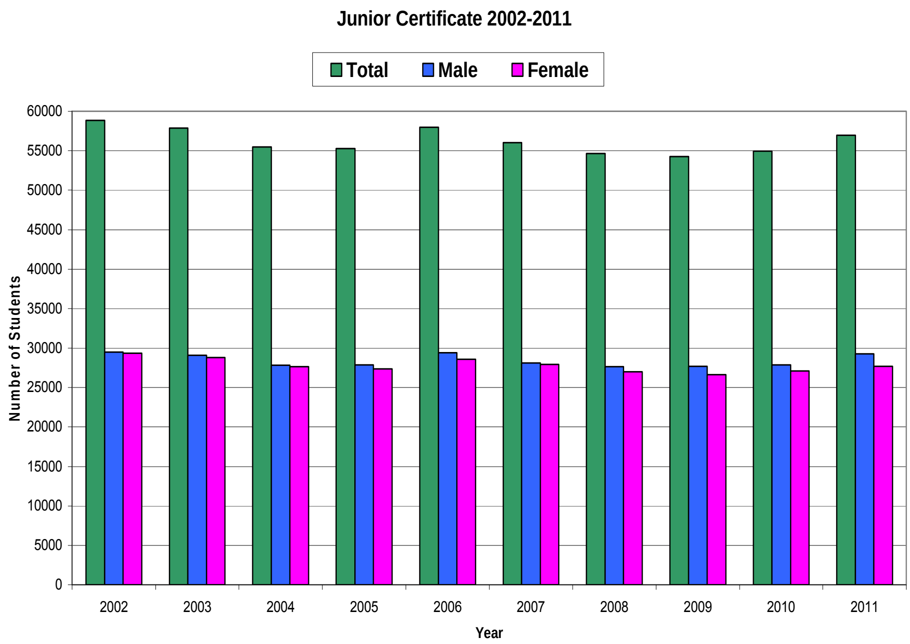


Figure 2.1 Total Number of Junior Certificate Students by Gender 2002-2011
Source: SEC. 2011 and CSO. 2011

The number of students taking Science at both higher and ordinary level in 2011 was 52, 570, an increase of approximately 1,000 from 2010 and again from 2009; the percentage taking higher lever Science has increased from 68% to 72% in the three year period. Science is the fourth most popular subject at Junior Certificate Level after Geography, English and History.

Table 2.2 Junior Certificate Science 2009-2011 by Level
Source: SEC. 2011 and CSO. 2011

Year	Higher Level	Ordinary Level	Total
2009	34,246 (68%)	14,289 (28%)	50,544 (100%)
2010	35,488 (69%)	13,960 (27%)	51,458 (100%)
2011	38,074 (72%)	12,485 (24%)	52,570 (100%)

38,074 students sat the higher level Science paper in 2011. The number of girls was higher than boys every year from 2002-2008. However, over the past three years the boys have outnumbered the girls. The number of girls achieving Grade A still remains higher than boys. Junior Certificate Science Higher Level 2002-2011 by Gender and A Grade are shown in Figure 4.2 below

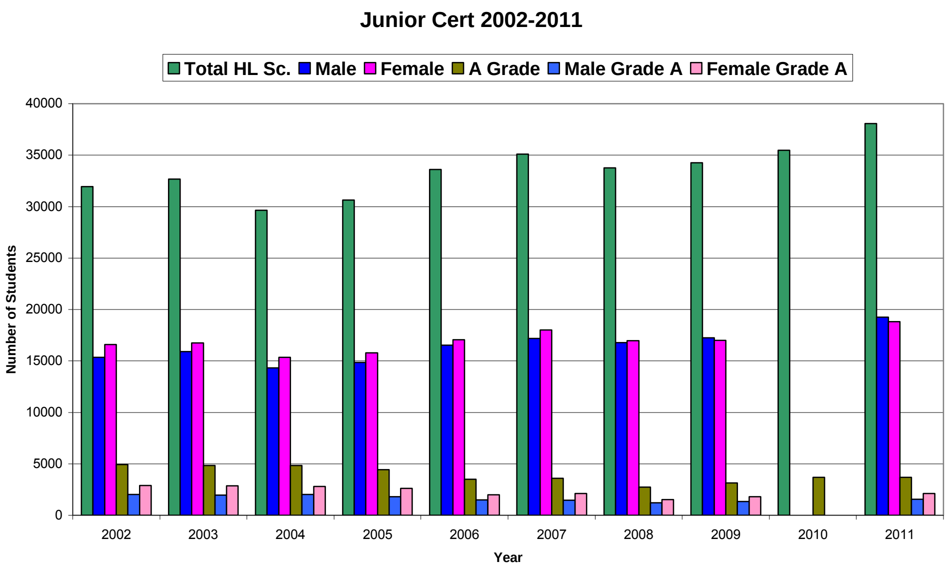


Figure 2.2 Junior Certificate Science Higher Level 2002-2011 by Gender and A Grade
Source: SEC, 2011 and CSO, 2011
(2010 gender data not available)

2.4 Irish EUSO (IrEUSO)

Over the past ten years of the IrEUSO, 2,113 students have taken part. Of these 45% were male and 55% female, even though the male/female ratio in Junior Certificate higher level Science was 50/50. Also girls get more A Grades. Because the test is subject specific students must choose one Science subject. In Biology, 69% of the finalists were girls, 55% of the Chemistry finalists were girls and only 39% of the Physics finalists were girls. Girls were over represented in Biology and Chemistry and underrepresented in Physics. The table below shows the percentage of male and female finalists in 2003-2012.

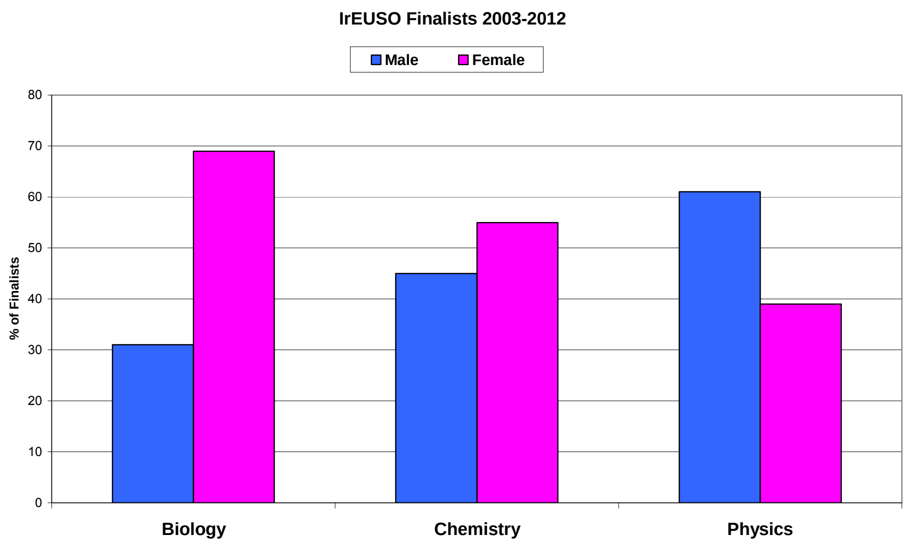


Figure 2.3 2003-2012 IrEUSO Finalists by Subject
Source: M.A.Cotter. IrEUSO Director

By looking at the pattern of male/female participation in higher level Biology, Chemistry and Physics in the Leaving Certificate during the same ten year period (see Senior Cycle below) we can see that girls, after the Junior Cycle, have opted out of Physics for the most part, even though they would have done as well as the boys in the Physics section of the Junior Certificate higher level Science Examination because the total score combines all three sections.

Because girls have out-performed boys consistently in higher level Science at the Junior Certificate level over the past ten years it would be reasonable to expect that more girls than boys would have represented Ireland at the EUSO each year over the past ten years, but this has not been the case. In 2003 and 2005 girls were in the majority; in 2011 the number was the same but during the other seven years the boys were in the majority, resulting in a total male / female ratio of 7:5.

Table 2.3 Irish EUSO Teams 2003-2011 by gender
Source: M.A.Cotter. IrEUSO Director

2003		**2004**		**2005**		**2006**		**2007**		**2008**		**2009**		**2010**		**2011**		**Total**	
M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
4	5	6	3	1	5	4	2	5	1	4	2	4	2	4	2	3	3	35	25

The reason for the under-representation of girls may be related to the selection / registration process used by the Irish team leaders or the test used. It is not a lack of interest or an aversion to taking part in competitions among girls because more girls than boys have taken part.

2.5 Selection of IrEUSO Teams

In mid August each year the State Examinations Commission (SEC) sends the results of the Junior Certificate Examination to the schools. At the same time the SEC, at the request of the Director of the IrEUSO, identifies the top 300 students who have achieved the highest marks in higher level Mathematics and Science combined. Mathematics is included because a mathematical ability is assumed to be useful at the EUSO. One week later the SEC sends letters and registration forms, signed by the Director of the IrEUSO, to the principal of the schools, which these top 300 students attend. The letter to the principal explains that -

- a named student (or students) in the school has been identified as a high achiever in Mathematics and Science in the Junior Certificate Examination
- six students under seventeen years of age are selected to represent Ireland at the EUSO at Easter from this pool of talented students
- a National Olympiad is held in November in DCU to select the two teams of three students
- only students identified by the SEC may participate; substitutes or replacements are not acceptable
- the top three students in each Science receive gold, silver and bronze medals; all participants receive a Certificate
- the medal winners are invited to participate in a final selection to represent Ireland at the EUSO.

Because of Freedom of Information Legislation, the Director of the IrEUSO cannot have direct access to these talented Science students. The SEC identifies them and contacts them indirectly via the school principal. The principal must then ask the parents to give permission to the named student to participate in the National IrEUSO by returning the registration form provided. The onus is on the principal to notify the parents of the selected student that he/she may participate in the IrEUSO and have an opportunity to represent Ireland at the EUSO. The principal must contact the parents at the earliest opportunity so that they have enough time to make an informed decision and meet the deadlines.

The letter from the IrEUSO to the parent/guardian of the SEC - named student contains similar information. In this instance, however, the onus is on the parent/guardian, if he/she wishes to have his/her son/daughter participate in the IrEUSO, to return the registration form on time. On receipt of the registration forms the names of the participating students are published on the website of IrEUSO. Letters confirming receipt of registration forms are not sent to finalists as they are expected to check the website.

In addition to the named Junior Certificate high achievers in Mathematics and Science, the list of finalists from the previous year is examined. All students who are still eligible to compete and who are not sitting the Junior Certificate Examination that year are invited to participate. The graphic below, which is published on the 2010 website, explains that any student, who was identified by the SEC in the Junior Certificate Examination of 2009 or 2010, who was born in 1994 and was in TY or 5th year, should register for IrEUSO 2010.

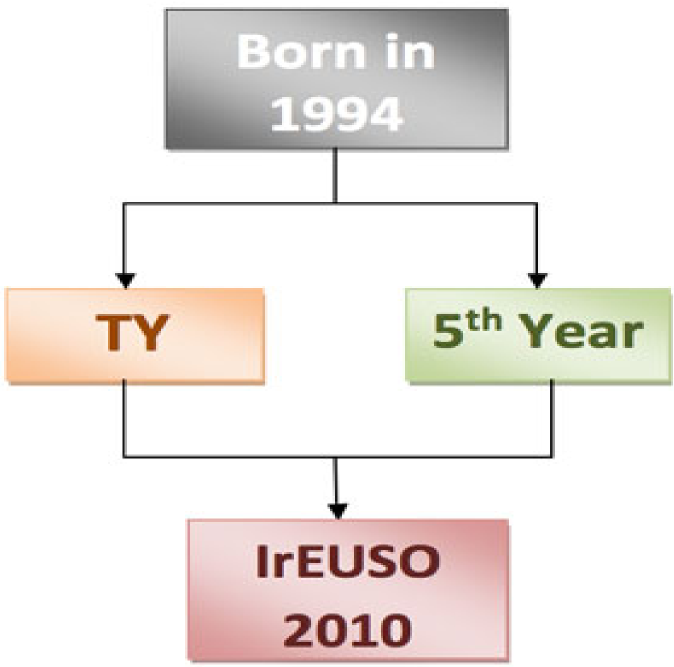


Figure 2.4 Eligible Students 2010 IrEUSO Students
Source: M.A.Cotter. IrEUSO Director

Students who may have skipped TY or were not offered TY in their school and are sitting the Leaving Certificate cannot participate. The reason for this is because such students would be trying to achieve the maximum points in the Leaving Certificate Examination and would not be able to commit the necessary time to participate in training and in the EUSO. It would involve taking time out to take part in the National Olympiad, prepare for the final team selection, take part in the training programme and take a week out at Easter to take part in the EUSO.

While the Junior Certificate Science programme is officially an integrated programme it is a combined or interdisciplinary Biology, Chemistry and Physics programme, taught in three distinct sections, from books, which have three distinct parts; it is also examined in three distinct segments. The marks achieved in the three sections are combined to give an overall Science grade, so the top students have achieved high scores in all three sections.

The Leaving Certificate Examination at Senior Cycle level has three separate subjects, Biology, Chemistry and Physics and a grade is given in each at this Examination. Some students take all three subjects, some take two and a number only one or none.

When the 300 top students in the Junior Certificate Examination receive the IrEUSO registration form they are already in the Senior Cycle and have chosen their Science subject or subjects for this cycle. In addition they are asked by the IrEUSO organisers to opt for only one of the three tests in Biology, Chemistry and Physics. Since these tests run simultaneously the students cannot take more that one test even if they are equally proficient at two or three subjects. Students who have decided not to take a particular subject at higher level in the Leaving Certificate Examination will therefore not opt for that subject. Also students who believe or perceive themselves to be better at one Science than another will chose their better subject. This system, while convenient for the organisers, limits the opportunities and the possibilities for students to represent Ireland at the EUSO.

2.6 Senior Cycle

From 2002-2011 the total number of students taking the Leaving Certificate Examination was approximately 50,000 annually. The number of females was consistently higher in the early years but in recent years the numbers have evened off.

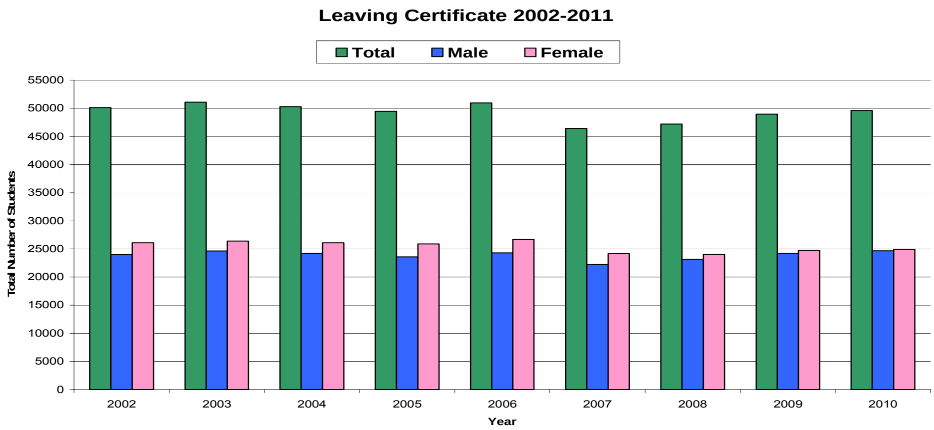


Figure 2.5 Leaving Certificate Examination 2002-2011 by Gender.

Source: SEC. 2011 and CSO. 2011

Of the three Leaving Certificate Science subjects at higher level, Biology is by far the most popular and increasing in popularity annually, followed by Chemistry and then Physics, which combined are taken by less than half the number taking Biology.

Table 2.4 Leaving Certificate Higher Level Biology, Chemistry & Physics 2002-2011
Source: SEC. 2011 & CSO. 2011

	Biology	Chemistry	Physics
2002	13773	5565	5897
2003	13783	5731	6175
2004	16011	6205	5836
2005	17485	6033	5508
2006	17047	5712	5200
2007	17521	5729	5223
2008	18322	5904	4929
2009	20102	6037	4694
2010	20971	6298	4877
2011	22677	6272	4782

The total number of higher level Biology students reached 22,677 in 2011 from 13,773 in 2002, an increase of 65%. Physics was the second most popular Science, peaking in 2003 at 6,175 students but it has dropped to third place with 4,782 students in 2011. Chemistry, which was the least popular Science subject in 2002 with only 5,565 students has gained 1,490 more students than Physics in 2011 and now has 6,272 students. One reason may be because some schools have dropped Chemistry and Physics from the school syllabus in recent years as reported in the Second Level Principals Survey, conducted by Association of Secondary Teachers in Ireland (ASTI 2012).

Table 2.5 Leaving Certificate Higher Level Biology Students by Gender and A Grade 2002-2011
Source: SEC. 2011 and CSO. 2011

	Total	Male	Female	Male A	Female A
2002	13773	3923	9850	508	1488
2003	13783	3849	9934	683	1941
2004	16011	4570	11441	666	1827
2005	17485	5115	12370	560	1468
2006	17047	5285	11762	759	2065
2007	17521	5441	12080	970	2447
2008	18322	6033	12289	973	2107
2009	20102	6858	13244	1041	2288
2010	20971	7293	13678	1253	2393
2011	22677	8410	14267	1252	2286

The number of students taking Biology has increased by 65% in the ten-year period. The number of boys has increased by 114% and the number of girls has increased by less than half or 45%, but from a very high base. The percentage of males is increasing while the percentage of female students is decreasing. The percentage of female students achieving A Grades is consistently at 8%-14% while for males it is 3%-6%. This may explain why 69% of the Biology finalists at the IrEUSO are female but it does not explain why females are under represented on the teams, since the number of participants and the percentage of A Grades is greater than for males. The other variables are the selection / registration process and the test itself, which produce more male than female medal winners and team members.

Table 2.6 Leaving Certificate Higher Level Chemistry Students by Gender and A Grade 2002- 2011
Source: SEC. 2011and CSO. 2011

	Total	Male	Female	Total A	Male A	Female A
2002	5565	2418	3147	1275	514	761
2003	5731	2483	3248	1493	624	878
2004	6205	2608	3597	1424	560	864
2005	6033	2544	3489	1339	561	778
2006	5712	2444	3268	1242	483	759
2007	5729	2407	3322	1193	511	682
2008	5904	2504	3400	1401	607	794
2009	6037	2614	3423	1321	661	750
2010	6298	2688	3610	1307	505	667
2011	6272	2743	3529	1375	602	773

The number of students taking higher level Chemistry has fluctuated by 1,000, between 5,500 and 6,500, in the past ten years and increased by only 13% from 5,565 to 6,037, compared to a 65% increase in higher level Biology. The number of boys has increased by 13% and the number of girls by 12%. The percentage of male students achieving A Grades is 8%-11% and the percentage of female students achieving A Grade is 11%-15%.

55% of the Chemistry IrEUSO finalists and 56% of the higher-level Leaving Certificate Chemistry students are female and they achieve a higher percentage of the A Grades, nevertheless they are under represented at the EUSO. This pattern of results should have produced more female students, or at least the same number as males on the EUSO teams.

Table 2.7 Leaving Certificate Higher Level Physics Students by Gender and A Grade 2002-2011.
Source: SEC. 2011 and CSO. 2011

Year	Total	Male	Female	Total A	Male A	Female A
2002	5897	4128	1769	813	496	317
2003	6175	4392	1783	1101	703	398
2004	5836	4166	1670	1119	743	376
2005	5508	3817	1691	1124	717	407
2006	5200	3633	1567	1013	659	354
2007	5223	3657	1566	1118	765	353
2008	4929	3495	1434	1012	694	300
2009	4694	3398	1296	962	652	310
2010	4877	3497	1380	1014	688	326
2011	4782	3462	1320	1001	701	264

The number of students taking higher level Physics has fluctuated by 1,393, between 4,782-6,175 in the past ten years. Physics is now the least popular higher level Science subject. The number of students taking Physics has decreased by 23% from a peak in 2003 of 6,175. The number of boys has declined by 21% and the number of girls has declined by 25%, but from an already very low base. The percentage of male students achieving A Grades is consistently at 8%-15% while for females it is at 5%-7%. This may explain why only 39% of the Physics finalists at the IrEUSO are female.

2.7 IrEUSO Results

One gold medal, one silver medal and two bronze medals are awarded to the top four students at the IrEUSO in the Biology, Chemistry and Physics tests. In 2003-2004 nine students were selected and from 2004-2006 the gold and silver medal winners formed the delegation of six students. In later years a further test among all the twelve medal winners took place to decide on the membership of the teams. The purpose of this additional test was to identify the students who best perform in the laboratories. It is clear from the data that the selection system is not favouring female students either in terms of medal allocation or EUSO team membership.

2.8 Gender Issues

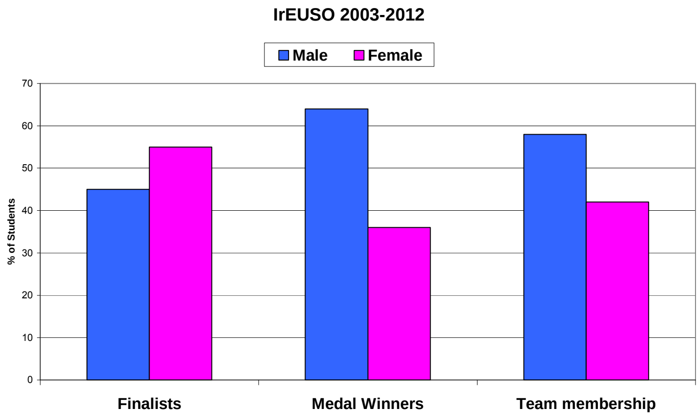


Figure 2.6 2003-2012 IrEUSO Finalists, Medal Winners and Team Membership
Source: M.A.Cotter. IrEUSO Director

During the years 2003-2012, 111 medals were awarded. 71 (64%) were awarded to male and 40 (36%) to female students. 38 (58%) team places were awarded medals and 28 (42%) were given to females. Even though 55% of the finalists were girls they achieved only 36% of the medals and 42% of the EUSO team places.

Table 2.8 IrEUSO Biology Finalists 2003-2011
Source: M.A.Cotter. IrEUSO Director

	Male (%)	Female (%)
Total	31	69
Medals	46	54
Places	36	64

In Biology 17 (46%) medals were awarded to male students and 20 (54%) to female students even though males comprised only 31% of the Biology finalists. 8 (36%) teams places were awarded to male students and 14 (64%) team places were awarded to female students, who were 69% of the finalists. A very high disproportionate number of medals have been awarded and slightly more team places to male students.

Table 2.9 IrEUSO Chemistry Finalists 2003-2011
Source: M.A.Cotter. IrEUSO Director

	Male (%)	Female (%)
Total	31	69
Medals	46	54
Places	36	64

In Chemistry 27 (73%) medals were awarded to male students, even though they accounted for only 45% of the finalists and 10 (27%) medals were awarded to female students, who were 55% of the finalists. 14 (64%) team places were awarded to male students and 8 (36%) team places were awarded to female students. A very significant disproportionate number of medals and slightly more team places have been awarded to male students.

Table 2.10 IrEUSO Physics finalists 2003-2011
Source: M.A.Cotter. IrEUSO Director

	Male (%)	Female (%)
Total	61	39
Medals	73	27
Places	73	27

In Physics 27 (73%) medals were awarded to male students, even though they comprised only 61% of the finalists and 10 (27%) medals were awarded to females. 16 (73%) team places were awarded to male students and 6 (27%) team places were awarded to female students. The most disproportionate number of Physics medals and team places has been awarded to male students.

Overall, more medals and team places have been awarded to boys than their numbers seem to warrant. It is clear that the test used in the IrEUSO is not identifying the strengths of female students evident from the Junior Certificate and Leaving Certificate results over the past ten years. This test needs to be changed.

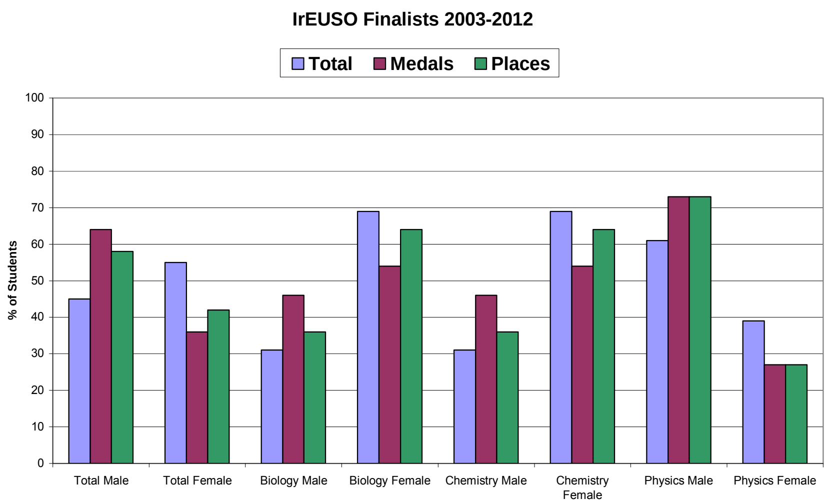


Figure 2.7 2003-2012 IrEUSO Finalists by Subject and Gender
Source: M.A.Cotter. IrEUSO Director

In Ireland female students are under represented both in the allocation of IrEUSO medals in all three subjects and in the allocation of EUSO team places.

During 2003-2008, the first five years of the EUSO, girls were in a very strong position regarding Science education within the Irish education system. However, between 2008-2011, (the last year for which data are available), the performance of boys has improved in all areas. The number of boys taking Science in the Junior Certificate has increased from 49% to 51% and the number achieving an A grade has increased from 40% to 43%. The number of boys taking

Biology at higher-level Leaving Certificate has increased from 28% to 37%, an increase of 9% and the number achieving an A Grade from 26% to 35%. The number of boys taking Chemistry remains almost unchanged but the percentage achieving an A grade has increased from 41% to 44%. Boys taking Physics has increased from 70% to72% and the achievement of A Grades by boys has increased from 64% to 73%. These figures show that since the first EUSO in 2003 the performance of Irish girls visa-a-vis Irish boys has dis-improved in all Science subjects. However, within some subjects at the top level, girls do better than boys. While 49% of girls took Junior Certificate Science in 2011 they took 57% of the A Grades; 63% took higher level Biology in the Leaving Certificate and they took 65% of the A Grades.

If this trend continues over the next five years 50% of the students taking higher level Biology will be male, which is not a bad thing, while the numbers taking higher level Chemistry may be balanced but the overall number will be approximately 6,000. Of the higher-level Physics students 80% to 90% will be male, with the overall numbers reduced to 3,000 students, and with females at 500 or less.

A radical shift in policy, attitude, teaching styles, use of technology and curriculum content is needed to increase the participation rate in higher level Chemistry and Physics. It is not helpful when decisions are made by school management to drop Physics and Chemistry from a school's time-table. The ASTI survey of school principals (n = 71) in 2012 showed the since 2009, 21 schools have dropped Leaving Certificate Physics and 11 have dropped Leaving Certificate Chemistry. The ASTI 2010 Junior Cycle Science Survey (ASTI, 2010) reported that a further 20% of schools are likely to drop a Science subject in the next year. This may account for the steep increase in participation in higher level Biology and the stagnation or decrease in participation in higher- level Chemistry and Physics.

As described above, the IrEUSO selection process held in one centre (DCU), forces students to choose between Biology, Chemistry and Physics, even though the EUSO is an integrated Science competition and the students have just completed an integrated Science Examination. Many of these students have opted out of Chemistry or Physics or both and opted into Biology. Some students will, however, have decided to take two or even three Sciences at higher level in the Leaving Certificate and may be equally good at all three, but perceive themselves to be better at one. An integrated or multidisciplinary test would, therefore, identify the students who would do well at an integrated Science competition. While the single subject selection process is common among EUSO participating countries and is possibly a remnant of the selection processes of the senior single Olympiads, other options should be considered in Ireland.

2.9 School and County

Irish students from 56 different schools, out of a possible total of 66 schools, have represented Ireland at the EUSO. Five schools have been represented twice, one school three times and one on four occasions.

Table 2.11 Schools with Two or More IrEUSO Team Members
Source: M.A.Cotter. IrEUSO Director

Post Primary School	Type of School	No. of Students
Alexandra College	Secondary	2
Gonzaga College	Secondary	2
Institute of Education	Private	2
Loreto, Balbriggan	Secondary	2
Our Lady's, Castleblayney	Secondary	2
Blackrock College	Secondary	3
CBC, Sidney Hill, Cork	Secondary	4
TOTAL		17

Sixteen of the 26 counties in the Republic of Ireland have been represented with the counties with the largest populations, Dublin and Cork, providing the bulk of the students. Kerry is in third place with 5 students. Ten counties have yet to be represented at the EUSO. Having regional heats may/should rectify this situation.

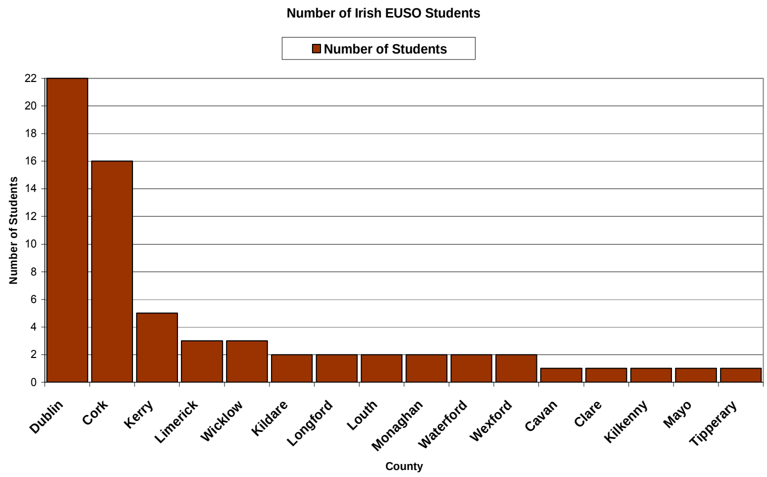


Figure 2.8 IrEUSO Team Membership by County
Source: M.A.Cotter. IrEUSO Director

Of the 66 students who have represented Ireland at the EUSO, 51 (77.3%) attend secondary schools. An additional 3 students (4.5%) attend private colleges. 12 (18.2%) attend non-private, state funded schools and colleges. A disproportionate number of Irish students from secondary schools and private college represent Ireland at the EUSO.

Table 2.12 Post Primary School Attended by Irish EUSO Students 2003-2012
Source: M.A.Cotter. IrEUSO Director

Type of Post Primary Schools	Number	%
Secondary Schools	51	77.3
Vocational Schools & Community Colleges Comprehensive Schools, Community Schools	12	18.2
Private Colleges/Other	3	4.5
	66	100

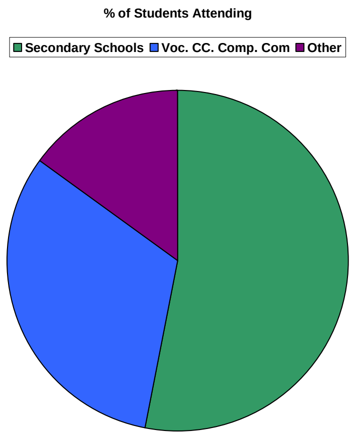


Figure 2.9 % of Students Attending Post Primary Schools in Ireland. *Source: M.A.Cotter. IrEUSO Director*

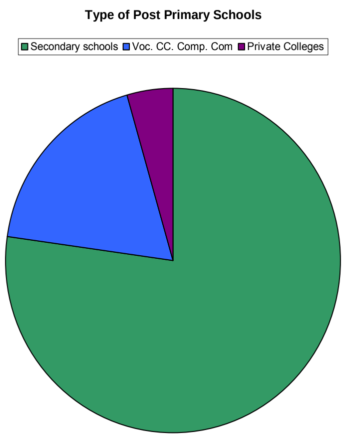


Figure 2.10 % of IrEUSO Students Attending Post Primary Schools. *Source: M.A.Cotter. IrEUSO Director*

2.10 Where Are They Now?

Of the 54 students (now in university) who have represented Ireland at the 2003-2010 EUSO, 30 (56%) have returned details of the university course they attended. 18 (60%) studied Medicine and 6 (20%) studied Theoretical Physics. Other courses followed are Mathematics (2), Chemistry (2), Pharmacy (1) and Veterinary Medicine (1). This is in stark contrast to the situation in Hungary and

Estonia where Medicine is not a popular choice among high achieving students. The poor working conditions and remuneration of doctors may direct students away from a medical career.

Table 2.13 University Courses Attended by 2003-2010 IrEUSO Team Members.
Source : M.A.Cotter. IrEUSO Director

Number of Students	University Course Attended
18	Medical Doctor
6	Theoretical Physics
2	Mathematics
2	Chemistry
1	Pharmacy
1	Veterinary Medicine

2.11 Team Gender

Of the 66 students who have represented Ireland at the 2003-2012 EUSO, 38 (58%) were male and 28 (42%) were female. Of the 906 students who have represented all countries at the EUSO, 626 (69%) were male and 280 (31%) were female. Compared to other EU countries, Irish female students are better represented than most but are not representative of the age cohort in Irish post primary schools. Information of the students' social background was not requested.

Table 2.14 EUSO 2003-2012 Gender of Team Members.
Source: M.A.Cotter. IrEUSO Director

Gender	Ireland		All Countries	
Male	38	58%	626	69%
Female	28	43%	280	31%
Total	66	100%	906	100

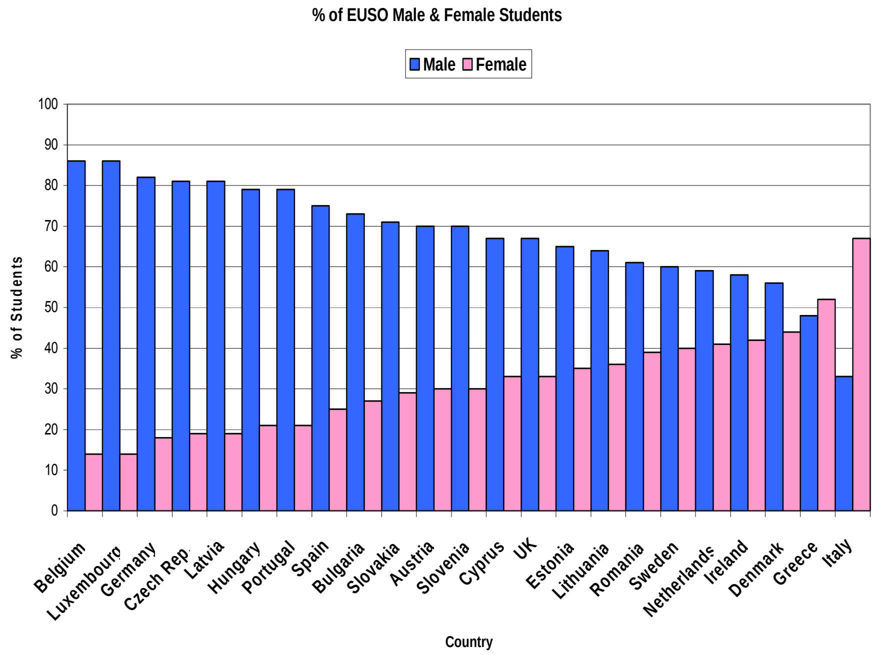


Figure 2.11 EUSO 2003-2012 Gender of Students by Country.
Source: M.A.Cotter. EUSO President

2.12 Ranking

Ireland has competed each year in the EUSO. In 2003 and 2004 Ireland competed with three teams as the rules allowed and in every subsequent year with two teams. Irish teams have been awarded 22 medals; 1 gold, 15 silver and 6 bronze. In the table below the relative position of each Irish team is given. In 2003 the three Irish teams were in 3rd, 5th and 8th positions and the total number of participating teams in the EUSO 2003 was 14. Ireland's best team position ranged from 3rd to 20th and the position of the second team ranged from 5th to 33rd .

Table 2.15 Positions of Ireland's Teams at EUSO 2003-2011
Source: M.A.Cotter. IrEUSO Director

Year	Place 1st Team	Place 2nd Team	Place 3rd Team	Total Teams
2003	3	5	8	14
2004	6	9	16	19
2005	7	13		18
2006	6	13		23
2007	11	14		29
2008	7	16		33
2009	9	24		40
2010	19	33		42
2011	20	26		40
2012	18	20		44

It is clear from the table above that Irish teams are a long way from winning gold medals unless a change is made in the way students are selected, trained or both. It should be the ambition of the IrEUSO mentors to have Ireland not receive bronze medals and challenge for gold medals.

2.13 Summary

This Chapter puts the EUSO in context and highlights some of the issues that led to the establishment of the EUSO and which may still exist today. The Irish Education system and in particular the Science Education system in Irish secondary schools during the lifetime of the EUSO forms the backdrop and explains the environment that instigated and motivated the established the EUSO which differs fundamentally in many respects from the existing Science Olympiads. The popularity of science at the Junior Cycle among all students to the virtual collapse of Chemistry and Physics participation particularity among girls at the Senior Cycle is highlighted and comparisons made with other EU countries. Ireland’s participation at the EUSO, the team selection process, the gender and school background of the team members and the ranking achieved provides the opportunity to compare Irish students with their cohort in the rest of the EU in this very limited area of schooling, while at the same time indicating where progressive approaches to Science education might be beneficial to Ireland and the rest of the EU

Chapter 3

Literature Review

3.1 Introduction

This chapter begins by outlining the history to the Science Olympiads from the International Mathematics Olympiad (IMO) establish in 1959, which traces it roots to the 1894 Eötvös Mathematical Competition in Hungary to the UNESCO sponsored International Physics Olympiad (1967), the International Chemistry Olympiad (1968), the International Informatics Olympiad (1989) the International Biology Olympiad (1990) and the many regional, national and local Olympiads. It goes on to provide some answers to a number of key questions on the nature of Science, the rationale for teaching it, and the role of the teacher and teaching methods in the quality of the science education provided. The curriculum, interest and attitude among the school population and in particular the declining numbers of students, particularly girls taking Chemistry and Physics to advances levels is looked at. The impact of assessment and the career guidance service on participation is also examined.

3.2 Science Olympiads

A review of the literature in relation to Olympiads has revealed that such competitions have existed in almost every school subject for many years. They range from local, city, regional, national and international. In the field of Science, Olympiads and competitions have existed in great abundance and with complete regularity for almost half a century. A total of seven well-established International

Science and Technology Olympiads continue to take place each year since their foundation (indicated in brackets): Physics (1967), Chemistry (1968), Informatics (1989), Biology (1990), Environmental Project (1993), Astronomy (1996) and Geography (1996). In addition, Regional Olympiads, such as the Science Olympiad in the USA and the Science Olympiad Foundation in India, are held annually and involve large numbers of schools and students. However, no Science Olympiad has been recorded as existing in Europe generally, or in the EU specifically, prior to the establishment of the EUSO. The Electronic Company, Philips, did support a Science competition in Europe, between 1968-1988, which involved students exhibiting their own projects. In 1989, this was re-named "The EU Contest for Young Scientists", an event that still continues today.

In researching the International and Regional Science Olympiads it has been difficult to find detailed information on their origins and history; the limited information that is available is sketchy and scattered over a number of web sites and publications. While some Olympiad web sites have been updated, many remain stagnant or fail to open. Little research has been carried out on these Olympiads, or on the rationale for their constitutions and statutes. While girls are conspicuous by their absence each year, no studies appear to have been carried out in relation to the male/female ratio of contestants; thus little effort would appear to have been made to rectify this situation. Changes in scientific practice and research, such as those which have resulted in individuals who traditionally worked in splendid isolation in their laboratories (if that ever really happened) becoming engaged in collaborative working and in the formation of teams of experts from the different fields of science, seem not to have influenced the running of the science Olympiads. The consideration that younger students might benefit from exposure to international science collaboration and competition seems not to have been regarded as worthwhile. The learning profiles of these highly intelligent and motivated contestants seem not to have been of interest to the mentors. Huge gaps exist in the Olympiad literature in the area of integrated science. Each Olympiad seems to have come about, year on year, with little change or improvement.

The researcher credits the coining of the title “Science Olympiad” to Thomas Ewbank, who in his report to the US Congress in 1849, proposed that an "Olympics of Science” be established,

> *“….invoking the attention of Congress to a series of proposed prizes for new prime-movers and other discoveries in science. …..had premiums been offered at Olympia for useful discoveries in science …….to stimulate Science and invention, which he believed would contribute to the prosperity of the nation”,* (Ewbank, 1849, p. 518).

Application of the term “Olympiad” to the school context and the linking of excellence in a Science competition with excellence in an athletics competition, e.g. the Olympic Games, may be credited to the Leningrad State University in the former USSR. It was here, in 1934, that the concept was born with the establishment of the Leningrad Mathematical Olympiad (LMO), (Fomin and Kirichenko, 1994). The Moscow Mathematical Olympiad (MMO), for junior students, was established during the following year. The primary aim of the both the LMO and the MMO was to promote interest in Mathematics among the school population and to encourage all Leningrad and Moscow students to strive for excellence in Mathematics. Identification of outstanding mathematicians would follow. These Olympiads soon spread to other parts of the Soviet Union, though mainly to large industrialized cities.

While the LMO and the MMO are the oldest Mathematics competitions in Russia, the oldest mathematical competition in the world (Fomin and Kirichenko, 1994) took place in Hungary in 1894. Initially called the Eötvös Mathematical Competition, this has since

1938 known as the Kürschák Mathematical Competition. It is the precursor of the current International Mathematical Olympiad (IMO).

The idea of an International Olympiad in Informatics (IOI) for school students was conceived by Professor Blagovest Hristov Sendov, lecturer in numerical analysis at Sofia University, Bulgaria. He originally presented his proposal to the 24th General Conference of the United Nations Educational, Scientific and Cultural Organization (UNESCO) in Paris, in October 1987. UNESCO sponsored the first IOI, which took place in Pravetz, Bulgaria in May, 1989. This was the fourth International Science Olympiad to have been established under the auspices of UNESCO, (IOI: http://www.ioinformatics.org/). The previous three involved, respectively, Mathematics (1959), Physics (1967) and Chemistry (1968). These were first established in the Eastern and Central European socialist countries aligned to the USSR and commonly referred to as Eastern Bloc, Communist Bloc or Soviet Bloc countries. The title "International Science Olympiad" was however, in each case, a misnomer because, for a number of years, the only countries either hosting or taking part, were these Communist Bloc countries: the Soviet Union, Bulgaria, Czechoslovakia, East Germany (GDR), Hungary, Poland and Rumania. Yugoslavia and Albania, while communist countries, had independent foreign policies. Clearly, to have called these 'The Soviet Bloc Science Olympiads' would have been more accurate. The aim was to teach Science in schools to a very high level and, thus, to benefit all students, including the less able.

As mentioned in page 2, the discovery that the members of an Irish team competing at an International Olympiad in Informatics (IOI) were in fact in competition with each other, that Irish students performed poorly vis-à-vis the rest of Europe or other small countries at the international Biology, Chemistry and Physics Olympiads, and the reality that taking part in Olympiads is about winning medals was a catalyst to establish and alternative International Science Olympiad.

3.3 Why Teach Science?

The fundamental question one must ask of any education system is why teach a particular subject or skill. Why teach a language that has been dead for a thousand years or that is only spoken by a minority, or that is only ever likely to be used in the classroom? Why teach a particular set of religious beliefs? Why teach the Humanities? Why teach Science?

With regard to the teaching of Science, the subordinate questions are: what Science should be taught, to whom should Science be taught, at what age should the teaching of Science begin, for how long should Science be taught, should Science be compulsory, how should Science be taught

The relevant literature provides many reasons as to why Science should be taught in schools. Millar (1998) articulates four arguments for teaching science in schools.

The "Economic Argument" demands a supply of highly trained scientific and engineering personnel for the economy, personnel vital to economic wellbeing and national competitiveness. This argument is also put forward in the 2004 EU report, *Europe Needs More Scientists* and the 2006 U.S. National Science Board's *Science and Engineering Indicators.*

The "Democratic Argument" for school science insists that schools should prepare students to be informed citizens and enlightened consumers who can intelligently negotiate the techno-scientific challenges of modern life, politics, and society.

The “Skills Argument” requires that certain kinds of science study inculcate desirable transferable skills that include the ability to formulate and conduct experiments, evaluate empirical evidence, appreciate quantitative arguments, carry out inductive generalization, and engage in critical thinking.

The “Cultural Argument.” stipulates that science is one of the great intellectual enterprises of modern civilization. The vision of nature embodied in modern science defines the universe for us, informs our vision of our human essence, and speaks to the hopes and fears of our world

Dr. Anthony Tomei, in the foreword to ‘Science Education in Europe: Critical Reflections, a Report to the Nuffield Foundation’, which quotes the authors, Osborne and Dillon (2008), states:

> *“Science is an important component of our European cultural heritage. It provides the most important explanations we have of the material world. In addition, some understanding of the practices and processes of Science is essential to engage with many of the issues confronting contemporary society,”* (p.5).

There is general agreement across governments and among educators that Science should be taught in schools. The main question exercising their minds, at the moment, however, is why some of the recipients and beneficiaries of education systems are turning their backs on and walking away from Science education. This same question was also exercising the mind of the researcher when he conceived of the notion of a European Science Olympiad. It eventually led to the foundation of the EUSO. This Olympiad was established to fill the void, at EU level, in relation to a competition specifically designed to challenge, encourage and support Science students in the first three years of secondary education (junior cycle in Ireland), a critical period in their education.

3.4 Science Education

Science permeates all aspects of our daily lives from the morning electric shower which contains a pump and heat exchanger, to breakfast cereals and pasteurized milk, to driving, cycling or taking the bus or train on the transport system of roads, bridges, railways, to the automation and control of the railway lines, traffic lights and the traffic control systems, to mobile phone, computer, laptop, television and a whole range of other everyday items. It is desirable, therefore, that citizens have some knowledge of its relevance in everyday life and an appreciation of its significance in the 21st century. Yet interest in Science and in the contributions of our scientists appears lacking. Rather, the research suggests widespread ignorance of scientific matters in the general population (Durant and Bauer 1997; Durant, et al., 1989; Miller, et al., 1997).

Allied to this is a perceptible decline in the number of students studying Science as a proportion of all students eligible for higher education. This trend is a source of considerable concern among EU governments (Dearing, 1996; Roberts, 2002). The numbers choosing not to pursue the study of Science in secondary schools has become a matter of considerable public concern and debate (Jenkins 1994; Lepkowska 1996). This has been highlighted in Ireland in reports on the Physical Sciences (O'Hare, 2000) and the relevance of Science Education (Matthews, 2007).

Much of the concern, however, relates to the future supply of well qualified scientists and engineers, the thinking being that it is only those students who study and are taught Science at secondary school that may realistically expect to pursue a scientific education at a higher level and ultimately a scientific career. Such a utilitarian approach to Science education is evident, for example, in the report entitled "Europe Needs More Scientists" (2004), which was compiled under the chairmanship of Professor José Mariano Gago. In recent years, there has been a series of reports warning about the disaster that a shortage of scientists would trigger in Ireland (O'Hare, 2002; Matthews, 2007); in the UK (Haskell and Martin 1994; Her Majesty's Government, 1993; Nottingham Skills & Enterprise Network, 1992) and across the EU (Gago, 2004). In the USA, similar concerns have been voiced in the influential report entitled "Before It's Too Late" (Riley, 2000).

Thus, the role of Science education as a way of providing a route into careers in Science looms large in the debate. Nevertheless, that it has a function in relation to the general social and political purposes of education is acknowledged. In this regard, the report 'Europe Needs More Scientists' (Gago, 2004) also recognises the role of Science subjects at primary and secondary levels in serving to develop students' intellectual capacity, interests, talents and social values (e.g. respect, tolerance, peace). It states clearly that Science education at the compulsory levels of schooling should not function solely/primarily as the first stage in the recruitment drive for the Science-related industry and workforce. It therefore is deemed to have a dual purpose: provision of an education in Science for all students and of a route into a scientific career for a minority (cf. Osborne and Dillon, 2008).

Achievement of this dual mandate will require:

> *'action on improving Science education from the bodies responsible for implementing change at local, regional, national and European Union level"* (Rocard 2007, p.3).

Indeed, the first recommendation in this report states that *'because Europe's future is at stake, decision-makers must demand action',* (Rocard 2007, p.3). Critically, it further states that the most important resource in this endeavour is the teacher, who must be supported and developed.

3.5 The Teacher

Most adults remember their own teachers, especially the 'good' teacher. Many will credit a good teacher with their success and interest in a particular subject and consequently, very often, with their subsequent choice of a career. The quality of its teachers is a factor that has a major impact on an education system. Good teachers are knowledgeable about and have a deep understanding of their subject. They ask searching questions, are effective communicators and have the ability to engage their students in substantive conversations.

The need for substantive conversations has been highlighted by Hayes et a.t (2006) in their "Intellectual Quality Dimension" of the Progressive Pedagogies Research (PPR) coding instrument where it asks the question

> *"Does talk break out of the initiation/response/evaluation pattern and lead to sustained dialogue between students, and between teachers and students"* (p. 42)

In the EUSO Tasks substantive conversations among the team members are facilitated and encouraged and this is one of the unique and important features of the EUSO, which is absent in all the other individual based science Olympiads.

Research suggests that the quality of the teacher is the major determinant of student engagement with Science. Good Science teaching is characterized by teachers who are enthusiastic about their subject, are capable of setting it in an everyday context and typically run well-ordered, stimulating classes. Such teachers are also supportive of their students and willing to spend time, both inside and outside the classroom, talking to them about Science, about careers in Science and about their individual problems in relation to Science (Osborne and Dillon, 2008).

However, it is difficult to be a good Science teacher, if tasked with teaching a subject in which one is neither qualified nor particularly interested (ASTI, 2012). In this context, it is instructive to note that all European countries require their teachers to have a relevant degree. In addition, some countries require an additional postgraduate certificate or diploma qualification while others demand the acquisition of a Master's degree. Nevertheless, the reality at school level is that where teachers who are qualified to teach certain Science subjects are in short supply, teachers of other Science subjects are expected to take those classes also. Alternatively, Science teachers are sometimes recruited from those with a background in the life Sciences.

According to Dillon et al., (2000), Physics is often taught by teachers who lack specialist knowledge and who have little enthusiasm for the subject. Havard (1996) suggests that the problem lies specifically with Physics itself, as over 50% of his sample indicated that they did not enjoy the subject at all or very little, whereas over 60% enjoyed Biology a lot or quite a lot. In the UK, surveys indicate that within the Science teaching community there is an imbalance towards an expertise in Biology teaching (Dillon et al., 2000). The consequence is that Biology is more likely to be taught by a specialist with enthusiasm and interest (Osborne and Simon, 1996) whereas both Chemistry and Physics are more likely to be taught by non-specialists. In such situations, due to lack of confidence, enthusiasm and expertise, teachers fall back on didactic modes of teaching. The quality of teaching and learning is impoverished as a result and the standards to which the EU might aspire fail to be achieved. In other instances, the subject is simply dropped from the school's timetable, (ASTI, 2012).

In Ireland, teachers commonly teach all three Sciences (Biology, Chemistry, and Physics) up to Junior Certificate level. In Norway, most teachers are required to teach two Sciences. This is not so in countries such as Cyprus and Poland. The view of Osborne and Dillon (2008) is that the trend is towards teachers being required to teach more than one Science. This is occurring partly because of the increasingly interdisciplinary nature of Science as practised and partly because the old division of Biology, Chemistry and Physics is difficult to defend given the legitimate claims of the astronomical, environmental and earth Sciences for inclusion. However, because teachers' own education tends to be in one specific discipline, there is some resistance to this trend, for example in France, where teachers generally do not wish to teach integrated Science. This interdisciplinary concept of Science was a major factor in the establishment of the EUSO but the reluctance of the subject specialists who were designing the tasks to embrace the concept of a three way integrated science Olympiads met with some resistance and proved difficult to establish. The analysis of the tasks in Chapter 5 shows the progression towards greater integration. Knowledge integration and connectedness to the world beyond the classroom, a feature of the EUSO tasks, is also an element of the PPR (Hayes et al., 2006) coding instrument referred to earlier.

Given that teachers are regarded as the most important resource in Science education, it is essential that the recruitment of well-qualified and able teachers is a policy priority for all governments in Europe. As Osborne at al., (2003) have observed, recruitment of the highest calibre of teachers of Science is a critical factor in the effort to improve and sustain the quality of school Science education. The issue is more problematic in some EU countries than in others. The Eurydice Report on Science Teaching in Europe (Eurydice, 2006) states that in Poland and Spain there is little difficulty in recruiting Science teachers. In countries such as Cyprus, Finland and Portugal, Science teachers still have high status and there is much competition to enter the teaching profession. In contrast, in England and in other countries, there is a shortage of Science and Mathematics teachers despite considerable financial inducements and extensive public recruitment campaigns in the press and on television. In Ireland, Professor Lucey (TCD), musing on his blog in March, 2012 repeated what many others here are saying:

> '*It's generally agreed that for a whole variety of reasons there is a crisis in terms of Irish scientific and mathematical education'* (Lucey, 2012).

His solution is that with so many people with tertiary education in the Sciences unemployed,

> *'we might indeed consider looking for people to teach Physics, mechanics and other applied Mathematics course, or even other Science disciplines. Let's take a couple of thousand engineers or mathematically intensive scientists on the dole… and deploy them into the second level school system, focused on bringing their experience to bear on the Mathematics and Science curricula'* (Lucey, 2012).

This statement fails to recognise the importance of teacher education.

A major classroom-based research project in Australia *"Queensland School Reform Longitudinal Study* (QSRLS 2001) by Lingard and

Ladwig (Co-Directors), credited with the creation of the concept of "Productive Pedagogies" emphasis the importance the teacher to the education process:-

> *…it is the good teachers who make the greatest difference to student outcomes from schooling. Individual teachers have more impact on student outcomes that do whole school effects: and particular classroom practices are linked to high-quality student performance*….*The good news from our research is that quality teaching can improve outcomes for all students. The bad news is that it is not commonplace.* (P.1 & 2)

There is considerable evidence in the literature that recruiting Science teachers of the highest quality is either problematic for many countries, or has the potential to become problematic over the next decade. Such concerns prompted the French to make Science education a priority of their presidency of the EU in 2000 and to organize a special one-day conference on the subject in Washington, which included representatives from the US and Europe, (Osborne, et al., 2003). The OECD has even suggested that teacher supply faces a 'meltdown' (O'Leary, 2001).

It is certainly likely to constitute a serious challenge in Northern Europe before too long due to the current age profile of many teachers of Science. In Norway, for example, half of all Physics teachers are over 57 years of age. A similar but less severe situation exists in Denmark, England and the Netherlands (Munro and Elsom, 2000).

An equally challenging but critical issue in the effort to improve the quality of Science education is the retention of able, bright, enthusiastic teachers of Science, (cf. Osborne and Collins, 2000). Data on teacher retention are sketchy. Munro and Elsom (2000) found that 50% of teachers (of all subjects) leave the profession within five years. Replacement of a teacher incurs significant, tangible costs for schools in terms, for example, of the recruitment and induction of the new staff member. Less tangible, but as critical, is the discontinuity in the school which results in students having to develop a new relationship with yet another teacher and the established staff having to facilitate their students in the effort to meet this need.

3.6 The Curriculum

Another central issue in Science education is the curriculum that is in place and the philosophy that underpins it. Across Europe, the structure of the Science curriculum varies, reflecting different views of how school Science should be organised. In some countries it is strongly rooted in the separate Sciences; in others it is a more integrated version. A combination of both types can also be found. In general, Science is taught as an integrated subject during primary education and for one to three years of lower secondary education. At upper secondary level, Science education is usually divided into at least three separate subjects: Biology, Chemistry and Physics. Students are usually free to choose one or more Science subjects and at a level of difficulty that most suits them, at this stage.

Norway follows a typical academic pattern in that Science education is obligatory throughout grades 1–11, during which time it is taught as an integrated subject called ‘Science’. Afterwards, Biology, Chemistry, Physics, geology and technology are optional subjects but, due to structural limitations and examination pressures, many students select two of these for more advanced study. In Spain, the curriculum in each of the Science subjects is divided into nine or ten units, while in England there are only four units of Science in total and the words ‘Biology’, ‘Chemistry’, ‘Physics’ do not appear anywhere. In Germany, the secondary curriculum clearly distinguishes the separate Sciences.

If taught in an integrated manner, this is usually done as a succession of separate Science subjects, as happens in Ireland.

In almost all EU countries, the list of Science subjects includes geography or earth science. Science teaching in Estonia, Cyprus and Latvia starts with geography and Biology. In Greece, Romania and Slovakia only Biology is taught in the first year of upper secondary. Lithuania teaches only Biology and Physics initially, delaying the teaching of Chemistry for one year.

However, the content of current Science curricula has largely been framed by scientists; some might even say, by male scientists who regard school Science as a preparation for entry into university and into their chosen professions, rather than as a broad education for all. Hence what some would regard as the main challenge for Science teachers, their dual mandate:

> *'No other curriculum subject serves such a strong dual mandate. The result for teachers is that they must work with the tension that exists between these twin goals – the needs of future scientists and the need of the future non-scientists. As we have argued earlier, different goals require different approaches',* (Osborne and Dillon, 2008, p.21).

In highlighting the difficulties facing science teachers, Osborne and Dillon, (2008) may be over stating the case. For example, the teacher of the mother tongue in a country also has the task of educating the general population so that they are capable of conversing with others, of being understood, of comprehending and evaluating what is being communicated to them by an ever-increasing plethora of media outlets, whilst at the same time, encouraging the more creative and expressive to become poets, playwrights, actors, journalists, etc. Likewise, the art teacher is not only interested in developing the next young expressionist, impressionist or postmodernist, or the music teacher the next Bach, Beethoven or Brahms, or the PE teacher the next Sonia O'Sullivan, Brian O'Driscoll or Katie Taylor; all teachers of all subjects are tasked with the mandate of educating every student, irrespective of his/her particular ability, ambition or circumstance.

Most EU governments recommend that Science curricula include contemporary social issues, environmental topics and the application of scientific achievements to daily life. The labels "integrated", "interdisciplinary", "multi-disciplinary" and "thematic teaching" are frequently used to describe the various curricular arrangements and degrees of integration that are known to exist. In Ireland, the integrated Science syllabus that is followed during the first three years of secondary schooling is in fact a combined syllabus containing the three distinct and separate subjects labelled 'Biology', 'Chemistry' and 'Physics'.

The aim of an integrated Science curriculum is to foster children's curiosity about their environment, provide them with basic knowledge about the world and give them the tools with which to investigate it further. The intent is to connect Science with students' personal experiences and with issues in society and to facilitate discussion of the moral and philosophical aspects of Science. Integrated Science promotes a questioning and investigative approach while preparing children for more detailed studies in later grades.

There are many proponents of an integrated approach to Science teaching. Czerniak (2007,) sees integration as making common sense and completing the *"big picture"* (p. 537) since, in real life, knowledge and experience are not separated into distinct parts. This line of argument usually highlights the fact that traditional discipline boundaries do not reflect contemporary needs and that scientific research itself is becoming increasingly integrated and interlinked (James et al., 1997; Atkin, 1998). Moreover, teaching Science in a holistic manner and making connections between different disciplines is seen as a process that results in new ways of thinking and in new kinds of knowledge (Riquarts and Hansen, 1998). This approach is said to connect various abilities, to develop critical thinking skills and to foster deeper understanding of issues (Ballstaedt, 1995). Such thinking reflects the philosophy underpinning the EUSO.

The critics of integrated Science teaching focus on the lack of empirical evidence of its positive impact on student motivation and achievement. This is due in no small part to the difficulties inherent in attempts to isolate the effects of integrated teaching from other variables that affect student learning. Lederman & Niess, (1997) argue that students following integrated approaches develop less foundational and conceptual understanding because certain discipline-specific topics are covered in less detail or are even omitted. Surely this is simply a question of organisation and management. It may be that because teachers are usually qualified in a limited number of academic disciplines, some might feel uncomfortable about integrating a subject into their lessons for which they have no qualification, (Geraedts et al, 2006; Watanabe & Huntley, 1998).

Despite the theoretical arguments supporting either integrated or separated Science teaching, little empirical evidence of their influence on student achievement has been produced over the years, (Lederman & Niess, 1997; George, 2006). Nevertheless, if a trend can be detected in the EU it is that school Science is becoming more integrated. However, the pace of change is slow notwithstanding significant investment, e.g. the ESTABLISH programme (http://www.establish-fp7.eu/). The goal is to educate students about Science and to provide them with the kind of understanding required of informed citizens. Such a curriculum would serve the needs of a scientifically literate public. It would recognise that, for the vast majority, their experience of learning Science in school would be an end-in-itself, a preparation for living in a society increasingly dominated by Science and technology and not just a preparation for future study or a scientific career.

3.7 Interest and Attitudes

Currently, for the vast majority, the experience of learning Science in school would appear to be less than satisfactory. The stark opening lines from the report of the high level group on Science education, 'Science Education NOW' (2007) read as follows:

> *'In recent years, many studies have highlighted an alarming decline in young people's interest for key Science studies. Despite the numerous projects and actions that are being implemented to reverse this trend, the signs of improvement are still modest. Unless more effective action is taken, Europe's longer term capacity to innovate, and the quality of its research will also decline. Furthermore, among the population in general, the acquisition of skills that are becoming essential in all walks of life, in a society increasingly dependent on the use of knowledge, is also under increasing threat',* (Rocard et al., 2007, p. 2).

A review of the relevant literature in this regard reveals a distinct difference between the experiences of students learning Science at primary level and subsequently at secondary level. At primary level, up to the age of 10, student interest in Science is high and this applies across both genders, (Haworth et al., 2007). By the age of 14, this interest has declined considerably, (Osborne et al., 2003). Such findings seem to suggest that students' interest in pursuing further study in Science and/or following a Science -orientated career has largely been formed by this young age. It would also appear that the Science education curriculum at the end of primary school and at the beginning of secondary school fails to stimulate students' interest in Science. In this context, an even more stark conclusion has been put forward by Osborne et al., (2003) based on data compiled by Hadden and Johnstone, (1983):

> *'In fact, Hadden and Johnstone's data show no improvement in attitude towards Science from the age of 9 onwards, which leads to the speculation that, in some senses, school Science education might do more harm than good!'* (p. 1060).

While the suggestion that *'school Science education might do more harm than good'* (p. 1060) is mischievous in the researcher's opinion and signals a misrepresentation of the views of Hadden and Johnstone (1983), the report recently issued by the OECD and entitled: 'Evolution of Student Interest in Science and Technology Studies', (2006) states quite clearly that while young children have a natural curiosity with regard to these subjects, traditional formal Science education can stifle this interest and lead to the development of negative attitudes towards the learning of Science. Significantly, this OECD report also identifies the crucial role of positive contacts with Science at an early stage. Clearly, a much greater effort needs to be made to ensure that the quality of Science education is of the highest standard throughout that critical period when students are transitioning into second level education and attempting to come to grips with a new education system. Such curricula should provide opportunities to engage with Science in varied, stimulating, enjoyable and gender-sensitive ways, as happens at the EUSO. What happens during Science education upon arrival into secondary schooling needs to be looked at. In Ireland Science in the Junior Cycle, even at the highest level, is popular with students but the drop-off in Chemistry and Physics in the senior cycle is considerable.

The link between lack of interest in the Sciences at an early age and the development of negative attitudes towards the learning of Science is evident in much of the literature on Science education. Though there is some evidence that children are developing negative attitudes towards school Science while still in primary education, (Murphy and Beggs, 2001; Pell and Jarvis, 2001; Breakwell and Beardsell 1992; Doherty and Dawe, 1988), it would appear that, in most countries, children enter secondary school with a favourable attitude towards Science, but that this becomes diluted rather quickly and in particular on the part of girls, (Kahle and Lakes, 1983).

Again, a key issue here is the quality of Science teaching to which this age group is exposed. Woolnough, (1994) found that the quality of the teaching was a major factor in decisions to continue with Science beyond the age of 16. This finding essentially confirms Ebenezer and Zoller's (1993) study of the attitudes of students of the same age. It also validates Haladyna et al's (1982) study of ten to fifteen year old students' attitudes towards Science. In each instance, these researchers found that the most important variable affecting students' attitude was the kind of Science teaching they experienced. This would appear to have a less engaging quality when compared with the teaching of other school subjects, (Cooper et al., 1996). However, the issue of subject knowledge is also a determinant of effective teaching (Turner-Bisset, 1999) and this has been found to also apply in the case of teachers working in the US, (Tobin and Fraser, 1988). In Ireland, The Teaching Council's commissioned report, 'Learning to Teach', (Conway et al., 2009) also connects teacher effectiveness with teacher knowledge.

A consistent finding in the literature (Martin et al., 2008) is the presence of predominantly negative attitudes with respect to Science education among secondary school students across the EU as they make their way through the second level system. Trends in International Mathematics and Science Study (TIMSS), which measures the performance in Mathematics and Science of 4th and 8th grade students and provides reliable data on the link between level of self-confidence in learning Science and achievement in Science, (Martin et al., 2000) shows that positive attitudes towards Science decrease between grades. According to the Index of Students' Positive Attitudes towards Science (PATS), 4th grade students generally have positive attitudes (Baker and LeTendre, 2005). However, in three of the four EU countries where comparisons were possible, 8th grade students had considerably poorer attitudes towards Science than 4th grade students. This was especially true in Italy, where 78 % of 4th grade students and only 47% of 8th grade students had positive attitudes towards Science, (Martin et al., 2000). In countries where Science is taught as separate subjects, 8th grade students' attitudes to Biology were the most positive, but slightly less positive than to earth Science, Chemistry and Physics.

Other findings in the literature suggest negative links between student attitudes towards Science and student attainment. For example, an analysis of data from TIMSS, conducted in 1999, which measured both student attainment and student attitude, shows that the higher the average student's achievement, the less positive is his/her attitude towards Science, (Ogura, 2006).

Equally worrying is the data from the "Relevance of Science Education" project (Sjøberg and Schreiner, 2010) which shows a 0.92 negative correlation between students' attitudes towards school Science and the UN index of Human Development. Norway, which is at the top of this index, has the most negative results in terms of student attitudes to school Science. This has been interpreted as possibly indicative of a feature that is systemic to the nature of advanced societies. It is not insignificant that in more than 20 countries students' responses to the statement '*I like school Science better than other subjects*' are increasingly negative the more developed the country.

This researcher is of the opinion that such outcomes may perhaps reflect the bewildering proliferation of subject and career choices to which students in these countries typically have access: computing, languages, economics, business studies, psychology, sociology, theatre and film studies, journalism. Many of these have only come on stream during the past decade. EUSO team leaders from the former Soviet Bloc countries are also cognisant of an increase in the number of non-Science subjects and career options available to their students. In this regard, they report a decrease in the number of high achieving students taking Science, a development which they believe will have implications for their continued success in future international Science Olympiads, including and the EUSO and the IJSO.

Whitfield (1980) argues that the rejection of Science can be accounted for by the perception that it is a difficult subject. Others, however, suggest that peers and friends have a significant impact on the attitude of both boys and girls towards school Science, (Breakwell and Beardsell, 1992). This appears to be more pronounced between the ages of 11 and 14, (Simpson and Oliver, 1985). That there is a relationship between parental support and positive attitudes towards Science is also clear, (Simpson and Oliver, 1990). Moreover, students having a parent in a Science-related career have been found to be more likely to show a general *interest* in (and positive attitude towards) Science and to identify how it may be useful to them in the future, (OECD, 2007a).

The decline in the numbers studying science in secondary schools, the sharp decline in the numbers studying Chemistry and Physics and the steep decline in the number of girls in particular studying Chemistry and Physics in the Ireland and the EU was a motivating factor in establishing the EUSO.

3.8 Gender Issues in Science

Much of the literature relating to issues of gender in Science focuses on the difficulties encountered by girls and on their consequent lack of engagement, generally, in comparison with boys. It is held by some that the very nature of Science, with its claims to universality and its non-reflexive, value-free and objective character, renders it inherently at odds with feminine values, which treasure the human and affective aspects of knowledge, (Harding, 1991; Keller, 1985; Watts and Bentley, 1993). Others have stated that a fear of depriving themselves of a well-rounded liberal education has been found to steer some secondary school girls away from it (Tobias, 1990).

Many refer to the decreasing number of girls taking Science, outlining some of the reasons emanating from their research. A major factor appears to be a perception among girls that they are better at other subjects. In this context, Jovanovic and King, (1998) discovered that as they progress through school, girls perceive themselves to be better, for example, at languages and therefore to be less adept, relatively, at Science. Hence, Science gets pushed down the pecking order by girls. However, there is evidence to suggest that girls discriminate between the different Science subjects early on. Osborne, et al., (2003) claim that there is a substantial bias against physical Science among girls and suggest that at an individual level the overwhelming majority of girls choose not to do physical Science as soon as they can. This scenario aptly captures the situation in Ireland, as demonstrated in the EUSO, where participation in Physics by girls is critically low by 14/15 years of age. Osborne and Dillon, (2008), state that the lower proportion of girls vis-à-vis boys studying the physical Sciences and engineering is becoming evident in many EU countries. Again, this situation is reflected in the gender make-up of both the EUSO teams and the participants in other international

Olympiads. It is hardly surprising, therefore, that Murphy and Whitelegg, (2006) should find that only a minority of girls go on to pursue careers in physical Science and engineering. Indeed, Osborne et al., (2003), quoting from a small-scale, unpublished study conducted by Fielding, (1998) claim that 16 year old girls of exceptional ability chose not to pursue further study in Science because it limited them to careers in Science, which they did not consider appealing.

This practice, among girls, of failing to choose Science appears, contrary to popular belief, to occur irrespective of the type of secondary school they attend. That more girls choose to study Science in a single sex environment is simply not well founded. The youth cohort study conducted by Cheng et al., (1995) and a report based on questionnaire responses from 722 schools in England and Wales found that uptake of the physical Sciences by girls in single sex schools was not higher than in co-educational schools. It must be acknowledged, however, that it is unclear as to whether the single sex schools offered a full range of subjects in the first instance. In Ireland, subjects such as Physics and honours Mathematics have not always been available to students in all-girls' schools. Where this occurs in towns in Ireland it is not uncommon for single sex boys' and girls' schools to cooperate with a view to providing greater choice for the students in both types of school. In this way, students in all-girls' schools are afforded access to Physics, honours Mathematics, etc. On the other hand, students in all-boys' schools can avail of subjects such as Biology and music, which tend to be less common in such schools.

Nevertheless, the number of boys and girls studying the individual Sciences has remained remarkably stable across EU countries over the years. The work of Osborne, Simon & Collins, (2003) aptly captures this situation. Their analysis by gender in the EU of students studying Science in secondary schools shows that the male to female ratio of students taking Physics remains stubbornly high at 3.4 (M): 1 (F). Biology is still dominated by girls, the ratio being 1 (M): 1.6 (F). The ratio is approximately equal in Chemistry. These statistics would appear to support earlier findings by Becker (1989) and Weinburgh (1995), who reviewed the literature on attitudes to Science between 1970 and 1991, that boys have a consistently more positive attitude to school Science than girls and that the effect is stronger in Physics than in Biology. That there is not just a consistent difference between the genders has been shown by Breakwell and Beardsell, (1992) and by Hendley et al., (1995). These researchers claim that girls' attitude to Science is significantly less positive than boys.

Given the link between interests and attitudes, as mentioned above, it is instructive to consider the nature of girls' and boys' interests as these relate to Science. To accomplish this, an analysis of the responses of students to a ROSE questionnaire will be conducted below. In this questionnaire, 108 topics about which students might like to learn, are presented and participants are asked to rate them on a scale of 1 ('not at all') to 4 ('very interested'). The researcher has summarised the findings of the English survey, as reported by Jenkins and Nelson (2005) and of the Irish survey as reported by Matthews (2007). While the Irish survey only covered 29 schools and 688 Transition Year students, the findings are broadly similar.

In the Jenkins and Nelson ROSE report (2005) there were 80 statistically significant differences between boys and girls. Taking a mean score of 2.5 as representing a 'neutral' position, it is possible to make a comparison between the genders. This exercise reveals virtually no difference between boys and girls in overall measure of interest in Science topics. (Girls = 2.47; Boys = 2.50). It is reasonable to conclude, therefore, that boys and girls are equally interested in

Science. However, on closer analysis, it is clear that their interests in particular aspects of Science are very different.

(1. Not Interested … 4. Very Interested)

BOYS	GIRLS
Explosive chemicals (3.38)	Why we dream when we are sleeping and what the dreams may mean (3.47)
How it feels to be weightless in space(3.29)	Cancer, what we know and how we can treat it (3.35)
How the atom bomb functions (3.24)	How to perform first-aid and use basic medical equipment (3.33)
Biological and chemical weapons and what they do to the human body (3.22)	How to exercise to keep the body fit and strong (3.20)
Black holes, supernovae and other spectacular objects in outer space (3.17)	Sexually transmitted diseases and how to be protected against them (3.11)
How meteors, comets or asteroids may cause disasters on earth (3.14)	What we know about HIV/AIDS and how to control it (3.10)
The possibility of life outside earth (3.12)	Life and death and the human soul (3.05)
How computers work (3.08)	Biological and human aspects of abortion (3.04)
The effect of strong electric shocks and lightning on the human body (3.07)	Eating disorders like anorexia or bulimia (3.03)
Brutal, dangerous and threatening animals (3.04)	How alcohol and tobacco might affect the body (3.03)

Table 3.1 Ten Most Popular Science Topics for Boys and Girls (Mean score ≥ 3.0*)
Source: Jenkins and Nelson (2005)

For girls, topics relating to health and medicine, the human body, ethics, aesthetics, and paranormal issues are strong. For boys, topics pertaining to destructive technologies and events are strong.

Gender differences are not as evident in relation to the topics that are least popular, as six of the ten least popular Science topics (highlighted) are common to both boys and girls.

(1. Not Interested … 4. Very Interested)

BOYS	GIRLS
Alternative therapies (1.95)	Benefits and possible hazards of modern farming (1.89)
Benefits and possible hazards of modern farming (1.93)	Plants in my area (1.86)
Famous scientists and their lives (1.93)	Organic and ecological farming (1.86)
Organic and ecological farming (1.86)	How technology helps us handle waste, garbage and sewage (1.84)
How plants grow and reproduce (1.83)	Atoms and molecules (1.83)
Plants in my area (1.82)	How petrol and diesel engines work (1.73)
How crude oil is converted to other materials (1.79)	How a nuclear power plant functions (1.72)
Detergents and soaps (1.74)	Famous scientists and their lives (1.71)
Lotions, creams and the skin (1.70)	Symmetries and patterns in leaves (1.67)
Symmetries and patterns in leaves (1.42)	How crude oil is converted into other materials (1.51)

Table 3.2 Ten Least Popular Science Topics about which Boys and Girls would like to Learn (Mean score ≥ 2.0). *Source: Jenkins and Nelson (2005)*

Although the distribution of interests among boys and girls is very different, it is important to acknowledge that a high level of interest in a given topic by one sex does not necessarily mean that the same topic is of no interest to the other. This method of "preference ranking" has been referred to earlier. Most boys indicate strong interest in learning about 'Black holes, supernovae and other spectacular objects in outer space' but it is also of interest to girls, though at a lower level (mean score 2.72). Likewise, boys would also like to learn about 'Why we dream when we are sleeping and what the dreams may mean' but their level of interest in this topic is lower (mean score 2.89). In contrast, many boys are not interested in learning about 'Eating disorders' (mean score 2.03) while girls have correspondingly little enthusiasm for knowing 'How the atom bomb functions' (mean score 2.27).

The results of the Irish Survey (Matthews 2007) show that in Ireland, a slight majority of Transition Year students would appear to enjoy school Science. Their highest degree of interest is in topics relating to health, sex, genetics, natural disasters, the origin of life, space and the universe; their lowest degree of interest is in nuclear power, plants, rockets, satellites and engines. Girls are more interested in eating disorders, babies and cosmetics; boys are more interested in explosive chemicals and nuclear weapons.

Additional information provided by Haussler and Hoffmann, (2002) in relation to Physics, suggests that those aspects of Physics, which are interesting to girls, are almost always interesting to boys also. However, the reverse is not necessarily the case. They further state that the content of interest to girls is underrepresented in Physics curricula. This data is supported by other research which suggests that in secondary schools girls would be more interested in Physics as a subject and as a career if it contained more human-related content, (Krogh and Thomsen, 2005).

The picture emerging with regard to girls and boys in secondary schools interests as these relate to Science is broadly in line with that provided by Haste, (2004). This researcher found that girls under 16 years of age have ethical concerns in respect of the environment and are sceptical about interfering with nature; on the other hand, boys under 16 years of age are enthusiastic about technology and about the beneficial effect of Science. Haste (2004) also discovered that girls over 16 years find Science boring and are sceptical of its potential while boys over 16 years believe that a ‘scientific way of thinking’ can be applied widely.

3.9 Pedagogy

> "…*the origins of the declining interest among young people for Science studies are found largely in the way Science is taught in schools*", (Rocard et al., 2007, p.2)

To change the way Science is taught in schools, while tackling but one element of the problem, would appear to be equally incontrovertible. This should be accomplished as outlined in the second recommendation in Science Education NOW, (Rocard et al., 2007):

> "*Improvements in Science education should be brought about through new forms of pedagogy: the introduction of inquiry-based approaches in schools, actions for teachers training to IBSE, and the development of teachers' networks should be actively promoted and supported*"
> (p. 3).

A growing body of research (Lyons, 2006; Osborne and Collins, 2000) shows that the pedagogy in school Science is dominated by an understanding that scientific knowledge is a commodity to be transmitted by a teacher to a student. This is commonly called the "Deductive" method. In this method, the teacher presents the concepts, their logical, deductive, implications and gives examples of applications. This method is also referred to as 'top-down transmission'. To be effective, students must be able to handle abstract notions. As a result, writing in school Science is seldom more that the copying of information from the board or textbook onto the students' notebooks. Seldom is any collaborative writing or work that involves the construction of an argument encouraged. Experiments, which are mainly used as illustrations or are a compulsory part of the programme, are usually written up using a formula of words and a structure that is geared towards answering an exam question later. Little opportunity is provided for students to use the language of Science even though there is good evidence that such opportunities lead to enhanced conceptual understanding. Research would suggest that this limited range of pedagogy is one reason why students, girls in particular, disengage with Science, (Lyons, 2006). The recent report produced for the EU Directorate General on Research, Science, Economy and Society, (Rocard et al., 2007) argues that a 'reversal of school Science-teaching pedagogy from mainly deductive to inquiry-based methods' (P. 9) is more likely to increase 'childrens' and students' interest and attainment levels while at the same time stimulating teacher motivation', (p. 9).

Hayes et al (2006) in their book "Teachers & Schooling - Making a Difference" offers a holistic approach to teaching which they call "Productive Pedagogies, Assessment and Performance". Classroom practice is divided into two components, Productive Pedagogies and Productive Assessments Tasks. Each in turn is divided into four dimensions: - Intellectual Quality, Connectedness, Supportive Classroom Environment and Working with and valuing Difference. The Productive Pedagogies promotes problematic knowledge, higher-order thinking, depth of knowledge, substantive conversations and metalanguage in the Intellectual Quality dimension. In the Connectedness dimension it promotes, connectedness to the world beyond the classroom, knowledge integration, background knowledge and problem-based learning. The Supportive Classroom Environment includes students' direction, explicit quality performance criteria, social support, academic engagement and student self-regulation. Finally in the Working with and valuing Difference dimension, cultural knowledge, active citizenship, narrative, group identities in learning communities and representation is supported. In the Productive Assessments Tasks component of the classroom practice each of these are in turn assessed.

This type of engagement might if adopted improve the teaching of Science in our schools by providing the opportunity for meaningful engagement with issues that are of concern to all students through methods which support true academic engagement and self regulation by the student.

Many researchers conclude that students' low or declining interest in Science is partly due to its presentation as a collection of detached, de-contextualised and value-free facts that are not connected to students' own experiences, (Aikenhead, 2005; Osborne, et al., 2003; Sjøberg, 2002). For this reason, traditional school Science teaching is perceived as stifling an awakening of students' curiosity about the natural world, (Aikenhead, 2005; Millar & Osborne, 1998). The EUSO experiments, on the other hand, are based on real-life events and on practical applications and phenomena, such as the production of food and drink, pollution, life and death, etc.

While neither boys nor girls tend to be motivated by traditional school Science, such lack of motivation seems to be more apparent in girls, (Brotman and Moore, 2008). This is partly due to the fact that boys' and girls' Science -related interests can differ and that boys are more interested in the technological aspects which usually form part of traditional curricula, as seen in ROSE. In contrast, girls' interests are generally under-represented in school Science, especially in Physics, (Baram-Tsabari and Yarden, 2008; Häussler and Hoffman, 2002; Murphy & Whitelegg, 2006). As stated earlier, gender differences with regard to interests should be taken into account when trying to raise motivation levels in Science learning.

The "Inductive" method, on the other hand, allows for more observation, experimentation and teacher-guided construction by the child of his/her own knowledge. This approach is also described as a 'bottom-up' approach. The terminology has evolved over many years and, today, the Inductive Approach is most often referred to as Inquiry-Based Science Education (IBSE). By definition, inquiry is the intentional process of diagnosing problems, critiquing experiments, distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers and forming coherent arguments, (Linn et al., 2004).

Context-based Science teaching emphasises the philosophical, historical and social aspects of Science, connecting scientific understanding with students' everyday experiences. This approach is considered by some researchers to increase students' motivation to engage in scientific studies and possibly leads to improved scientific achievement and increased uptake (Bennett et al., 2007; Irwin, 2000). This method of improving student motivation and interest uses real-life contexts and practical applications *"as the starting point for the development of scientific ideas", (*Bennett et al., 2007, p. 348). It is also referred to as the Science -Technology-Society (STS) approach.

As both context-based and STS Science teaching incorporate students' everyday experiences and contemporary societal issues, such as ethics in Science and the environment, they facilitate the development of critical thinking skills and social responsibility, (Gilbert, 2006; Ryder, 2002). In describing STS Science courses, Aikenhead, (2005) has stated that the focus is on

> *"…practical utility, human values, and a connectedness with personal and societal issues, taught from a student-centred orientation"*, (p. 384).

The goal is to develop responsible future citizens who understand the interactions between Science, technology and society. This approach echoes that referred to by Hayes et al. (2006)

In addition to ensuring that Science is taught in context, other remedies could include inviting experts from scientific fields into schools, organising workplace visits and providing focused career guidance and counselling services. Furthermore, student surveys indicate that professional scientists and others involved in the science industry could provide valuable information on possible careers in Science , in addition to acting as positive role models, (Bevins et al., 2005; Lavonen et al., 2008; Roberts, 2002).

In Mathematics teaching, IBSE is often referred to as “Problem-Based Learning” (PBL). PBL describes a learning environment where problems drive the learning. Learning begins with the problem to be solved and the problem is posed in such a way that students need to gain new knowledge in order to solve the problem. Rather than seeking a single correct answer, students interpret the problem, gather information, identify possible solutions, and evaluate options and present conclusions. The EUSO Tasks could be described in this way.

However, many regard such a definition of inquiry-based learning as too broad and lacking in clarity. This issue has been addressed by a number of researchers, (Anderson, 2007; Appleton 2007; Brickman et al., 2009). As Minner et al., (2009) point out in their research review,

> *‘the term inquiry has figured prominently in Science education, yet it refers to at least three distinct categories of activities, what scientists do (e.g., conducting investigations using scientific methods), how students learn (e.g., actively inquiring through thinking and doing into a phenomenon or problem, often mirroring the processes used by scientists) and a pedagogical approach that teachers employ, (e.g., designing or using curricula that allow for extended investigations)*’, (p. 476).

Bell et al., (2005) propose a model to deal with different forms of inquiry-based learning. This model includes four inquiry categories, which vary according to the amount of information provided to the student. The first category, ‘confirmation inquiry’, in which the student is provided with the most information, is the most strongly teacher-directed. The other levels are known as ‘structured inquiry’, ‘guided inquiry’ and ‘open inquiry’. At the ‘confirmation’ level, students know the expected outcome; at the other end of this scale (‘open inquiry’), students formulate questions, choose methods and propose solutions themselves. In Minner et al.'s (2009) major research synthesis of 138 studies on the impact of inquiry-based Science teaching, the authors attribute lack of a common understanding of the term for making it difficult to investigate its effects. In their investigation, they included studies on teaching, which illustrate engagement of students with scientific phenomena, active thinking, responsibility for learning and involvement in the investigation cycle.

Minner et al. (2009) found that the majority of the studies examined showed positive impacts of "inquiry instruction" on student content learning and retention and a positive effect of inquiry-based, hands-on activities on conceptual learning. Overall, the results indicated that

> *'…having students actively think about and participate in the investigation process increases their science conceptual learning'*, (p. 493).

Brotman and Moore, (2008) reviewing multiple empirical studies, show that inquiry-based Science education, especially if introduced at an early stage, has a positive effect on girls' interests in and attitudes towards Science. Other recent studies, such as Brickman et al., (2009) have shown that students working in inquiry laboratories demonstrated a significant improvement in scientific literacy skills.

What can be considered a good teaching approach is evidently linked to the aims of what is considered to be 'good Science education'. Harlen (2009) summarises these aims as developing scientific literacy and the ability to continue learning. She defines scientific literacy as

> '*being comfortable and competent with broad scientific ideas, with the nature and limitations of Science and with the processes of Science, and having the capacity to use these ideas in making decisions as an informed and concerned citizen'*, (p. 34).

In order to achieve these goals of scientific literacy and continuity of learning, a large variety of teaching approaches and underlying learning theories exists. Harlen (2009) has categorized these as individual and "*social constructivism", "discussion, dialogue and argumentation, enquiry"* and *"formative assessment*". (p. 35).

Recent reports such as "Science Education NOW" (Rocard et al, 2007) have found that with initiatives using the IBSE approach, girls in secondary schools participate more enthusiastically and develop a better level of self-confidence than with traditional approaches to teaching Science. PISA, while it does not give us the reason why, discovered that, on average, girls have lower levels of belief in their scientific abilities than boys in all EU countries and those boys have a higher level of confidence in tackling specific scientific tasks. In most other aspects of self-reported attitudes towards Science, as in ROSE, there have been no consistent gender differences. Both boys and girls demonstrate similar levels of interest in Science and there is no overall difference in boys' and girls' inclination to use Science in future studies or careers, (EACEA/Eurydice, 2010; OECD, 2007a).

The report, Science Education Now (Rocard et al, 2007) argued that a

> *'reversal of school Science -teaching pedagogy from mainly deductive to inquiry-based methods' was more likely to increase 'children's and students' interest and attainment levels while at the same time stimulating teacher motivation'* (p.2*).*

However, all the research on teacher professional development shows that changing teacher pedagogy is not possible through short, one-off courses, (Joyce & Showers, 2002; Loucks-Horsley et al., 1998). Rather it requires extended opportunities to engage in professional development.

In this context, whereas the Science education community mostly agrees that pedagogical practices based on inquiry-based methods are more effective, the reality of classroom practice is that in a majority of European countries, these methods are simply not being implemented and actual Science teaching does not follow this approach, (Angier, 2007). Current initiatives in Europe, which actively pursue the renewal of Science education through "inquiry based" methods, show great promise but are not of a scale to bring about substantial impact and are not capable of fully exploiting the potential European-level support for dissemination and integration (Angier, 2007). Among the reasons may be national testing procedures in place in many countries

IBSE has proved its efficacy, at both primary and secondary levels, in increasing children's interest and attainments levels while at the same time stimulating teacher motivation. IBSE is effective for students from the weakest to the most able and is fully compatible with the ambition of excellence. Moreover, IBSE promotes girls' interest and participation in Science activities. Finally, IBSE and traditional deductive approaches are not mutually exclusive; they should be combined in all Science classrooms in order to accommodate different mindsets and age-group preferences. Harlen, (2009) argues for a combination of these approaches to produce a "best pedagogy" for Science education. The EUSO encourages students to use a variety of methods in solving tasks.

3.10 Career Guidance

With respect to career guidance, research (Lavonen et al., 2008; Roger and Duffield, 2000) often concludes that career counsellors and advisors are not well informed about Science careers themselves and are, therefore, ill-equipped to advise students on such matters, Studies on students' attitudes and perceptions reveal that they frequently fail to see the relevance of their Science studies to their future working lives, (Bevins et al., 2005; Cleaves, 2005). In addition, they display stereotypical and narrow views about Science careers, sometimes having little or no information about what it means to be a scientist or an engineer, (Krogh and Thomsen, 2005; Lavonen et al., 2008; Roberts, 2002). The reality is that, in the main, neither their Science teachers, nor their career guidance counsellors, (Lavonen et al., 2008; Roger and Duffield, 2000) have worked as practising scientists. These professionals, therefore, have a very limited understanding of what it means to have a career in Science; moreover, they may not recognise the possibility that a Science degree can offer a pathway to careers in areas such as finance, management and law, which do not require Science qualifications, (Munro and Elsom, 2000) may result in, the majority of students in Europe not considering becoming scientists or engineers, (Sjøberg and Schreiner, 2008). This is also true of Transition Year (TY) students in Ireland, as reported in the ROSE project (Matthews, 2007).

Gender issues also affect career aspirations, girls being much less interested than boys in choosing careers in Science, (Furlong and Biggart, 1999; Schoon et al., 2007). It is important, therefore, in developing high-quality career advice in schools, to pay special attention to the needs of girls. Career guidance councillors and advisors need to counteract the perception that Science is a male preserve and to reassure girls that choosing Science does not constitute a loss of femininity, a concern which they frequently raise, (Roger and Duffield, 2000). This latter recommendation is based on suggestions that identity plays a strong role in career choice, i.e. that Science is construed as a masculine discipline and that this is a factor in discouraging women from having an interest in the subject, (Brotman and Moore, 2008; Gilbert and Calvert, 2003). There is some evidence in the literature, though, that girls can be interested in Science and confident of their ability to undertake Science courses, (Colley et al. 1994; Havard 1996; Lightbody and Durndell, 1996b; Whitehead, 1996). Archer (1992), too, has found that girls aged between 10 and 15 reported liking most strongly the three subjects regarded as stereotypically 'masculine' – Mathematics, Science and games. Moreover, in terms of achievement in Science, Elwood and Comber, (1995) have shown that the situation has now reached a position, at least in the UK, where girls aged 10-15 are doing as well as, if not better than, boys.

> *What these figures (1994 GCSE results) show is that in only one of these subjects, biology, are boys substantially ahead of girls, a subject for which girls have traditionally entered in large numbers to meet the requirement of taking a science subject. In all other eleven subjects girls are substantially ahead of boys in the proportion of A–C grades obtained or else the gap is very narrow between the genders*. (p. 1063)

Nevertheless, there is a need for both Science-related and gender-sensitive educational and vocational guidance to increase the interest of both girls and boys in Science subjects and careers.

3.11 Assessment

In the Science Education in Europe report, Osborne and Dillon (2008) state that

> *"For too long, the issue of assessment in Science has received minimum attention",* (p. 9).

The system is dominated by practices that encourage rote learning rather than mastery learning for understanding. Assessments are largely characterised by questions that predominately require recall, a relatively undemanding cognitive task. These assessments often have limited validity and reliability. Yet, in many countries, the results of a range of such tests, both national and international, are regarded as valid and reliable measures of the effectiveness of school Science education.

The main aim of assessment is to ensure that students' knowledge and skills are tested in accordance with the objectives and/or learning outcomes defined in the curriculum. Assessment according to the NCCA (http://www.ncca.ie)

> *"…is that part of the learning process where the learner and the teacher can evaluate progress or achievement in the development of a particular skill or in the understanding of a particular area of knowledge"* NCCA (http://www.ncca.ie) *.*

In Hayes et al. (2006) Productive Assessments tasks are based on the Productive Pedagogies as are the Productive Performance criteria. These include, problematic knowledge, higher-order thinking, depth of knowledge, elaborate communication, connectedness to the world beyond the classroom, cultural knowledge, and responsible and transformative citizenship.

However to ensure that the performance of their students in the Leaving Certificate in Ireland at least is the highest it can be, teachers tend to read the intentions of the curriculum or from the syllabi or from textbooks but from the assessment items. In effect, teachers teach to the tests, restricting and fragmenting the relevant content and using a limited pedagogy. Where the result of the test is crucial for entry into a particular university course, as in Ireland, parents and students demand such an approach. Hence the development and proliferation of "grind" schools and classes in the major urban areas in Ireland.

Guidelines on student assessment generally include recommendations on techniques to be used by teachers. Those most commonly recommended include use of traditional written/oral examination, assessment of students' performance in class and assessment of their project-based work. According to the Eurydice (2011) report

> '*no clear distinction can be made between the specific guidelines for Science assessment and the general guidelines that apply to all curriculum subjects; the techniques recommended are similar in both', (* p. 10).

However, there would appear to be some official guidance material to help teachers assess students' Science-specific skills in half of the Eurydice countries, though this is limited.

In general, students' knowledge and skills in Science are assessed, through standardised examination, at least once during their lower secondary education and once during their upper secondary education. While Science does not have the prominence those other subjects, such as Mathematics or the mother tongue, have in these examinations, it is clear that it is becoming part of national testing procedures in an increasing number of countries.

In these circumstances, it is imperative that the assessment issue receive urgent and appropriate attention. This must include the development of assessment items that are more challenging, that cover a wider range of skills and competencies and that make use of a greater variety of approaches, e.g. diagnostic and formative assessment. At the same time, it must be borne in mind that irrespective of the reforms that are put in place, limited places in high prestige university courses will demand good exam results.

3.12 Summary

This Chapter reviews the limited literature on the history to the International Science Olympiads from the Leningrad Mathematical Olympiad (LMO) in 1934 to the present day Olympiads by using primary sources where possible. Little research has been carried out on the impact of the Olympiads or the role of competitions on science education. Literature on relevant topics raised by the research question such as, why teach Science? are explored. The central role of Science Education in the Education systems across the EU is investigated, in particular the perceptible decline in participation in the Senior Cycle of the secondary Education systems in Chemistry and Physics by all students, but especially girls. This has raised concerns about the future supply of well qualified Scientists, Engineers and Science Teachers. This has led to much research on the pivotal role of the teacher, their qualifications and training, the curriculum content of the subjects they teach and the teaching methods that employ and how this in turn influences the interest and attitude of students. The critical role of assessment is reviewed.

Chapter 4

Methodology

4.1 Introduction

In this chapter the research methodology is outlined. While acknowledging the overarching importance of an Action Research approach, it is also important to bear in mind that this thesis also provides a historical account of the development of the EUSO over a ten-year period, complete with analysis of results and an account of the historical developments. These are presented from a historical perspective but mindful of the Action Research philosophy and approach, which underpinned all aspects of the process throughout. Thus issues such as presentation of medal tables, etc are presented in such a manner as to respect the underpinning philosophy of growth and improvement that characterise the EUSO over the decade.

The researcher's Epistemological Stance and Theoretical Perspective are outlined in Section 4.2. His rationale for choosing Action Research is provided in Section 4.3. The Action Research process itself is described in Section 4.4. The Research Design, Research Model, Research Approach and Challenges are outlined in Section 4.5. The Research Methods including General considerations, Diaries, Interviews and the Cycles are explained in Section 4.6. Finally, the key conclusions are presented in Section 4.7. The chapter concludes with a summary, Section 4.8.

4.2 Epistemological Stance and Theoretical Perspective

In approaching this study, the researcher was mindful of the fact that he is an important influence in the research process. Thus, from the outset, he recognised the need to be ever-alert to his own personal values and viewpoints as he attempted to find the best way to answer his research question. With regard to these underlying perspectives and preconceptions, he realised that he subscribes to the view that the kind of knowledge regarding human behaviour that is legitimate and adequate is that which is created through the subject's interactions with the world. Thus, truth and meaning emerge from the interplay between the subject and the outside world. However, subjects construct their own meaning in different ways, even in relation to the same phenomena and encounter the world from different perspectives. Such a constructivist perspective invites a theoretical approach which is closely linked to constructivism: interpretivism. In interpretivism, *the 'world is interpreted through the classification schemas of the mind' (*Gray, 2006, p.20); the emphasis is on understanding the real workings behind 'reality'. For the researcher, attempts to understand this reality should be grounded in people's experiences of that reality. It is the human experience of the 'life-world' that is of interest. The task, therefore, is to explore and unpick people's multiple perspectives in natural, field settings. This implies the inductive collection of large amounts of qualitative data and immediately places the research in the qualitative, as distinct from the quantitative, domain.

The researcher acknowledges that others may operate from a very different epistemological stance and theoretical perspective, resulting in different methodological approaches to data collection. While the literature is replete with examples of distinct approaches to scientific inquiry, it is the perspectives offered by positivism and various strands of interpretivism which have been among the most influential and, also, the most controversial. Indeed, within the field of educational research, the conflict between positivism and interpretivism has received much attention since it first emerged during the second half of the twentieth century.

In contrast to interpretivism, truth and meaning, in positivism, exist in some external world, in an objective reality that is ‘out there’. Research is about discovering this objective truth; meaning is discovered, not constructed. In this world, ideas only deserve incorporation into knowledge if they can be put to the test of empirical evidence. In this world, reality consists of what is available to the senses; its properties can be measured directly through observation and research results presented as objective facts and established truths. Such a stance implies use of quantitative research methods and a deductive approach to theory development. In reality, while purists may regard qualitative and/or quantitative research as representing different paradigms, many practitioners use a combination of methods despite the differing epistemological approaches that may underpin each one.

4.3 Rationale for Choosing Action Research

In choosing a research methodology for this study, it was necessary, in the first instance that it should align with the researcher’s epistemological stance and theoretical perspective, i.e. constructivism and interpretivism, respectively. In this regard, a methodology which argues for a postmodernist approach to knowledge creation and which acknowledges that people with identical information may interpret it in different ways was chosen: Action Research (AR). The aim of AR is to present the various truths and realities (constructions) held by individuals and groups as a result of their particular worldview, as distinct from definitive solutions to problems. Through AR it is both possible and legitimate to:

'Develop a context in which individuals and groups with divergent perceptions and interpretations can formulate a construction of their situation that makes sense to them all – a joint construction' (Stringer, 1999: P. 45).

Moreover, AR is about inclusion and empowerment versus exclusion and authority. For the researcher it is about becoming directly involved in the research process, about functioning as a change agent in natural social settings and about displaying a commitment to effect improvements in such settings. The definition of AR provided by Reason and Bradbury (2006) is closest to this researcher's mindset and approach to research:

'Action research is a participatory, democratic process concerned with developing practical knowledge in the pursuit of worthwhile human purposes, grounded in a participatory worldview which we believe is emerging at this historical moment. It seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people, and more generally the flourishing of individual persons and their communities', (Reason and Bradbury 2006. p. 1).

The overarching importance of an Action Research approach is recognised and the importantce of the historical account of the development of the EUSO over a ten-year period is acknowledged.

4.4 Action Research Process

There is also no agreement as to when Action Research was first defined. A study of the literature on the history of Action Research indicates that Kurt Lewin (1890-1947) a Prussian/Polish psychologist who immigrated to America in 1933 is generally credited in many books and theses on the subject with coining the phrase 'Action Research' (Lewin 1946; Carr & Kemmis 1986; Reason and Rowan

1981; McFarland & Stansell, 1993). In 1946, while a professor at MIT Lewin published a paper 'Action Research and Minority Problems' which was aimed at promoting democracy and reducing prejudice. Having lived through two world wars, it is perhaps not surprising that his examples of AR were influenced by those wars and that he saw the approach as a method of improving social behaviour and promoting social change. Lewin also argued that it was important to conduct social experiments in natural, social settings and not in the artificial world of controlled laboratory environments, which suited other forms of research. His influence spread to the United Kingdom through his work with the 'Tavistock Institute' and the Journal of Social Issues (Bargal et al, 1992). Due to his untimely death, however, he did not develop his theory further and he did not live to see his influence on research spread to many disparate fields of endeavour, including education. Others, who followed him, have developed his original idea and now there exists a vast corpus of work in the area of AR.

Many authors give credit to John Collier (1884-1968) the Commissioner of the Bureau of Indian Affairs during the President Franklin D. Roosevelt (FDR) administration in 1933-1945, for providing the first identifiable starting point for action research (McNiff et al, 2000; Kemmis & McTaggart, 1982; McKernan, 1991; Noffke, 1994; McTaggart, 1997). Like many intellectuals of his generation he was concerned with the adverse effects of the industrial age on mankind. He thought society was becoming too individualistic and argued that American culture needed to re-establish a sense of community and responsibility. However, in the 1950s, AR was castigated as unscientific, amateurish and little more than common sense (McFarland & Stansell, 1993). It was seen as '*applied Science'* (McFarland & Stansell, 1993 p. 15) involving expert-led experimentation in the social domain. During this period much of the research findings that had been produced was regarded by practitioners as too theoretical and not grounded in practice.

Nevertheless, within twenty years AR had re-emerged, among education practitioners in particular, who questioned the applicability of scientific research designs and methodologies as a means of solving education issues. AR was now seen as a tool for professional development, bringing a greater focus on the teacher and on school reform and a renewed commitment to educational change (Noffke & Stevenson, 1995). Those who wish to locate AR in the field of education link it with the great educational innovation of the early 1900's. Noffke (1994) places the foundations of action research in education in the progressive education writings of John Dewey (1859-1952): Throughout these writings Dewey argues that education is a social and interactive process and that even the school itself is a social institution through which reform could and should take place.

Practitioners like Hilda Taba, through her involvement with the 'Center of Inter-group Education' at the University of Chicago, was an influential figure in curriculum planning in the USA. (Taba & Noel, 1957). Ferrance states that Stephen M. Corey at Columbia University

> *'was among the first to use action research in the field of education. He believed that the scientific method in education would bring about change because educators would be involved in both the research and the application of information'.* (Ferrance. 2000. p. 7).

Elliott (1991) links Action Research in the United Kingdom also with curriculum reform and in particular, with the work of Lawrence Stenhouse (1926-1982). Stenhouse, a British educational thinker like Dewey, sought to promote an active role for teachers in education research and curriculum development. He believed in empowering teachers and treating students with respect as learners. He was a founder member of the 'Centre for Applied Research in Education'

(CARE) at the University of East Anglia which was a development from the 'Schools Council Humanities Project' within which he cultivated innovative class-work. He also served as the President of the British Educational Research Association (BERA). His books, 'An Introduction to Curriculum Development and Research' (1975) and 'Authority, Education and Empowerment' (1982) highlighted a concept of the teacher, not only as the implementer of educational theory, but rather as a professional who theorize in practice, (Elliott, 1991; Noffke. 1994).

Writings on Action Research are extensive in the United Kingdom and because of the work of Stenhouse, Elliott and others involved in the 'Ford Teaching Project' and in the 'Teacher–Pupil Interaction and the Quality of Learning Project', action research has grown in the UK (McNiff, 1988; Elliott, 1991; McKernan, 1991; Altrichter et al, 1993). The Collaborative Action Research Network (CARN), founded in 1997, has brought the works of academics and practitioners to a wider audience. Kemmis & McTaggart (1982) links Australian Action Research also with curriculum innovation and planning.

Action Research was first carried out in Germany, Switzerland and Austria in the 1970s and more recently in connection with the CARN. This was founded to continue the development work of the 'Ford Teaching Project' in the United Kingdom. Regional CARN Networks now exist and include a Spanish-speaking section, a Dutch speaking section and a New Zealand section. (Klafki, 1973; Moser, 1975; Altrichter et al, 1993).

There are multiple definitions of Action Research, resulting in a variety of models, each of which provides its own unique way of working through the action research process; thus, many academics offer different routes to the interpretation of action research, (Kemmis &

McTaggart 2003; Anderson 2007, Herr and Nihlen 1994; Elliot, 1991; McNiff et al., 2000).

An important characteristic shared by all models, however, and one which distinguishes AR from other methodologies, is its cyclical nature. The process, as originally conceived by Lewin, is a cyclical one: it involves a cycle or spiral of planning, action, monitoring and reflection upon the effects of the action. These stages overlap, thus some activities are happening in parallel with each other. This basic structure was graphically illustrated by Lewin, as follows:

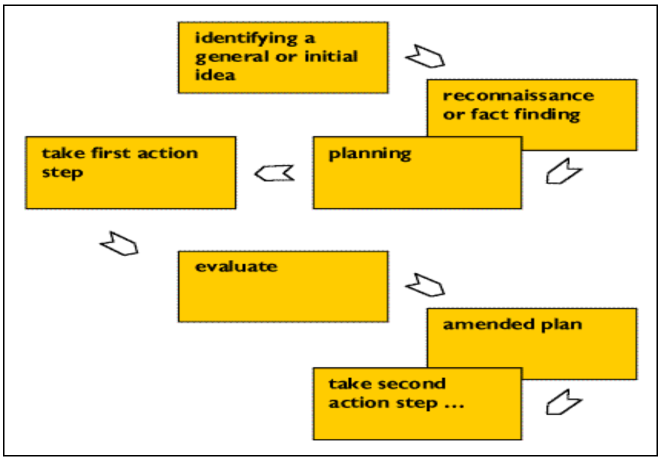


Figure 4.1 Kurt Lewin Action Research Spiral of Steps
Source: http://www.infed.org/thinkers/et-lewin.htm

Lewin's verbal definition of AR states:

> '*The research needed for social practice can best be characterized as research for social management or social engineering. It is a type of action-research, a comparative research on the conditions and effects of various forms of social action, and research leading to social action. Research that produces nothing but books will not suffice'* (Lewin 1946, reproduced in Lewin1948-202-3)

Since Lewin, the spiral structure has been elaborated upon by a series of researchers.

In 1953 Corey published 'Action Research to Improve School Practice' in which he defined action research as the process through which practitioners study their own practice to solve their personal practical problems.

> '*We are convinced that the disposition to study…the consequences of our own teaching is more likely to change and improve our practices than is reading about what someone else has discovered of his teaching'*.(Corey, 1953, p. 70) .

His process, too, is cyclical, involving a 'non-linear pattern of planning, acting, observing, and reflecting on the changes in the social situations' (Noffke and Stevenson, 1995, p.2). This Action Research routine - Plan, Act, Observe, Reflect – has been operationalised in the following way:

Plan: involves identifying the problem area; narrowing it down so that it is manageable; investigating the problem; when does it happen? Who does it affect? Where does it happen?; Thinking about what might be the cause the problem and talking to other teachers; Thinking about a solution and how it can be implemented; thinking about what evidence you will collect to decide whether your action is successful or not. How will you collect the data for it and how to analyse it? Teach / Act: involves implementing your solution. Observe: involves gathering evidence to analyse to decide whether your solution was successful or not. Reflect: involves Analysing the evidence gathered to determine if the problem has been solved? If not, what step to try next?

Gerald Susman (1983) distinguished five phases to be conducted within each research cycle. Firstly, the problem is identified and data is collected. This is followed by assumptions and several possible solutions resulting in a single plan of action leading to implementation. Additional data is collected and analysed and the findings are interpreted in light of how successful the action has been. At this point, the problem is re-assessed and the process begins another cycle. This process continues until the problem is resolved.

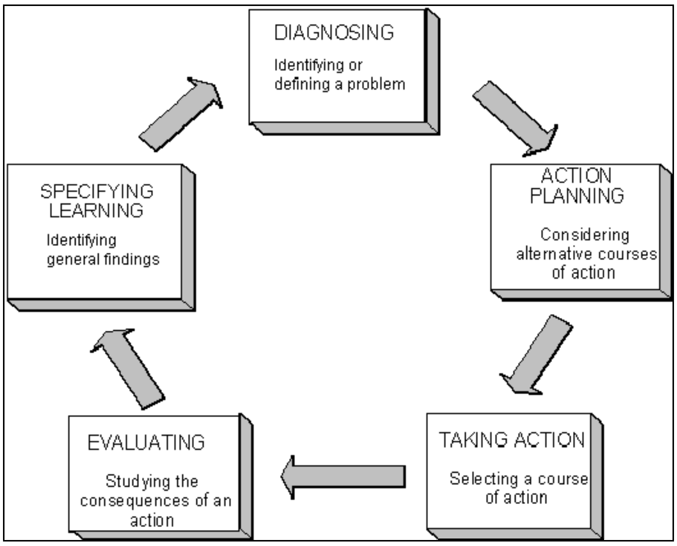


Figure 4.2. Susman (1983. P.102) Five Phases of Action Research
Source: http://www.web.ca/robrien/papers/arfinal.html

Ebbutt, (1985) further illustrates the evolution of the overall plan through a spiral analogy. Action research according to Ebbutt is the systematic study of attempts to improve educational practice by groups of participants by means of their own practical actions and by means of their own reflection upon the effects of those actions. His cyclical representation of the circles within circles, illustrates that actions lead to change, that change leads to monitoring which in turn leads to an amendment of the original idea. It is reasonable to state that this approach clearly represents the modus operandi of the EUSO since its inception.

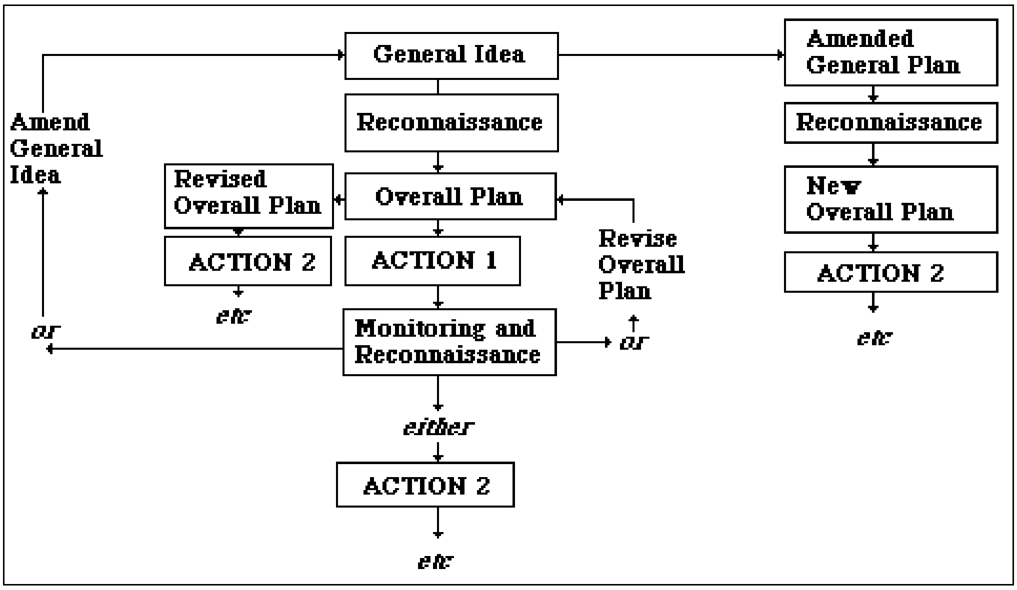


Figure 4.3 Ebbutt, (1985) Spiral Analogy
Source: http://www.web.ca/robrien/papers/arfinal.html

John Elliott (1991) points out that the 'general idea' cannot be fixed in advance and should be allowed to change, that reconnaissance is not merely fact-finding, but should include analysis as well as fact finding and this should occur throughout the action research process and not only at the beginning. He says that implementation is not a simple task and one should monitor the effects of action before evaluation takes place.

In this research on the history and development of the EUSO, the 'general idea' was not be 'fixed' but neither was it so nebulous that is could be pulled totally out of shape or changed into something so completely different that it bears little resemblance to the 'original idea'.

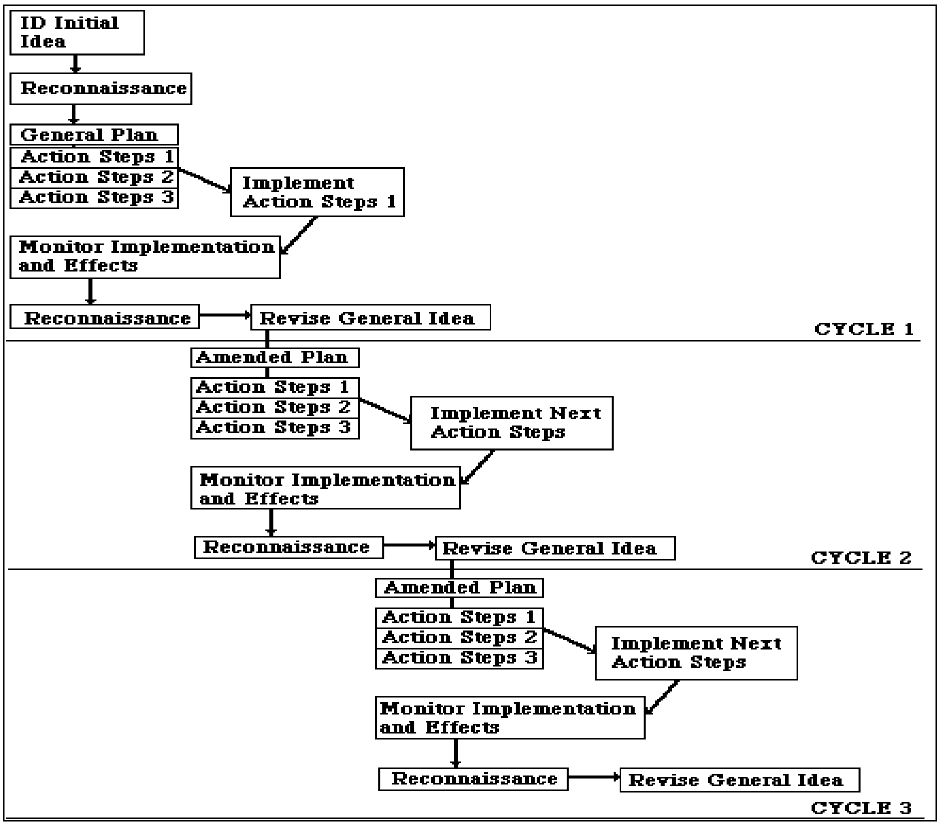


Figure 4.4 Elliott Action Research Model (2004)
Source http://physicsed.buffalostate.edu/danowner/actionrsch.html

The fundamental aim of Action Research according to Elliott is to improve practice rather than to produce knowledge.

> *'The production and utilisation of knowledge is subordinate to and conditioned by this fundamental aim'* (Elliott, 1991, p. 49).

This was at the heart of the rationale for developing the EUSO. Elliott's model emphasizes constant evolution and redefinition of the original goal through a series of reconnaissance recurring at every cycle. The reconnaissance necessarily includes some degree of analysis. This is because Action Research is a continuous exercise of involvement and empowerment.

Stringer (1996) envisages his action research routine as Look, Think, and Act. (p.16)

Table 4.1 Stringer's (1996) Action Research Basic Routine

Look	Gather relevant information
	Build a picture, describe the situation
Think	Explore and analyse (hypothesize)
	Interpret and explain (theorise)
Act	Plan (report)
	Implement
	Evaluate

Although presented in a linear format he graphically illustrates Action Research as a continually recycling set of activities.

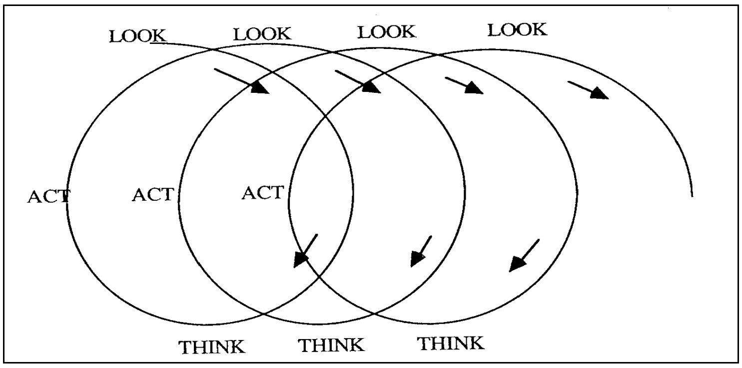


Figure 4.5 Stringer's Action Research Interacting Spiral (1996. P. 17)

He identified four working principles and their corresponding strategies in Action Research to help the researcher / facilitator towards the implementation of the plan. He sees relationships, communication, participation and inclusion as centrally important. If adhered to in the research the result is: feelings of equality, harmony, cooperation, openness and conflict resolution. His advice is to listen, be sincere and truthful and keep lines of communication open. The participants must feel that they are involved in a meaningful way and that they benefit from participation. Again, this approach held a strong resonance for the stance adopted during this research.

Table 4.2 Working Principles of Community-Based Action Research
(Adapted from Stringer (1996 P.38)

Working Principle	Principle as implemented in action research community
Relationships	Promote feelings of equality for all involved
	Maintain harmony
	Resolve conflict openly
	Encourage cooperative relationships
Communication	Listen attentively to people
	Be truthful and sincere
	Act in socially and culturally appropriate ways
	Regularly advise others as to what is happening
Participation	Enable sufficient levels of involvement
	Enable people to perform significant tasks
	Provide support for people as they learn to act for themselves
	Deal personally with people rather than with their representatives or agents
Inclusion	Maximize the involvement of all relevant individuals
	Ensure cooperation of other groups, agencies and organisations
	Ensure that all relevant groups benefit from activity

The researcher having given due study to each of these approaches was convinced that Action Research clearly represented the preferred approach to the design and development of the EUSO. The philosophical underpinnings of AR are still very much adhered to within the cycles of improvement and the democratic stance adopted to the further development and improvement of the EUSO. However the selection of one specific approach that truly encapsulated the work of the EUSO and its myriad phases and negotiations as well as its rationale led to the adoption of a model of Participatory Action Research that is described below.

4.5 Research Design

4.5.1 Research Model

The overarching model chosen in this research is that termed Participatory Action Research (PAR) developed by Kemmis and

McTaggart (2003). However because this is primarily practice-focused research, with historical, social, political and cultural dimensions, it is important to highlight that the work is strongly underpinned by the PAR philosophical and methodological base, but by the nature of the research it is reported from a historical perspective. Thus several of the chapters presented here are historical in content with a clearly defined social background and setting. However the interactions between the key participants and the overarching rationale for the development of the EUSO, are clearly located in a PAR philosophy and "behind the scenes" action and progression pattern.

This is captured in the Kemmis and McTaggart routine - Plan, Act, Observe, Reflect: – graphically illustrated below:

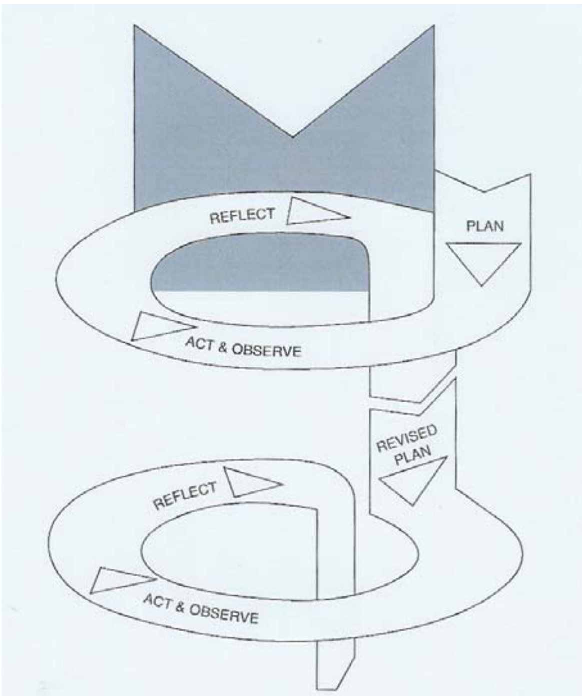


Figure 4.6 Kemmis and McTaggart (2003) Model of Action Research
Source: Kemmis and McTaggart (p.278)

This model follows the generic AR model in that it *'focuses on simultaneous action and research in a participative manner'* and shares its characteristics: (Gray 2006 p. 374))

- Research subjects are themselves researchers or involved in a democratic partnership with a researcher.
- Research is seen as a mechanism for change.
- Data are generated from the direct experiences of research participants.

However, it takes this latter point particularly seriously: it is participatory action research. For McTaggart (1997) participation is much more than mere involvement.

> *'The criterion of success is not whether participants have followed the steps faithfully but rather whether they have a strong and authentic sense of development and evolution in their practices, their understandings of their practices, and the situations in which they practise',* (Kemmis and McTaggart, 2003, p. 277).

Authentic participation means that the participants become immersed in the research, a requirement for PAR given that its key element is, arguably,

> *"…a process of reflection, social learning and the development of 'critical consciousness'* (Gaventa and Cornwall, 2001, p.76).

Another defining characteristic for this researcher is the focus on investigation of actual as distinct from abstract practices and the concentration on transformation of practitioners' practices in an egalitarian manner. Hence its frequent application in the educational sphere and its particular suitability in the current context towards the establishment of the EUSO.

4.5.2 Research Approach

In adopting the PAR model, the researcher was keen to ensure that adherence to its tenets would be as comprehensive as possible. This implied careful and continuous consideration not just of its dominant feature, the spiral of cycles of self-reflection, but also of seven additional features identified by Kemmis and McTaggart, (2003, p. 280) as attaching to the approach and as being ‘at least as important’. These include the following, which have been applied to this research.

PAR is a social process: In this research the Olympiad community met, interacted and established social relationships at the annual event. Within this social group they were invited to discuss their one Olympiad and how it might be improved and how a new Olympiad could be different.

PAR is participatory: This research engaged the mentors in examining their own understanding of the Olympiad and the Olympiad movement and involved them in discussions on how bring about change.

PAR is practical and collaborative: This research engaged the participants in examining the social practices that link them, the Olympiads, and through their collaboration effect change.

PAR is emancipatory: This research provided the participants with the opportunity to release themselves from the constraints of the Olympiads structures that seemed unchangeable, to one in which they could make their own rules.

PAR is reflexive (e.g., recursive, dialectical): This research helped the participants to investigate their own reality in order to change it and to change that reality in order to investigate it.

PAR aims to transform: This research provided the platform for the participants to transform both theory and practice. They could through their actions, transform the science Olympiad idea from single subject of multidisciplinary, from individual to team, from competition to cooperation and from a theory based to exclusively experimental.

4.5.3 Challenges

As the researcher reflected upon the aim of this project and the requirements of the PAR model being applied, the scale of task appeared, at times, almost insurmountable. Clearly, the concept of an EUSO had to appeal to EU governments, educators and students and to the international community. The PAR approach would require the establishment and maintenance of a comprehensive process of collaboration, the exact nature of which was not initially obvious. It would encounter an array of influences and activities but would only be successful if control was shared between participants and relationships sustained across time zones and geographical boundaries. It would also have to produce outcomes that would be mutually beneficial to participants from a variety of nations and cultures, while at the same time ensuring that ownership would be firmly and equitably in their possession.

A key concern for the researcher was the capacity of the PAR model to handle the inevitable challenge that the concept of an integrated, multidisciplinary science Olympiad would constitute for participants accustomed to conventional teaching methods and distinct subject specialisms. An additional concern related to its capacity to deal with the unexpected, whether in the personal and/or impersonal (e.g., economic) arena. In all such circumstances, the researcher consulted with relevant colleagues and with his supervisor, engaged in self-reflection and re-immersed himself in the project with renewed confidence and vigour.

4.6 Research Methods

4.6.1 General Considerations

In approaching this aspect of the study the researcher was mindful of the need to ensure the reliability of the data and to reduce the potential for error. Thus, the principle of triangulation is adhered to in that data are collected over different times for a period of 10 years and from a number of sources. The data gathering exercise was systematic, transparent and collaborative. It was consistently followed by feedback, both verbal and written and the results incorporated into revised editions of reports and of the EUSO Constitution. The latter represents a permanent record of the collective decisions of participants and is published on the EUSO website.

The researcher was also careful to maintain an ethical stance throughout all stages and phases of this study. In this regard, he actively engaged with his co-researchers in an inclusive and democratic fashion. He also practised communicative action (Kemmis and McTaggart, 2003) which opened communicative space between participants, thus enabling the establishment of unforced consensus.

4.6.2 Diaries

In deciding to propose the establishment of the EUSO, the researcher had drawn on his personal diaries and reflective accounts of discussions with colleagues at informal meetings/gatherings to enable him to form tentative interpretations of remarks made and to review his own feelings as recorded on those occasions. In this regard, he discovered that the following questions continued to recur in participants' contributions:

- In a time of declining participation by secondary students in Science education, was it relevant to hold a Science competition for students who had already chosen a university course or career path in Science?
- Why were so few female students participating in Olympiads?
- Was participation at these Olympiads by smaller countries with limited resources and with very little chance of getting the top honours, value for money?
- Was it fair or equitable that some countries bent or flagrantly broke the rules by providing intensive training of a significant duration beyond that laid down?
- Was the award of a gold medal so important to some students and their mentors that they were prepared to cheat to achieve it?
- Were the education systems of some countries so different, with specialist Science schools or advanced Science courses for the top secondary school students that countries such as Ireland and other smaller European countries, with broader education systems, could never hope to compete at the top level?

He also detected some variation in levels of interest among participants in the idea of a EUSO. In this context, he identified three broad groupings. The first group consisted of people who appeared deeply committed to the concept, who always contributed enthusiastically to the debate, who expressed a keen interest in being involved and who could be relied upon to make the necessary changes to ensure its success. The second group had but a moderate interest but could be depended on to make an input when required despite being reluctant to volunteer. They would support the idea if someone else were to take it on. The third group were not actively involved but would accept the decisions of the remainder of the group. The exact proportion represented by each group varied from year to year and from issue to issue.

The question continuously bandied about was 'what, if anything, '*could'* be done about it'. For the researcher the question was 'what '*should*' he do about it'.

Kemmis and McTaggart (2003) say that planning starts with '*a general or initial idea'* and a desire to reach a certain goal. However, how to reach this goal is frequently not clear. The '*general idea'*, in this instance "three parallel junior Olympiads modelled closely on the senior Olympiads" is examined carefully in the light of the means available followed by fact-finding / reconnaissance about the situation. An 'overall plan' (amended initial idea) on how to reach the goal emerges and a decision regarding the first steps towards the modified / amended plan is taken.

The next period is devoted to executing the first step of the overall plan followed by more fact-findings / reconnaissance. These fact-finding / reconnaissance steps have four functions: - evaluation, new general insight, correctly planning the next step and modifying/amending the overall plan. The next steps are composed of a cycle of planning, executing, and fact-finding/reconnaissance, evaluating the results and modifying/amending of the overall plan. This process is elaborated in more detail in pages 98-109.

4.6.3 Interviews

The interview is a conversation between two or more individuals and it can take many forms. These include: - structured interview, semi-structured interview, non-directive interview, focused interview and informal conversational interview (Gray, 2006)

> '*Interviewing is a powerful way of helping people to make explicit things that have hitherto been implicit – to articulate their tacit perceptions, feelings, and understandings'* (Asksey and Knight 1999: p. 32)

The interview therefore has an impact on the interviewer and on the interviewee during Action Research. By having to frame and ask the question the interviewer has to be clear as to exactly what kind of information he wants to elicit. In the same way the interviewee, by having to articulate a response has to be clear what it is he/she wants to communicate.

As the researcher progressed through the many cycles of this Action Research almost all of the interview techniques were used, some more than others. The interviews were on a one-one basis, or focus group interviews.

The researcher was conscious that his own personal views about the topic were not important at this time. The purpose was to collect data and not to change the respondents' views or opinions (Gray, 2006). When information was asked for, it was provided but it was still vague and unfinished and it was made clear that their views were being sought.

Each of the senior Olympiad (IBO, ICHO or IPhO) could be regarded as a focus group in that each was a sample of the total number of respondents to be interviewed, but each came from different Science background and each Olympiad produced a different set of data. The IBO in Uppsala was attended by seven EU countries and similar numbers of EU countries attend the IChO & IPhO. After the initial presentation of the concept the team leaders from the EU countries had discussions with the researcher. This process continues at the

1999 IPhO in Padova Italy, the 2000 IChO in Copenhagen, Denmark, the 2000 IBO in Antalya, Turkey, the 2001 IPhO in Antalya, Turkey and the 2001 IChO in Mumbai India. The concept of an '*integrated Science'* Olympiad seemed to be a greater obstacle to the Physics mentors than the Biology mentors, with the Chemistry mentors being somewhat ambivalent. It was seen as *'relatively easy'* to combine any two Sciences, but all three was *'less easy if not impossible'*. The concept of '*integrated Science'* itself led to discussion as to its definition. Was it a single subject or was it three subjects co-existing side-by side in close harmony?

The informal conversational type interview was employed at first because it is an open-ended technique and allows for flexibility. The researcher probed the interviewee about his/her attitude towards the Olympiads he/she was attending in relation to the level of difficulty of the tasks, the number of female students participating and his/her openness to a new Olympiad for EU students. The data collected served to find out if that person was in favour or against the idea. Some mentors showed more interest in having a deeper conversation on the topic. In that instance the researched switched to a focused interview. The researcher was able to direct the conversation towards the idea or concept of the EUSO. This focussed interview identified the supporters and also helped clarify the concept in the researcher's own mind.

Where an interviewee showed a strong interest in the idea a non-directive or unstructured interview took place. The researcher was specific as to the purpose of the interview and the respondent was allowed to speak openly, freely and frankly. The researcher's role was to check for accuracy of what the interviewee thought of the concept or idea, which provided data for qualitative analysis. These interviews took place in social surroundings like at a coffee table and could involve more than one interviewee. This provided an opportunity for different opinions to be put forward even if some were irrelevant. The interviewer had to be a good listener, not just when the topic of the EUSO was being discussed, but also when the conversation drifted off in another direction. It was often the case that the dialogue sometimes returned back to the topic after a little probing.

The semi-structured or non-standardized, interview was most useful since a particular hypothesis was not being tested (David and Sutton, 2004) but only a list of key issues, topics and themes were pursued. The researcher wanted to be free to change the direction of the interview and ask additional unanticipated questions if the need arose and also use whatever vocabulary he chose.

> *Within each topic, the interviewer is free to conduct the conversation as he thinks fit, to ask the questions he deems appropriate, in the words he considers best, to give explanation and ask for clarification if the answer is not clear, to prompt the respondent to elucidate further if necessary, and to establish his own style of conversation.* (Corbetta, 2003. p. 270).

This type of interview gave him the opportunities to prompt and to probe the views and opinions of the interviewees. The semi-structured or non-standardized, interview is;

> *'where the respondent is asked to clarify what they have said. This phenomenological approach is concerned with the meaning that people ascribe to phenomena'* (Gray 2006, p. 214)

The questions that needed answering gave a structure to the interview and eliminated time wasting because time was limited. While there was no written agenda knowing the key themes developed by the researcher, an Olympiad for the EU, single subject or integrated, girls at the Olympiads, girls studying Science, importance of experimental Science, context-based Science education etc., gave that interview a sense of order (David & Sutton, 2004). Reports on these meetings were written up immediately.

During 1998-2001 the researcher attended the IBO and IChO on three occasions and the IPhO twice. A number of informal meetings took place during these Olympiads and each also had a formal meeting.

Structured or standardized interview were not used. The reason was that in the structured or standardized interview the same questions needs to be asked of all respondents (Bryman 2001; Corbetta 2003; Gray 2006). Structured or standardized interview are…

> *'Interviews in which all respondents are asked the same questions with the same wording and in the same sequence.' (*Corbetta, 2003, p.269)

Gray states that *'Ideally questions are read out in the same tone of voice so as not be influence the answer'* (Gray, 2006, p. 215).

Bryman explains that during structured or standardized interview, the aim is for all interviewees to be given exactly the same context of questioning. This means that each respondent receives exactly the same interview stimulus as any other. The data required from these interviews did not demand or warrant this kind of accuracy.

4.6.4 Cycles

Table 4.3. Cycle Timeline 1998-2002*

Year	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5
1998					
1999					
2000					
2001					
2002					

**Between 1998 and 2002 the researcher had discussions and conducted interviews with the EU team leaders of the IBO, IChO and IPhO before drawing up the proposal in the form of the first EUSO constitution.*

In 1994 the researcher began Ireland's participation at the International Chemistry, Biology and Physics Olympiad by attending the 1995 IChO in Beijing, China as an observer. The 1st All Ireland Schools Chemistry Competition was held in DCU on March 30th 1996. The following year the researcher established the All Ireland Competitions in Biology and Physics. This resulted in the launching of the "Annual Schools Science Festival" (ASSF) in September 1997 later named the "Irish Science Olympiad" (ISO). Minister Noel Treacy TD was invited to present the medals at the 1st Irish Science Olympiad on 1st February 1998. During the closing ceremony the researcher had informal discussions with the Minister about replicating the ISO at an EU level. This was the beginning of Cycle 1.

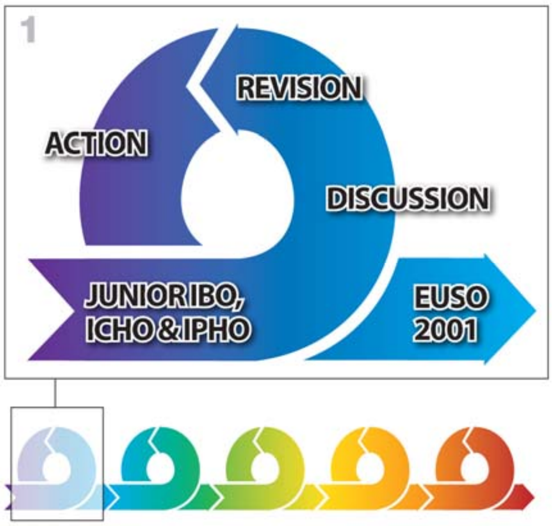


Figure 4.7 Cycle 1: 1998-1999
Junior IBO, IChO & IPhO -> EUSO 2001

Cycle 1 took place over a two-year period 1998-99 and involved informal discussions with Minister Treacy and presentation and discussions with the IBO, IChO & IPhO Team Leaders from EU countries. The 1998 IChO took place in Melbourne Australia on July 5-14 and the IBO in Kiel, Germany in July 19-26. Presentations and discussions continued at the 1999 IBO in Uppsala, Sweden in July 4-16 and at the IPhO in Padova, Italy in July 18-27 and with Minister

Treaty throughout the two year period. The researcher did not attend the 1998 IPhO or the 1999 IChO. In October 1999 the researcher wrote to Professor Albert Pratt, Director General, DCU, requesting permission to hold the EUSO in DCU in 2001.

These discussions with the EU Olympiad team leaders and Minister Treacy are be regarded as the start of the PAR spiral of cycles. The idea of a Junior Science Olympiad in Biology, Chemistry and Physics was put forward, discussion and dialogue followed allowing debate, questioning, answering and recording of suggestion, assessing their reaction, summarising the findings and promising follow up discussions.

The action that resulted form these informal discussions was that formal discussions on establishing an EUSO in 2001 would take place with Minister Treacy, officials from the Department of Education and Science and the EU Olympiads leaders at the 2000-01 IBO, IChO & IPhO.

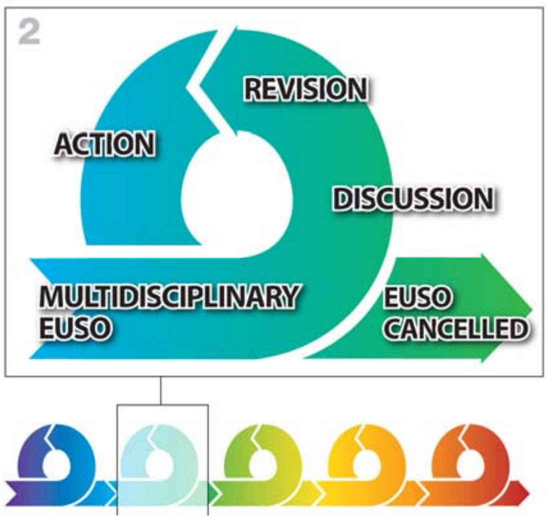


Figure 4.8 Cycles 2: 2000-2001
Multidisciplinary EUSO -> EUSO Cancelled

Cycle 2 took place over the two year period 2000-2001. Mr. Noel Treacy TD, Minister for Science, Technology and Commerce, launched the 2000 ISO at the DES, Marlborough Street, as one of the DCU activities of Science Week 2000. Professor John Carroll, Registrar DCU, Mr. William Burgess MD IBM-Ireland and the ISO Director attended. While under-age categories had been a feature of the previous ISO, a new category, Transition Year/ students Under 17, was introduced in 2000. This was introduced to pave the way for the establishment of an EU Science Olympiad for this age group. Minister Treacy had made a proposal to the Council of EU Science Ministers in Brussels that a European Union Science Olympiad (EUSO) in Biology, Chemistry and Physics, modelled on the Irish Science Olympiad be established. Funding was sought under the Socrates Programme. Three meeting took place in 2000 with the Minister and the DES officials in January 13th, June 25th and October 18th. In November 1st the estimated cost of hosting the EUSO was presented to the Minister

By now the idea of an EUSO was no longer just the idea of a single individual, the researcher, but was a collaborative effort and it had some support of the EU delegation leaders. The researcher was on a fact-finding / reconnaissance mission and had to evaluate the level of support, gain new insights, correctly plan the next step and modify or amend the plan. There was an underlying assumption or understanding that if it was to take place, Ireland and DCU would host the first EUSO and the Irish Olympiad team leaders would be the scientific committee, responsible for all scientific aspects. The researcher would be responsible for all other aspects, including the provision of funding

Informal discussions at the Olympiads had already identified supporters and these were encouraged to join in the debate by promoting the concept. The idea of an EUSO was formulated in a vague way. It would be a Science Olympiad for younger EU students only. The details were not worked out and would only be finalised after much discussion.

The target audience, the EU team leaders, were invited to a meeting and the idea of a new Science Olympiad was introduced to them formally. The purpose of the meeting was to allow more discussion on the shape and content of the event, ascertain the support level or otherwise, and to identify the more supportive and less supportive members.

The 2000 IChO took place in Copenhagen, Denmark in July 2-11 and the 2000 IBO took place in Antalya, Turkey in July 9-16. Easter 2001 had been identified as the most likely date for the 1st EUSO.

In February 19th 2001 the Foot and Mouth disease was detected in an abattoir in Essex, the UK and in mid February the European Union imposed a worldwide ban on all British exports of livestock, meat and animal products. Despite restrictions on the movement of vehicles used for the transport of livestock, animals, fresh meat and meat products, milk and milk products by the Department of Agriculture within Ireland, on the 22nd March 2001, an outbreak of the disease was detected on a farm in County Louth. Minister Noel Treacy TD called the EUSO Director to his office to inform him that the EUSO would be postponed indefinitely. He could not guarantee that the money already allocated to the EUSO would remain in place. The future of the EUSO was uncertain. However with the last cull of infected animals in the UK in January 2002 the disease was brought under control and the restrictions on travel were lifted.

The researcher did not attend the 2000 IPhO or 2001 IBO. The 2001 IPhO took place in Antalya, Turkey 28th June -6th July and the 2001 IChO in Mumbai India, in July 6th -15th.

At this point the risk of total failure had to be assessed. If the idea had traction and if minor changes could be made without comprising the integrity of the original concept, the idea could be more formally presented to the decision makers. It was agreed that the level of support was such to warrant progressing to the next phase or Cycle 3.

Figure 4.9 Cycles 3: 2001
Revised EUSO -> EUSO Scientific Committee

There was general agreement that all three Sciences, Biology, Chemistry and Physics should be tested and that the age of the students should be seventeen years of age. A concrete EUSO structure was developing which indicated support for an EU Science Olympiad with three parallel strands, Biology, Chemistry and Physics. Meeting with the Irish Science IBO, IChO and IPhO Team leaders and additional meetings with the DES officials were organised.

The revised idea for an EUSO was formulated and discussed with the Irish team leaders who would lead the Scientific Committee of the 1st EUSO. The researcher drew up a more precise document (constitution, statutes or set of rules) and sought funding from the Irish government.

The priority was to construct a new revised concrete idea with precise objectives and outputs as the starting point. The result was the first EUSO constitution. The constitutions of the IBO, IChO and IPhO were analysed and the common structures, management system and jargon identified and used. The new features of the EUSO were that:

- EU Member States were invited to send a delegation of three students in each Science discipline (Biology, Chemistry and Physics), nine students in total, accompanied by one mentor for each discipline
- The contestants to be EU citizens in full time education in EU schools, be 17 years of age or younger and the winners of the national Science Olympiad for younger students.
- The competition to consist of theoretical and practical examination.
- The duration of each part to be approximately four hours.

The Irish team leaders had agreed to lead the 1st EUSO Scientific Committee. They had been party to all the discussion to date and had a very clear idea of what kind of competition the EUSO would be. During Cycle 4 the idea of an interdisciplinary Science competition was agreed.

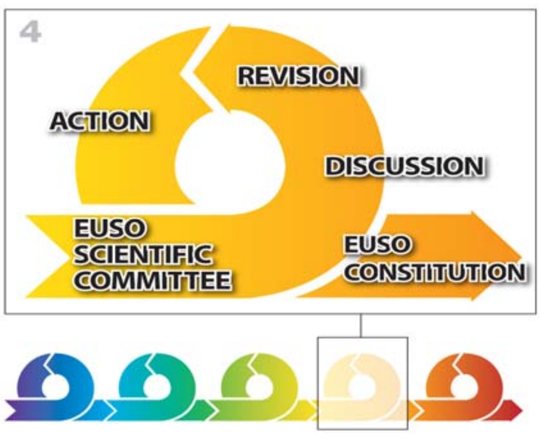


Figure 4.10 Cycles 4: 2002
EUSO Scientific Committee -> EUSO Constitution

A draft document was prepared and contact made with the Minister for Science and Technology, Minister Noel Treacy TD. The document was presented to the Minister and his officials. Following a long discussion they accepted the document without revisions of the content but asked that the final document would include an introduction by the Minister. It was agreed that the DES would fund the event. The constitution would be printed in English, French, German Italian and Spanish and circulated to all the Ministers of Education, Science and/or Technology in the fifteen EU countries by Minister Treacy.

Figure 4.11 Cycles 5: 2002
EUSO Constitution -> 1st EUSO GB Meeting

This document also formed the basis for discussions with the Irish IBO, IChO & IPhO team leaders who were to form the 1st scientific Committee. Each Country would be asked to appoint an EUSO country Coordinator who would be invited to Dublin to discuss, finalise and agree the new constitution.

Table 4.4 Cycle Timeline 2002-2012

Year	GB*	GB	GB	GB	GB
2002					
2003					
2004					
2011					
2012					

(GB = Governing Body)*

The 6th Cycle began when thirteen of the fifteen EU countries nominated their EUSO Coordinator to the EUSO. The named individuals were sent copies of the draft constitution and invited to a meeting of the 1st EUSO Governing Body in Dublin. They were told that the constitution as printed was only a draft document and all aspects were open for discussion. The researcher himself had revised his own ideas of the EUSO as proposed in the constitution and he wanted to encourage an open discussion. Without such a discussion it would not be a collaborative effort, the country coordinators would not feel that the process was democratic, buy-in and the feeling of ownership would not be achieved and they may not continue to support it or take part, which was the ultimate goal.

This Action Research followed the same pattern as described by Stringer (1999) , Kemmis and McTaggart (2003), Elliot (1991) and others. Only the words describing each activity have changed. As stated earlier by McNiff et al (2000) and Stringer (1996), Action Research is not always neat and tidy. The postponement for two years was a major blow to the EUSO and its future was in doubt and was dependent on this funding remaining in place for a further two years, which fortunately was the case. The idea itself, manifested by the constitution, was constantly revised by the partners and this revision continues with the constitution going through its 6th reincarnation in Vilnius in April 2012. The process, which resulted in the EUSO, is illustrated as a series of consequential spirals linked together by a common goal.

The idea had become a reality and the EUSO developed a life of its own. If the buy-in had been successful and ownership of the idea transferred to the participants, they would repeat the exercise indefinitely. The EUSO Constitution was circulated to the EUSO Country Coordinators appointed by their respective governments

Following the circulation of the EUSO Constitution to the Ministers of Education, Science and European Union Affairs, Mr. Noel Treacy TD addressed his colleagues in the European parliament and requested their support for the EUSO.

It was decided to hold the first EUSO in Dublin City University in April 2003 with funding provided by the Irish government. Letters were sent to all fifteen EU Ministers of Education, Science and Technology inviting them to confirm their nominee as EUSO Country Coordinator.

Fourteen countries appointed EUSO Country Coordinators and informed the Director of the appointment. A meeting was called of the Country Coordinators, now called the EUSO Governing Body (GB) in Dublin in May 2002. Delegates from six countries, Belgium, Germany, Ireland, Luxembourg, Greece and Spain attended, with apologies received from all the others. The meeting was also attended by the scientific committee of the 1st EUSO, all based in DCU.

In line with the Action Research process, it was pointed out that the Constitution as presented, was merely a discussion document and all participants were encouraged to propose whatever changes they deemed necessary and appropriate. The 1st EUSO Constitution, under discussion, proposed a junior version of the IBO, IChO and IPhO: - an individual, subject based competition but held in one location. The discussion lasted two days and all aspects of the proposed EUSO were debated. What emerged was a radically new constitution. While the text changes were small, the actual changes to the original concept were very significant and radically changed the EUSO from a junior version of the IBO, IChO and IPhO to a completely new and unique Olympiad.

At the first Governing Body meeting in May 2001, the student age requirement was reduced by six months, the stipulation that all teams must have both male and female members was dropped (against the wishes of the researcher) and the theoretical task was discarded in favour of a second practical team task. The Irish Olympiad team leaders also attended the meeting and contributed to the discussion, which led to the revised constitution. Their role as the Scientific Committee was clarified. Cycle 6 ended with a new action plan. A new agreed constitution was to be printed, circulated to the Country Coordinators and a date set for the first EUSO

The new EUSO would become a team competition and not an individual one. The age of the students would be lowered to under-seventeen on June 30th of the year of the competition. The theory task would be eliminated and replaced by a second practical task incorporating elements of Biology, Chemistry and Physics in approximate equal proportions. Gold medals would be awarded to approximately 10% of contestants, silver medal to approximately 30% of contestants and bronze medals to the remaining contestants. The registration fee and the stipulation that all teams must have both male and female members would be dropped.

EUSO 2003 was held under the 2nd Edition of the EUSO constitution

At the 2003 Governing Body meeting in Dublin attended by all seven Country Coordinators, the 2nd edition of the Constitution was discussed. Because of confusion as to what exactly was meant by *"under seventeen on June 30th of the year of the competition"* a cleared definition of the "age of the students" was needed. The new wording *"The European Union Science Olympiad (EUSO) is a team competition for EU second level school Science students who are sixteen years of age or younger on the December 31st prior to the competition"* meant a student born on a particular year was eligible and a student born in the previous year, even if the birth date is December 31st was not.

The role of Country Coordinator was amalgamated with the role of one of the country mentors. In future the number of mentors, including the Country Coordinator would be three.

At the 2004 Governing Body meeting in Groningen, the Netherlands attended by all seven Country Coordinators, the 3rd edition of the Constitution was discussed. It was agreed to reduce the number of teams from three teams to two. The increase in EU membership by ten countries and the influx of seven observers to EUSO 2004 would result in a significant increased future cost for hosting countries. Also because of the integration of the Sciences it was no longer necessary to have three teams representing each Science subject.

At the 2011 Governing Body meeting in Pardubice, the Czech Republic attended by all twenty Country Coordinators the 2011 Edition (5th) of the Constitution was agreed. The changes included the establishment of the Office of Vice Presidents, a Finance Committee and changes as to how the President would be elected. The Advisory Board was abolished and the Vice Presidents assumed their responsibilities

At the 10th EUSO in Vilnius, Lithuania additional changes were made to the constitution. At the GB meeting attended by the twenty-two Country Coordinators the 2012 Edition (6th) of the Constitution was agreed.

The sudden death, in September of one of the vice presidents, Dr. Eckhard Lucius, resulted in his duties not being completed and little development on the proposed EUSO improvements took place. It was decided therefore that specific functions and duties be identified and volunteers from among all the mentors were asked to offer their services. As a result three new Vice Presidents were elected with responsibility for publications, internal and external communications and EU funding.

The agreed actions to be completed by EUSO 2013 in Luxembourg include the publication of the EUSO Tasks 2003-2007, the re-structuring of the constitution into two parts, “The Constitution” and “The Manual” (on how to organise an EUSO) and the pursuit of EU funding.

4.7 Nature of Action Research

Having gone through this Action Research process this researcher has concluded that to be successful it must be democratic, participative, cyclical, empowering and an instrument for change. As a democrat he does not believe that he has the right to impose his views on others. If one has an idea it is their job to present it to interested parties and try to persuade them of its merits. They must feel that their contribution to the discussion is valued and valuable and will influence the shape of the idea should it materialise. This can be a long process involving many interested parties. He agrees with McNiff (2002) when she states that ‘*the spiral of action reflection unfolds from themselves and fold back again into themselves’* (P. 56).

Once a decision is made, everyone in the group or community has to work within the confines of that decision, until a majority decide otherwise and a change is necessary. This is why the researcher believe that at the start, a point has to be reached when a clear and unambiguous stance is taken by the group who have the most interest in the project. He did not agree that the stipulating that all delegations be mixed, male & female be dropped from the first EUSO constitution, but it was necessary to accept this change to preserve the project. The insistence that all tasks include Biology, Physics and Physics in equal proportion has been accepted but it is more interdisciplinary that integrated.

The aim of this Action Research was that change would take place. Change did take place and the EUSO in April 2012 completed its tenth consecutive year. Twenty-three EU countries have participated and three have sent observers.

4.8 Summary

Chapter 4 outlines the Research Methodology chosen. The Epistemological Stance and Theoretical Perspective of the researcher are presented as is the rational for choosing Participatory Action Research (PAR), because of its aim to transform and to be participatory, practical, collaborative, emancipatory and reflexive. While acknowledging the overarching importance of the PAR approach, the import of the setting and historical account of the EUSO over a ten-year period is emphasised. The advancement of the Action Research methodology from the early work of Kurt Lewin (1890-1947) through its many modifications and developments to PAR developed by Kemmis and McTaggart (2003) is described. The challenges faced and overcome, the data collection method of informal and informal meetings, diaries and interviews are presented in a graphically illustration in five cycles over a five year period. The cyclical nature of the research is further described in the development of the EUSO constitution from 2002-2012.

euso dublin·2003	EUSO GRONINGEN 2004	EUSO 05 GALWAY
EUROPEAN UNION SCIENCE OLYMPIAD EUSO BRUSSELS 2006		euso 2008 cyprus
	EUSO Göteborg 2010	EUSO 2011 CZECH REPUBLIC
euso VILNIUS 2012	EUSO Luxembourg 2013	**EUSO 2014** **GREECE**

Figure 4.12 EUSO Logos of the Host Countries 2003-2013
Source: MA Cotter – EUSO Founder & President

Chapter 5

Tasks

5.1 Introduction

In this chapter a summary of the twenty EUSO 2003-2012 tasks is presented. This is a historical record, which describes how these unique team science tasks, a central feature of the EUSO were created. They were developed by the different Scientific Committees of the host countries over a ten-year period and finalised and accepted in collaboration with the mentors from the participating countries. It also clarifies how and to whom, within the constraints of the EUSO constitution, medals were allocated. The source of the data is identified and the limitations on the identification of the medal winning teams explained. A rational is given as to how this data contributes to answering the research question and the link to the Participatory Action Research (PAR) model is elucidated. In the discussion of the tasks, reference is made to the work of Hayes et al (2006) on what are called *"Rich Tasks"* (P. 148). While the summary descriptions of the EUSO tasks do not include all of the dimensions of what Hayes et al call "Rich Tasks", the EUSO tasks include many of the elements of their coding instrument of Productive Pedagogies Research (p 22-23).

5.2 Rich Content Tasks

It is not possible to critically analyse how the nature of the tasks or the instructions or briefings given to the students impacted on individual team performance. Each task is designed by different personnel in the different host countries. Each is on a different theme and varies in levels of difficulty and integration, even though the general structure of the tasks had been agreed and the mentors have the final verdict on the tasks. Once a task is designed and the laboratory and equipment laid out it is very difficult to make whole-scale fundamental changes to the tasks. Since 2006 it has been agreed that the President will visit the host country at least thee months before the EUSO to ensure that all the preparations are made and that the Scientific Committee has prepared tasks in conformity with the constitution. Further research could be carried out on what elements of the EUSO task themselves most impact on individual team performances. However this does not form part of this research report.

Each EUSO task is expected to be intellectually challenging and support cooperation, collaboration and teamwork. It should be integrated and connect the sciences across some or all of the science disciplines in equal proportions. It should be problem/inquiry - based, relevant and connected to the real world and, if possible, have some relationship to the location of the EUSO or the students' everyday lives (context-based). It should engage all the team members, be self-directed in terms of pace, route and outcomes and support and value all students' efforts, whatever their roles within the team. It also should involve the construction of knowledge, higher-order thinking, alternative solutions and strategies and depth of knowledge and understanding. It should also facilitate the manipulation of information and ideas and encourage sophisticated and substantive communication between the team members. High-stakes assessment is minimised by allocating medals to all the students.

5.3 Task Development and PAR

The Scientific Committee from the host country chooses the topics (usually with a local connection or representing science in everyday lives) and designs the Task. They take their cue from the previous years, get advice from the EUSO President and follow the directions given in the EUSO Constitution which recommends that the task should be of four hours duration and incorporate elements of Biology, Chemistry and Physics in approximate equal proportions. The task is presented to the mentors by the Scientific Committee at a General Assembly (GA) meeting attended by Mentors and Observers from all participating countries, on the day before the Task is performed by the students. All aspects of the Task: - its level of difficulty, clarity of purpose, integration of the sciences, experimental problem/inquiry based aspects and possible engagement of all students on the team are discussed by the mentors and the Scientific Committee. The marking scheme is also discussed and agreed. In line with the PAR methodology, the process of finalising the tasks engages all the participants, task designers and mentors in a collaborative manner.

Because the mentors have access to their students at all times (unlike in all the other science Olympiads), the PAR model demands that everyone involved, gives an undertaking to act ethically and not give any help or hints to their students or assist them in any way which might give them an advantage over other teams. This model deliberately encourages trust among the participants and reflects a change in the approach to Olympiads where, in this instance, high-stakes assessments is minimised and not maximised, where cooperation replaces competition, and where participants are encouraged to question the accepted constraints of the established Olympiads.

5.4 Team Interaction

No research has been carried out on the amount of interaction that takes place between team members while completing the task. It is therefore not possible to conclude that each team works as a functioning integrated team or as three or two individuals working in isolation. This is an area which would merit further investigation. The researcher, who has attended the laboratories during the performance of the EUSO tasks, has observed that some teams communicate among themselves more than others and some team members assist each other with the practical elements, across the subject boundaries more that others. However there is no empirical evidence that working as individuals or as integrated team members has an impact on the final score achieved by the individual teams. Also, there is no evidence that the tasks engaged all the students on the team or if one or two students dominated the decision making process and carried out all or some of the practical activity.

No conclusions can be arrived at therefore in relation to team integration or whether the students worked independently or together. The structure of the EUSO Tasks encourages and allows for the students to work together as three equals. Reference will be made to the structure of the different tasks to see if their design encourages team-work or individual work.

5.5 Grading

Because all students receive medals, high-stake assessment is minimised. Scores are published only for the countries receiving gold and silver medals. The range of scores is given for the bronze medal categories. This rule has been part of the EUSO since its inception. During the early stages of the Participatory Action Research (PAR) it was agreed that all students would receive a medal but that the place or rank achieved by an individual country in the bronze medal category would not be revealed. The bronze medals are therefore presented either in alphabetical order or randomly, followed by the silver medal winners from the lowest to the highest. The gold medals are the last to be awarded.

Each task is a “Stand Alone Task”, even where the same topic was the theme of both tasks in the same EUSO, such as in Galway, Ireland in 2005 where the theme was “Water” or in Potsdam, Germany in 2007 where the theme was “The Potato”. The results and findings discovered by the students in Task 1 were not carried over and were not required or connected in any way to the completion Task 2.

5.6 Briefing

Over the years the instructions given to the students have been standardised. Mentors are expected to have explained and translated these instructions in advance of the EUSO to reduce translation time. There is no evidence that these instructions have an impact on the individual team performance. Below is a summary of such instructions.

General instructions

- Wear the supplied laboratory coat at all times in the laboratory.
- Disposable gloves and protective goggles must be worn when working with chemicals.
- It is not permitted to eat or drink in the laboratory.
- The laboratory assistant’s directions are to be followed at all times
- All results must be entered into the Final answer sheet.
- Only one signed answer sheet version per team can be handed in and assessed.
- When you are requested to have one of your results verified before continuing with the next stage of your work, points will

only be allocated if the results are verified by the laboratory assistant

5.7 Research Question Addressed

The Tasks are examined in light of the Research Question, in particular in relation to whether attempts were made by the task designers to connect two or more science area (biology, chemistry or physics), to make the topic relevant and connected to the real world, to manipulate information and ideas and use previous knowledge and understanding of science, to construct new knowledge to solve a problem and arrive at a conclusion, to engage the students in an active manner and if the task provided opportunities for alternative solutions or strategies to be employed or were simply a menu of activities to be followed.

The definition of integration adopted here is that put forward by Hayes et al, (2006) which includes;

> *"(a) students are expected to make explicit attempts to connect two or more sets of subject knowledge; or (b) subject boundaries are not readily seen. Themes or problems that either require knowledge from multiple areas, or that have no clear subject areas basis in the first place, are indicators of curricula that integrate school subject knowledge"* (p. 97)

The definition of inquiry/problem/context based learning is elaborated on in Chapter 3 "Literature Review" where Linn et al (2004) calls Inquire-Based learning, the process of diagnosing the problem, distinguishing alternatives, planning the investigation and debating with peers to come to a conclusion. Problem-based learning (PBL) is a student-centred approach in which students learn from the experience of problem solving. Their learning is self-directed and involves effective collaboration. Working in groups, students identify what they already know and what they need to know (Hmelo-Silver, 2004, p.236). In context-based science learning, connecting science understanding with student's everyday experience is highlighted (Bennett et al., 2007).

In the summary at the end of the chapter the tasks are analysed to see to what extent they were developed and constructed to answer the question posed at the outset by the researcher. Are the team science tasks that integrate science, are problem-based and connected to the real world, involve the construction of knowledge, higher–order thinking, alternative solutions, depth of knowledge and sophisticated communication between the team members.

5.8 EUSO 2003 – Dublin, Ireland

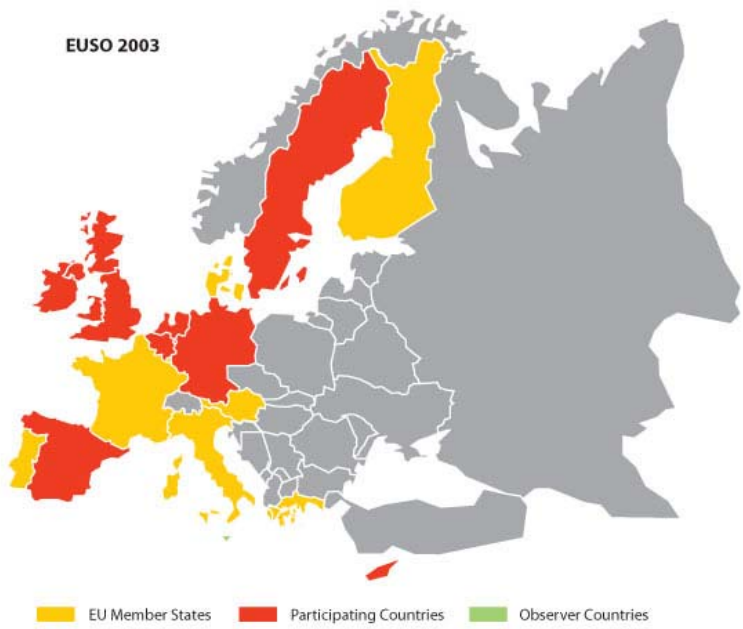


Figure 5.1 Participating Countries EUSO 2003 (Dublin)
(Source: MA Cotter – EUSO Founder & President)

Fourteen teams (forty-two students) attended the first EUSO in Dublin in 2003. Only the fifteen countries that were European Union member states in 2003 were invited to take part. Under the rules governing the EUSO each country could attend with three teams of three students each. Three countries, Germany, Ireland and the United Kingdom sent three teams, the Netherlands sent two teams and Belgium, Spain and Sweden sent one team each. The Ministries of Education of Austria, Denmark, Finland, France, Greece, Italy, Luxembourg and Portugal declined the invitation, deferred joining or did not reply. Finland is the only country of the original fifteen EU members that did not join the EUSO before 2012. A government observer was chosen to attend in Vilnius, but was unable because of other commitments. Finland will attend EUSO 2013.

Table 5.1. Students by Gender EUSO 2003 (Dublin)
(Source: MA Cotter – EUSO Founder & President)

Country	Number of Students	Male	Female
Belgium	3	2	1
Germany	9	6	3
Ireland	9	4	5
Netherlands	6	6	0
Spain	3	2	1
Sweden	3	1	2
UK	9	6	3
Total	42 (100%)	27 (64%)	15 (36%)

5.8.1 Task 1

"Photosynthesis" was the focus of Task 1. Designed by Dr. Paul van Kampen and his team it involved chlorophyll extraction, nanocrystalline solar cell and photochemical reduction. Photosynthesis is explained as the process of converting light energy to electrical, thermal or chemical energy, this principle was applied to the construction of a solar cell, called a Graetzel cell. They also investigated the use of natural dyes in improving the efficiency of the cells. They did this in three separate sub-tasks, the extraction of chlorophyll from spinach, the building of a chlorophyll-based solar cell and a comparison of its working with that of a silicon photodiode and an investigation of a photoreduction reaction. They compared the voltage readings of both the conventional silicon photodiode and the Graetzel cell when illuminated with a lamp. To compare the different dyes the students undertook "Photochemical reduction of indophenol." This tested the ability of chloroplasts to carry out photosynthesis under different conditions and also to examine the importance of biological structure as well as light absorbing properties in utilising light energy.

In his article on this task by the lead author Dr. van Kampen, published in the European Journal of Physics (2004) he states that,

> *"It would be very difficult to give each of the sciences equal importance in both experimental problems. As it turned out, one of the experimental problems had a stronger physics/chemistry emphasis, while the second had higher biology content"* (P. 26)

This was a regular observation made during discussions with the researcher in the early years of PAR and the researcher needed to accept this position if the EUSO project was to advance. As a result, this task is predominately a Physics/Chemistry task (approximately 80%) with approximately 20% Biology. However it conforms to the concept of integration elucidated on earlier, in that two or more science subjects areas are connected and there was a strong element of construction and practical activity. The students were given advice on how to manage the experiment but they also had to decide for themselves how to approach solving the problem and how to use their previous acquired scientific knowledge to construct new knowledge. They had the opportunity to be involved in substantive conversation and decision making. The task was not connected in any way to Dublin, the location of the EUSO but the topic was relevant and connected to the real world. The students would have been familiar through school science with the concept of the sun providing an inexhaustible supply of clean energy in the form of light and using this energy requires the conversion of light into electrical, thermal or chemical energy. Solar cells allow for the conversion of light into electricity. Plants harvest solar energy by the conversion of light directly to chemical energy, known as photosynthesis. In order to absorb light, plants use coloured compounds such as chlorophyll. Historically, extraction is one of the oldest of all chemical operations and one which is used in everyday life. By simply making a cup of tea or coffee an extraction has been carried out.

5.8.2 Task 2

This Task, the "Properties of Proteins", was developed by Professor Richard O'Kennedy's team, who are experts in the field of proteins. The students investigated the concentration of the protein, p-nitrophenol, and the effect of pH on a protein and on a phosphatase enzyme. A phosphatase enzyme causes reversible posttranslational modification to an enzyme. To determine the concentration of p-nitrophenol, the Beer Lambert law was applied. This law states that there is a linear relationship between absorbance and concentration of an absorbing species, in this instance the protein, p-nitrophenol. The students then look at the effect of pH by its effect on the protein, casein and determine whether it could be renatured. Finally the students determined the optimum pH activity for enzymatic activity using a phosphatase enzyme and varying pH concentrations.

In his article published in the Journal of Biological Education (2005) p. 58-61), Professor O Kennedy, the lead author of the task states that,

> *" … an element of construction was introduced requiring 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" (P.59)

This was predominately a Biology task (approximately 50%) because of the composition of the task development team, with 25% Chemistry and 25% Physics. The students should have been engaged in an active manner and substantive discussions should have taken place. The students were given clear instructions on how to carry out the experiments but how they approached the task was not prescribed. The students should have used their previous scientific knowledge and constructed new knowledge to arrive at a conclusion. There was no direct connection between this task and Dublin.

These tasks were the first EUSO tasks. There was no immediate analysis of them and therefore no feedback to the host of the next EUSO in Groningen, the Netherlands. This lack of analysis and feedback is something that needs to be addresses formally by the EUSO. However the Scientific Committee for the incoming and future host countries attend all the discussions on the tasks, see that areas that exercise the mentors and now have more "model tasks" to direct them. As a result it is no longer the belief among the mentors that it is "*difficult to give each of the sciences equal importance"* and more and more tasks now integrate all three sciences in a meaningful manner as will be illustrated in this chapter.

5.8.3 Medals

By presenting the results from each year it may be possible to determine the level of difficulty of each task or to detect a pattern as to which countries do better than others. However many other factors may influence the scores achieved by the individual teams such as their previous experience of practical science and working in laboratories, the level of science taught in their schools, the science subject choices available to them, the pre-Olympiad preparation, their experience of working in groups or of decision making and the teaching styles of their teachers.

The 2002 Constitution states that approximately 10% of all contestants receive gold medals, approximately 30% of all contestants receive silver medals and the combined number of gold and silver medals should not exceed 50% of the total number of medals. The remaining 40%-50% of contestants receive bronze medals. This would mean that in 2003 four/five students would receive gold medals, which translated into two teams (six students). The United Kingdom Team C, with a score of 80% and the Netherlands Team B, with a score of 78.5% was awarded gold medals. Fifteen students (five teams) were awarded silver medals. These included Ireland Team C with a score of 76%, Germany Team C with a score of 75.5%, Ireland Team B with a score of 70.5%, the Netherlands Team A with a score of 68.5% and the United Kingdom Team A with a score of 67.5%.

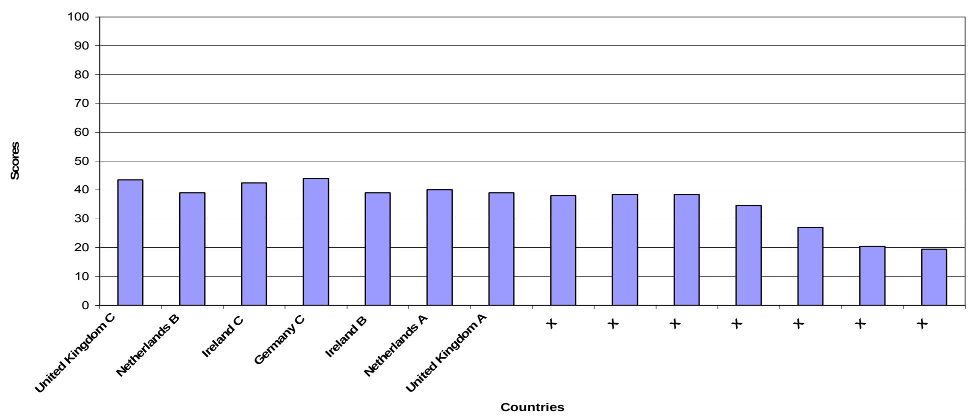
Throughout this chapter the marks for Task 1 and Task 2 have been standardised to 50 marks per task and the total mark is out of 100 marks or a percentage. This makes for easier comparisons between years and between countries.

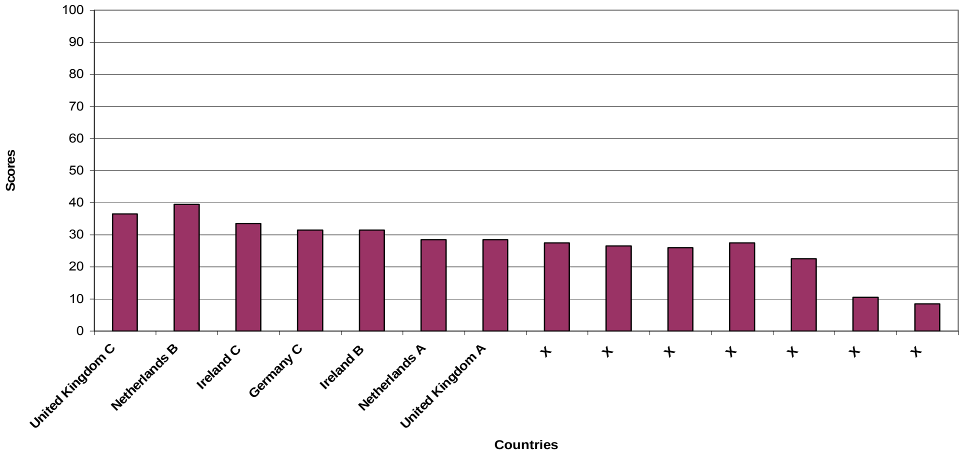
Because the competition is undertaken by the best science students in each country, is a team event and the students are given detailed instructions on how to carry out the experiment and how to record their findings, it is expected that there will not be great fluctuation in the marks achieved by the individual teams within a country or between countries. Most teams are expected to be close to the mean (average). When illustrated in a normal distribution curve or histogram, the results should be skewed towards the higher marks because all teams will achieve good scores. The higher marks will be achieved by the teams, who understand the task, are most precise in carrying out the experiments and record their data accurately.

Table 5.2. Scores & Medals EUSO 2003 (Dublin)
(Source: MA Cotter – EUSO Founder & President)

Country	Task 1 (50)	Task 2 (50)	Total (100)
United Kingdom C	43.50	36.50	80.00
Netherlands B	39.00	39.50	78.50
Ireland C	42.50	33.50	76.00
Germany C	44.00	31.50	75.50
Ireland B	39.00	31.50	70.50
Netherlands A	40.00	28.50	68.50
United Kingdom A	39.00	28.50	67.50
Bronze Range	38.5- 19.5	27.5 - 8.5	65.5 - 28

The remaining seven teams or 50% of the contestants were awarded bronze medals. The range of scores of the bronze medal winners are published but not the rank order of the individual teams. Bronze medals were awarded in alphabetical order with a total score range of 65.5% - 28% to the Teams A of Belgium, Germany, Ireland, Spain and Sweden and the Teams B of Germany and the United Kingdom. The score range for Task 1 (out of 50 marks) was 38.5- 19.5 and for Task 2 was 27.5 - 8.5.





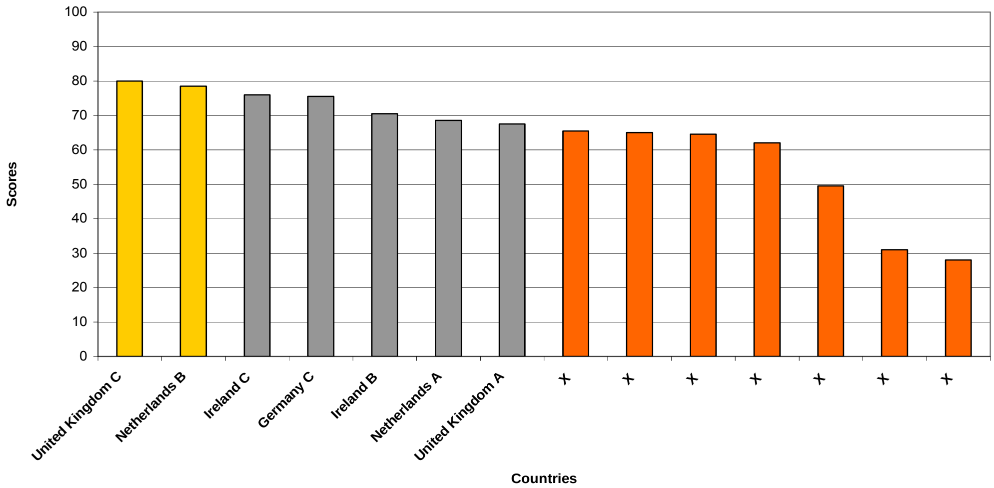


Figure 5.2 EUSO 2003 (Dublin) Results: Task 1, Task 2 & Total
(Source: MA Cotter – EUSO Founder & President)

The difference between the top gold medal winner and bottom silver medal winner was 12.5 points and only 3.5 points separated the next four teams. As the table above shows the majority of the students were able to carry out the tasks. Task 1 did not discriminate well between the top ten teams with only 6 points separating the first from the last team. Thirteen points separated the top ten teams in Task 2.

Task 2 proved to be slightly more difficult than Task 1 for all teams, except for the Netherlands Team B which got almost the same score in both tasks. The re-naturing of casein seemed to have caused difficulty for all students because they added the HCl and NaOH too quickly and too often to the casein solution without taking time to observe and record the effect of each addition on the solution. Clearer directions should have been given to the students about the approximate number of cycles that they might be expected to perform given the time constraint. The optimum number of cycles would have been five while some teams recorded figures as high as twenty (Burke, 2003, p. 91).

The letters A, B or C as given to teams are randomly allocated and do not denote ability. Both Irish teams did very well in both tasks.

As expected, the majority of the students were in the 60%-80% range or skewed to the higher marks. Each column in the histogram shows a 10 point range. Eleven of the teams had a score close to or greater than the mean.

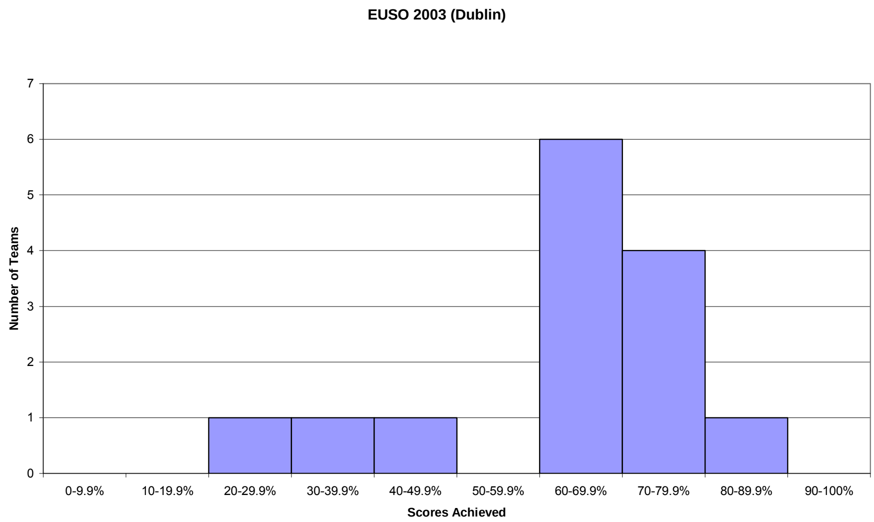


Figure 5.3 Scores Achieved at EUSO 2003 (Dublin)
(Source: MA Cotter – EUSO Founder & President)

5.9 EUSO 2004 - Groningen, The Netherlands

At the second EUSO in Groningen in 2004 the same seven countries attended with delegations, five of which had three teams. The number of students increased from 42 to 57 but the number of female students increased by only one. In 2003, 36% of the participants were female but by 2004 it had reduced to 28%.

Table 5.3. EUSO 2003-2004 Students by Gender and Country
(Source: MA Cotter – EUSO Founder & President)

	2003			2004		
Country	Total	M	F	Total	M	F
Belgium	3	2	1	6	5	1
Germany	9	6	3	9	8	1
Ireland	9	4	5	9	6	3
Netherlands	6	6	0	9	4	5
Spain	3	2	1	9	8	1
Sweden	3	1	2	9	7	2
UK	9	6	3	6	3	3
Total	42 (100%)	27 (64%)	15 (36%)	57 (100%)	41 (72%)	16 (28%)

The tasks were developed by the staff of the Faculty of Mathematics and Natural Sciences, the University of Groningen (RuG) who were assisted by the technical staff and undergraduate and postgraduate students. Task 1, "Hexokinase Assay, an Experimental Procedure", designed by Professor Dr. Bert Poolman, focused on the working of biocatalysts.

5.9.1 Task 1

In the first task the students are introduced to enzyme Hexokinase. Its activity can be measured indirectly by measuring the concentration of Adenosine-5'-triphosphate (ATP) through a chemiluminescence reaction. ATP is called the "energy unit of the cell" and is required for the enzyme, hexokinase, to act. Students were then asked to perform experiments to measure the activity of hexokinase under various conditions (i.e. different substrate concentrations, different hexokinase concentrations, and plus and minus a hexokinase inhibitor).

This was predominately a Biology/Chemistry (80% approximately) experiment with 20% Physics and therefore adhered to the integration criteria. Students would have been familiar with living organisms producing light through chemiluminescent reactions called 'bioluminescence' (fireflies) and the beach glowing greenish at night by light produced by microorganisms thus connecting the experiment with the real world. In this experiment the students were asked to create this form of chemical light. It provided the students an opportunity to be engaged in practical activity and in discussions with team members. Their previous scientific knowledge could have been utilised and new knowledge constructed.

5.9.2 Task 2

This Task, "Luminesence and Plastic LEDs", was designed by Professor Dr. Kees Hummelen and Professor Dr. Paul Blom. The students prepared chemiluminescence by synthesising a compound called adamantylideneadamantane -1,2-dioxetane. They then went on to prepare an organic light emitting diode. They did this by using electroluminescence from a poly-phenylene vinylene(PPV) conjugated polymer-based diode and measured the light emitted from the diode.

This task was predominately a Chemistry/Physics experiment (approximately 80%) and 20% Biology and was integrated at least in two science areas of knowledge. The students were engaged in the activity and would have had an opportunity to engage in discussions and in the decision making process. The students should have used their previous scientific knowledge and understanding, manipulated information and ideas and constructed new knowledge to solve the task presented to them.

5.9.3 Medals

In keeping with the constitution two teams (six students) would receive gold medals, six teams (eighteen students) would receive silver medals and ten teams (thirty students) would receive bronze medals.

Germany took the two gold medals. Team B received 97.5% and Team C received 92.25%. When the cut-off point between the silver and bronze medals was examined it was noticed that the gap between the eighth and ninth team was only 0.5% and the gap between the ninth and tenth teams was 3% with two teams sharing tenth place. It was therefore decided to allocate seven silver medals.

The silver medals were allocated to Sweden Team C with a score of 78%, Netherlands Team C with a score of 74.5%, Germany Team A with a score 71%, Ireland Team A with a score of 68.5%, Belgium Team A with a score of 66.25%, the United Kingdom Team A with a score of 65% and Ireland Team C with a score of 64.5%.

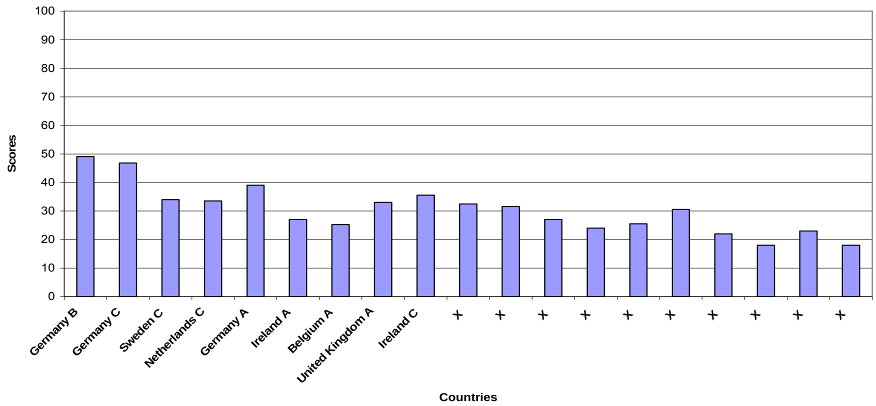
Table 5.4. Scores & Medals EUSO 2004
(Source: MA Cotter – EUSO Founder & President)

Country	Task 1 (50)	Task 2 (50)	Total (100)
Germany B	49.00	48.50	97.50
Germany C	46.75	45.50	92.25
Sweden C	34.00	44.00	78.00
Netherlands C	33.50	41.00	74.50
Germany A	39.00	32.00	71.00
Ireland A	27.00	41.50	68.50
Belgium A	25.25	41.00	66.25
United Kingdom A	33.00	32.00	65.00
Ireland C	35.50	29.00	64.50
Bronze Range	32.5-18	33-24	61.5 - 36

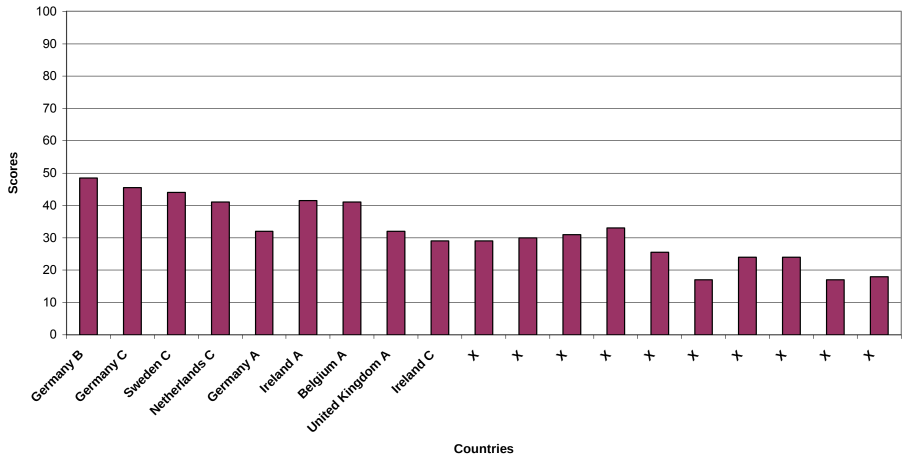
The remaining ten teams with a total score range of 61.5% - 36% were awarded bronze medals. These included, in alphabetical order the Teams A from the Netherlands, Spain and Sweden, the Teams B from Belgium, Ireland, the Netherlands, Spain, Sweden and the United Kingdom and Team C from Spain. The score range for Task 1 was 65% - 36% and for Task 2 was 58% - 36%.

Both Tasks held the same level of difficulty for each team from the different countries with some teams finding Task 1 more difficult than Task 2 and others the opposite. Six teams got very similar scores in each task.

Task 1



Task 2



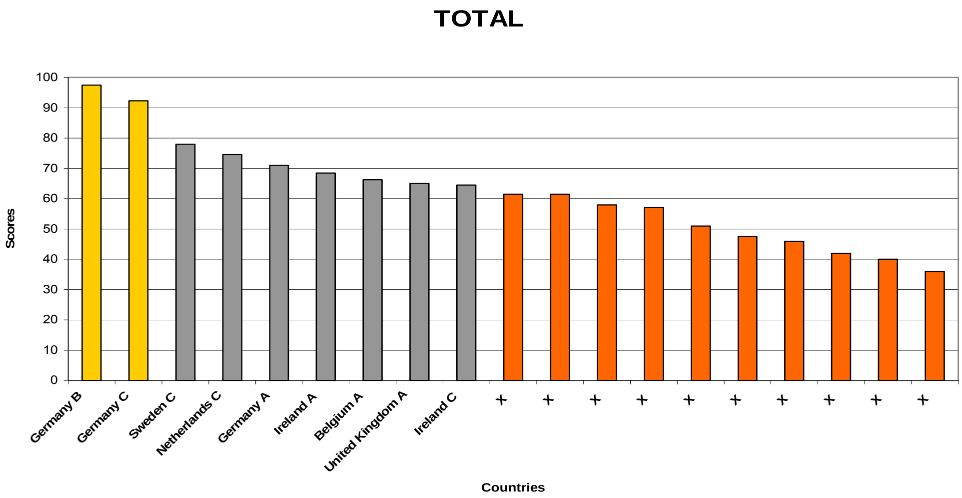


Figure 5.4
EUSO 2004 (Groningen) Results: Task 1, Task 2 & Total
(Source: MA Cotter – EUSO Founder & President)

In Task 1, Germany took the top three places with Ireland Team C in fourth place. In Task 2, Germany Team A dropped to seventh place and Ireland Team C dropped to ninth place while Ireland Team A was in fourth position. Ireland Teams A and C took 6^{th} and 9^{th} places respectively with Team B getting a bronze medal. The Irish teams were inconsistent. The best team got a score of 27 points in Task 1 and the second team got a score on 29 points in Task 2 which was less than the score that many of the bronze medal winners achieved

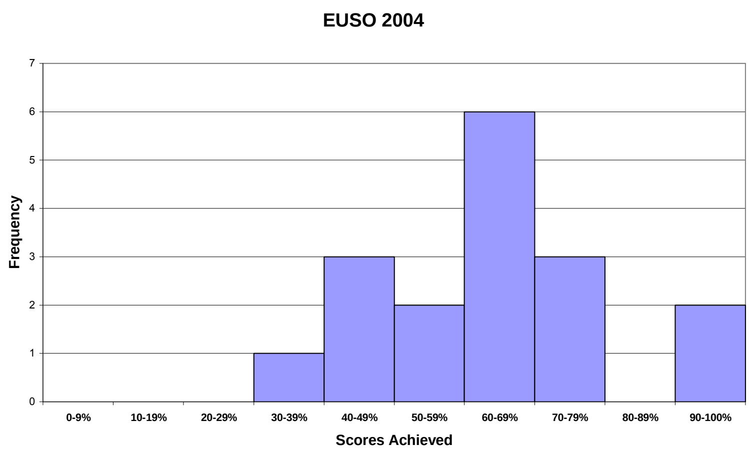


Figure 5.5 Scores Achieved at EUSO 2004
(Source: MA Cotter – EUSO Founder & President)

At the 2004 EUSO GB meeting in Groningen, the Netherlands, it was agreed that the number of teams should be reduced from three to two for all subsequent EUSOs because of the EU enlargement in 2004. It was felt that with the sudden increase in new EUSO members, the possibility of an increase from nineteen to thirty teams and the budget constraints of EUSO 2005, which had already been decided, a reduction of student numbers from nine to six per country was an appropriate response. Each country was invited to send one or two teams to all future Olympiads. EUSO 2003 and EUSO 2004 would therefore be the last EUSOs to which countries could send three teams.

Table 5.5. EUSO 2003-2004 Medal Winners by Country
(Source: MA Cotter – EUSO Founder & President)

	Gold	Silver	Bronze	Total
Belgium	0	1	2	3
Germany	2	2	2	6
Ireland	0	4	2	6
Netherlands	1	2	2	5
Spain	0	0	4	4
Sweden	0	1	3	4
United Kingdom	1	2	2	5

5.9.4 2003-2004 Positions

The Science Olympiads originated in the Soviet Bloc countries. Their entry into the EUSO, because of their vast experience of Olympiads, was expected to make the winning of gold and silver medals more difficult for the original EU members. Because the fifth enlargement of the EU did not take place until 2004 the former Soviet Bloc countries did not join the EUSO with participating teams until 2005. Estonia, Latvia and Slovakia joined in 2005: the Czech Republic, Lithuania and Slovenia in 2007; Bulgaria in 2008; Hungary in 2009 and Romania in 2010. While East Germany (GDR) was part of the Eastern Bloc and the re-unification of Germany had taken place in 1990, 53% of the

German EUSO students and many of their leaders have come from the former GDR.

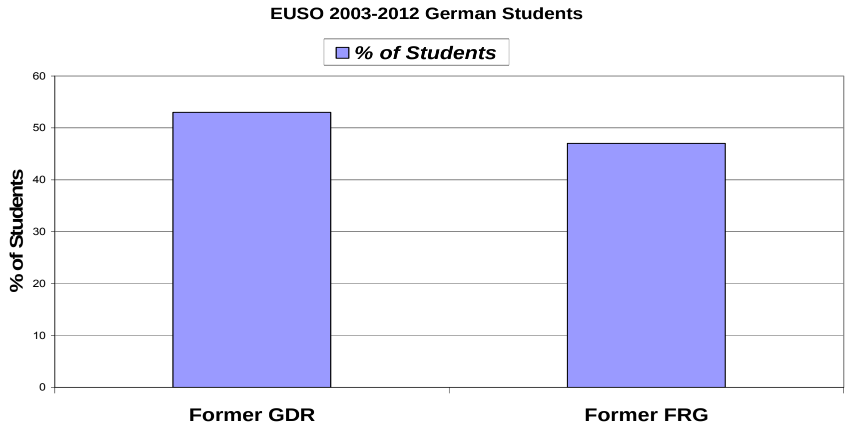


Figure 5.6 EUSO 2003-2012 German students (GDR & FRG)
(Source: MA Cotter – EUSO Founder & President

As the table below shows the former GDR has provided students for the German EUSO teams each year mainly, according to the country coordinator, because of the continued existence of the special Science schools in East Germany. For this reason Germany should be classified as a former Soviet Bloc country.

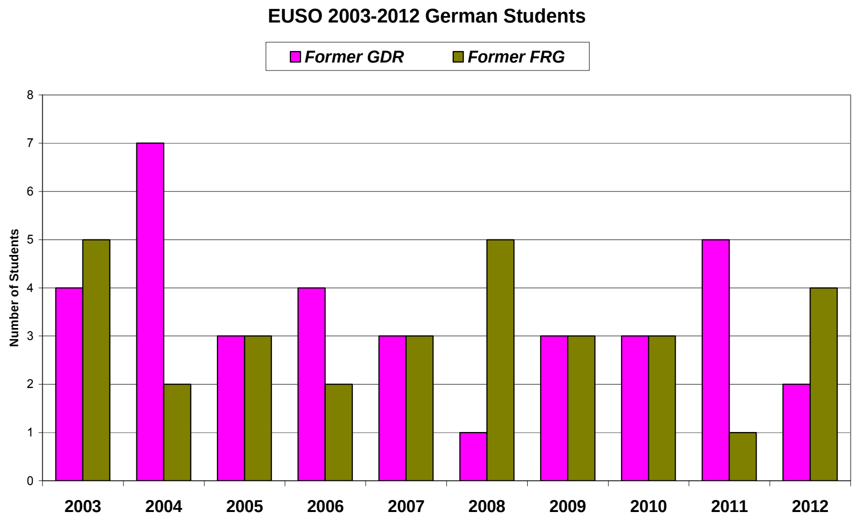


Figure 5.7 EUSO 2003-12 German Students (GDR & FRG)
(Source: MA Cotter – EUSO Founder & President

To compare the relative position of the participating countries in 2003 and 2004 before the number of teams was reduced from three to two, the lowest performing team in each country is eliminated and the teams re-named A and B. Germany had gone from 4th and 9th positions to 1st and 2nd in 2004 and Ireland had gone from 3rd and 5th positions to 6th and 9th.

Table 5.6. Top Two Teams per Country 2003-2004
(Source: MA Cotter – EUSO Founder & President)

Country	Team	Position 2003	Position 2004
Belgium	A	12	7
Belgium	B		18
Germany	A	4	2
Germany	B	9	1
Ireland	A	3	6
Ireland	B	5	9
Netherlands	A	6	14
Netherlands	B	2	4
Spain	A	14	17
Spain	B		10
Sweden	A	13	13
Sweden	B		3
United Kingdom	A	1	8
United Kingdom	B	11	11

Table 5.7.Average Position of Top Two Teams per Country 2003-2004
(Source: MA Cotter – EUSO Founder & President)

Country	Average position Top two teams
Germany	4.00
Ireland	5.75
Netherlands	6.50
UK	7.75
Sweden	9.60
Belgium	12.33
Spain	13.66

The 3rd EUSO was held in Galway in 2005. A Constitution change in 2004 had reduced the number of teams from three to two. Seven countries had attended EUSO 2004 with participating teams and because of the enlargement of the EU on the 1st May, 2004 a further eight countries had sent observers to EUSO 2004. They were all invited to attend EUSO 2005.

Table 5.8. EUSO 2003-2004 Position of Top Teams
(Source: MA Cotter – EUSO Founder & President)

Country	Position 2003	Position 2004
Belgium	12	7
Germany	4	1
Ireland	3	6
Netherlands	2	4
Spain	14	10
Sweden	13	3
United Kingdom	1	8

5.10 EUSO 2005 - Galway, Ireland

Ten countries were represented at EUSO 2005 by a total of eighteen teams (fifty-four students). Two teams represented Belgium, Cyprus, Estonia, Germany, Ireland, Netherlands, Spain, and Sweden. One team represented Latvia and also Slovakia. The United Kingdom did not send a team. The countries attending for the first time were Cyprus, Estonia, Latvia and Slovakia.

Table 5.9. EUSO 2003-2005 Students by Country & Gender
(Source: MA Cotter – EUSO Founder & President)

	2003		2004		2005	
	M	F	M	F	M	F
Belgium	2	1	5	1	6	0
Cyprus					6	0
Estonia					3	3
Germany	6	3	8	1	5	1
Ireland	4	5	6	3	1	5
Latvia					3	0
Netherlands	6	0	4	5	2	4
Slovakia					3	0
Spain	2	1	8	1	6	0
Sweden	1	2	7	2	4	2
UK	6	3	3	3		
Total	27 (64%)	15 (36%)	41 (72%)	16 (28%)	39 (72%)	15 (28%)
	42		57		54	

The two tasks developed by the National University of Ireland, Galway (NUIG) and the Galway/Mayo Institute of Technology (GMIT) centred on Galway Bay and the Corrib River.

5.10.1 Task 1

Because the researcher was also the director of EUSO 2005, greater attention was paid to making sure that both tasks integrated all three sciences in equal measure, were local in that they could be identified with the host city Galway, were relevant and connected to the real world, gave students the opportunity to use their previous knowledge and construct new knowledge to solve the problem and arrive at conclusions, engaged all the students in the team in the activities and discussions and were not prescriptive.

The first task, “Water Quality”, was developed by the team in NUIG. The students were provided with three water samples. From these samples they had to determine the nature of the water sample (freshwater or marine), the nature and the level of the organic pollutants, the identity and source of the chemical pollutant and the location of where the samples were taken from a river. In order to do this, the students were asked to determine, in the order of their choice, the bacterial levels present (in colony forming units per 100 millilitres), the chemical pollutant present in one sample, the density of each of the samples, the type of bacteria present by way of a Gram stain, cell shape and arrangement, the organic loading present by way of BOD tests and identify the Sampling Sites for Samples A, B and C. This task was regarded by the mentors as the best task to-date, in that it satisfied all the criteria of integration of the sciences, relevance and connectedness to the real world, the use by the students of their own knowledge and the construction of new knowledge, the manipulation of information and ideas, the students engagement with each others in conversations and discussions and with the experiments. It was not prescriptive in that students could employ their own strategies to arrive at conclusions.

This task was both topical and universal in that the students were requested to investigation both the source and the nature of the pollution which is being discharged into the river Corrib running through Galway. The task was divided into six parts giving students ample opportunities to discuss their options and operate as a team. The students were expected to use their previous knowledge and understanding of science and construct new knowledge to solve the task. At the end the students had to give themselves enough time to pull all the information together from the three scientific disciplines, Chemistry, Physics and Biology, to produce the final answer sheet.

This task became the model or benchmark against which all other tasks were to be judged.

5.10.2 Task 2

This task was developed by the team in GMIT. The students analysed "Salinity & Mussel Physiology". The chemists worked at deriving the salinity of water using a chemical titration. The biologists analysed the effect of salinity on mussels and from this identified the ideal location for a Blue Mussel (*Mytilus edulis*) farm and the physicists analysed the conductivity as a measure of salinity.

This task was divided into three sections which, while not specified as biology, chemistry and physics tasks, could be identifies as such. However, because of the nature of the task, it did offer the possibility of two or more students working together on a section or sections at different times. It was an integrated task, connecting all three sciences and was relevant and connected to the real world in that the blue mussel (*Mytilus edulis*.) is one of the main species of mussel cultivated in Galway and throughout Europe. This filter-feeding mollusc thrives in cold seawater. Market size is typically 50 mm or more and it can take from 12 to 24 months to reach this, depending on local conditions. Bivalve (two shelled) molluscs such as *Mytilus edulis* open or close their shells in response to salinity changes.

5.10.3 Medals

With eighteen teams taking part, two teams (10%) were entitled to gold medals. Slovakia Team A, a first time participant in the EUSO and from the former Soviet Bloc took the top place with a score of 89.75%, with Germany Team B taking the second gold medal place with a score of 85.6%. This was the third gold medal place won by Germany in three years. Six or seven silver team medals could have been awarded. It was decided to award silver medals to seven teams because the difference between the eight and ninth placed teams was 0.13% while the difference between the ninth and tenth was 0.65%.

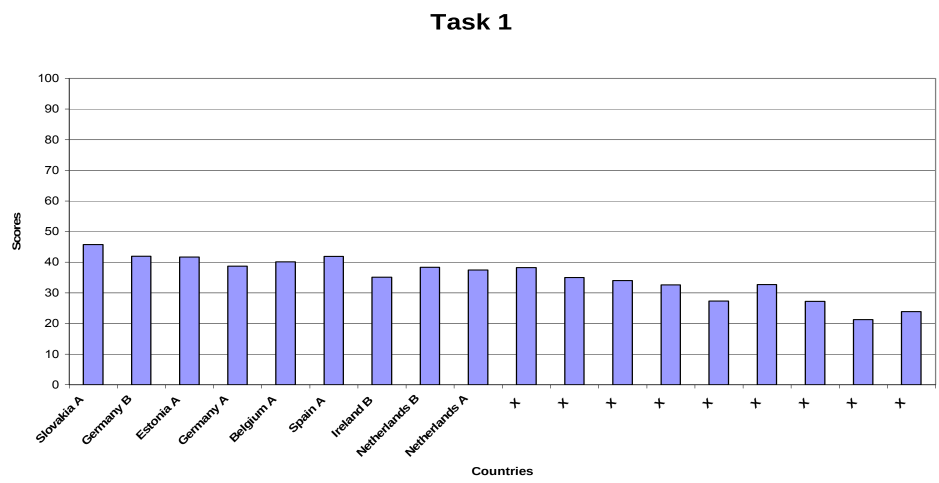
50% of all teams still received bronze medals. Silver medals were awarded to Estonia Team A, a first time participant in the EUSO and from the former Soviet Bloc, with a score of 82.95%, Germany Team A with a score of 82.85%, Belgium Team A with a score of 81.33%, Spain Team A with a score of 80.98%, Ireland Team B with a score of 78.73%, and the Netherlands Teams B and A took the last two silver medals with scores of 78.33% and 78.2% respectively.

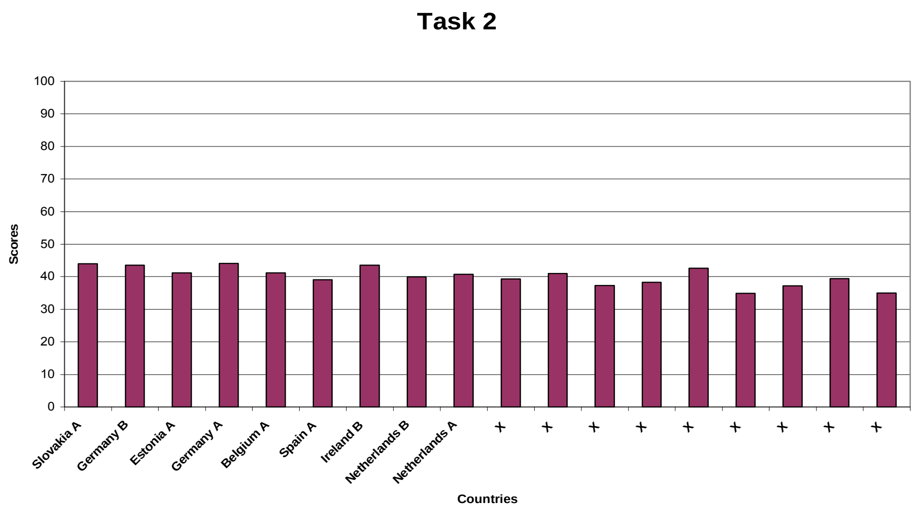
Slovakia Team A and Germany Team B took the top two places in Task 1 with Spain Team A in 3rd place. Ireland Team B was in 9th place. In Task 2 Germany Team A took the top place while Ireland was in 4th place. Estonia took the top silver medal. Even at this early stage the new countries from the former Soviet Bloc were beginning to feature in the top places.

Table 5.10. Scores & Medals EUSO 2005 (Galway)
(Source: MA Cotter – EUSO Founder & President)

Country	Task 1 (50)	Task 2 (50)	Total (100)
Slovakia A	45.75	44.00	89.75
Germany B	42.00	43.60	85.60
Estonia A	41.75	41.20	82.95
Germany A	38.75	44.10	82.85
Belgium A	40.13	41.20	81.33
Spain A	41.88	39.10	80.98
Ireland B	35.13	43.60	78.73
Netherlands B	38.38	39.95	78.33
Netherlands A	37.50	40.70	78.20
Bronze Range	38.25-21.25	42.6-34.9	77.55-56.88

Bronze medals were awarded to nine teams with a score range of 77.55-56.88. In alphabetical order, these were awarded to the Teams A of Cyprus, Ireland, Latvia and Sweden and the Teams B of Belgium, Cyprus, Estonia, Spain and Sweden. The score range for Task 1 was 38.25-21.25 and for Task 2 was 42.6-34.9.





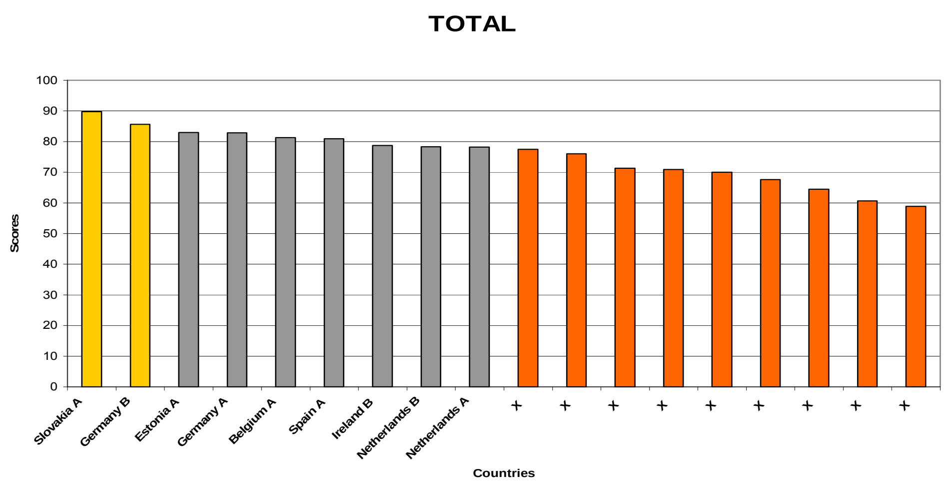


Figure 5.8 EUSO 2005 (Galway) Results: Task 1, Task 2 & Total
(Source: MA Cotter – EUSO Founder & President)

It is clear from the graphs above that all teams were able to carry out the Tasks and achieved good scores. The gap between the gold and silver medal winners was 2.65%. Only 0.65% separated the silver from the bronze. Most country teams got very similar scores in both tasks. The difference between the first and last teams in Task 2 was only 9.1 marks, while the difference between the first and last teams in Task 1 was 25.5 marks. This difference was more pronounced with the weaker teams.

The same countries consistently win the top honours at the International Olympiads. A similar pattern was expected at the EUSO, especially following the entry of the former Soviet Bloc countries in 2005. This would result in some teams consistently being in the last 50%. It was for this reason that it was decided that the bottom 50% would get bronze medals. In the International Olympiads up to 70% of students get awards.

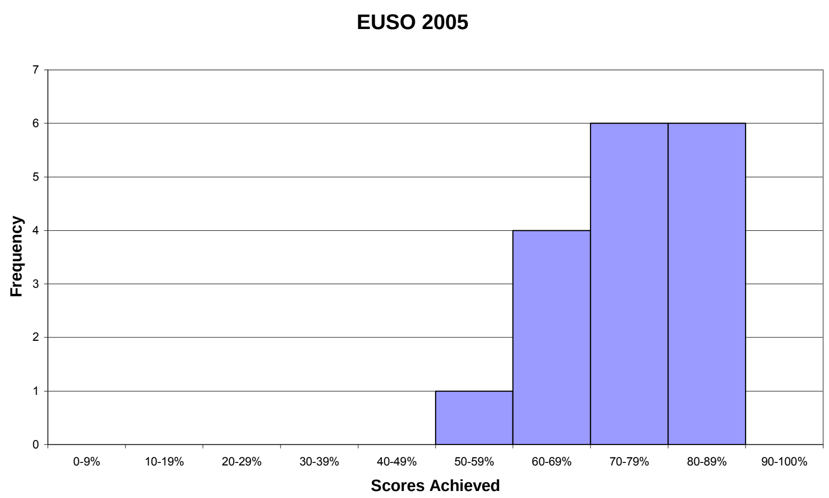


Figure 5.9 Scores Achieved at EUSO 2005 (Galway)
(Source: MA Cotter – EUSO Founder & President

Professor Masno Ginting from Indonesia, President of the International Junior Science Olympiad (IJSO) was a guest at the 3rd EUSO in Galway. The IJSO was established one year after the

EUSO in 2004. The EUSO founder was a member of the development team and with the support of the other EUSO member succeeded in having a team practical included in the event. In order not to clash with the EUSO, it was also established that the IJSO would apply to students one year younger than the EUSO and would be held in December. The reason the invitation extended to the IJSO President was to let him see at first hand how the team practical worked and to convince him of its merits.

5.11 EUSO 2006 - Brussels, Belgium

The 4th European Union Science Olympiad was held in Brussels in 2006. Thirteen countries, an increase of three countries on EUSO 2005 were represented by a total of twenty-three teams, an increase of five teams. Greece attends for the first time even though Greece had attended the inaugural meeting in Dublin in 2002 and Denmark sent a scientific observer. The countries attending with two teams were Belgium, Cyprus, Estonia, Germany, Greece, Ireland, Netherlands, Slovakia, Spain, Sweden, the United Kingdom and Latvia with one team.

The Vrije Universiteit Brussel (VUB), the Université Libre de Bruxelles (ULB) and a team of scientists and teachers of the Flemish and French communities developed the tasks.

5.11.1 Task 1

This task ‘CSIB: - Crime Scene Investigation Brussels’ was a real *‘Whodunit’*. Each EUSO team was a group of scientists working for CSI Brussels. An intruder had broken in to a soft drinks factory and sabotaged the production line. Analysis of swabs taken from the floor of the factory indicated that the intruder was adding extra phosphoric acid to batches of the soft drink, causing the drink to be too acidic and ultimately cause economic disaster for the company. Before the saboteur could contaminate all the lots he was spotted by a security guard, however this ended tragically for the guard. Skin tissue found under the fingernails of the deceased guard, belonging to the killer, were recovered. Six suspects were arrested and biological samples taken. DNA isolated from these samples was provided and the Biology students carried out DNA fingerprint analysis to identify the culprit. In addition the students had to quantitatively determine which lot or lots contained too much acid from the five samples provided, at least one of which was not contaminated. They also how to neutralize the excess phosphoric acid and what quantity was required for this neutralization.

This experiment proved one of the most challenging for the students to-date and was reflected in the poor marks the students received. One of the reasons for this could be accredited to working with DNA, which can prove difficult, and this kind of DNA fingerprinting is generally only used in final year undergraduate laboratories in university. This was primarily a Biology/Chemistry task with little or no Physics involved. It did provide students the opportunity to use their previous knowledge and understanding of science and construct knew knowledge as the solved the problem. It was also relevant to the students and connected to the real world.

5.11.2 Task 2

This task centred on 'CO2 production and Boyle's Law'. Specific assignments were to calculate the amount of carbon dioxide produced by soya sprouts and an experiment used to calculate the volume of living animals. The task is divided into two separate parts. The first one is about CO2 production during respiration and the second is about the use of Boyle's Law in the determination of volumes. The production of CO_2 during respiration of soya shoots will be measured with a very simple device. The device allows one to flow CO_2 free air over the plant shoots and to recover the CO_2 produced by respiration. Boyle's Law is applied to determine the volume of chickens. In the experiment the teams are asked to simulate this procedure with a syringe (barrel with piston) and a little red object, the chicken. This was primarily a Biology/Chemistry task (approximately 80%) and approximately 20% physics. The students should have been familiar with “Boyle’s Law” and could use this knowledge and working through the experiment to create new knowledge. Because the task did not clearly identify the subject boundaries the students should have had discussions and conversations to decide how to solve the problem, which may have resulted in teamwork.

5.11.3 Medals

With twenty-three teams (sixty-nine students) attending, three teams were entitled to receive gold medals. Germany Team A with a score of 77.5% took first place. Germany was by far the most successful country to date winning four gold medals places out of a possible seven in three years. Latvia, who had joined the EUSO in the previous year and with only one team participating, took second place with a score of 70.73%. The Netherlands Team A, with a score of 69.75%, took the third gold medal place. This was the second gold medal place for the Netherlands having taken second place at EUSO 2003 in Dublin. Seven teams were entitled to receive silver medals. However the difference between the tenth and the eleventh placed team was only 1.86%. Three teams, including the eleventh placed team were bunched together with the next two teams with a score difference of 0.63% and 0.79% respectively. It was decided to award ten silver medals. These were awarded to Germany Team B with a score of 65.9%, Slovakia Team A with a score of 65.25%, Ireland Team B with a score of 60.75, Estonia Team A with a score of

58.40%, the Netherlands Team A with a score of 57.66%, Estonia Team B with a score of 55.65%, Belgium Team B with a score of 53.18%, Slovakia Team B with a score of 51.52%, Spain Team A with a score of 50.79 and Ireland Team A with a score of 50%.

One team scored 38 marks in Task 2, or 8th place but only scored 8.44 marks in Task 1 and a team scored 24.8 marks or 5th place in Task 1 but only 20 in task 2 resulting in a bronze medal for both teams.

Table 5.11 Scores & Medals Achieved EUSO 2006 (Brussels)

(Source: MA Cotter – EUSO Founder & President)

Country	Task 1 (50)	Task 2 (50)	Total (100)
Germany A	36.25	41.50	77.50
Latvia A	28.23	42.50	70.73
Netherlands B	28.75	41.00	69.75
Germany B	26.40	39.50	65.90
Slovakia A	22.50	42.75	65.25
Ireland B	20.75	40.00	60.75
Estonia A	22.40	36.00	58.40
Netherlands A	21.16	36.50	57.66
Estonia B	23.65	32.00	55.65
Belgium B	23.18	30.00	53.18
Slovakia B	17.82	33.50	51.32
Spain A	12.29	38.50	50.79
Ireland A	17.50	32.50	50.00
Bronze range	24.8 - 4.59	38 -14.5	46.44 - 20.2

The remaining nine teams were awarded Bronze Medals in alphabetical order with a score range of 46.44% – 20.2% to the Teams A of Belgium, Cyprus, Greece, Sweden, and the United Kingdom and to the Teams B of Cyprus, Greece, Spain, Sweden and the United Kingdom. The score range for Task 1 was 24.8 - 4.59% and for Task 2 was 38 -14.5.

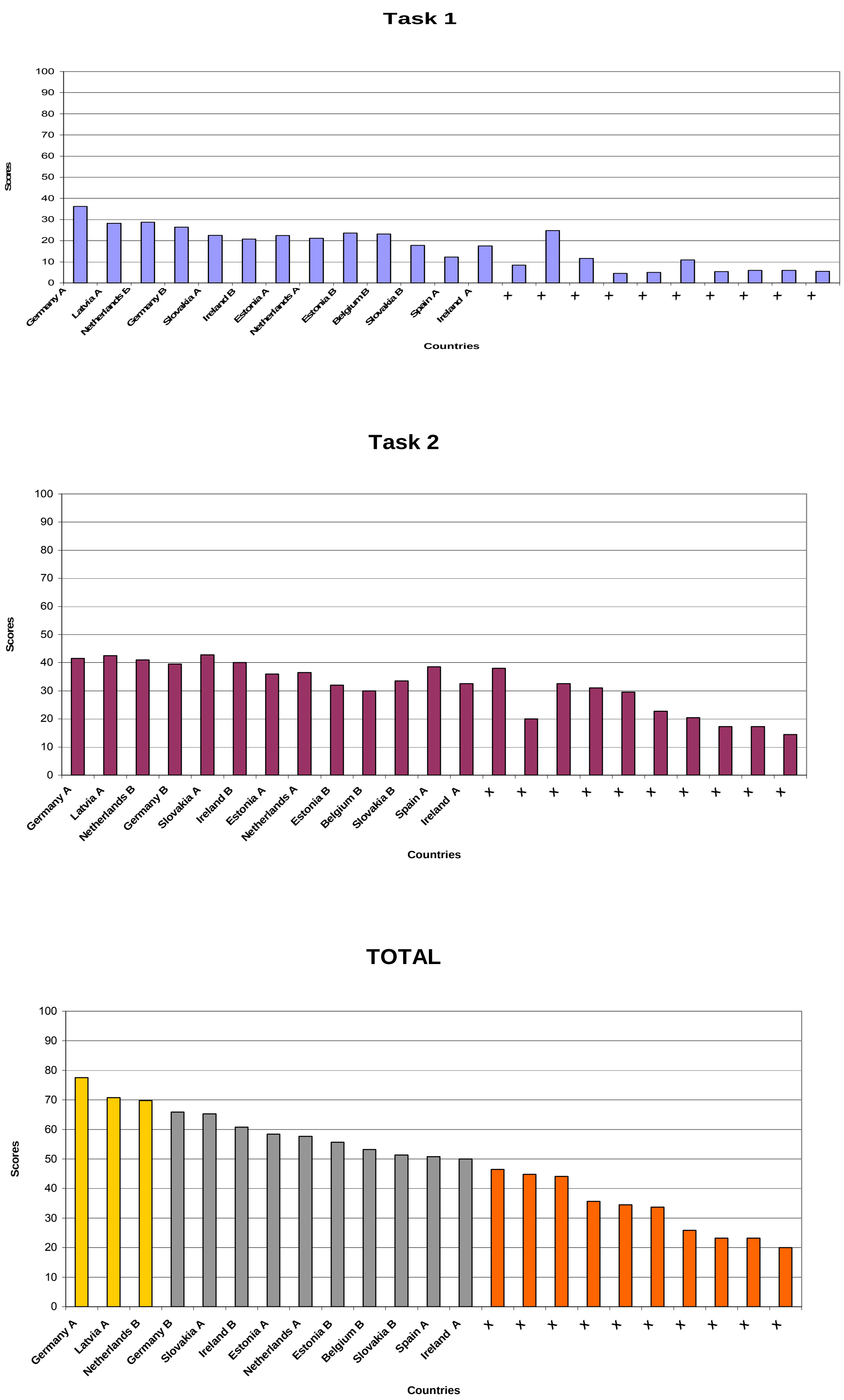


Figure 5.10 EUSO 2006 (Brussels) Results: Task 1, Task 2 & Total
(Source: MA Cotter – EUSO Founder & President)

The total scores range shows a difference of 57.47% between the top team and the last team. This shows that some teams struggled with these tasks. A closer examination of the individual tasks shows that this difference was evident in each task but the scores fluctuated wildly. Task 1 proved to be much more difficult (or was badly designed) than Task 2 with one country recording a difference of 29.56 points between both tasks for its team. Seven countries got less than 10 marks in Task 1. All except four countries got below the average score for both Tasks.

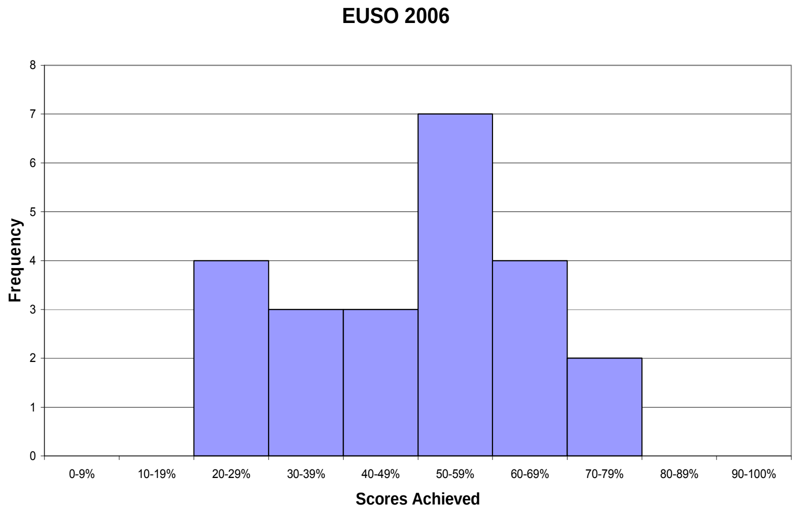


Figure 5.11 Scores Achieved EUSO 2006 (Brussels)
(Source: MA Cotter – EUSO Founder & President

5.12 EUSO 2007 - Potsdam, Germany

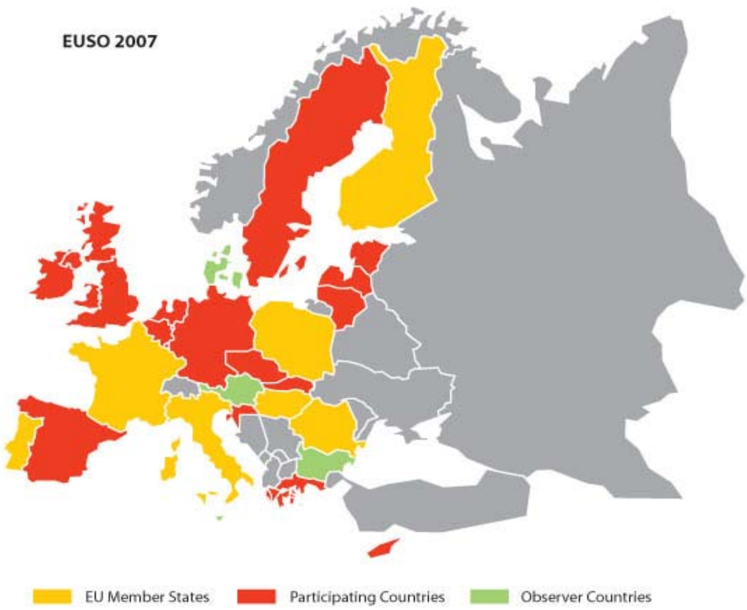


Figure 5.12 Participating Countries EUSO 2007 (Potsdam)
(Source: MA Cotter – EUSO Founder & President)

The 5th EUSO was held in Potsdam, in 2007. At the previous EUSO in Brussels the Director, Dr. Eckhard Lucius, had asked that he be given permission to invite all the non-participating EU countries to send a full delegation without having sent an observer in 2006. This permission was granted by the GB on the understanding that it would not become the norm. As a result, eighteen EU countries, an increase of five member states, were represented at EUSO 2007 by a total of twenty-nine teams (eighty seven students). The Czech Republic, Lithuania, Luxembourg and Slovenia attended under this dispensation. In addition Austria and Bulgaria sent observers and the President of the IJSO from Indonesia and the Director of IJSO 2007 from Taiwan were also invited as guests of the host country. This was to further consolidate the relationship between the EUSO and the IJSO so that both Olympiads would be run in harmony with each other. Denmark did not attend even though an observer had attended in 2006. The countries participating with two teams included Belgium, Cyprus, the Czech Republic, Estonia, Germany, Greece, Ireland, Luxembourg, the Netherlands, Slovakia, Spain, Sweden, and the United Kingdom. Three countries were represented by one team, Slovenia, Latvia and Lithuania.

The University of Potsdam, Brandenburg and the IPN in Kiel developed the tasks. These two tasks centred on potatoes and starch. The potato has a strong link with Potsdam and Brandenburg as Frederick the Great, who lived in the palace of Sanssouci, played an important role in introducing potatoes as a major food crop in central Europe.

5.12.1 Task 1

Both tasks were modelled closely on the EUSO 2005 Galway experiments.

In this task 'All about the Potato' the students are asked to help a potato grower find out what is wrong with his crop, since pests and blights are excluded. To investigate the growing conditions, the biologists identified the species of potato plants by the use of a dichotomous key. They then had to analyse the leaf pigment extracts of the potato plants by photometric examination. The chemists analysed the different ions present in soil such as Magnesium-Ions, Phosphate-Ions and Nitrate-Ions while the physicists determined the soil air volume and the density of the potato tubers.

This task, like task 2 "All about Starch", integrated the three sciences, in that the completion of the task involved carrying out an experiment on all three subjects is equal measure but for the first time each science Biology, Chemistry and Physics, was identified and colour coded. It was clear from the outset that the biologist, chemist and physicist had specific tasks to perform and could do them separate from, independent of and without reference to the other team members. Thirty percent was allocated to each section and 10% for drawing all the strands together to answer some integrated questions. This structure of the task may have minimised the need for the students to work as a team during the task completion but cooperation and teamwork was not prohibited or discouraged.

These tasks were clearly identified with the locality in that Brandenburg was and is a potato-producing region of Germany and also the potato is a staple part of the European diet and a source of starch. Students were required to use their own knowledge and to construct new knowledge to come to conclusions. Because of the design of the task there may have been little opportunity to communicate with other team members except at the end.

5.12.2 Task 2

In this task, 'All about Starch' the biologists had to identify the different type of starches used in starch glazes by means of microscopy and then demonstrate starch synthesis. The chemists examined the stability and durability of starch for downstream applications such as starch based film and bags, while the physicist looked at the nature of expansion of starch, determining the thickness of the film and its elastic modulus.

As stated earlier this task was integrated in that all three sciences, biology, chemistry and physics were included in equal measure and linked through the theme "Starch" but each team members could operate completely separately and independent from the other. It may have offered little opportunity for substantive conversation or discussion.

5.12.3 Medals

With twenty-nine teams attending, three teams were entitled to receive gold medals. When the scores were examined, however, it was seen that only 0.5% separated the third and fourth teams and the fourth and fifth teams were on the same score. It was therefore decided to increase the number of gold medals to five or 17% of the number of students. This was the highest number of gold medals allocated so far. Gold medals were awarded to Germany Team B with a score of 83% and Germany Team A with a score of 82.75%. Germany had now taken six gold medal team places out of a possible fourteen. Spain Team A with a score of 77.38%, the Netherlands Team A and Estonia Team A with the same score of 76.88% were awarded the remaining gold medals. The Netherlands had taken three gold medal places. Spain and Estonia achieved a first gold medal.

Table 5.12 Gold Medals Awarded EUSO 2003-2007
(Source: MA Cotter – EUSO Founder & President)

Country	Gold Medals Teams	Gold Medals
Germany	6	18
Netherlands	3	9
Estonia	1	3
Latvia	1	3
Slovakia	1	3
Spain	1	3
United Kingdom	1	3
Total	14	42

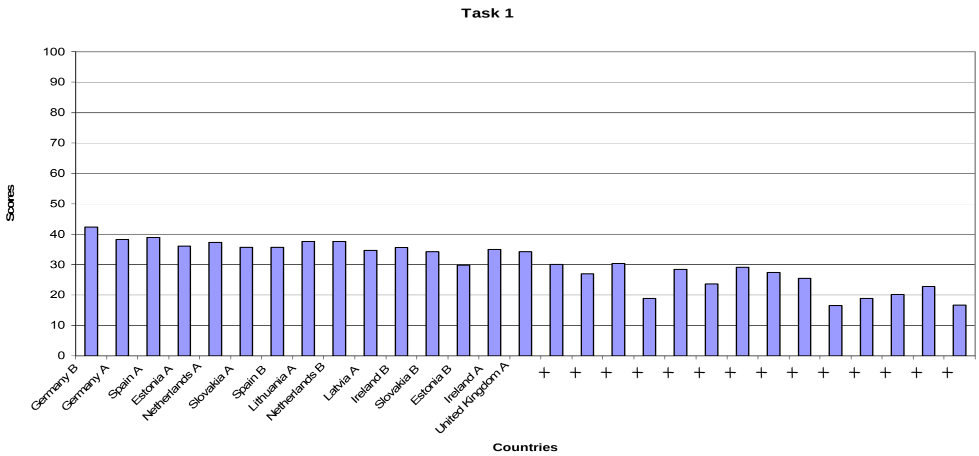
To keep the number of bronze medals at approximately 50%, ten countries were allocated silver medals.

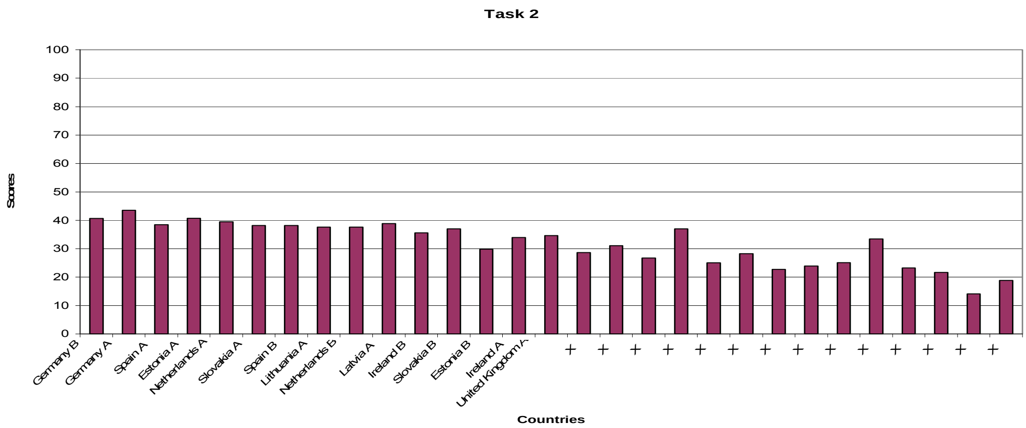
Silver medals were awarded to Slovakia Team A, Lithuania Team A which was participating for the first time, Latvia Team A, Ireland Team B, Slovakia Team B, Estonia Team B, Ireland Team A, United Kingdom Team A, Spain Team B and the Netherlands Team B.

Table 5.13 Scores & Medals Achieved EUSO 2007 (Germany)
(Source: MA Cotter – EUSO Founder & President)

Country	Task 1 (50)	Task 2 (50)	Total (100)
Germany B	42.38	40.63	83.00
Germany A	38.25	43.50	81.75
Spain A	38.88	38.50	77.38
Estonia A	36.13	40.75	76.88
Netherlands A	37.38	39.50	76.88
Slovakia A	35.75	38.25	74.00
Spain B	35.75	38.25	74.00
Lithuania A	37.625	36.13	73.75
Netherlands B	37.625	36.13	73.75
Latvia A	34.75	38.88	73.63
Ireland B	35.625	36.25	71.88
Slovakia B	34.25	37.00	71.25
Estonia B	29.875	39.25	69.13
Ireland A	35.00	34.00	69.00
United Kingdom A	34.25	34.63	68.88
Bronze Range	30.38-16.50	37.00 -14.13	58.75-35.63

The remaining fourteen teams with a total score range of 58.75% - 35.63% were awarded bronze medals, in alphabetical order: the Teams A from Belgium, Cyprus, the Czech Republic, Greece, Luxembourg, Slovenia, Sweden and the Teams B from Belgium, Cyprus, Czech Republic, Greece, Luxembourg, Sweden, and the United Kingdom. The score range for Task 1 was 30.38 -16.50 and for Task 2 was 37.00-14.13.





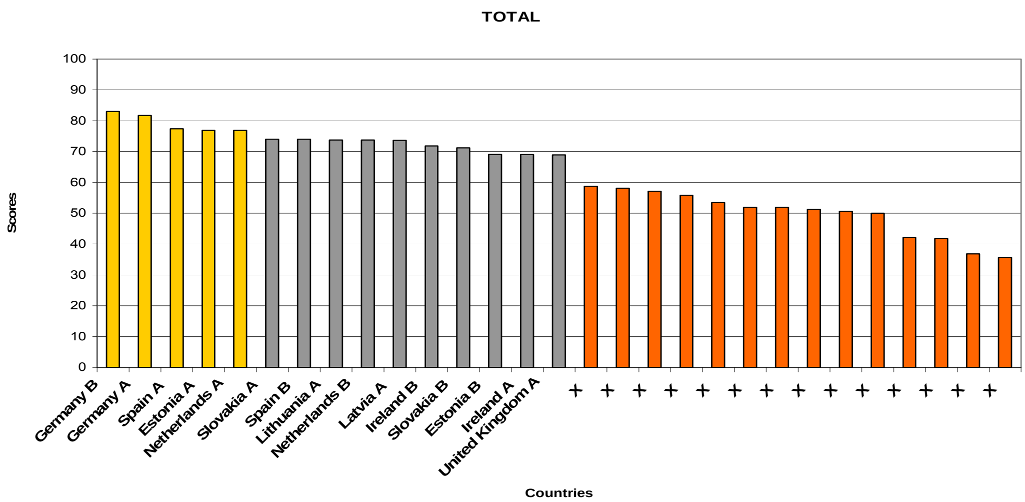


Figure 5.13. EUSO 2007 (Potsdam) Results: Task 1, Task 2 & Total
(Source: MA Cotter – EUSO Founder & President)

These tables show that the majority of the teams were evenly balanced and all teams were able to carry out both tasks. Two teams who received bronze medals scored well in Task 2, with 38 and 31 marks but performed badly in Task 1

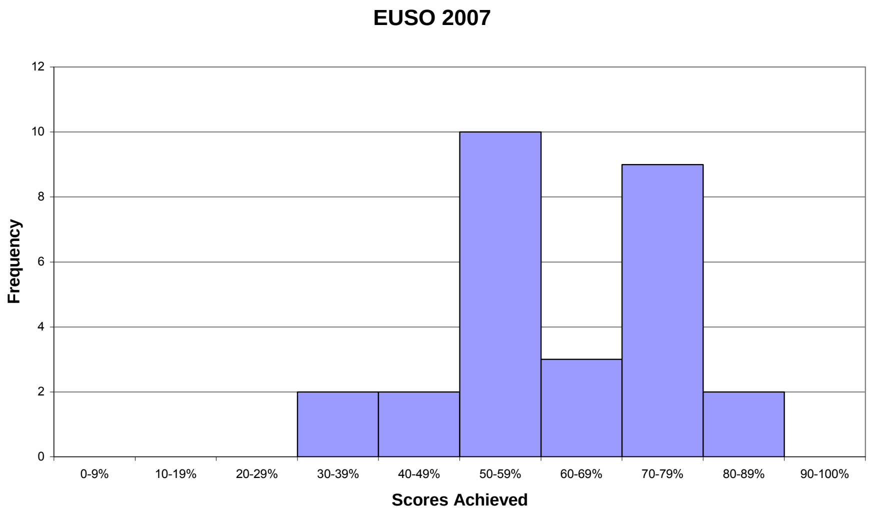


Figure 5.14. Scores Achieved at EUSO 2007 (Potsdam)
(Source: MA Cotter – EUSO Founder & President

5.13 EUSO 2008 - Nicosia, Cyprus

The 6th EUSO was held in Nicosia, Cyprus in 2008. Twenty-one EU countries were represented by a total of thirty-three teams (ninety nine students). Two teams attended from Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Germany, Greece, Ireland, Lithuania, Luxembourg, the Netherlands, Slovakia, Slovenia, Spain and Sweden. There was one team from Latvia.

The University of Cyprus developed the Tasks.

5.13.1 Task 1

The main focus of Task 1 was light energy. This task was split into two separate sections. The first section involved an ecology field study where observations of this habitat formed the answers to this section. The second section focused on light energy, which was based back in the classical laboratory setting. Firstly, students studied the rate of photosynthesis in the presence of different light intensities. They then extracted and identified pigments from red lettuce leaves using thin layer chromatography (TLC), separated these pigments and then looked at the absorption spectra of these separated pigment fractions. Finally, they went on to look at what effect absorption of light had on these extracts. The marks for this Task weighted heavy for the ecology field study, which involved a large amount of team work.

For the first time at the EUSO the students were involved in fieldwork. However, this task focused more on biology (approximately 50%) because of the expertise of the task designer with chemistry and physics each allocated 25%. Most of the experimentation took place back in the laboratory. The students were offered the opportunity to work on site and on experiments together, to use their previous knowledge and understanding of science and construct new knowledge. It was not surprising; because of the climate of Cyprus that “light” was the theme of both tasks.

In an unpublished paper, presented by the task designer Dr. Constantinos Phanis at the 2012 Science and Mathematics Education Conference (SMEC) in Dublin, stated;-

> *“Students gained an appreciation of the ecosystem which was under investigation and discovered how integrated science has the potential to solve important environmental issues……In our field assessment approach the idea of connecting subject areas has considerable face validity, because in the real world,*

> *people's lives are not separated into separate subjects; therefore, it seems only logical that subject areas should not be separated in schools. Almost every national reform effort is currently stressing the need to integrate or make connections among the curriculum* (P.1)

5.13.2 Task 2

The second task examined light energy also by looking at artificial photosynthesis from a solar cell. This involved construction of a solar cell, determination of iodine in the electrolyte solution and recording the electrical characteristics of the output of the solar cell, which had been prepared.

This task was primarily a Chemistry / Physics experiment (75% approximately) with Biology only 25% approximately. Because the subject boundaries were blurred the students were expected to get engaged in substantive conversations before deciding how to carry out the experiments. The lack of clear subject dividing lines may have encouraged greater team work. As the medal allocation in the next section shows, many students received high scores making it difficult to differentiate between the teams resulting in a higher number of teams receiving gold medals that in previous years.

5.13.3 Medals

With thirty-three teams attending, four teams (10%) were entitled to receive gold medals. When the scores were examined it was seen that there was only 0.4 % between the fourth and fifth teams and the difference between the fifth and eight teams was 0.7%. It was decided to award eight gold medals. Up to 2008 the allocation of gold medals had been between 11%-17% of the total number of medals awarded but in 2008 it reached 8 teams (24%). As a result Lithuania, Ireland and Cyprus got their first gold medals. Estonia Team B took first place with a score of 83.15%, which was a second gold medal for Estonia. The next seven teams - the Netherlands Team B, Germany Team A, Slovakia Team B, Latvia Team A, Lithuania Team B, Ireland Team B and Cyprus Team B - were awarded gold medals with scores ranging from 81.75% - 79.2%. Of the eight gold medals, five were awarded to the former Soviet Bloc countries as well as the first two silver medals.

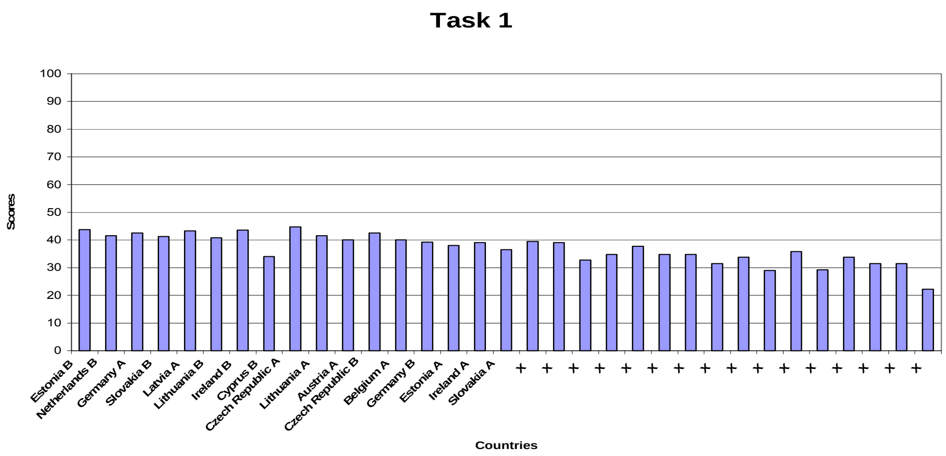
If the tasks had been designed in such a way as to discriminate in a more realistic way between the teams then only four of five teams would have received gold medals. This was regarded as a fault in the task design and future host countries were asked to have their tasks tested well in advance to see that they produced a greater range of scores.

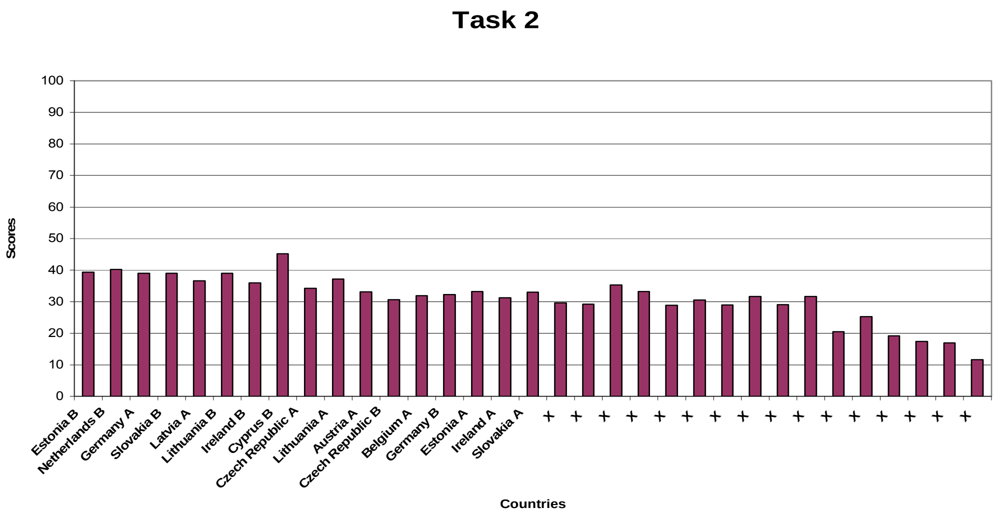
To keep the ratio of medals in line with the Constitution, 10 teams (30%) were entitled to be awarded silver medals. However, because 24% of students had already been allocated gold medals it was decided to limit the number of silver medals to nine, bringing the total of gold and silver to 52%.

Table 5.14 Scores & Medals Achieved EUSO 2008 (Cyprus)
(Source: MA Cotter – EUSO Founder & President)

Country	Task 1 (50)	Task 2 (50)	Total (100)
Estonia B	43.75	39.4	83.15
Netherlands B	41.5	40.25	81.75
Germany A	42.5	39	81.5
Slovakia B	41.25	39.05	80.3
Latvia A	43.25	36.65	79.9
Lithuania B	40.75	39.05	79.8
Ireland B	43.5	36	79.5
Cyprus B	34	45.2	79.2
Czech Republic A	44.75	34.2	78.95
Lithuania A	41.5	37.15	78.65
Austria A	40	33.15	73.15
Czech Republic B	42.5	30.65	73.15
Belgium A	40	31.95	71.95
Germany B	39.25	32.3	71.55
Estonia A	38	33.2	71.2
Ireland A	39	31.3	70.3
Slovakia A	36.5	33	69.5
Bronze Range	39.5-22.25	35.3-11.65	69.15-33.9

Silver medals were awarded to the Czech Republic Team A, Lithuania Team A, Austria Team A, the Czech Republic Team B, Belgium Team A, Germany Team B, Estonia Team A, Ireland Team A and Slovakia Team A. Bronze medals were awarded, in alphabetical order, in the score range of 69% -34% to the Teams A from Bulgaria, Cyprus, Greece, Luxembourg, Netherlands, Slovenia, Spain, Sweden and the Teams B from Austria, Belgium, Bulgaria, Denmark, Greece, Luxembourg, Spain and Sweden.





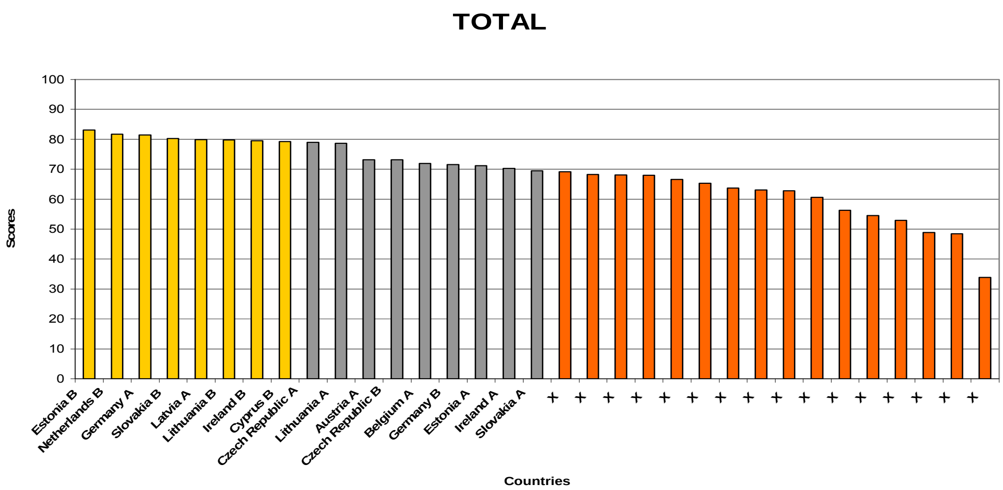


Figure 5.15 EUSO 2008 (Nicosia) Results: Task 1, Task 2 & Total
(Source: MA Cotter – EUSO Founder & President)

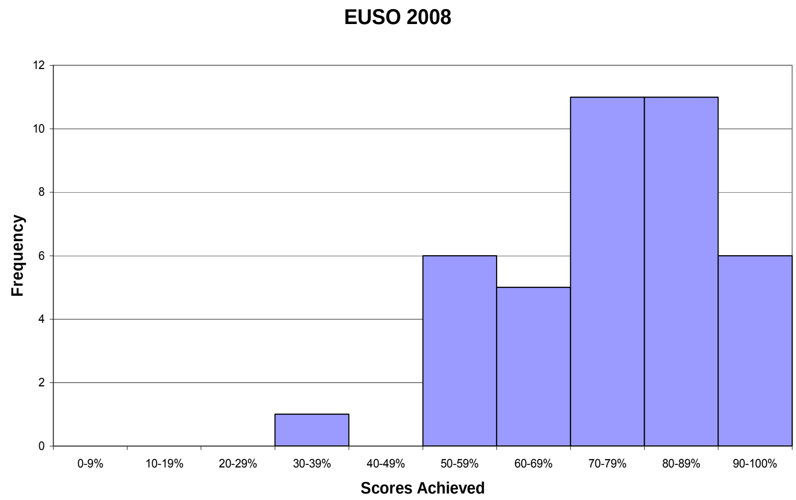


Figure 5.16 Scores Achieved at EUSO 2008 (Nicosia)
(Source: MA Cotter – EUSO Founder & President

5.14 EUSO 2009 - Murcia, Spain

The 7th EUSO was held in Murcia in 2009. Twenty-one EU countries were represented by a total of 40 teams (120 students). This was an increase of seven teams (twenty one students). Romania and France sent observers for the first time. Hungary and Portugal who had sent observers to EUSO 2008 participated with two teams each. The countries participating with two teams included: Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Germany, Greece, Hungary, Ireland, Lithuania, Luxembourg, Netherlands, Portugal, Slovakia, Slovenia, Spain, Sweden and the United Kingdom. There was one team from Latvia.

Murcia University developed the tasks.

5.14.1 Task 1

In this task, silk, a common produce of this Spanish region, was the theme. The students were asked to calculate the protein concentrations of the mulberry leaf, the food source of silk worms and the extracts from a silk worm. This would indicate the biological cost needed by silkworms to create silk. They were also asked to create a synthetic material Nylon by polymerisation. Finally the students compared the mechanical properties of these two materials, silk and nylon.

This task was in three sections but the sections were not identified as biology, chemistry and physics. However the biologist might be expected to calculate the protein concentrations while the chemist might create the nylon and the physicists and the mechanical properties of silk and nylon. The task was integrated in that the three sciences were included in equal measure but once the students had decided on who did what task the scope for substantive discussion may have been limited. The students were asked to use their previous knowledge and understanding of science and construct new knowledge. No attempt was made at the end drew all this information together which may indicate that each section could be a "stand alone" task. The topic was local in that area of Murcia that had a tradition in silk production.

5.14.2 Task 2

The second task focused on fruit juices. Looking at parameters such as Vitamin C content by the chemical analysis of titration was the Chemistry section. Identification of micro-organisms by microscopic analysis and production of enzymes by these micro-organisms was undertaken by the biologists. Thermal properties of juices were examined by the physicists.

In this task biology, chemistry and physics was present in equal proportions. This task was also divided into three sections and while not specifically stated it was clear which section each student was expected to undertake. Once this decision was made there may have been little scope for cooperation to complete the task and therefore little opportunity for discussion. Each task was a subject specific "stand alone" experiment. It was firmly located in the region of Murcia, which is famous for fruit and fruit juice production. Students were required to use their previous scientific knowledge and newly constructed knowledge to complete the task.

5.14.3 Medals

With forty teams attending, four teams (10%) were entitled to receive gold medals. When the scores were examined it was seen that there was only 0.56% between the fourth and fifth teams and the difference between the fifth and sixth teams was 1.68 points. It was decided to award five gold medals. The Czech Republic Team A, which attended for the first time in 2007, took first place with a score of 97.21%, the highest score recorded up to that time, followed by Hungary Team A in second place, which was attending for the first time and got a score of 96.09%. Germany Team B and Team A took the next two places with 95.53% and 93.30% bringing their total to nine gold medals. Estonia Team A was awarded the fifth place with a score of 92.74%, bringing their total to three gold medal team places in three years. At EUSO 2009, all the gold medal winners were from the former Soviet Bloc countries for the first time.

To keep the ratio of medals in line with the Constitution, twelve teams (30%) were entitled to be awarded silver medals. While the gap between the twelfth and thirteenth position was only 0.56%, the next two teams were on the same score. It was decided to award silver medals to twelve teams.

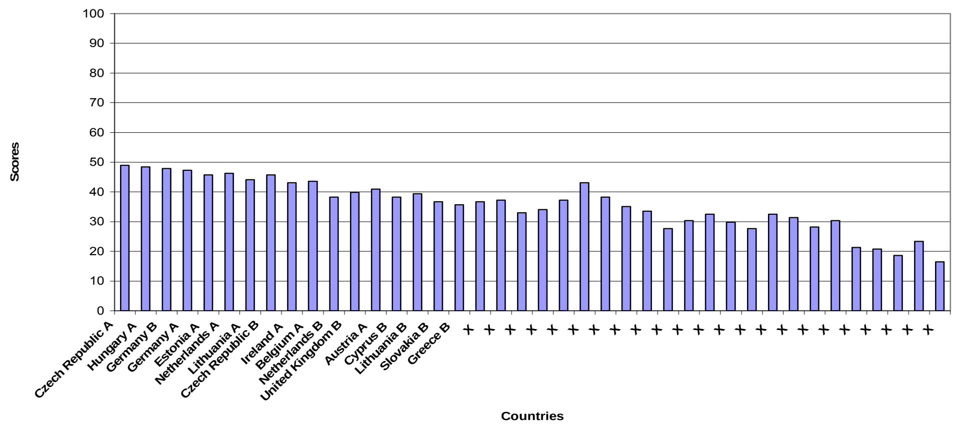
Table 5.15 Scores & Medals Achieved EUSO 2008 (Spain)
(Source: MA Cotter – EUSO Founder & President)

Country	Task 1 (50)	Task 2 (50)	Total (100)
Czech Republic A	48.94	48.24	97.21
Hungary A	48.40	47.65	96.09
Germany B	47.87	47.65	95.53
Germany A	47.34	45.88	93.30
Estonia A	45.74	47.06	92.74
Netherlands A	46.28	44.71	91.06
Lithuania A	44.15	44.71	88.83
Czech Republic B	45.74	48.24	88.27
Ireland A	43.09	45.29	88.27
Belgium A	43.62	42.35	86.03
Netherlands B	38.30	44.71	82.68
United Kingdom B	39.89	42.94	82.68
Austria A	40.96	41.18	82.12
Cyprus B	38.30	43.53	81.56
Lithuania B	39.36	42.35	81.56
Slovakia B	36.70	45.29	81.56
Greece B	35.64	45.29	80.45
Bronze Range	43.09-16.49	47.06-15.29	79.89-31.84

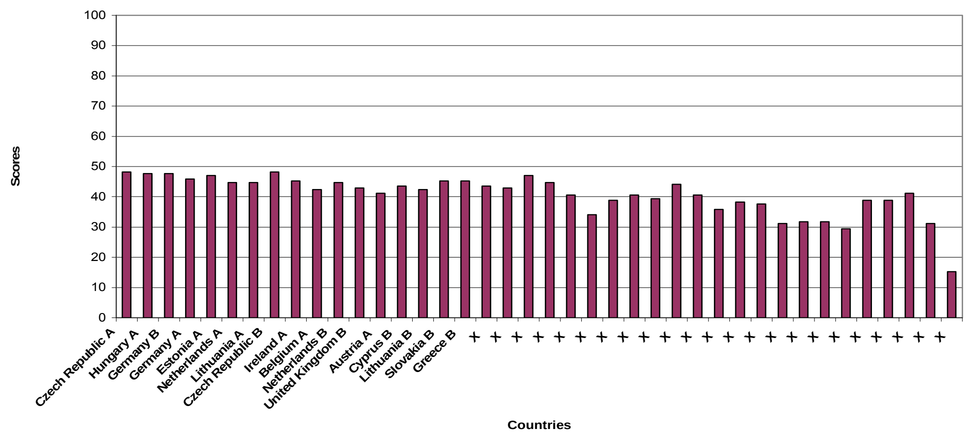
An analysis of Task 1 shows that the Netherlands Team A was in fifth position followed by Estonia. The Netherlands Team A however was in tenth position in Task 2. The Czech Republic Teams A & B were in the top two positions in Task 2 with the same score of 48.24. Ireland Team A was in seventh position. Silver medals were awarded to the Netherlands Team A, Lithuania Team A, the Czech Republic Team A, Ireland Team A, Belgium Team A, the Netherlands Team B, The United Kingdom Team B, Austria Team B, Cyprus Team B, Lithuania Team B, Slovakia Team B and Greece Team B with a score range of 91.06 – 80.45.

Bronze medals were awarded, in alphabetical order, and with a score range of 79.89-31.84 to: Teams A from Bulgaria, Cyprus, Denmark, Greece, Latvia, Luxembourg, Portugal, Slovakia, Slovenia, Spain, Sweden & United Kingdom and Teams B from Austria, Belgium, Bulgaria, Denmark, Estonia, Hungary, Ireland, Luxembourg, Portugal, Spain and Sweden. One bronze team achieved 43.09 in Task 1 and another achieved 47.06 in Task 2

Task 1



Task 2



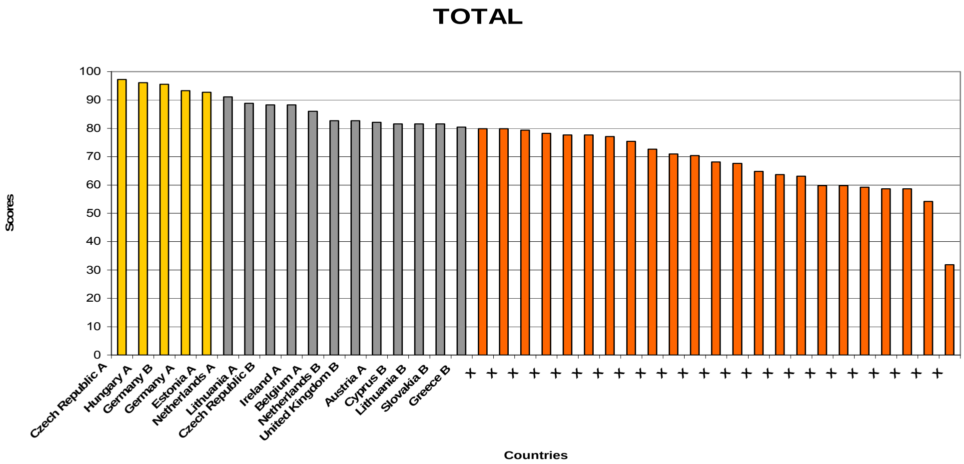


Figure 5.17 EUSO 2009 (Murcia) Results: Task 1, Task 2 & Total
(Source: MA Cotter – EUSO Founder & President)

Twenty-four teams scored above the mean of 75.96, including seven bronze winning teams. Each Task was of a similar level of difficulty. In Task 1, only 5.85 marks separated the top team from the top bronze team and in Task 2, 4.71 marks separated the top team from the top bronze team. 17.32% separated the top team overall from the top bronze medal winning team. Seven teams from the Soviet Bloc were recipients of gold or silver medals

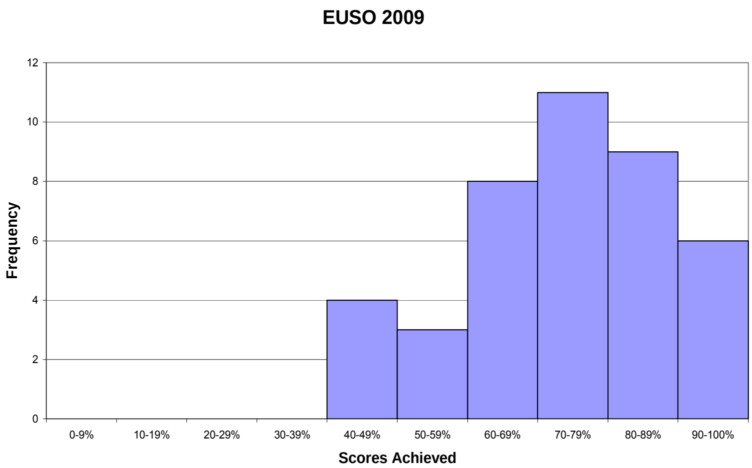


Figure 5.18 Scores Achieved at EUSO 2009 (Murcia)
(Source: MA Cotter – EUSO Founder & President)

5.15 EUSO 2010 - Gothenburg, Sweden

The 8th EUSO was held in Gothenburg in 2010. Twenty-one EU countries were represented by a total of 40 teams (120 students). Romania and France sent observers for the first time.

The University of Gothenburg, Science Faculty academics develop the tasks.

5.15.1 Task 1

The first task examined the “Properties of Water”. An astronaut, from another planet, Rullet, comes to Earth in search of water, as it has become a very limited resource on his own planet. The students analysed the relative humidity of the laboratory, as the astronaut from Rullet did Earth’s environment and then measured the viscosity of the water the astronaut had collected. They also examined the properties surface tension, and hardness of the water.

This was primarily a Chemistry/Physics task (approximately 80%). The task was divided into four sections each with different credit values and the sections were separate and therefore could be undertaken in any order. Because of the absence of a biology section one student could be expected to take on one of the tasks or assist the other two in completing the task they had chosen. However previous knowledge was requires and new knowledge constructed to complete the task.

5.15.2 Task 2

The second task involved a “CSIG - Criminal Scene Investigation Gothenburg”, where the students were asked to solve a murder.

Firstly they had to estimate the time of death of the victim using a swede (yellow turnip: - Brassica napobrassica). The measurement of the cooling (or cooling curve) of this swede would be used a as a model of a dead body and elucidate the time of death of the victim. The chemists then had to analyse the mass and concentration of poison in the "blood”. Biologists had to identify the nature and origin of particles on an anonymous letter sent to the victim. They did this by comparison to plants found close to the suspects’ houses.

This task involved “forensic” biology, chemistry and physics in equal measure and was therefore an integrated task. The students had the option of dividing the tasks into three subject sections or of sharing the responsibility for each section. The task was relevant and linked to their own world in that CSI - TV programmes are popular and show scientists with different specialities cooperate to solve the offence. The students had to manipulate information and ideas, use their previous knowledge and construct new knowledge to solve the crime. This task gave the student the opportunity to engage in substantive conversations and debate and they had to make decisions on how to proceed because the task was not prescriptive.

5.15.3 Medals

With forty two teams attending, five teams (10%) were entitled to receive gold medals. When the scores were examined it was seen that there was only 1.88 % between the fourth and fifth teams and the difference between the fifth and sixth teams was 0.62%. It was decided to award seven gold medals. The Czech Republic Team B which attended for the first time in 2007 took first place for the second year in a row with a score of 96.88%, followed by Germany Team B in second place with a score of 95% and also Germany Team A in fourth place with 93.13%. Hungary Team B took the next place with a score of 94.38% and the sixth place for Team A with a score of 90%. Nine Hungarian students, from a total of twelve, had now received gold medals. Romania Team B, participating for the first time took fifth place with a score of 91.88% while the final gold medal went to Estonia Team A with a score of 89.38% bringing its total of gold medals to four. At the 2010 EUSO the former Soviet Bloc countries took all the gold medals for the second year in a row.

Table 5.16 Scores & Medals Achieved EUSO 2010 (Sweden)
(Source: MA Cotter – EUSO Founder & President)

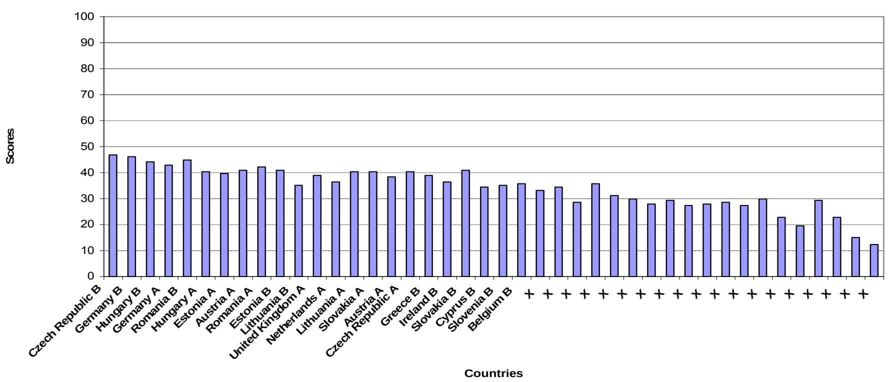
Country	Task 1 (50)	Task 2 (50)	Total (100)
Czech Republic B	46.75	50.00	96.88
Germany B	46.10	48.80	95.00
Hungary B	44.16	50.00	94.38
Germany A	42.86	50.00	93.13
Romania B	44.81	46.99	91.88
Hungary A	40.26	49.40	90.00
Estonia A	39.61	49.40	89.38
Austria A	40.91	45.18	86.25
Romania A	42.21	43.98	86.25
Estonia B	40.91	43.98	85.00
Lithuania B	35.06	48.80	84.38
United Kingdom A	38.96	45.18	84.38
Netherlands A	36.36	45.78	82.50
Lithuania A	40.26	40.96	81.25
Slovakia A	40.26	40.36	80.63
Austria A	38.31	40.96	79.38
Czech Republic A	40.26	39.16	79.38
Greece B	38.96	39.76	78.75
Ireland B	36.36	42.17	78.75
Slovakia B	40.91	36.75	77.50
Cyprus B	34.42	42.17	76.88
Slovenia B	35.06	40.96	76.25
Belgium B	35.71	39.76	75.63
Bronze Range	35.71–12.34	40.96-20.48	71.88-40

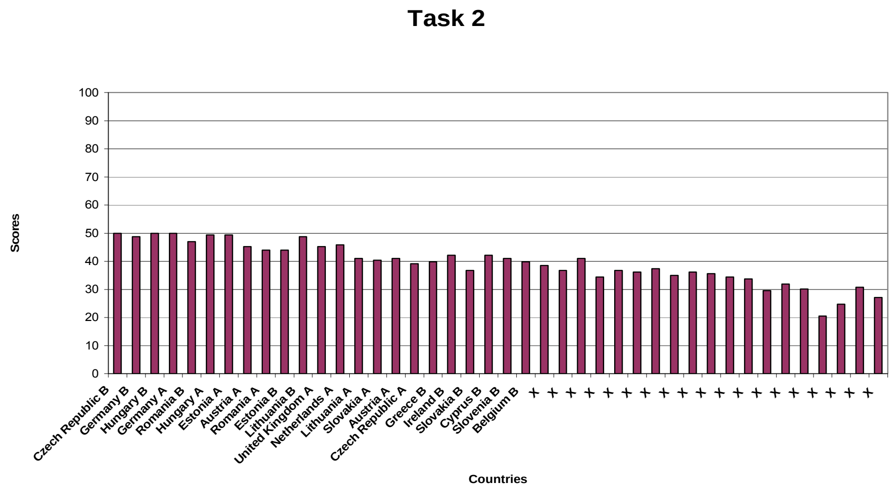
Silver medals with a score range of 86.25-75.63 were awarded to: Austria Team A, Romania Team A, Estonia Team B, Lithuania Team B, the United Kingdom Team A, the Netherlands Team A, Lithuania

Team A, Slovakia Team A, Austria Team B, the Czech Republic Team A, Greece Team B, Ireland Team B, Slovakia Team B, Cyprus Team B, Slovenia Team B and Belgium Team B. Bronze medals were awarded, in alphabetical order, with a score range of 71.88-40 to: the Teams A of Belgium, Bulgaria, Cyprus, Denmark, Greece, Ireland, Luxembourg, Portugal, Slovenia, Spain, Sweden and the Teams B of Bulgaria, Denmark, Luxembourg, Netherlands, Portugal, Spain, Sweden and United Kingdom.

In Task 1, Hungary Team A was in tenth position and Estonia Team A was in fourteenth position. In Task 2, three teams, the Czech Republic Team B, Hungary Team B and Germany Team A achieved full marks, the first time that any team had achieved full marks in any EUSO Task. Lithuania Team B was in joint sixth place with Germany Team B. While most country teams got a similar score in both tasks, Task 2 was less difficult for almost all teams.

Task 1





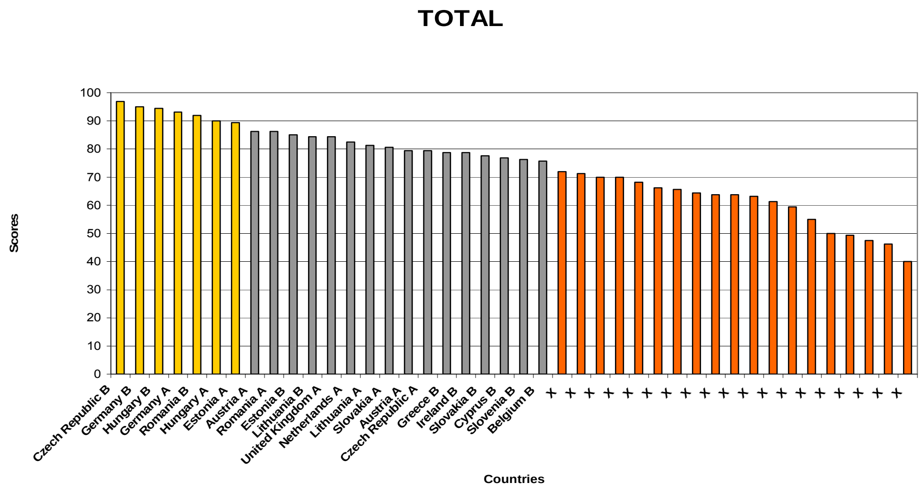


Figure 5.19. EUSO 2010 (Gothenburg) Results: Task 1, Task 2 & Total
(Source: MA Cotter – EUSO Founder & President)

Task 2 determined the allocation of the gold medals with seven teams achieving almost full marks. These tasks discriminated well between the teams with a range of scores from 96.9 - 40% and clear, cut off points between the medals.

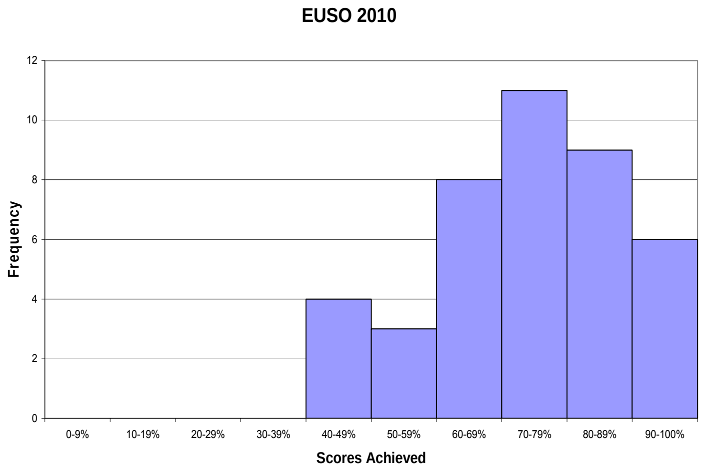


Figure 5.20. Scores Achieved at EUSO 2010 (Gothenburg)
(Source: MA Cotter – EUSO Founder & President

5.16 EUSO 2011- Pardubice, The Czech Republic

The 9th EUSO was held in the Czech Republic in 2011. Twenty-one EU countries were represented by a total of 40 teams (120 students). Italy sent Professor Giuliana Cavaggioni as an observer, bringing to twenty six the number of EU countries to take part in the EUSO.

Academics from the University Pardubice and the University Pardubice, developed the tasks.

5.16.1 Task 1

The first task involved examining one of the Czech Republic's national produce, beer. In Task 1 'All about Beer' the students several parameters involved the brewing process. They investigated the fermentation process by identifying yeasts intolerant to ethanol which are highly desirable for the industrial scale ethanol production, determined residual sugar in beer which gives certain beers more of a sweet taste than others and finally measured the density, determined degree of beer and the quantitative estimation of CO2 production by yeasts.

This was an integrated task, linked to the locality, the content was familiar to the students and involving the three sciences in equal proportions. It was not presented as a Biology/Chemistry/Physics problem which requires students to have discussions to determine who would take on which task and whether to work independently or together on the individual section. They had the opportunity to use their previous knowledge and understanding of science and to create now knowledge to arrive at a conclusion. This had been regarded as an excellent example of an EUSO task.

5.16.2 Task 2

This task was 'About Lenses'. Soft contact lenses were invented by the Czech chemists Otto Wichterle and Drahoslav Lím, who also invented the hydrogel used in their production. These corrective lenses usually placed on the cornea of the eye are now used worldwide. The students were required to examine the optical properties of various lenses, examine residual formaldehyde in industrial polymers, as formaldehyde has been used historically in contact lens production and to stain and examine the front section of an actual eyeball, the cornea.

This task was very relevant to the students as many of them wore corrective lenses, including contact lenses. It integrated the three sciences without clearly indicating which section was Biology, Chemistry or Physics. This could have initiation discussion as to the division of labour in completing the task. It provided the opportunity for students to work together as a team or individually. Previous knowledge and understanding of the three sciences was required and new knowledge needed to be constructed to complete the task. This had also been regarded as an excellent example of an EUSO task.

5.16.3 Medals

With forty teams attending, four teams (10%) were entitled to receive gold medals. When the scores were examined it was seen that only 0.53% separated the 4th, 5th and 6th places. It was decided to award six gold medals. Hungary Team A took first place with a score of 93.62% and Hungary Team B took 3rd place with a score of 90.27%. Fifteen Hungarian students, from a total of eighteen had now received gold medals. Estonia Team A was in second place with 91.63% bringing the Estonian total to fifteen gold medals. Germany Team A, Slovakia Team A and Bulgaria Team A, winning its first gold medal, took the next three medals with a score range of 84.96%-84.41%. At the 2011 EUSO, for the third year in a row, all the gold medals were awarded to the former Soviet Bloc.

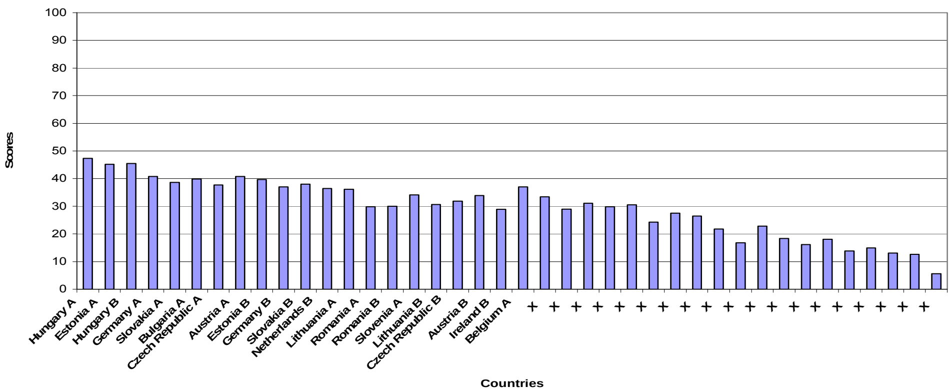
Table 5.17 Scores & Medals Achieved EUSO 2011 (Czech Republic)
(Source: MA Cotter – EUSO Founder & President)

Country	Task 1 (50)	Task 2 (50)	Total (100)
Hungary A	47.37	46.25	93.62
Estonia A	45.17	46.46	91.63
Hungary B	45.48	44.79	90.27
Germany A	40.76	44.17	84.94
Slovakia A	38.66	45.83	84.52
Bulgaria A	39.81	44.58	84.41
Czech Republic A	37.71	45.63	83.37
Austria A	40.76	40.83	81.59
Estonia B	39.71	41.04	80.75
Germany B	36.97	43.33	80.33
Slovakia B	38.03	39.79	77.82
Netherlands B	36.45	40.21	76.67
Lithuania A	36.13	39.38	75.52
Romania A	29.83	45.00	74.90
Romania B	29.94	43.96	73.95
Slovenia A	34.14	38.54	72.70
Lithuania B	30.67	41.67	72.38
Czech Republic B	31.83	40.21	72.07
Austria B	33.82	36.46	70.29
Ireland B	28.89	41.25	70.19
Belgium A	36.97	33.13	70.08
Bronze Range	33.40-5.67	41-88-18.54	68.83-28.24

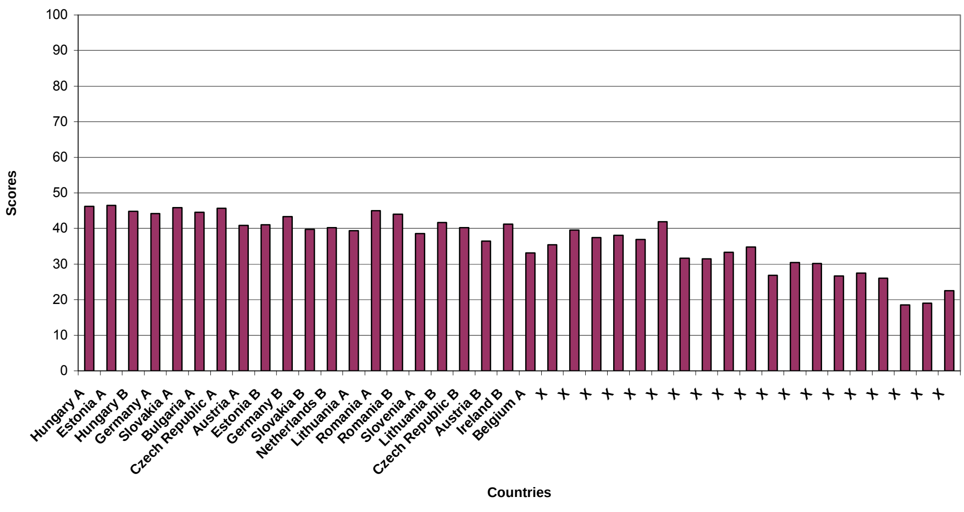
To keep the ratio of medals in line with the Constitution, twelve teams (30%) were entitled to be awarded silver medals. While the gap between the 13th, 14th and 15th was only 0.11%, it was decided to award fifteen silver medals. Silver medals were awarded in the score range of 83.37%-70.08% to: the Czech Republic Team A, Austria Team A, Estonia Team B, Germany Team B, Slovakia Team B, the Netherlands Team B, Lithuania Team A, Romania Team A, Romania Team B, Slovenia Team A, Lithuania Team B, the Czech Republic Team B, Austria Team A, Ireland Team B and Belgium Team A. Bronze medals were awarded, in alphabetical order, in the score range of 68.83-28.24 to: Teams A from Cyprus, Denmark, Greece, Ireland, Luxembourg, Netherlands, Portugal, Spain, Sweden and

Teams B from Belgium, Bulgaria, Cyprus, Denmark, Greece, Luxembourg, Portugal, Slovenia, Spain and Sweden. In the gold medal category in Task 1 Austria was in 5th position and in Task 2 the Czech Republic and Romania were in 4th and 5th position. In the silver category Romania Teams were in 2nd and 3rd positions. Task 1 proved more difficult for the weaker teams.

Task 1



Task 2



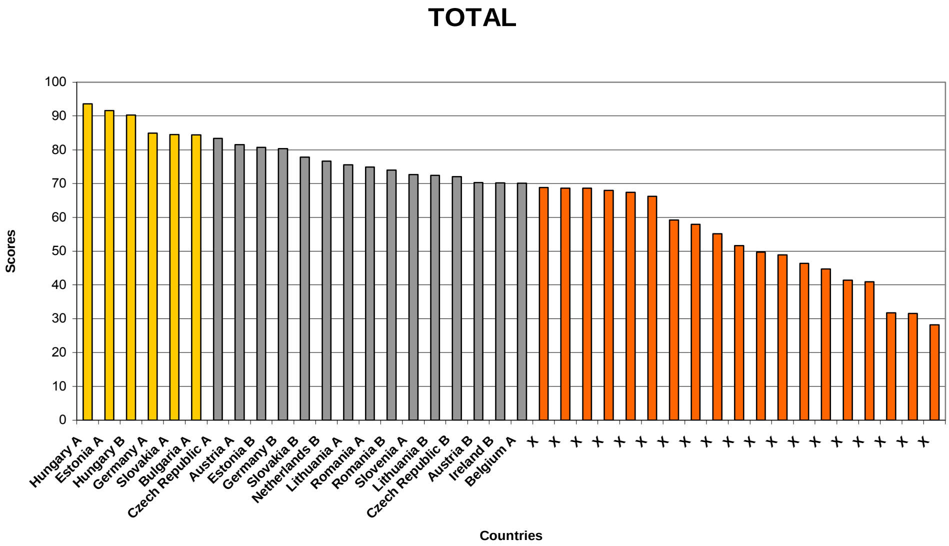


Figure 5.21 EUSO 2011 (Czech Republic) Results:
Task 1, Task 2 & Total
(Source: MA Cotter – EUSO Founder & President)

Seven gold medals should have been allocated because the obvious cut-off point was between the seventh and eight teams. When the discussion took place regarding where the cut- off point would be, the country coordinators did not know which country got which score. The host country, the Czech Republic, was aware that it was the seventh country but the 2011 Director did not try to influence the decision.

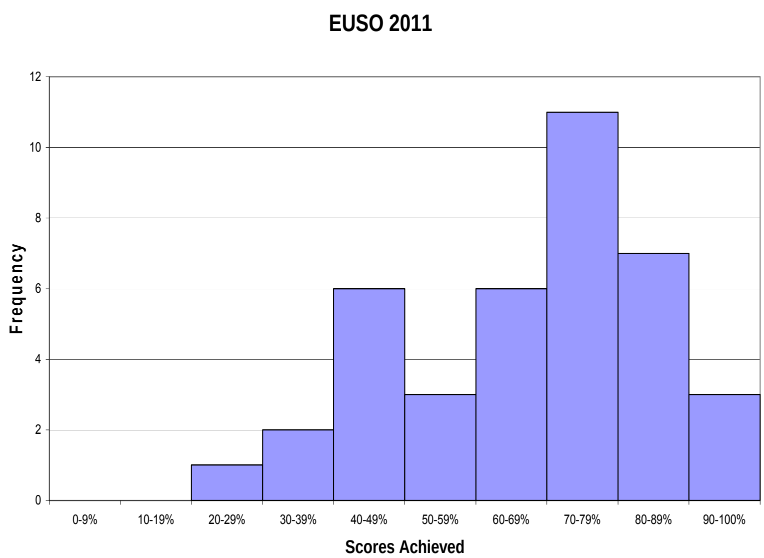


Figure 5.22 Scores Achieved EUSO 2011 (Czech Republic)
(Source: MA Cotter – EUSO Founder & President

5.17 EUSO 2012 - Vilnius, Lithuania

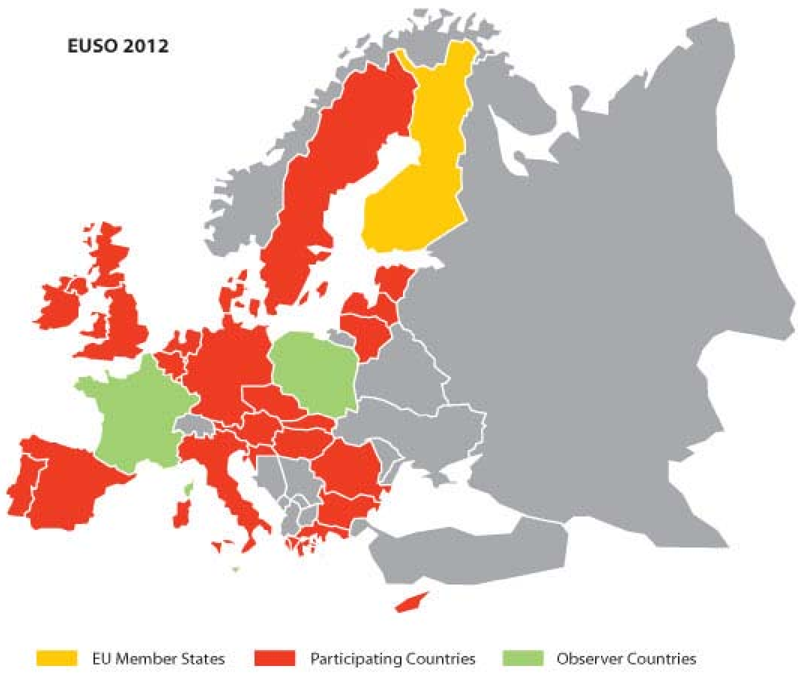


Figure 5.23 Participating Countries EUSO 2012 (Vilnius)
(Source: MA Cotter – EUSO Founder & President)

The 10th EUSO was held in Vilnius, Lithuania in 2012. Twenty-two EU countries were represented by a total of 44 teams (132 students), the largest number of students to date. Italy participated for the first time and Latvia returned after an absence of two years. The University of Vilnius developed the tasks.

5.17.1 Task 1

Amber was the theme of Task 1. The overall objective was to value the 'sunstone', a museum piece of amber. This was calculated by investigating the sunstone's mass, density, colour tone, intensity and the presence of inclusions. Insects make up 90% of amber inclusions and this was the focus of the Biology section. By the use of a dichotomous key, insects isolated from the amber were identified by their morphology and a phylogenetic tree. This tree depicted the evolutionary descent of each species, elucidating the most primitive species and thus indicating the oldest, rarest and therefore the most valuable piece of amber. The chemists examined colour tone and intensity by chromatography; the separation of mixtures, in this case the red and yellow of the amber. The concentration of these colours was then determined by a process called colorimetric analysis. The physicists examined the density of the amber. Finally the information collected was used to determine the value of the 'sunstone'.

This was an integrated task involving the three sciences in equal proportion. The task was not divided into Biology, Chemistry and Physics but it was clear that the Biologist, Chemists and Physicists had a specific role in solving the problem but it did not exclude cooperation or teamwork among the team members. This task was firmly rooted in the Baltic region, which is famous for its amber production, and was relevant to the students and connected to their world because of the film, "Jurassic Park" and amber jewellery. Their previous knowledge and understanding of all three sciences was useful and the construction of new knowledge necessary to complete the task. The students were expected to collate their findings at the end to determine the value of the "sunstone"

5.17.2 Task 2

This task examined the essential requirement of oxygen regeneration in space exploration. The physicists first looked at the properties of light, dependent on the distance to the light source. The generation of oxygen by algae was then examined by the biologists and chemists by the use of a chemical air filter. This information was then compiled by all three scientists to evaluate the oxygen supply sources for a space mission.

This task was integrated and involved biology, chemistry and physics in equal measure. The topic was relevant and connected to the real world. The students were expected to manipulate information and ideas, use their previously acquired knowledge and understanding of science to construct new knowledge to solve the problem. This task gave the students the opportunity to operate as a team and to cooperate in coming to a conclusion.

5.17.3 Medals

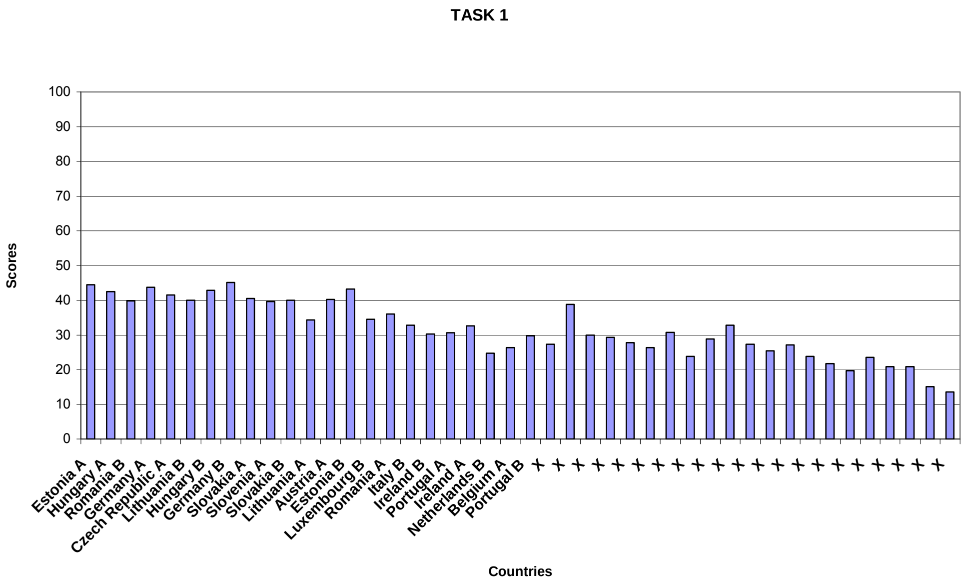
With forty-four teams attending, five teams (10%) were entitled to receive gold medals. When the scores were examined it was seen that only 0.06% separated the 5th and 6th places. It was decided to award six gold medals. Estonia Team A took first place with a score of 87.21% %. This was the sixth gold medal winning team from Estonia and the second time to take first place. Hungary Team B took 2nd place with their sixth gold winning team. Eighteen Hungarian students, from a total of twenty-one, had now received gold medals. Romania Team B took third place, the second gold medal in four years. Germany Team A was in fourth place bringing the German total to thirteen gold medal winning teams. The Czech Republic was in fifth place, winning a third gold medal and Lithuania won a second gold medal in sixth place. For the fourth year in a row, at the 2012 EUSO all the gold medals were awarded to the former Soviet Bloc countries and they also took the first six silver medal places.

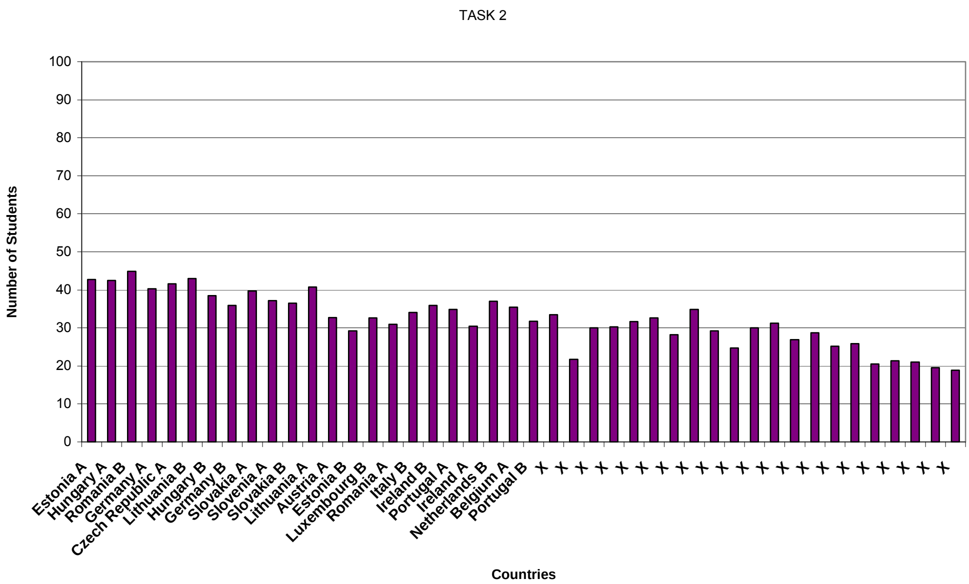
Table 5.18 Scores & Medals Achieved EUSO 2012 (Lithuania)
(Source: MA Cotter – EUSO Founder & President)

Country	TASK 1 (50)	TASK 2 (50)	Total (100)
Estonia A	44.49	42.72	87.21
Hungary A	42.49	42.50	84.99
Romania B	39.81	44.90	84.71
Germany A	43.66	40.33	83.99
Czech Republic A	41.47	41.61	83.08
Lithuania B	40.03	43.02	83.04
Hungary B	42.80	38.46	81.26
Germany B	45.10	35.91	81.01
Slovakia A	40.51	39.69	80.19
Slovenia A	39.66	37.22	76.88
Slovakia B	39.96	36.54	76.51
Lithuania A	34.33	40.72	75.04
Austria A	40.19	32.72	72.91
Estonia B	43.27	29.22	72.49
Luxembourg B	34.48	32.61	67.08
Romania A	36.00	30.97	66.97
Italy B	32.83	34.06	66.89
Ireland B	30.22	35.94	66.16
Portugal A	30.62	34.89	65.51
Ireland A	32.61	30.44	63.05
Netherlands B	24.73	37.04	61.77
Belgium A	26.31	35.44	61.74
Portugal B	29.74	31.77	61.51
Bronze Range	38.73-13.55	34.84-18.86	60.75-32.41

To keep the ratio of medals in line with the Constitution, up to fifteen teams were entitled to be awarded silver medals. While the gap between the 15th and the 17th was only 0.26% it was decided to award seventeen silver medals. Silver medals were awarded, in the score range of 81.26%-61.51% to: Hungary B, Germany B, Slovakia A, Slovenia A, Slovakia B, Lithuania A, Austria A, Estonia B, Luxembourg B, Romania A, Italy B, Ireland B, Portugal A, Ireland A, Netherlands B, Belgium A and Portugal B.

Bronze medals were awarded, in alphabetical order, in the score range of 60.75% - 32.41% to: Teams A from Bulgaria, Cyprus, Denmark, Greece, Italy, Latvia, Luxembourg, Netherlands, Spain and Sweden and Teams B from Austria, Belgium, Cyprus, Czech Republic, Denmark, Greece, Latvia, Slovenia Spain and Sweden.





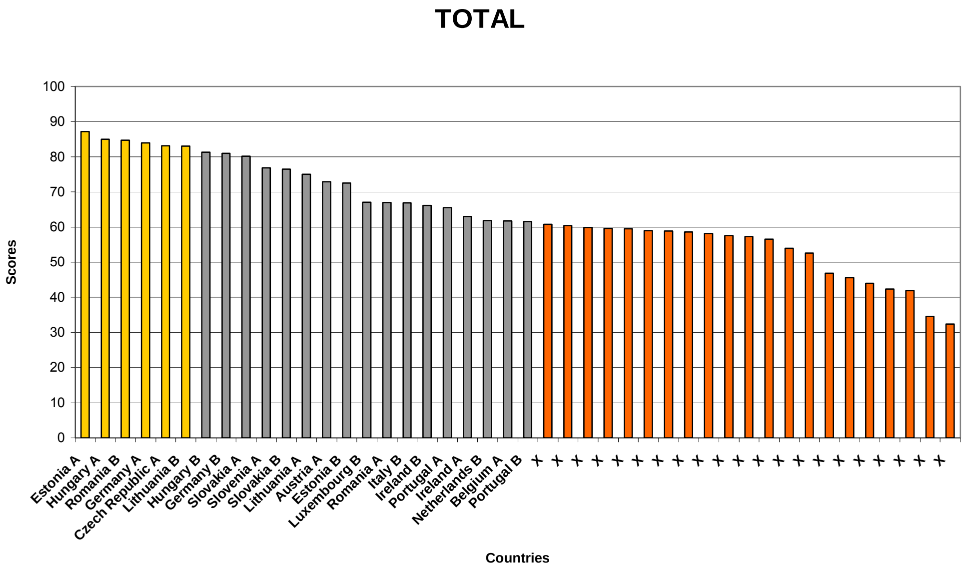


Figure 5.24 EUSO 2012 (Vilnius) Results: Task 1, Task 2 & Total
(Source: MA Cotter – EUSO Founder & President)

These tasks discriminated well between the teams. Some of the bronze medal winners did very well in one task but not in the other and some of the silver medal winners got better scores than the eventual gold medal winners. The range of scores was 87.7% - 32.4%.

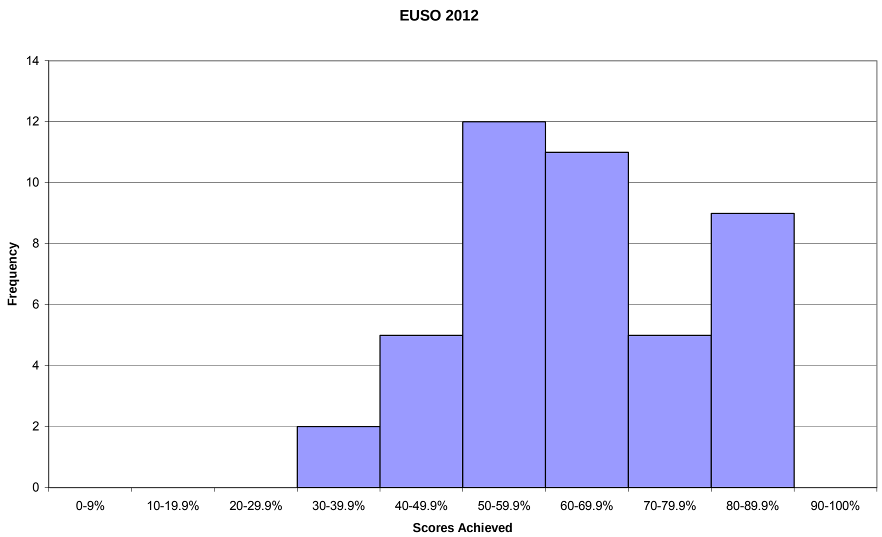


Figure 5.25 Scores Achieved at EUSO 20012 (Vilnius)
(Source: MA Cotter – EUSO Founder & President

5.18 The Team

One of the novel aspects of the EUSO is the "Team". The students compete as a team. However, there are two other teams whose existence is central to the success of the EUSO: the task design team and the team of mentors. On those occasions when their country hosts the EUSO, task designers do not serves as mentors. The researcher could not locate any literature or research on task design teams or on teams of mentors in settings such as occur at the EUSO or at Science Olympiads, single subject or integrated. The researcher has, however, observed, over the past ten years, that the task designers and the mentors display the same characteristics even though they play different roles.

The task designers are usually a team of three equals, each with an expertise in one field of Science: Biology, Chemistry or Physics. In practice, this means that each task designer behaves as an "individual" with responsibility for one subject only; he/she only gets involved in discussions relating to the part of the task which he/she designed. The mentors, also, are a team of three equals, each with an expertise in Biology, Chemistry or Physics. This means that each mentor behaves as an "individual" with responsibility for one subject only; he/she plays no role in discussions with the task designers relating to aspects of the task which involve other subjects.

The task design team and the team of mentors resemble the hospital team of medical specialists, in many respects. Each is comprised of members with quite separate responsibilities who function within distinct areas having well-defined boundaries, which must not be crossed. The literature reveals that integrated, cooperative working is difficult in hospital teams, (Maslin-Prothero and Bennion, 2010). The barriers to cooperation appear to arise, in the main, from status differences between members, (Holtom, 2001). The researcher has observed similar difficulties within the adult teams at EUSO level. Over the past ten years, the barriers to cooperation within these teams have been deep-seated and almost impossible to overcome. Despite having equal status, the members' strict loyalty to their particular subject areas limits collaborative working.

However, that there are benefits to be enjoyed from collaborative working are well established, (Cameron, 2007). These include increased satisfaction for participants, development of a shared culture, improved communication and enhanced co-operation. The researcher can identify with such findings and is of the opinion that they could apply to all EUSO teams, both adult and student. With regard to the latter, there is a considerable body of research into cooperative learning among students in schools, (Kose et al., 2010; Lin, E., 2006). This makes sense given the participants' stage in life and the economic benefits that could potentially be amassed from having groups of students work together on scarce and expensive equipment. Again, nonetheless, the researcher could not find any literature on student teams at Science or other competitions.

5.19 Summary

This chapter addressed the question of how the tasks themselves contributed to answering the research question posed at the outset, their contribution to a progressive version of science education and how their development is linked to the Participatory Action Research model. There is a critical assessment of each task to ascertain if they correspond with what might regarded as the "ideal" EUSO task or "Rich Task".

The limitations of this research are alluded to, such as the lack of empirical evident as to the impact of the nature of the tasks, the briefings given to the students or pre-Olympiad training of teams or on performance of individual teams and it also highlighted the need for further research in these area. This chapter is the only critical review of the all the tasks available (a review of EUSO 2003 Dublin tasks has been published) and since no post-Olympiad reviews have take place, this should provide useful guidelines for future Olympiads.

In the task construction the designers chose topics relevant and meaningful to lives of the students such as solar power, food, drink and material production, Crime Scene Investigates (CSI) and space travel. The topics were for the most part, connected to the real world and had a strong association or relationship with the location of the EUSO such as water in Galway, potatoes in Potsdam, light energy in Cyprus, contact lenses in the Czech Republic and amber in Vilnius. In all cases biology, chemistry or physics were integrated and the students needed to manipulate information and ideas and use previous knowledge and understanding to construct new knowledge to solve a problem and arrive at a conclusion. The completion of the task demanded the active engagement of the students in the practical activity but the level of engagement among the team members themselves is not determined by this research. Each task provided opportunities for alternative solutions or strategies or different pathways to arrive at a conclusion.

All the tasks were practical experiments. Of the twenty, half (50%) of the tasks integrated all three sciences, biology, chemistry and physics in equal proportions. In most cases the subject divisions were blurred which should have encouraged substantive conversation and teamwork. Where the subjects were more clearly defined the students were not discouraged from discussion or from assisting each other in carrying out the experiment.

In five instances (25%) Chemistry / Physics were the dominant sciences with Biology playing a lesser role. This structure may have had the effect of creating a "floating" member of the team who could assist each or one or the other team members. Likewise five of the tasks (25%) were predominately Biology tasks with Chemistry and Physics playing a minor role. While two members could have confined themselves to their own subject speciality the structure of the task could have encouraged more teamwork and substantive conversations.

Chapter 6

Analysis of Results

6.1 Introduction

In this chapter the results from EUSO 2003-2007 are analysed first and then the results from 2008-2012. In 2003, seven EU countries from a possible fifteen attended the 1st EUSO in Dublin. Within five years the 5th EU enlargement had taken place and sixteen countries from a possible twenty-seven had taken part with an additional three observing. By 2012 twenty- three countries had taken part. Finland had agreed to attend EUSO 2012 as an observer but was unable and agreed to attend in 2013.

The research will analyse the EUSO results of all 23 member participating countries. The ten year time period is divided in two five year blocks because of the influx of the new members following EU enlargement in 2004 and again in 2007. It was expected that the former Soviet Bloc countries, because of their success at the International Olympiads would perform well, which they did. To see if an explanation could be found and if lessons could be learned, by the countries performing less well the country coordinators and mentors were interviewed. Germany, with students from the former GDR and FRG, provides a concrete example of how the Soviet system of special science schools gives a distinct advantage to their students when competing with the rest of the EU. This advantage is still present but declining in many of the former Soviet Bloc countries since joining the EU. These special schools are under threat, which may result in the advantage presently enjoyed being short lived. Estonia has been able to blend the old with the new for the benefit of its students. The Netherlands has been the most successful early EU countries at the EUSO, possibly because it has changed its Olympiad selection and training system from an individual-subject-centred approach to a school team-integrated Science approach. Later in this chapter, the results of the interviews and email correspondence with the country coordinator from the Netherlands, Germany, Hungary, Estonia and Latvia may provide answers to the question as to why these countries are successful and what other countries can learn from them.

6.2 EUSO 2003 - 2007

6.2.1 Gold Medals 2003-2007

During the first five years of the EUSO (2003-2007) ten of the original fifteen EU countries and seven Soviet Bloc countries competed in the EUSO. Medals were awarded as follows:

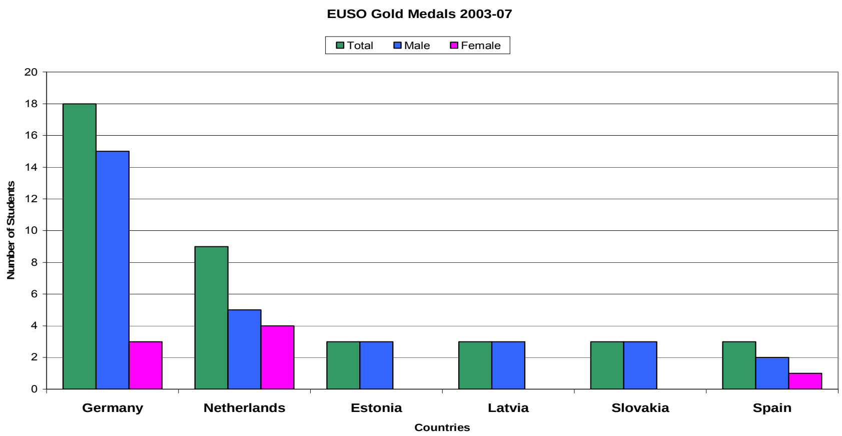


Figure 6. 1. EUSO 2003-2007 Gold Medals by Country & Gender
(Source: MA Cotter – EUSO Founder & President)

Of the 114 Gold medals awarded, Germany was awarded 18 (43%), the Netherlands 9 (21%) and Spain 3 (7%). All three countries had taken part in the EUSO for the five years. The United Kingdom attended for four years. Three Soviet Bloc countries, Estonia, Latvia and Slovakia, with their long tradition of Science Olympiads and who joined the EUSO in 2005 each won gold medals.

6.2.2 Silver Medals 2003-2007

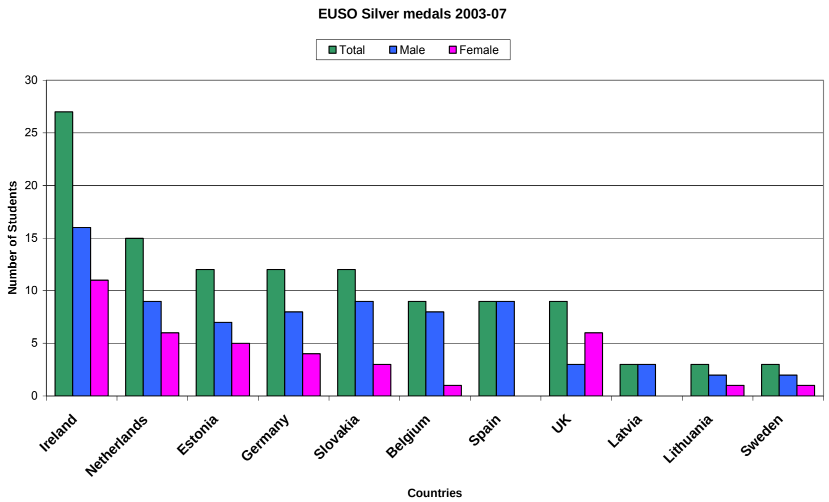


Figure 6.2. EUSO 2003-2007 Silver Medals by Country & Gender
(Source: MA Cotter – EUSO Founder & President)

Of the 114 silver medals awarded, Ireland took 27 (24%) with the Netherlands taking 15 (13%). Three countries, Estonia, Slovakia, (former Soviet Bloc countries) and Germany took 12 (11%). Belgium, Spain and the United Kingdom took 9 (8%) each and Latvia, Lithuania (former Soviet Bloc countries) and Sweden took 3 (3%) each. By eliminating 2003-2004, (the year preceding EU enlargement), Ireland's share of the 75 silver medals awarded was reduced to 15 (20%). Estonia and Slovakia got 12 (16%), the Netherlands and Spain 9 (12%), Germany 6 (8%) and Belgium, Latvia, Lithuania and the United Kingdom 3 (4%) each. The United Kingdom did not take part in 2005 and Lithuania did not join until 2007.

6.2.3 Bronze Medals 2003-2007

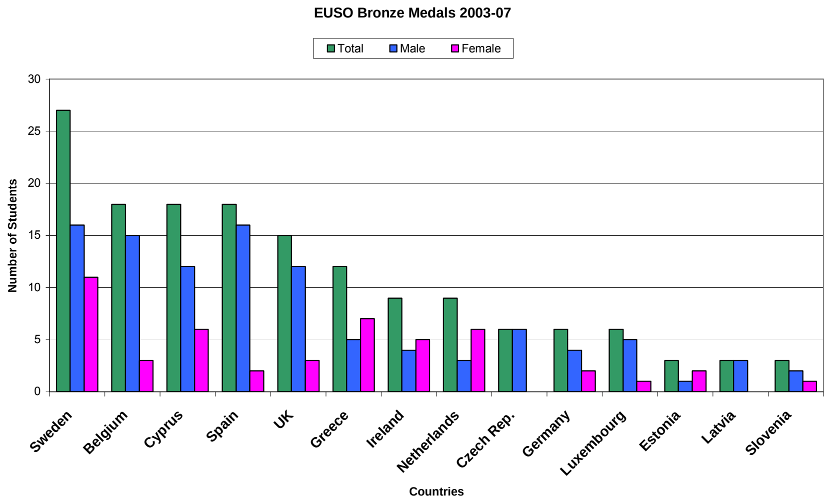


Figure 6.3 EUSO 2003-2007 Bronze Medals by Country & Gender
(Source: MA Cotter – EUSO Founder & President)

Of the 153 bronze medals awarded, Sweden received 27 (18%), Belgium, Cyprus, and Spain 18 (12%), the United Kingdom 15 (10%), Greece 12 (8%), Ireland and the Netherlands 9 (6%), the Czech Republic, Germany and Luxembourg 6 (4%) and Estonia, Latvia and Slovenia 3 (2%).

During the first five years, Ireland failed to win any gold medal, which meant that Irish teams were not in the top 10%-15%. Of the seven countries that won gold medals, three were from early EU members and four were from the former Soviet Bloc. In the silver medal category, Ireland and the Netherlands achieved the highest number with the next three places going to countries from the former Soviet Bloc. In the bronze medal category, the top eight places went to early EU members, the former Soviet Bloc countries having only one or two teams in this category.

6.3 EUSO 2008-2012

During the second five years (2008-2012) twenty-three EU countries took part in the EUSO. Austria, Belgium, Bulgaria, the Czech Republic, Cyprus, Estonia, Germany, Greece, Ireland, Lithuania, Luxembourg, the Netherlands, Slovakia, Spain and Sweden participated, each providing a full compliment of 30 students. Denmark participated with 27 students; Hungary, Portugal and Slovenia with 24 students; Romania with 18 students; Latvia and the United Kingdom with 12 with 12 students each and Italy which participated in 2012 for the first time, with 6 students.

Table 6.1 EUSO Participants 2008-2012
(Source: MA Cotter – EUSO Founder & President)

	2008	2009	2010	2011	2012	Total
Austria	6	6	6	6	6	30
Belgium	6	6	6	6	6	30
Bulgaria	6	6	6	6	6	30
Cyprus	6	6	6	6	6	30
Czech Rep.	6	6	6	6	6	30
Estonia	6	6	6	6	6	30
Germany	6	6	6	6	6	30
Greece	6	6	6	6	6	30
Ireland	6	6	6	6	6	30
Lithuania	6	6	6	6	6	30
Luxembourg	6	6	6	6	6	30
Netherlands	6	6	6	6	6	30
Slovakia	6	6	6	6	6	30
Spain	6	6	6	6	6	30
Sweden	6	6	6	6	6	30
Denmark	3	6	6	6	6	27
Hungary		6	6	6	6	24
Portugal		6	6	6	6	24
Slovenia	3	3	6	6	6	24
Romania			6	6	6	18
Latvia	3	3			6	12
UK		6	6			12
Italy					6	6
Total	99	120	126	120	132	597

6.3.1 Gold Medals 2008-2012

Gold medals were awarded to 96 (16%) of the students in the five years 2008-2012. Germany took 21(22%) gold medals. This represents 70% of their students. Hungary which joined the EUSO in 2009 took 18 (19%) which represents 75% of their students. Estonia was awarded 15 (16%) gold medals which represents 50% of their students. The Czech Republic took 9 (9%) or 30% of their students. Lithuania, Romania and Slovakia each were awarded 6 (6%) gold medals. For Romania this represents 33% of their students and for Lithuania and Slovakia it represents 20% of their students. Bulgaria, Cyprus, Ireland, Latvia and the Netherlands each were awarded 3 (3%) gold medals.

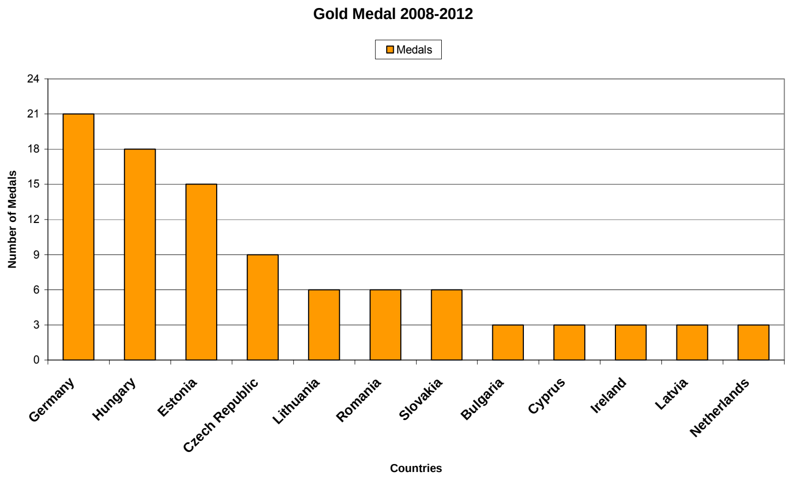


Figure 6.4 EUSO 2008-2012 Gold Medals Winners
(Source: MA Cotter – EUSO Founder & President)

By including Germany as a Soviet Bloc country, which has been represented by fourteen former GDR students and sixteen former FRG students (2008-2012), 88% of the EUSO gold medals have been won by former Soviet Bloc countries. With Germany excluded it still represents 66% of the gold medals awarded.

73% of the gold medals were awarded to male students and 27% to female students. Of the 597 students who took part in the EUSO in these five years, 413 (69%) were female and 184 (31%) were female.

6.3.2 Silver Medals 2008-2012

During the five years, 210 (100%) silver medals, representing 35% of the total number of medals, were awarded. Lithuania was awarded 24 (11.4%) silver medals. This represents 80% of their students. Austria and Slovakia were awarded 21 (10%) or 70% of their students. The Czech Republic and Ireland won 18 (8.6%) representing 60% of their students. Belgium, Estonia and the Netherlands were awarded 15 (7.1%) silver medals representing 50 % of their students. Romania took 12 (5.7%), which represents 67% of its students. Germany was awarded 9 (4.3%) or 30% of its students. Slovenia also took 9 (4.3%), which represents 38% of its students. Cyprus, Greece and Portugal each took 6 (2.9%) silver medals and finally Hungary, Italy and the United Kingdom took 3 (1.4%) each.

111 (53%) silver medals were awarded to former Soviet Bloc countries. All the students from Estonia, Germany, Lithuania, Romania and Slovakia and all but three of the students from the Czech Republic and Hungary were awarded gold or silver medals.

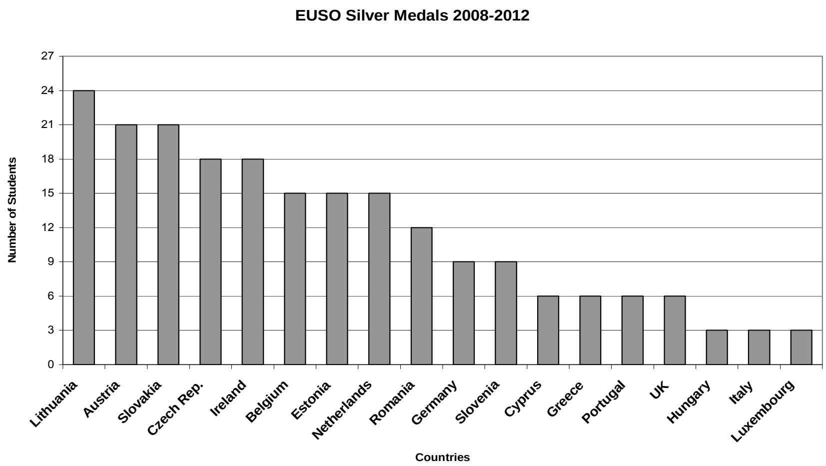


Figure 6.5 EUSO 2008-2012 Silver Medals Winners
(Source: MA Cotter – EUSO Founder & President)

6.3.3 Bronze Medals 2008-2012

291 (100%) bronze medals were awarded in 2008-2012. This represents 49% of the total medals awarded, slightly less (by 1%) than the recommended amount. Two countries, Spain and Sweden, got the maximum number of 30 bronze medals, which represents 100% of their students. Three countries, Bulgaria, Denmark and Luxembourg got 27 (9.3%) bronze medals representing 90% of their students. Greece with 24 (8.2%) represents 80% of its students. 75% of students from Portugal got bronze medals and Cyprus got 21 (7.2%) or 70% of its students. 62.5% of Slovenian students got bronze medals and 50% of students from Belgium and 40% of students from the Netherlands were awarded bronze medals. Austria and Ireland both had 30% of their students receiving bronze medals. The remaining three former Soviet Bloc countries, the Czech Republic, Hungary and Slovakia, each had one team of three students in the bronze category. Latvia and the United Kingdom were represented by 12 students and Italy by 6.

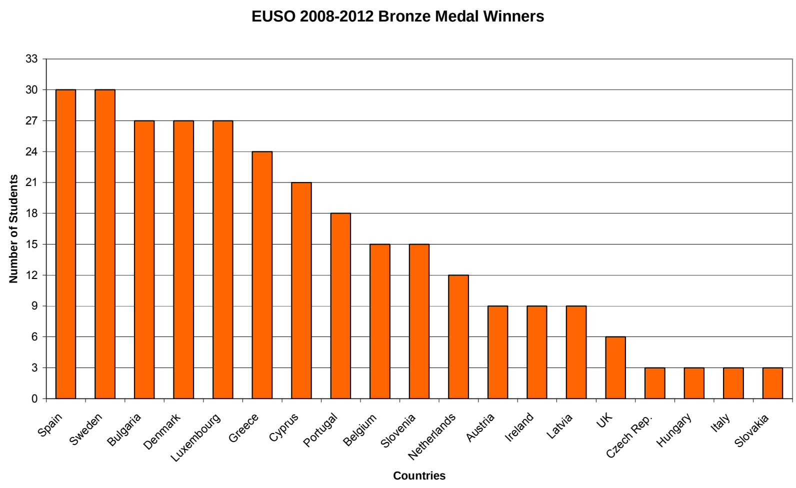


Figure 6.6 EUSO 2008-2012 Bronze Medals Winners
(Source: MA Cotter – EUSO Founder & President)

6.4 Medal Summary

96 (100%) gold medals, 16% of all medals were awarded during the five years 2008-2012 and 93 (96%) were awarded to former Soviet Bloc countries. Three countries, the Netherlands, Ireland and Cyprus were awarded gold medals in 2008. The Netherlands was in second place and Ireland and Cyprus got the two last gold medals, number 7 and number 8. While the number of gold medals awarded is approximately 15% each year, in 2008, 24% of the medals awarded were gold. The reason was that when the scores were examined it was seen that there was only 0.4 % between the fourth and fifth teams and the difference between the fifth and eight teams was 0.7%. It was decided to award eight gold medals. Had the tasks been tested in advance to see if they would generate a greater range of marks this situation could have been avoided. In the previous five years, the Netherlands had been awarded 3 gold and 6 silver medals, bringing the total over ten years to 4 gold and 16 silver medals. The Netherlands has also been successful at the international Olympiads.

Table 6.2 Places 1-5 at EUSO 2003-2012
(Source: MA Cotter – EUSO Founder & President)

Year	1st Place	2nd Place	3rd Place	4th Place	5th Place
2003	UK	Netherlands	Ireland	Germany	Ireland
2004	Germany	Germany	Sweden	Netherlands	Germany
2005	Slovakia	Germany	Estonia	Germany	Belgium
2006	Germany	Latvia	Netherlands	Germany	Slovakia
2007	Germany	Germany	Spain	Estonia	Netherlands
2008	Estonia	Netherlands	Germany	Slovakia	Latvia
2009	Cz. Rep.	Hungary	Germany	Germany	Estonia
2010	Cz. Rep.	Germany	Hungary	Germany	Romania
2011	Hungary	Estonia	Hungary	Germany	Slovakia
2012	Estonia	Hungary	Romania	Germany	Cz. Rep.

Lessons to be Learned

Lessons can be learned from the Olympiad system as it operates in the Netherlands by all countries, including Ireland, wishing to improve the performance of their students, not only at International Olympiads, including the EUSO, but also in the way they are promoting Science integration and interdisciplinary Science at home.

6.5 The Netherlands

(Researcher in conversations with Dr. Emiel de Kleijn, IChO, EUSO and IJSO delegation leader)

On 11/06/2012 the researcher contacted Dr. Emiel de Kleijn, inviting him to be interviewed as part of this research on the EUSO as it operated in the Netherlands. He agreed to a telephone interviewed on the following Friday. He was informed that it would be a semi-structured interview and that the researcher would have a list of issues and questions to be covered but that the interviewee was not limited to these issues and questions.

> *"The semi-structured interview allows for probing of views and opinions where it is desirable for respondents to expand on their answers*" (Gray 2006. p. 217).

He was asked and readily agreed to give his permission for the inclusion of the report in this thesis and for permission for it to be used in any future publications. The researcher took notes during the interview. Shortly afterwards he sent a report by email to the interviewee asking him to correct any inaccuracies.

SLO, the institute for curriculum development in the Netherlands (http://www.slo.nl) is tasked by the Ministry of Education to organise and manage participation in the international Olympiads in Biology, Chemistry, Physics, Mathematics, Geography, Informatics, Junior Science and the EUSO. Each delegation leaders / county coordinator is allowed to allocate 20 working days per year to each Olympiad and funding is provided to cover the selection and training of teams, travel to the Olympiads by the delegations, registration fee and other incidental costs incurred by the leaders. The team leaders are selected from the eleven universities / institutes that are involved in the preparation of the tasks and selection and training of the teams. The EUSO is managed by Dr. Emiel de Kleijn (country coordinator) who is also the IChO and IJSO delegation leader.

At the beginning of the school year a package developed by SLO is delivered by EDG, the same organization that delivers the (state) examinations of the Central Examinations Centre (which is responsible for the organization and management of the state examinations at the end of secondary schooling) to every secondary school in the Netherlands. This package contains all information and other documentation in relation to all the Olympiads. Included is an envelope on the EUSO containing three copies of the EUSO information for distribution to the head teachers in biology, chemistry and physics so that they are all fully informed. Up to 50% of schools have participated in the preliminary round of the EUSO in the past ten years and in any one year, 25% of schools take part.

The eleven third level institutions in the Netherlands operate as EUSO centres and each school is asked to send one team of their best three science students to the nearest centre for a one day regional Olympiad. The top three teams get awards and the best team from each centre is invited to the national EUSO in January.

These eleven teams take part in a simulated EUSO over two days. They compete as a team in the integrated experimental tasks prepared by the team leaders. The top three teams are awarded gold, silver and bronze medals and the top two teams win the right to represent the Netherlands at the EUSO. However if a team member is unable to travel to the EUSO, substitutes are not allowed, the whole team is eliminated and the bronze team is invited.

Participation in the EUSO has a big impact on the education system. SLO, the Universities, Government and Industry all support the EUSO philosophy of integrated science in schools and the need for multi-skilled graduates in science. “We need to have our scientists look over their walls and see what the other scientists are doing” is how Dr, de Kleijn summarized the views of the of the Olympiad partners. In the past fifteen years the number of participants in the Olympiads has increased from approximately 6,500 (when six Olympiads were involved) to over 43,00 participants in the present eight Olympiads (2011-12) While some of these students may take part in more that one Olympiad this is a huge increase in the participation rate. In addition many of the EUSO and IJSO participants are now eligible for the senior Olympiads, which has resulted in a swelling of the numbers in each Olympiad.

While much of the work in schools is still in single subjects, in the recent past, greater emphasis is placed on integrated science. While about 25% of teaching time is spent in laboratories, each final year student in secondary school, either as an individual or in a team of two or three must spend 80 hours working on an experiment of his/her/their own choosing and design and enter into the national young scientists competition. The top ten experiments are published annually in an Radboud University/SLO 400 page book which also includes a report on the eight science Olympiads.

The male /female ratio of students studying science is a cause for concern in the Netherlands as in the rest of the EU and it is government policy to increase the participation rate of female students. With the support of the Olympiad partners the situation is improving but not quickly enough. Since 2000, industry, government universities and schools have formed a partnership to work together to increase participation in science, especially by girls. However the number of males studying physics is still much greater that females, in chemistry it is not as great and in biology the majority are female.

The majority of the teaching population is female with a serious shortage of chemistry and physics teachers of both genders. Teachers of the sciences follow a common three-year science undergraduate bachelor's degree at University. During the two-year Masters degree, a requirement on all teachers, they must study education to become a teacher. If they do not take education in the Masters degree they must take an additional one-year education course after the Masters to qualify as a teacher in one of the science subjects. This is seen as an obstacle to science graduates becoming teachers after working in industry. The use of information technology in teaching is increasing but at a very slow rate.

There is no shortage of university places for most courses except in the medical fields. Because of the introduction of new science based courses in the universities such as molecular life sciences, the number of students studying science has increases and the feared reduction in the “hard” sciences has not materialized.

6.6 Former Soviet Bloc Countries

Figures 6.1 – 6.6 are a stark illustration of the strength of the former Soviet Bloc countries vis-à-vis the early EU members in Science competitions. This dominance has also been shown, over the years, at the International Science Olympiads. Winning medals at international competitions was important for the political leaders of the Soviet Bloc and Science Olympiads were no exception once they became international events, according to the EUSO country coordinators from Estonia, Germany, Hungary and Latvia. However, the establishment of the Science Olympiads was not to win international medals, because in the early years only Soviet Bloc countries initiated, hosted and took part in the Olympiads. The purpose was to identify the high achievers in Mathematics and Science and to raise the standard of Mathematics and Science teaching throughout the Soviet Union. (Fomin and Kirichenko, 1994). By holding these Olympiads, competition between schools and between countries was generated, which not only identified the top students but also the top teachers and the top schools, if by ‘top’ is meant those producing medal winners at Olympiads. It also created a league table of teachers and schools and parents were better informed as to which school they wanted to have their children attend. This in turn led to the establishment of ‘Special Schools’ with better facilities in all the bigger centres of population focusing primarily on Science and Mathematics teaching. These schools became very popular and getting one's child into one of these schools became a priority of parents. The Olympiads, some for children as young as ten, became one of the routes into these schools. As a result, preparation for these Olympiads and for the entrance examination to the special schools became a priority. The universities, which were in competition with each other to attract these students, offered advanced courses to young children. Children could attend two parallel schooling systems, the regular school, which covered all the compulsory subjects and the advanced programmes which focused on Mathematics, Science and foreign languages.

These schools and courses still exist but in fewer numbers and as the older teachers retire a vacuum has been created which the new teachers are not prepared to fill. Attempts are being made by the Berlin Government to phase out the special schools in the formed GDR but this is being resisted with some success. In Latvia, direct Government funding for the Science Olympiads has been stopped because, according to the EUSO Country coordinator, Professor Leonids Buligins,

> *'these Olympiads are seen as the hobby of old fashioned academics from a bygone age and not in keeping with the egalitarian philosophy of the new Latvia. If departments within the universities wish to continue participation in the Olympiads they must find the funding from within their own budget'.*

This has resulted in fewer students taking part in the Olympiads in Latvia and also in Hungary in the recent past.

6.7 Latvia

(Researcher in conversations with Professor Leonids Buligins, IPhO and EUSO team leader)

On 11/06/2012 the researcher contacted Professor Leonidis Buligins, inviting him to be interviewed as part of this research on the EUSO as it operated in Latvia. He agreed to a telephone interview. The same interview and reporting technique used with Dr. Emiel de Kleijn was employed.

The University of Latvia wants to continue with the Olympiads. Latvia continues to use the Olympiad structure of Soviet times. It has school tests, regional tests and finally 25 students from each of the school grades 9, 10, 11, & 12 are selected to come to the university. From these 100 students, the Olympic teams are selected: the IBO, IChO & IPhO teams from grades 11-12; the EUSO teams from grades 9 -10. The training programmes last three weeks. All these students come from state (publicly funded) schools.

Since 2008, with the introduction of the EU structural fund, laboratory facilities in schools have been greatly improved in the larger schools but smaller schools still lack laboratory facilities. About 30% of teaching time is allocated to experiments. Schools do not have access to technicians to lay out the laboratory equipment for a lesson or to clean/tidy up afterwards. This is done by the class teacher.

> *'The teaching method is traditional in that the teacher teaches the lesson as a lecture and demonstrates the phenomena. In the laboratory, the students perform 'ready-made' experiments but there is some room for experimentation and creativity'* according to Professor Buligins

The number of students in Latvia has been declining, generally, over the past five years because of the impact of deaths during the WW II and emigration. The population has dropped from a high of 2.67 million in 1989 to 2.07 million in 2011 (http://www.csb.gov.lv/en). The proportion of males/females taking Science in schools has not changed. The male/female ratio taking Biology is 50/50, Chemistry 60/40 and Physics is 70/30 and no efforts are being made to change this. The majority of Science teachers are female. There is no shortage of Biology teachers but there is a shortage of Chemistry and Physics teachers. Males are not attracted to teaching because of low salaries and unfavourable working condition.

> *'The status of scientists and Science teachers is not high in Latvia because the mass media does not inform the general public of the work or relevance of Science and Science teachers and researchers'*.

The average class size is 30:1. Teachers use ICT in the preparation of lessons and during teaching and a lot of use is made of interactive white boards in schools.

There is a limit on the number of university places in all the Sciences and some universities do not offer Physics. Latvia University produces 50 Physics graduates each year. The male/female ratio of Science graduates is similar to that of students taking the Sciences in secondary schools.

> *'Since the introduction of the structural funds a number of teacher training and in-service units have been established. There is a lot of re-training and up-skilling but there is no quality control on these programmes and quality of the outcomes is unknown. It has not addressed or rectified the shortage of Chemistry and Physics teachers'.*

Because of the decline in student numbers there is no shortage of university places. Unlike the situation in Ireland, Medicine is not the most popular course. Social Science, Communications, Psychology, Economics, Law, Engineering and IT are the most popular.

In the opinion of the EUSO country coordinator, the performance of the Olympiad teams is directly linked to the selection procedure and to the training programme provided. The high achievers in Science need to be identified early and involved in the Olympiad movement.

6.8 Hungary

(Researcher in conversations with Dr. Peter Vanko, EUSO and IPhO team leader)

On 11/06/2012 the researcher contacted to Dr. Peter Vanko, inviting him to be interviewed as part of this research on the EUSO as it operated in Hungary. He agreed to a telephone interview. The same interview and reporting technique used with Dr. Emiel de Kleijn was employed.

Hungary has a very long tradition of Science and Mathematics competitions and the structure existed even before Soviet times (1894, Eötvös Mathematical Competition). The EUSO is directly linked to the IBO, IChO and IPhO with each holding a subject specific junior Olympiad. The IBO/EUSO-Biology is organised in Szeged University, the IChO/EUSO-Chemistry and the IPhO/EUSO-Physics in Budapest.

Science is taught in Hungarian secondary schools as separate subjects, Biology, Chemistry and Physics and the Olympiads in Biology, Chemistry and Physics for 12/13 year olds (grades 7-8), 14/15 year olds (grades 9-10) and 17/18 year olds (grades 11-12) are still continuing. These are mostly theoretical competitions with experiments in the final round. Round one takes place in the schools, round two in a regional centre and the final in a university. The EUSO mentors send an experimental task in the subject to the top 30-35 students in the 14/15 year olds' Olympiads. The quality of their answers /reports determines which 10 students in each subject get called to the final two day training and selection. Two biologists, two chemists and two physicists are selected to represent Hungary at the EUSO. All the students come from state or church (publically-funded) schools. There is no official organisation in Hungary to run the EUSO;

it depends on the country coordinator who has a small budget from the Department of Education.

The Ministry of Education supports the EUSO because it is an integrated, Science, team, practical Olympiad for younger students which is also the expressed philosophy of the Ministry. 'In reality nothing is done about it' according to Dr. Peter Vanko, EUSO country coordinator 'except that each year the students who represent Hungary at the different Olympiads are invited to the Ministry for a photo-call and publicity in the media follows'. The universities support the Olympiads because it puts them in contact with the top students in the Science subjects who will eventually become the senior Olympiad team members and students at the university. After the EUSO the mentors discuss the teams' performance and plan improvements and strategies for the next year.

In the opinion of Dr. Vanko, Science education in Hungary *'is directly opposite in character to the EUSO'.* Students work as individuals and are examined individually. The school laboratories are old-fashioned and badly equipped. Because there are no technicians, the teacher who decides to conduct experiments must prepare the laboratories beforehand and clean up afterwards. This takes time and teachers generally, *'except for some older or especially interested ones'*, are not prepared to do this. Teaching is generally traditional, the teacher tells the students what they need to know and the students write this into their copies. There are a lot of books in schools but in the high achieving special schools books are seldom used in Mathematics and Physics. The main examination is the state exam for 18 year olds, which is centrally controlled. Students are allocated university places based on the result of this exam and the school reports of the previous two years. Biology is the most popular Science and 60% of the students are female. Only about 15% of the university Chemistry and Physics students are female.

In Soviet times, a university Science student had to choose between a teaching career and a career as a scientist. Today, there is a common Science BSc degree. Within fourteen years a teacher must take a Masters degree. In 2011 no teacher took a Masters Degree in Physics and Chemistry. Most Science teachers are female and there is a huge shortage of Chemistry and Physics teachers. Teachers are badly paid and the working conditions are poor. The most popular university courses are in the areas of finance, economics, law and the social sciences while Medicine is not very popular because doctors are poorly paid and the graduates tend to emigrate.

In the opinion of the EUSO country coordinator, Dr. Peter Vanko, the dominance of Hungary at the EUSO and its success at the senior Olympiads will be short lived. The State is not investing in long term planning and education reform only delivers results after many years so there is no long term investment in education. Only about 20 schools now provide the Olympiad students and this number is decreasing annually as the dedicated teachers retire. The gap between these top Olympiad students and the average students is huge and the number and quality of the students coming through the Olympiads is dwindling. *'Soon there will only be average students to choose from'.* Under the Soviet system students *'did what they were told'*. If they were told to do Physics, they did Physics because they did not think that they had a choice and with little else to do they studied hard. Membership of the Science Olympiad teams or of sports teams offered the possibility of travel, which was forbidden or very difficult for the ordinary citizen. The state also took great pride in its citizens winning at international events so money was invested in elite students, but now the incentive has been removed.

> *'It isn't wrong, that there are no more such incentives, and I can accept that Hungary will not be so successful in the future Olympiads. The big problem is that the group of top-level students is slowly decreasing. In the past I could take two or three teams to each of the Olympiads and they would all do equally well. Some EU countries could take any of 300 students and they would all perform reasonably well. I think that it is more important to raise the education standard of as many students as possible but it would be nice if it was possible also to develop the talents of the very best'*
> (Vanko 2012)

6.9 Germany

(Researcher's conversations with Dr. Stefan Petersen, EUSO and IPhO delegation leader)

On 11/06/2012 the researcher contacted Dr. Stefan Petersen, inviting him to be interviewed as part of this research on the EUSO as it operated in Germany. He agreed to a telephone interview. The same interview and reporting technique used with Dr. Emiel de Kleijn was employed.

Germany, like the Netherlands's SLO, has a curriculum development unit called 'The Leibniz Institute for Science Education (IPN) http://www.ipn.uni-kiel.de/, which since 1990 when East Germany (GDR) and West Germany (FRG) were reunited, coordinates national and international student Science competitions, including the EUSO, for all of Germany. Fulltime staff members with a background in a particular Science have responsibility for the individual Olympiads in IPN.

The EUSO students are selected through the junior section of the IBO, IChO and IPhO and are therefore subject specialists. Approximately 100 finalists will take part in both the Biology and

Chemistry sections and 50 in the Physics section. The top twelve students are invited to a final selection process where the two teams of three are selected, each with an expertise in one of the three Sciences. Because of the existence of special Science schools in the former GDR, 53% of the team members come from those schools and 47% come from the former FRG.

> *'This means that students from those schools naturally have a broader knowledge in natural Sciences and these schools also attract students from the former FRG'*

according to Dr. Stefan Petersen, EUSO and IPhO delegation leader. These schools continue to receive additional funding but it is getting more difficult to justify their existence in an egalitarian society and some have recently lost their status as special schools. However, in the former FRG some schools have intensified their efforts in Science teaching and even though they may not be called special schools, they offer a similar level of intensity with regard to Science education as the special schools in the former GDR.

In most schools the teaching of Science still follows traditional methods in the main and laboratory work only accounts for 25% of the teaching time. This may be because the laboratories are not very well equipped and technicians are not available to prepare the laboratories for the lessons or to clean up afterwards. However, there is a greater emphasis on inquiry methods recently and progress is being made.

There is a decline in the numbers taking Science but it is not seen as a major problem. There is no shortage of Biology teachers, Chemistry teachers are not very plentiful but there is a big shortage of Physics teachers.

Ireland may not have much to learn from the systems in operation in Hungary, Germany and Latvia but Estonia has a lot to offer.

6.10 Estonia

(Researcher in conversations with Dr. Karin Hellat, EUSO and IChO leader)

On 11/06/2012 the researcher contacted to Dr. Karin Hellat, inviting her to be interviewed as part of this research on the EUSO as it operated in Estonia. She agreed to a telephone interviewed. The same interview and reporting technique used with Dr. Emiel de Kleijn was employed.

Estonia, as a former Soviet Bloc country, has a very well established Science Olympiad structure, which is still supported by the government. In December, the first round of the junior Olympiads for 14-16 year olds (basic school level) and senior Olympiads for 16-19 year olds (gymnasium level) in Biology, Chemistry, Physics and Mathematics are held in the schools. In January / February the regional Olympiads take place and in March / April the finals are held in the University of Tartu. Many ‘Open Competitions’ are also held. The standard of these competitions is higher than the school curriculum for the corresponding age but ‘keywords’ or hints are given beforehand to assist in the preparation for the competitions. An individual integrated Science Olympiad in Biology, Chemistry and Physics for 14-15 years old also takes place. This is in two parts: a theoretical competition in February and an experimental part in the following May for the top 50 in the theory test. As well as the Olympiads, Estonian students take part in other international competitions such as the International Kangaroo Mathematics Contest. The overall world winner of this mental arithmetic competition in 2010 was Kadi Liis Saar from Estonia who also represented her country at the EUSO in 2009 in Spain when she and her team got first place.

Taking part in these Olympiads / competitions is very important for many students and their parents because success means a place in the much sought after ‘special’ schools for 16-19 year olds. These schools date back to the first Estonian Republic of 1918-1940 but during the Soviet era they were developed into intensive centres specialising in foreign languages, natural Sciences and Mathematics. These schools are situated in Tallinn, Tartu, Narva (Russian-speaking school) and also scattered all over Estonia. Tallinn, the capital, has three schools and Tartu has one which focuses on Environmental Science, Natural Science and Physics as separate subjects. Each year, 600-700 students apply for the 100 places in each school to follow advanced courses in the Sciences, while less time is allocated to the other compulsory subjects. To get a place in these schools is regarded as a great honour for the students and the family, not to mention hugely beneficial to the students career prospects.

The universities support these schools and the students attend lectures and have laboratory sessions in the universities either throughout the school year or for shorter periods. The junior Mathematics courses in the University of Tartu are for students of ten years and over and the Biology, Chemistry and Physics courses are for older children. These courses are voluntary, free and very popular. Former Olympians and other interested students also help with the teaching at these special schools and prepare the Estonian Olympiad teams in all subjects.

The EUSO is organised and managed by Tartu University Science School staff and is financed by the Ministry of Education and Research. A theoretical integrated Science examination is sent to the schools. Approximately 350 students take part and the top 50 students are invited to Tartu University for a practical four-hour integrated Science examination. The top six who are under age for the EUSO and the top six who are under age for the IJSO are selected. These students are guaranteed a place in the special schools. The EUSO team is invited to Tartu University on three occasions throughout the year for a three-day training programme. This nine-day course concentrates on laboratory work.

The regular secondary school has a much lower expectation of its students than the special schools and the facilities, while improving, are not very good. While winning medals and getting on teams is a 'badge of honour' in the special schools, students in the regular schools who do well are discouraged by peer pressure. In all schools, but especially in the special schools, students sit many examinations throughout the year. This constant monitoring is regarded as an important way of keeping up a high standard.

At university, Biology and Chemistry are popular among girls with up to 50% of students taking each subject but the number taking Physics is much less. More girls than boys go to university. Boys tend to seek work because, while university is normally free, living costs are high. Fees are charged for medicine and law and the more popular professions. However, an inquiry is underway as to why female graduates are not joining the work force, according to Dr. Karin Hellat, the EUSO country coordinator.

> *Estonia is a very traditional country and girls like to get married in their mid twenties so they opt out to rear their children. The majority of teachers are female. Each teacher follows a three-year undergraduate BSc degree followed by a two year Masters degree. While there are still a significant number of male Physics teachers, their average age in over sixty and there are no young male teachers to replace them. Teachers are not well paid; their role models are mostly female which results in young men not taking up teaching as a career*
> (Hellat 2012).

ICT is used well in the preparation and delivery of lessons. Under the 'Tiger Leap' programme in 1996-97 the infrastructure in schools was improved greatly and teachers' and students' use of IT is now highly developed.

6.11 Summary

The stark finding from this chapter is that the former Soviet Bloc countries have a distinct advantage when it comes to international Science competitions. The data from EUSO 2003-07 shows that when some former Soviet Bloc countries joined the EUSO in 2005 they performed better that their old European counterparts. By 2008 when most of the former Soviet Bloc countries had joined the take over of the gold medal category was almost complete. In the silver medal category they also performed very well.

Chapter 6, a natural continuation of the previous chapter, presents the results from the EUSO in two five-year periods because of EU enlargement in 2004 and 2007. This Chapter contributes to the historical record of the EUSO and highlights some of the trends that have developed. It was expected that the former Soviet Bloc countries, because of their success at the International Olympiads would perform well. The interviewing, which was one of the research methods uses in PAR and allowed for the inclusion of expert Voices from these countries, helped the researcher to comment on the results. In the first five years the former Soviet Black countries featured strongly in the gold and silver medal categories while the early EU members performed well in the silver category and were dominant in the bronze category. In the years 2008-2012 the former Soviet Bloc countries were dominant in the gold and silver categories while the early EU members featured strongly in the bronze category.

Interviews were conducted with the EUSO Country Coordinators from Latvia, Hungary and Estonia to provide the researcher with a clear picture of Science Education in the former Soviet Bloc so as to provide amswer to why the had performed so well. EUSO Country Coordinators from Germany was also interviewed because many schools in East Germany are in a transition phase. EUSO Country Coordinators for the Netherlands was also interviewed because that country performs well at the EUSO and other Olympiads. Their contribution to the debate has influenced the Recommendations in Chapter 7.

Chapter 7

Conclusions and Recommendations

7.1 Introduction

The EUSO has been an enormous success and is unique and novel in that it is the only multidisciplinary integrated, Science, practical-based, team competition reported in academic journals. All the other Science Olympiads are single subject, individual competitions dating back to the 1934 first Leningrad Mathematical Olympiad. (Fomin and Kirichenko, 1994). The EUSO inspired the creation of the International Junior Science Olympiad (http://ijso-official.org/) which has among its tasks a practical team experiment, there on the insistence of the researcher and EUSO founder who was one of the authors of its Constitution.

One of the reasons for the success of the EUSO was because of the way in which it was established. Setting up the EUSO was complex because it introduced something which had not been tried before, a multi-subject Olympiad with no theory exam and with students working in teams. This could only have been achieved with the support and active involvement, from the outset, of representatives from many EU countries; representatives who were involved in the discussions and decision making at every stage of the event. The methodology used was Participatory Action Research (Kemmis and McTaggart, 2003) which is characterised by a commitment to openness, transparency, equality, respect, collaboration and communicative action. Throughout the whole process the EUSO members were consulted and their views taken. This democratic process continues to be a central feature of the EUSO. However we should not lose sight of the fact that the work presented for examination also to a large extent presents a historical account of the evolution of this unique initiative in Science-based competition.

The EUSO: - a multidisciplinary, integrated, Science, practical-based, team competition is analysed to identify if the title of this thesis, The European Union Science Olympiad (EUSO):- Towards a Multidisciplinary Strategy for Science Education is justified.

7.2 Ten Years of Success

The EUSO has run successfully every year since the first EUSO in 2003 in Dublin. In May 2002, the first GB meeting was held and included representatives from six EU countries who agreed the revised Constitution (Appendix C). There has been a massive growth in the number of participating countries, from 7 to 23, with an additional 3 countries sending observers. Moreover, the number of students participating annually has increased from 43 in 2003 to 132 in 2012 and the total number of EUSO student participants has reached 906 in 2012.

Ten EU governments have acknowledged the value of the EUSO as can be seen from the significant amounts of money they have provided to fund the hosting of the Annual EUSOs in their countries from 2003-2012; a further three EU countries have already committed to hosting and funding the EUSO in 2013 - 2015.

The EUSO may have has been seen as a benefit to the Science faculties of universities in ten countries which have committed time, money and resources in helping to make it the success story that it is.

The academics in these universities have produced 20 practical Science tasks in ten years, which require four hours each to complete by three 15-16 year old students working as a team. The 2003-2007 Tasks will be published in March 2013 and the 2008-2012 Tasks in 2014. The creation of these unique experiments brings together academics, teaching staff, administrators, and laboratory and technical personnel to produce integrated, multidisciplinary Science tasks, an activity which they possibly have never had the opportunity to engage in.

In each participating country, thousands of students have taken part in the preliminary rounds. This has involved many schools and their teachers. It has also introduced the concept of integrated, multidisciplinary Science Tasks (Rich Tasks) to students and teachers and the challenge of having to work as a team in solving the tasks. Participating countries have expended large amounts of resources in selecting teams, training students and sending these and their mentors to the host country year after year. No research has been carried out as to why countries volunteer to host the event or why participating countries take part and this may be explored in the future.

7.3 The Students

The EUSO has provided 906 Science students with the opportunity to represent their countries in an international Science competition and to spend a week in the company of students of the similar age and interest from over twenty countries. Participants are challenged to solve a task as a team, a unique feature of the EUSO, which may not be common or usual for them in their school science programmes. They are given the opportunity to experience the work of scientists. They are provided with invaluable experience, which may help them should they be selected to represent their countries in the International Science Olympiads in Biology, Chemistry and Physics. No research has been carried out to see if EUSO students represent their country at the IBO, IChO or IPhO.

Among the outcomes expected in relation to the students is an active interest in and a positive attitude towards Science and scientists. However no research has been carried out to see if participation in the EUSO or other Olympiads changes attitudes to scientists or science in school.

The EUSO promotes and rewards the pursuit of excellence in scientific endeavour, encourages an appreciation of the value of Science amongst the wider community and conveys to students, schools and the community the importance of advanced study in Science. (EUSO Constitution)

7.4 The Mentors

The mentors who accompany the students, many of whom are secondary school teachers, are exposed to integrated, multidisciplinary, team, Science experiments which may have an impact on their own teaching, encourage greater contact and co-operation between them and provide an opportunity to exchange ideas and materials pertaining to Science education in the EU. For some it provided an opportunity to work collaboratively on research and projects. No research has bee carried out to see if their involvement in the EUSO has impacted of the way they teach science.

7.5 The Tasks

The twenty tasks produced by the EUSO may provide a road map towards a multidisciplinary strategy for Science education. Each task can be completed over a number of lessons or can be “broken-up” to provide a number of stand alone tasks. The important and unique aspect of the tasks is that they are designed to be team activities requiring different and varied skills. They are all context-based and focus on everyday products such as food and drink, contacts lenses, etc. All are integrated in that all make explicit attempts to connect two or more sets of subject knowledge and/or subject boundaries are not readily seen (Hayes et al 2006) and they are all interdisciplinary and/or multidisciplinary.

It is regrettable that no post-Olympiad review and no immediate analysis of the Tasks was undertaken to see if they adhered to the principles set down by the EUSO constitution. Such an investigation and a statistical analysis of the results would have been beneficial to the future task designers

The creation of this set of tasks highlighted some of the difficulty involved in creating an integrated task. This may explain why integrated Science curricula across the EU are difficult to establish (Rocard et al. 2007). The experience of the EUSO shows that much more research is needed into the obstacles to integration and how they might be overcome. The EUSO has shown that this is a very complex, multifaceted and sometimes a difficult problem to resolve. However the existence of twenty integrated, rich content Science Tasks, most of which have three subjects integrated equally and the rest with at least two subjects dominant but all three integrated, shows that such difficulties can be overcome (Chapter 5)

During the initial PAR phase the possibility of developing integrated Science Tasks seemed at times remote and even during preparations for the first EUSO, integrating Biology, Chemistry and Physics into a single task proved almost impossible (van Kampen 2004 and O' Kennedy 2005). It seemed initially that subject specialists were not willing to cooperate with other subject specialists from different fields. However as the EUSO has developed integrated tasks such differences seemed to have been overcome or at least less pronounced.

Another aspect contributing to the reluctance to integrate the sciences may be the way the students from the different EU countries are taught Science (Durant, et al., 1989; Miller, et al., 1997). This research has shown that in the early years of many EU secondary education systems, science is integrated or at least the subject is identified as single subject with three parts, while in the senior cycle Biology, Chemistry and Physics are separated and taught as three distinct subjects.

This research has also shown that in many EU countries (the Netherlands and Estonia being exceptions) the students are selected as subject specialists and are trained by subject specialists, play the role of a subject specialist on the team and the mentors also view their role as subject specialists.

The researcher's original intention was that the three Sciences would be integrated and by this he meant that the subject matter of the task would not have any clear dividing lines between Biology, Chemistry and Physics and that the three Sciences would be amalgamated and combined into a single unit. The students working on the task would have to work together as a team to solve whatever problem presented itself. This idea developed from his experience of the Senior

Olympiads where there seemed to be little agreement as to what exactly constituted Biology at the IBO task discussions or Chemistry at the IChO task discussions or Physics at the IPhO task discussions. Allied to this was the plethora of EU reports, research papers and publications encouraging the integration of the Sciences in schools. This led the researcher to the conclusion that an integrated Science Olympiad should be tried.

It had been suggested before the setting up of the EUSO that this kind of integrated task was virtually impossible (van. Kampen 2004). This has not proved to be the case as has been highlighted in Chapter 5. Integrated Science teaching has its supporters, who point to the interlinked nature of Science and to the benefits of teaching integrated Science both for the student and for the teacher. The EUSO has shown that integrated science tasks can be developed and subject loyalty can be set aside.

7.6 Technology

It appears that the use of technology does not play a big part in the education systems of the EUSO participating countries, with the exception of Estonia because of its use of the 'Tiger Leap' programme of 1996-97. In Ireland, IT is on the periphery of the Education system despite many organisations, such as Intel, which developed and education website http://www.skoool.ie/ and Eircom which developed https://secure.eircom.net providing online education content. It is recommended by the researcher that IT plays a more central role in Science education.

7.7 Medal Destination

The most striking finding of the ten year history of the EUSO is the dominance of the gold medal category by the former Soviet Bloc countries. Germany is regarded as a Soviet Bloc country, in this instance, because a majority of its students either live in or attend schools in the former East Germany. The latter, known as the German Democratic Republic (GDR - East Germany), together with the Federal Republic of Germany (FRG - West Germany), were established in 1949. However, following the collapse of communism, in 1989, both Republics were reunited. It was, therefore, as a united country that Germany took part in the 1st EUSO in 2003. During the first five years (2003 – 2007), 36 students represented Germany at the EUSO and of these, 21 (58%) were from the former GDR sector and 15 (42%) were from the former FRG sector. The 5th EU enlargement, in 2004, resulted in the participation of three Soviet Bloc countries (Estonia, Latvia and Slovakia) in the EUSO in 2005, an additional one (Czech Republic) in 2006 and a further two (Lithuania and Slovenia) in 2007.

Germany was awarded 18 (42%) gold medals in this period. The Netherlands won 9 (21%). Even though Estonia, Latvia and Slovakia had only joined and begun to compete in 2005, they each had one team awarded a gold medal (3 students) in that time.

During the next five years (2008 – 2012) three more countries from the former Soviet Bloc joined the EUSO: Bulgaria in 2008, Hungary in 2009 and Romania in 2010. Again, Germany remained the dominant force winning 21 (22%) gold medals in this time. Hungary (2009-2012) had the second highest number, winning 18 (19%), while Estonia was in third place with 15 (16%) gold medals.

The top eight gold medal-winning countries, out of twelve, were former Soviet Bloc countries with only three from early EU members in the gold medal category. In this regard, it is interesting to note that the same former Soviet Bloc countries have been awarded gold medals at the International Biology, Chemistry and Physics Olympiads.

This research has discovered that as the former Soviet Bloc countries join the EU their education systems become more egalitarian and the specialist science schools attract less political support and funding. There is an expectation that in the future countries such as Hungary may not perform as well at the Science Olympiads. This downgrading of the science schools has been resisted in the former East Germany in particular and there has been an increase in such schools in the former West Germany.

7.8 Girls and the EUSO

The first EUSO Constitution drawn up by the researcher proposed that there should be positive discrimination in favour of girls. It did not propose a quota system but simply the *"all teams must have both male and female members"* He proposed this because of his knowledge of the IBO, IChO and IPhO where the representation of females is abysmal. The small numbers of Irish female students taking Chemistry and Physics in the Leaving Certificate was also a factor. This proposal was rejected at the first Governing Body meeting in 2002 and has not been a feature of subsequent Constitutions. It was not the intention of the researcher in this thesis to develop his own critical understanding of gender but rather to present the data on female participation and draw conclusions. By simply presenting the facts, some countries may be encouraged to look at their selection systems and see if they are biased towards males.

The findings in relation to Ireland and the EUSO show, that while girls take part in greater numbers overall and in Biology and in Chemistry in particular, fewer girls take part in the Physics section. (P.21 - this thesis) Boys are over-represented in the allocation of medals and team places and in all three categories. Figures also show that girls are under-represented at the EUSO across all countries and at the International Science Olympiads (P.30 – this thesis). No research has been carried out at the EUSO or other Science Olympiads to see why female students are underrepresented

The reason why, in Ireland, there is such an increase in the uptake of Biology and such a low uptake in Chemistry and Physics at higher level in the Leaving Certificate and why girls, in particular, are dropping Physics in such large numbers has been alluded to in this research and a number of reasons have become obvious. (P.27- this thesis) The dropping of Chemistry and Physics from the timetable in the senior cycle is, in the opinion of the researcher, a significant contributor (ASTI 2012). This seems to be a repeating downward spiral phenomenon. If Chemistry or Physics are taught by teachers who have no qualifications in the subject, students may not choose that subject as one of their Leaving Certificate subjects unless it is a requirement for the university course they wish to pursue. This raises the question of incentivising teachers to qualify in and teach Chemistry and Physics or for increased remuneration for teachers to teach these subjects. In Ireland at least such moves have been resisted by the teacher unions who argue that all subjects are of equal importance and significance in the education of young people and that the level of difficulty in teaching a subject is the same for all subjects. Very few university courses have Chemistry and Physics as a requirement. Without students studying Chemistry and Physics at secondary level, the number of possible entries into Chemistry and

Physics at university must decline; lack of graduates in Chemistry and Physics from university will mean that fewer Chemistry and Physics teachers will be available to teach in secondary schools. The solution, therefore, is not to have students drop Chemistry and Physics after the Junior Certificate. It is recommended by this research that a major international research programme be initiated, to build on existing research findings quoted in this research and try to find out why students in general and girls in particular are dropping Chemistry and Physics in the senior cycle and propose solutions.

Because in Ireland Biology is taught by qualified teachers and some schools are not offering Chemistry or Physics, (ASTI 2012) more and more students are choosing Biology as their 'Science' subject. An applicant's six best results from one sitting of the Leaving Certificate is counted for scoring purposes for entry to university. Most Science-related courses do not require students to have more than one Science subject. There is little incentive, therefore, for a student to choose Chemistry or Physics, unless out of interest or because of the requirement of a specific course. The 'one fits all' Points system is, in the opinion of the researcher, another contributor to the decline in the uptake of Chemistry and Physics. The 'Points Race' for the high status courses also encourages students to offer the subjects that will generate the maximum number of points.

The finding that girls are underrepresented both in medal allocation and team places at the EUSO could be addressed by the Irish and other team leaders. One way may be by not dividing the IrEUSO test into three (Biology, Chemistry, Physics) theory papers. The Junior Certificate result has already identified the top students in a theory paper and this is simply a less accurate repetition. The junior cycle Science course is not an integrated course but three separate subjects and as a contribution to the concept of integration, the

IrEUSO should offer a genuine integrated practical test as offered in the Netherlands. Also more IrEUSO test centres, located in other universities and in Institutes of Technology, should be established, thus engaging more students from areas outside the big cities. In addition, the academics involved would be introduced to integrated Science practicals. Integrating the three Sciences is not an easy option and, as the EUSO has shown, may be resisted by the subject purists and loyalists. It requires a lot of cooperation between the Science teachers and the IrEUSO could be the catalyst to achieve this.

The progressive science education teaching and assessment methods proposed by this research which has been graphically illustrated by Hayes et al (2006) as Productive Pedagogies may improve participation by both genders in science. There are however other influences militating against this such as university entry requirements, shortage of teachers in some science subjects and the content of the courses.

7.9 Recommendations

7.9.1 Integrated Science Curriculum

This research has highlighted the possibility of a new concept in Science Education: - a multidisciplinary, integrated, Science, practical-based, team curriculum. The twenty tasks about to be published in 2013 - 2014 could be a starting point for such a curriculum but these experiments should not be seen as an exhaustive list. The science topics which may be deemed essential for a school science curriculum could be analysed and re-moulded to satisfy the

Intellectual Quality, Connectedness, Supportive Classroom Environment and Working with and Valuing Difference (Hayes et al 2006) as illustrated by the EUSO Tasks

The work of pathologists and scientists has been popularised through TV programmes such as 'Crime Scene Investigates (CSI)'. This idea was used at EUSO 2006 in Brussels and at EUSO 2010 in Gothenburg. By giving the students 'clues and evidence' they were required to use all their scientific skills and knowledge to solve the 'Who-dun-it'. The writing up of the report should challenge the students' creative and descriptive writing ability, thus giving students a greater interest in involvement in Science. Such creative writing is lacking in many science examination systems.

Water, the theme at EUSO 2005 in Galway and at EUSO 2010 in Gothenburg, has unlimited possibilities for study at some depth and breadth, from density, viscosity, humidity, surface tension, salinity, balance, hardness, bacterial and chemical pollutant levels and source, to effects of temperature and physiology of aquatic life. The study of and impact of climate change is an important topic in the lives of a students and make science relevant and part of the real world beyond the classroom. Inventions in common use today such as the contact lens, the subject of EUSO 2011 in Pardubice, offer unlimited possibilities, as does food (EUSO 2009), beer (EUSO 2011) or the potato (EUSO 2007).

7.9.2 Advanced Science Programmes

The idea of Specialists Science Schools or classes runs contrary to the researcher's views on equality and his preference for a broad education. Nevertheless the Irish education system is currently being examined and change is inevitable. The present "One Fits All" system, where entry to all third level courses is based on a common point system applied to six subjects may be about to change. Fewer subjects, studied at a higher level may be the outcome leading to the concept of specialist subject schools. His belief is that an integrated science curriculum, an analysis and fine tuning of the content of current science programmes and the promotion of progressive pedagogies, assessment and performance could improve the participation rate and performance of students generally. This research and the existence of 20 “Rich Content Tasks” could point towards a possible Science curriculum in such schools. In such advanced courses science could be divided into themes, topics, or issues, each one integrated a regular recommendation of the EU commission. These sections may be interdisciplinary with Biology, Chemistry and Physics sections not clearly identified. The interest of students in certain aspects of Science could also influence the content of the programme.

The teachers would be required to be qualified, not only in the content of the subject but also in productive pedagogies, assessment and performance, to teach the themes or topics. Because of the shortage of Science teachers throughout the EU generally, a new system of employing teachers would need to be developed. The teachers in the advanced classes may need to be employed in more than one school. This would involve cooperation between the schools, the universities, the Science industry and, in particular, the teacher unions (ASTI and TUI).

These classes could have access to fully equipped laboratories in school or at the local university or third level Institution/College Science laboratories; technical and teaching staff could also be made available at certain times to these students as in Estonia and the Netherlands. The Science industry could have teaching facilities on its premises to which it would invite the advanced class where they may experience real world science experiments and meet real scientists. This research has shown that Science teachers and career guidance counsellors may have no experience of the life and work of scientists and therefore may not enthuse students about Science or show the career enhancing possibilities of a Science qualification.

Ireland has experienced a sharp decline in the uptake of higher level Chemistry and/or Physics in the senior cycle with only 10% or less of the student cohort taking the subjects. The reasons already referred to include lack of qualified teachers and the dropping of the subjects from some school timetables.

7.9.3 The Future of Olympiad Participation

If participation by Ireland at the International Science Olympiads is to continue and if a realistic chance of winning silver or gold medals is to be a probability, the system developed in the Netherlands may offers a possible solution, that is, assuming that compatible factor exist between Ireland the Netherlands.

All the universities and third level Institutes of Technology could become Olympiad hubs, thus providing a series of local centres. They could provide advanced training programmes, as developed for the Irish Mathematics Olympiad for the high achievers in Mathematics in the Junior Certificate examination, a round one test and a final test in one of the universities. This could have the immediate effect of increasing the number of Irish students benefiting from an advanced programme in Biology, Chemistry and Physics. This approach in the Netherlands has resulted in a seven-fold increase in the participation rate in the Olympiads over a fifteen year period, with more and more teachers and schools becoming introduced to integrated Science Practical.

The success of the Netherlands and of Estonia in the EUSO may be because of their use of an integrated practical Science test and not a single subject theory paper as in Ireland. It is recommended that Ireland should use a similar integrated test. This could only be done with limited numbers of students, so it is important that early rounds involving more students are held in the universities and Institutions of Technology. Integrated Science needs to be seen to work in practice.

The Netherlands also began with the concept that school teams of three and not three individuals should compete in the EUSO preliminary rounds. This has the effect that the school team and not a collection of individuals take part in the EUSO. The school, therefore, has a vested interest in preparing the team for the event. It is recommended that a combination of a team and individual students represent Ireland at the EUSO. The SEC would identify the top 300 students in the Junior Certificate in a specified range of subjects, so that the selection process is seen to be open and transparent. Any schools with three students in this group would be invited to send the team of three to the local EUSO Test Centre. This would result in the best team being selected to represent Ireland. A second round of tests would be held for the individual candidates, including the team members who were unsuccessful and the top three students selected and formed into the second team. It is also recommended that “school teams” should form a category, thus introducing team work into the schools.

Students entering secondary schools in Ireland and across the EU (Jovanovic and King, 1998) have a positive attitude to Science, as illustrated by the uptake of Science in the junior cycle, including at higher level and elsewhere across the EU this positive attitude is also present. However, it decreases as students progress through the school system and proceed to drop certain Science subjects. This research has shown that by using preference ranking, interest inventories and subject enrolment data Physics and Chemistry are seen to be two of the least popular subjects among 14 year old students. In Ireland, Biology has become the subject of choice in the Leaving Certificate for a number of reasons. This research also shows that across the EU boys have a consistently more positive attitude to school Science than girls and that the effect is stronger in Physics than in Biology, is not borne out in Ireland. The number of Irish boys taking Biology has doubled over the past ten years. This has led the researcher to conclude that the availability of good Biology teachers, the absence of Chemistry and Physics teachers and the cancellation of Chemistry and Physics from time-tables, have forced boys to take the best or sometimes the only option open to them. It has little to do with attitude towards a subject or with the perception of its difficulty. Attitude towards a subject is fickle and given that the attitude towards Biology of Irish boys has radically altered over the past ten years, attitudes towards Chemistry and Physics could be changed just as easily. This researcher is of the opinion that the bewildering array of subject and career choices, many of which are new, is a contributory factor. EUSO team leaders from the former Soviet Bloc countries have confirmed that as the increase in the number of non-Science subjects and career options becomes available to their students, they are moving away from Science. ROSE (2003-2005) has interpreted the negative attitude to Science as a feature that is systemic to the nature of advanced societies.

This research has shown that girls, including those with exceptional ability, choose not to pursue further study in Science or careers in Physical Science and engineering in many EU countries. In EU secondary schools, the male to female ratio of students taking the Sciences is, Biology 1.6, Chemistry 1: 1 and Physics 3.4: 1. In Ireland the male/female ratio is Biology 1: 1.7, Chemistry 1: 1.3 and Physics 2.6: 1. It is recommended that the number of Chemistry and Physics teachers be increased.

7.10 Conclusions

This research began with a question,

> *Can a Science competition be developed, organised, maintained and monitored over an extended period of time by the researcher, which will appeal to EU governments, universities, mentors and EU students, particularly girls, which will develop team Science Tasks that integrate the Sciences, are problem-based and connected to the real world, involve the construction of knowledge, higher–order thinking, alternative solutions, depth of knowledge and sophisticated communication between the team members and contribute to stemming the tide of decline in interest in school Science across the EU ?*

A Science competition was developed and organised which did appeal to EU mentors and students. Twenty three EU countries have taken part usually with two teams of three students. Three countries have sent observers and only one EU country has not taken part to-date. A total of 906 students have taken part.

Ten countries have hosted delegations of students and mentors in a university city for a week and five more have plans to do likewise over the next five years.

Fourteen countries were represented by more girls than boys which is unique at international Olympiads. In Ireland more girls take part in the preliminary rounds than boys. No country has participated with boys only.

In all participating countries thousands of students have taken part in the preliminary rounds and in Luxembourg in 2013, the 1,000th EUSO student will be identified.

University staff and teachers have developed twenty substantial practical context-based, multidisciplinary or integrated tasks for students of fifteen years of age and over. These tasks will be available for use in schools.

The EUSO developed twenty context-based, multidisciplinary, integrated, experimental Science team tasks. These may contribute to curriculum development in the future

Did it stem the tide of decline in interest in school Science across the EU? It may be too soon to answer that question but it did show that there is interest in participation in an integrated Science competition.

The answer to the question research question is, YES!

7.11 Areas for Future Research

The EUSO has carried out little research. It is proposed that a research unit be established in 2013 which would coordinate and encourage research into aspects of the EUSO.

Among the research questions which might be asked are:

- Why countries have volunteered to host the EUSO in the past and why countries would wish to do in the future.
- Why countries participate in the EUSO
- How the student/team selection process works in different countries
- If during the EUSO the students operate as teams or as individuals and the impact on their ranking.
- If participation in the EUSO has a positive or negative impact in participants
- If students progress from the EUSO to the Senior Olympiad teams and if participation the EUSO has been beneficial.
- What impact if any taking part in the EUSO has on the mentors.
- If the tasks are in conformity with the aims of the EUSO

Bibliography

Aguiar, O., Mortimer, E.F. and Scott, P. (2010) 'Learning from and responding to students' questions'. *Journal of Research in Science Teaching*, 47 (2): 174-193.

Aikenhead, G.S. (2005) 'Research into STS Science Education'. *Educación Química*, 16 (3): 384-397.

Altricher, H., Posch, P. and Somekh, B. (1993) *Teachers Investigate their Work: An Introduction to the Methods of Action Research*. London: Routledge.

Anderson, C. (2007) 'Perspectives on Science Learning'. In: Abell, S. and Lederman, N. eds. *Handbook of Research on Science Education*. NJ: Lawrence Erlbaum Associates, Inc.

Angier, N. (2007) *The Canon: A Whirligig Tour of the Beautiful Basics* of *Science*. Boston, MA: Houghton Mifflin Company.

Appleton, K. (2007) 'Elementary Science Teaching'. In: Abell, S. and Lederman, N. eds. *Handbook of Research on Science Education*. NJ: Lawrence Erlbaum Associates, Inc.

Archer, J. (1992) 'Gender stereotyping of school subjects'. *The Psychologist*, 5: 66–69.

Asksey, H. and Knight, P. (1999) *Interviewing for Social Scientists.* London: Sage.

ASTI (2010). Junior Cycle Science Survey. Available at: http://www.asti.ie/ (Accessed 10 June 2011)

ASTI (2012). Second Level Principals Survey. Available at: http://www.asti.ie/ (Accessed 5 April 2012)

Atkin, J.M. (1998) 'The OECD study of innovations in science, mathematics and technology education'. *Journal of Curriculum Studies*, 30 (6): 647-660.

Baker, D. and Leary, R. (1995) 'Letting girls speak out about science'. *Journal of Research in Science Teaching*, 32 (1): 3–27.

Baker, D. and LeTendre, G.K. (2005) *National differences, global similarities: world culture and the future of schooling.* Stanford, CA: Stanford Social Sciences.

Ballstaedt, S. (1995) *Interdisziplinäres Lernen: Aspekte des fächerverbindenden Unterrichts [Interdisciplinary learning: Aspects of subject-integrative courses].* Tübingen: DIFF.

Baram-Tsabari, A. and Yarden, A. (2008) 'Girls' Biology, boys' Physics: evidence from free-choice Science learning settings'. *Research in Science & Technological Education*, 26 (1): 75-92.

Bargal, D. (1992) *Action Research, A Paradigm for Achieving Social Change.* California: Thousand Oaks Inc.

Bargal. D., Gold, M. and Lewein, M. (1992) 'The Heritage of Kurt Lewin – Introduction'. *Journal of Social Issues*, 48 (2): 3–13.

Beaton, A.E., Martin, M.O., Mullis, I.V.S., Gonzales, E.J., Smith, T.A. and Kelly, D.L. (1996) *Science Achievement in the Middle School Years: IEA's TIMSS*. Chestnut Hill, MA: Boston College.

Becker, B.J. (1989) 'Gender and science achievement: a re analysis of studies from two meta-analyses'. *Journal of Research in Science Teaching*, 26: 141-169.

Bell, L., Smetana L. and Binns, I. (2005) 'Simplifying inquiry instruction: assessing the inquiry level of classroom activities'. *Science Teacher*, 72 (7): 30-33.

Bennett, J., Lubben, F. and Hogarth, S. (2007) 'Bringing Science to Life: A Synthesis of the Research Evidence on the Effects of Context-Based and STS Approaches to Science Teaching'. *Science Education*, 91 (3): 347-370.

Bergin, D.A. (1999) 'Influences on classroom interest'. *Educational Psychologist*, 34: 87–98.

Bevins, S., Brodie, M. and Brodie, E. (2005) *A study of UK secondary school students' perceptions of science and engineering*. Available at: http://shura.shu.ac.uk/956/1/fulltext.pdf (Accessed 5 November 2007)

Breakwell, G.M. and Beardsell, S. (1992) 'Gender, parental and peer influences upon science attitudes and activities'. *Public Understanding of Science,* 1 (2): 183–197.

Breen, R. and Jonsson, J.O. (2005) ‘Inequality of Opportunity in Comparative Perspective: Recent Research on Educational attainment and Social Mobility’. *Annual Review of Sociology,* 31: 223-43.

Brickman, P., Gormally, C., Armstrong, N. and Hallar, B. (2009) ‘Effects of Inquiry-based Learning on Students' Science Literacy Skills and Confidence’. *International Journal for the Scholarship of Teaching and Learning*, 3 (2): 1-22.

Brotman, J.S., Moore, F.M. (2008) ‘Girls and Science : A Review of Four Themes in the Science Education Literature’. *Journal of Research in Science Teaching*, 45 (9): 971-1002.

Bryman, A. (1998) *Quantity and Quality in Social Research.* London: Routledge.

Burke, M. (2003) *The Development and Organisation of the First*

Cameron, A., Macdonald, G., Turner, W. and Lloyd, L. (2007) ‘The challenges of joint working: lessons from the Supporting People Health pilot evaluation’. *International Journal of Integrated Care.* Available from: http://www.ijic.org. (Accessed 15 June 2009)

Carr, W. and Kemmis, S. (1986) *Becoming Critical: Education, Knowledge, and Action Research.* Philadelphia: Falmer Press.

Central Statistics Office. Available at: http://www.cso.ie/en/index.html (Accessed 15 March 2012)

Cheng, Y., Payne, J. and Witherspoon, S. (1995) *Science and Mathematics in full-time education after 16: England and Wales Youth Cohort Study.* London: Department for Education and Employment.

Cleaves, A. (2005) ‘The formation of Science choices in secondary school’. *International Journal of Science Education*, 27 (4): 471-486.

Coghlan, D. and Brann, T. (2005) *Doing action research in your own organization.* 2nd ed. London: Sage Publications.

Colley, A., Comber, C. and Hargreaves, D. (1994) ‘School subject preference of pupils in single sex and co-educational secondary schools’. *Educational Studies*, 20: 379-386.

Conway, P., Murphy, R., Rath, A. and Hall, K. (2009) *Learning to Teach.* Available at: http://www.teachingcouncil.ie/ (Accessed 21 June 2010)

Cooper, P. and McIntyre, D. (1996) *Effective Teaching and Learning: Teachers' and Students' Perspectives*. Buckingham: Open University Press.

Corbetta, P. (2003) *Social Research Methods, Theory, Methods and Yechniques.* London: Sage.

Corey, S.M. (1953) *Action Research to Improve School Practice*. New York: Teachers College Press.

Cunningham, J. (1993) *Action research and organisational development*. Westport, CT: Praeger.

Czerniak, C.M. (2007) 'Interdisciplinary science teaching'. In: Abell, S. and Lederman, N.G. eds. *Handbook of research on science education*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Dearing, R. (1996) *Review of Qualifications for 16–19 year olds.* London: Schools Curriculum and Assessment Authority.

Denzin, N. and Lincon, Y. (Eds.). (2003) *Strategies of Qualitative Inquiry.* London: Sage.

Department of Education and Skills. Available at: http://www.education.ie/ (Accessed 25 February 2012)

Dewey, J. (1916) *Democracy and Education*. Whitefish, MT: Kessinger Publishing.

Dewey, J. (1938) *Experience and Education*. New York: Collier MacMillan Publishing Company.

Dillon, J. and Osborne, J. (2008) *Science Education in Europe: Critical Reflections*. London: The Nuffield Foundation. Available at:

Dillon, J., Osborne, J., Fairbrother, R. and Kurina, L. (2000) *A study into the professional views and needs of science teachers in primary & secondary schools in England*. London: King's College.

Doherty, J. and Dawe, J. (1988) 'The relationship between development, maturity and attitude to school science'. *Educational Studies*, 11: 93–107.

Durant, J.R., Evans, G.A. and Thomas, G.P. (1989) 'The public understanding of science'. *Nature*, 340: 11–14.

EACEA/Eurydice (2010) *Gender Differences in Educational Outcomes: Study on the Measures Taken and the Current Situation in Europe.* Brussels: EACEA/Eurydice.

EACEA/Eurydice, Eurostat (2009) *Key Data on Education in Europe 2009*. Brussels: Eurydice.

Ebbutt, D. (1985) 'Educational Action research: some general concerns and specific quibbles'. In: Burgess, R. ed. *Issues in Educational Research: qualitative methods.* Lewes: Falmer.

Ebenezer, J.V. and Zoller, U. (1993) 'Grade 10 Students' Perceptions of and Attitudes toward Science Teaching and School Science'. *Journal of Research in Science Teaching*, 30 (2): 175–186.

Eccles, J.S. (1987) 'Gender roles and women's achievement related decisions'. *Psychology of Women Quarterly*, 11: 135–171.

Elliott, J. (1991) *Action research for educational change.* Milton Keynes: Open University Press.

Elwood, J. and Comber, C. (1995) 'Gender differences in 'A' level examination: the reinforcement of stereotypes'*. A New ERA? New contexts for gender equality*. BERA Conference, 11–13 September.

Epstein, J.L. and McPartland, J.M. (1976) 'The concept and measurement of the quality of school life'. *American Educational Research Journal*, 13: 15–30.

Erickson, G. and Erickson, L. (1984) 'Females and Science achievement: evidence, explanations and implications'. *Science Education*, 68: 63–89.

ESTABLISH. Available at: http://www.establish-fp7.eu/ (Accessed 18 September 2011)

European Commission. (2002) *The Helsinki Group on Women in Science: National Policies on Women and Science in Europe.* Brussels: European Commission.

European Commission. (2004) *Europe needs More Scientists: Report by the High Level Group on Increasing Human Resources for Science and Technology*. Brussels: European Commission.

European Commission. (2005) *Europeans, Science and Technology*. Brussels: European Commission .

European Commission. (2007) *Science Education Now: A Renewed Pedagogy for the Future of Europe*. Brussels: European Commission.

European Commission. (2012) *Developing Key Competences at school in Europe*: *Challenges and Opportunities for Policy.* Luxembourg: Publications Office of the European Union.
European Union Science Olympiad (EUSO). Unpublished MSc

Eurydice. (2006) *Science teaching in schools in Europe*. Brussels: Eurydice.

Eurydice. (2011) *Science Education in Europe: National Policies, Practices and Research*. Brussels: Eurydice.

Ewbank, T. (1849) *Report to the US Congress*. Available at:

Ferrance, E. (2000) *Themes in Education: Action Research, The Education Alliance*. Providence, Rhode Island: Brown University.

Fielding, H. (1998) *The Undesirable Choices?* Unpublished undergraduate thesis. Kings College, London.

Formin, D. and Kirichenko, A. (1994) *Leningrad Mathematical Olympiads 1987-1991*. Available at: www.MathProPress.com (Accessed 12 August 2009)

Furlong, A. and Biggart, A. (1999) 'Framing 'Choices': a longitudinal study of occupational aspirations among 13- to 16-year-olds'. *Journal of Education and Work*, 12 (1): 21-35.

Gago, J.M. (2004) *Europe Needs More Scientists*. Brussels: European Commission.

Gaisce - The President's Award. Available at: http://www.gaisce.ie/ (Accessed 10 February 2009)

Gaventa, J. and Cornwall, A. (2001) 'Power and Knowledge'. In: Reason, P. and Bradbury, H. eds. *Handbook of action research: the concise paperback edition.* London: Sage.

George, R. (2006) 'A Cross-domain Analysis of Change in Students' Attitudes toward Science and Attitudes about the Utility of Science'. *International Journal of Science Education,* 28 (6): 571-589.

Geraedts, C., Boersma, K.T. and Eijkelhof, H.M.C. (2006) 'Towards coherent science and technology education'. *Journal of Curriculum Studies*, 38 (3): 307-325.

Gilbert, J. and Calvert, S. (2003) ‘Challenging accepted wisdom: looking at the gender and science education question through a different lens’. *International Journal of Science Education*, 25 (7): 861-878.

Gilbert, J.K. (2006) ‘On the Nature of 'Context' in Chemical Education’. *International Journal of Science Education*, 28 (9): 957-976.

Gray, D. (2006) *Doing research in the real world.* London: SAGE Group.

Hadden, R.A. and Johnstone, A.H. (1983) ‘Secondary school pupils’ attitudes to science: the year of erosion’. *European Journal of Science Education*, 5: 309–318.

Haladyna, T., Olsen, R. and Shaughnessy, J. (1982) ‘Relations of student, teacher, and learning environment variables to attitudes to science’. *Science Education*, 66 (5): 671–687.

Harding, J. (1983) *Switched Off: The Science Education of Girls.* New York: Longman.

Harding, S. (1991) *Whose Science? Whose Knowledge?* Ithaca, NY: Cornell University Press.

Harlen, W. (2009) ‘Teaching and learning science for a better future. The Presidential Address 2009 delivered to the Association for Science Education Annual Conference’. *School Science Review*, 333: 33-41.

Harlen, W. and James, M. (1997) ‘Assessment and Learning’. *Assessment in Education*, 4 (3): 365-379.

Haskell, J. and Martin, C. (1994) *Will Skill Shortages End the Recovery?* London: Department of Economics, Queen Mary College.

Haste, H. (2004) *Science in My Future: A study of the values and beliefs in relation to science and technology amongst 11-21 year olds*. London: Nestlé Social Research Programme.

Haussler, P. and Hoffmann, L. (2002) ‘An Intervention Study to Enhance Girls' Interest, Self-Concept, and Achievement in Physics Classes’. *Journal of Research in Science Teaching*, 39 (9): 870-888.

Havard, N. (1996) ‘Student Attitudes to Studying A-level Sciences’. *Public Understanding of Science,* 5 (4): 321–330.

Haworth, C.M.A., Dale, P. and Plomin, R. (2007) ‘A Twin Study into Genetics’. *Child Development,* 80 (3): 662–673.

Hayes, D., Mills, M., Christie, P. and Lingard, B. (2006). *Teachers and Schooling*. Sydney: Allen and Unwin.

Head, J. (1985) *The Personal Response to Science.* Cambridge: Cambridge University Press.

Hendley, D., Parkinson, J., Stables, A. and Tanner, H. (1995) ‘Gender Differences in Pupil Attitudes to the National Curriculum Foundation Subjects of English, Mathematics, Science and Technology in Key Stage 3 in South Wales’. *Educational Studies*, 21 (1): 85–97.

Her Majesty’s Government (1993) *Realising our Potential: a strategy for science, engineering and technology.* London: HMSO.

Hmelo-Silver, C.E. (2004) ‘Problem-Based Learning: What and How do Students Learn’. *Educational Psychology Review,* 16 (3): 235-266.

Holtom, M. (2001) ‘The partnership imperative: joint working between social services and health’. *Joint Management in Medicine*, 15 (6): 430–45.

IJSO - International Junior Science Olympiad. Available at: http://ijso-official.org (Accessed 16 May 2008)

IPN (German Research Institute). Available at: http://www.ipn.uni-kiel.de/ (Accessed 24 September 2009)

Irwin, A.R. (2000) ‘Historical Case Studies: Teaching the Nature of Science in Context’. *Science Education*, 84 (1): 5-26.

James, E., Eijkhelhof, H., Gaskell, J., Olson, J., Raizen, S. and Saez, M. (1997) ‘Innovations in science, mathematics and technology education’. *Journal of Curriculum Studies*, 29 (4): 471-484.

Jenkins, E. and Nelson, N.W. (2005) ‘Important but not for me: students' attitudes toward secondary school Science in England’. *Research in Science & Technological Education*, 23: 41-57.

Jenkins, E.W. (1994) ‘Public Understanding of Science and Science Education for Action’. *Journal of Curriculum Studies*, 26 (6): 601–612.

Johnson, C. (2010) 'Making the Case for School-based Systemic Reform in Science Education'. *Journal of Science Teacher Education*, 21 (3): 279-282.

Johnson, C., Kahle, J., Fargo, J. (2007) 'A study of the effect of sustained, whole-school professional development on student achievement in Science'. *Journal of Research in Science Teaching*, 44: 775-786.

Johnson, S. (1987) 'Gender Differences in Science: parallels in interest, experience and performance'. *International Journal of Science Education*, 9 (4): 467–481.

Jones, G. and Howe, A. (2000) 'Gender Differences in Students' Experiences, Interests, and Attitudes towards Science and Scientists'. *Science Education,* 84: 180-192.

Jones, G., Howe, A. and Rua, M. (2000) 'Gender Differences in Students' Experiences, Interests, and Attitudes towards Science and Scientists'. *Science Education*, 84: 180-192.

Jovanovic, J. and King, S.S. (1998) 'Boys and girls in the performance-based science classroom: who's doing the performing?' *American Educational Research Journal*, 35 (3): 477–496.

Joyce, B. and Showers, B. (2002) *Student Achievement Through Staff Development*. White Plains, NY: Longman.

Kahle, J.B. and Lakes, M.K. (1983) 'The myth of equality in Science classrooms'. *Journal of Research in Science Teaching*, 20: 131–140.

Keller, E.F. (1985) *Reflections on Gender and Science.* New Haven, CT: Yale University Press.

Kemmis, S. and McTaggart, R. (1982) *The Action Research Planner*. Victoria, Deakin University Press.

Kemmis, S. and McTaggart, R. (2000) 'Participatory Action Research'. In: Denzin, N. and Lincon, Y. eds. *Handbook of Qualitative Research.* 2nd ed. Thousand Oaks, CA: Sage.

Kemmis, S. and McTaggart, R. (2003) 'Participatory Action Research'. In: Denzin, N. and Lincon, Y. eds. *Strategies of Qualitative Inquiry.* London: Sage.

Klafki, W. (1973) ‘Handlungsforschung im Schulfeld’. *Zeitschrift für Pädagogik,* 19 (4): 487-516.

Kose, S., Sahin, A., Ergu, A. and Gezer, K. (2010) ‘The effects of cooperative learning experience on eighth grade students’ achievement and attitude toward science’. *Education,* 131 (1): 169–180.

Krogh, L.B. and Thomsen, P.V. (2005) ‘Studying students’ attitudes towards science from a cultural perspective but with a quantitative methodology: border crossing into the physics classroom’. *International Journal of Science Education*, 27 (3): 281-302.

Lather, P. (1986) ‘Research as Praxis’. *Harvard Educational Review,* 56 (3): 157-277.

Lavonen, J., Gedrovics, J., Byman, R., Meisalo, V., Juuti, K. and Uitto, A. (2008) ‘Students' motivational orientations and career choice in science and technology: A survey in Finland and Latvia’. *Journal of Baltic Science Education*, 7 (2): 86-103.

Lebak, K. and Tinsley, R. (2010) ‘Can Inquiry and Reflection be Contagious? Science Teachers, Students, and Action Research’. *Journal of Science Teacher Education*, 21 (8): 953-970.

Lederman, N.G. (1992) ‘Students' and teachers' conceptions of the nature of science: A review of the research’. *Journal of Research in Science Teaching*, 29: 331-359.

Lederman, N.G. and Niess, M.L. (1997) ‘Integrated, interdisciplinary, or thematic instruction? Is this a question or is it questionable semantics?’ *School Science and Mathematics,* 97 (2): 57-58.

Lepkowska, D. (1996) The non-appliance of science. *Evening Standard*, 3 September, p. 33–34.

Levin, D. and Greenwood, M. (2006) *Introduction to Action Research: Social Research for Social Change.* CA, USA: Sage Publications.

Lewin, K. (1946) ‘Action Research and Minority Problems’. *Journal of Social Issues*, 2 (4): 34-36.

Lightbody, P. and Durndell, A. (1996b) ‘The Masculine Image of Careers in Science and Technology – Fact or Fantasy’. *British Journal of Educational Psychology*, 66 (2): 231–246.

Lin, E. (2006) ‘Cooperative Learning in the Science Classroom’. *The Science Teacher,* 73(5): 34-39.

Lingard, B. and Ladwig, J. (Co-Directors) (2001) *"Queensland School Reform Longitudinal Study* (QSRLS 2001). Unpublished.

Linn, M.C., Eylon, B.S. and Davis, E.A. (2004) 'The knowledge integration perspective on learning'. In: Linn, M.C., Davis, E.A. and Bell, P. eds. *Internet environments for Science education.* Mahwah, NJ: Lawrence Erlbaum.

Loucks-Horsley, S., Hewson, P., Love, N. and Stiles, K.E. (1998) *Designing Professional Development for Teachers of Science and Mathematics.* Thousand Oaks, CA: Corwin Press.

Lucey, B. (2012) Brian Lucey Blog. Available at: http://brianmlucey.wordpress.com/ (Accessed 24 May 2012)

Lyons, T. (2006) 'Different Countries, Same Science Classes: Students experiences of school science in their own words'. *International Journal of Science Education*, 28 (6): 591–613.

Martin, M.O. and Mullis, I.V.S. (2000) *TIMSS 1999 International Science Report: Findings from IEA's Repeat of the Third International Mathematics and Science Study at the eighth grade*. Chestnut Hill, MA: Boston College. Tokyo: National Institute for Educational Research.

Martin, M.O., Mullis, I.V.S. and Foy, P. (2008) *TIMSS 2007 International Science Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades.* Chestnut Hill, MA: Boston College.

Maslin-Prothero, S. and Bennion, A. (2010) 'Integrated team working'. *British Journal of Cardiac Nursing,* 1 (6): 294-304.

Matthews, P. (2007) *The Relevance of Science Education in Ireland*. Dublin: Royal Irish Academy.

Matthews, P.S.C. and McKenna, P.J. (2005) 'Assessment of practical work in Ireland: A critique'. *International Journal of Science Education*, 27(10): 1211-1224.

McFarland, K.P. and Stansell, J.C. (1993) 'Historical Perspectives'. In: Patterson, L., Santa, C.M., Short, C.G. and Smith, K. eds. T*eachers are Researchers: Reflection and Action.* Newark, DE: International Reading Association.

McKernan, J. (1991) *Curriculum Action Research: a handbook of methods and resources for the reflective practitioner.* London: Kogan Page.

McNiff, J. (1988) *Action Research: Principles and Practice*. London: Routledge.

McNiff, J. (2000) *Action Research in Organisations.* London: Routledge.

McNiff, J. and Whitehead, J. (2002) *Action Research: Principles and Practice.* London: Routledge.

McNiff, J., McNamara, G. and Leonard, D. (Eds.). (2000) *Action Research in Ireland*. Dorset: September Books.

McTaggart, R. (1997) 'Guiding principals for participatory action research'. In: McTaggart, R. ed. *Participatory Action Research.* Albany, NY: State University of New York Press.

Millar, R. (1996) 'Toward a Science Curriculum for Public Understanding'. *School Science Review,* 77: 7-18.

Millar, R. and Osborne, J. (Eds.). (1998) *Beyond 2000: Science Education for the Future.* London: King's College, School of Education.

Millar, R. and Osborne, J. (Eds.). (1998) *Beyond 2000: Science education for the future.* London: King's College.

Miller, J.D., Pardo, R. and Niwa, F. (1997) *Public Perceptions of Science and Technology: A Comparative Study of the European Union, the United States, Japan, and Canada.* Bilbao: BBV Foundation.

Minner, D., Levy, A. and Century, J. (2009) 'Inquiry-Based Science Instruction – What is it and does it matter? Results from a Research Synthesis Years 1984 to 2002'. *Journal of Research in Science Teaching*, 47 (4): 474-496.

Moser, H. (1975) *Aktionsforschung als kritische Theorie der Sozialwissenschaften.* München: Kösel Verlag.

Mumford, E. (2001) 'Advice for an Action Researcher'. *Information Technology and People,* 14 (1): 12-27.

Munro, M. and Elsom, D. (2000) *Choosing Science at 16: The Influences of Science Teachers and Careers Advisors on Students' Decisions about Science Subjects and Science and Technology Careers*. Cambridge: Careers Research and Advisory Centre.

Murphy, C. and Beggs, J. (2001) ‘Pupils’ attitudes, perceptions and understanding of primary science: comparisons between Northern Irish and English Schools’. *Annual Meeting of the British Educational Research Association.* Leeds, 14–16 September.

Murphy, C. and Beggs, J. (2003) ‘Children’s attitudes towards school Science’. *School Science Review*, 84: 109-116.

Murphy, P. and Whitelegg, E. (2006) ‘Girls and physics: continuing barriers to belonging'. *The Curriculum Journal*, 17(3): 281-305.

Murphy, P. and Whitelegg, E. (2006) *Girls in the Physics Classroom: A Review of Research of Participation of Girls in Physics*. London: Institute of Physics.

National Commission on Mathematics and Science Teaching for the 21st Century. 2000. *Before It’s Too Late.* Washington, DC: US Department of Education.

Noffke, S. (1994) 'Action research: towards the next generation’. *Educational Action Research*, 2 (1): 9–21.

Noffke, S.E. and Stevenson, R. (Eds.). (1995) *Educational Action Research: Becoming Practically Critical.* New York, TY: Teachers College Press.

Nottingham Skills and Enterprise Network. (1992) *Skills and Enterprise Briefing.* Nottingham: University of Nottingham.

O’ Hare, D. (2002) *Task Force on the Physical Sciences*. Available at:

O’Brien, R. (2001) *An Overview of the Methodological Approach of Action Research.* Available at: http://www.web.ca/robrien/papers/arfinal.html (Accessed 15 October 2005)

O’Leary, J. (2001) Pay teachers or face meltdown. *Times*, 29 March, p.8.

OECD. (2006) *Evolution of Student Interest in Science and Technology Studies Policy Report*. Paris: OECD.

OECD. (2007a) *PISA 2006: Science competencies for tomorrow's world. Volume 1: Analysis*. Paris: OECD.

OECD. (2007b) *PISA 2006: Science Competencies for Tomorrow’s World*. *Executive Summary*. Paris: OECD.

OECD. (2009b) *PISA 2009: Assessment Framework – Key Competencies in Reading, Mathematics and Science.* Paris: OECD.

OECD. (2010a) *PISA 2009: Results: What Students Know and Can Do – Student Performance in Reading, Mathematics and Science (Volume I).* Paris: OECD.

Ogura, Y. (2006) 'Graph of Student Attitude v Student Attainment'. Based on data from: Martin, M.O. and Mullis, I.V.S. (2000) *TIMSS 1999 International Science Report: Findings from IEA's Repeat of the Third International Mathematics and Science Study at the eighth grade*. Chestnut Hill, MA: Boston College. Tokyo: National Institute for Educational Research.

O'Kennedy, R., Burke, M., van Kampen, P., James, P., Cotter, M.A., Browne, W.R., O' Fagain, C. and McGlynn, E. (2005) 'The First EU Science Olympiad (EUSO): a Model for Science Education'. *Journal of Biological Education*, 39 (2): 39-61.

Oliver, J.S. and Simpson, R.D. (1988) 'Influences of attitude toward science, achievement motivation, and science self concept on achievement in science: A longitudinal study'. *Science Education*, 72 (2): 143–155.

Oliver, M. and Venville, G. (2011) 'An Exploratory Case Study of Olympiad Students' Attitudes towards and Passion for Science'. *International Journal of Science Education,* 33 (16): 2295-2322.

Ormerod, M.B. and Duckworth, D. (1975) *Pupils' Attitudes to Science.* Slough: NFER.

Osborne, J. and Dillon, J. (2008) *Science Education in Europe: Critical Reflections*. London: The Nuffield Foundation.

Osborne, J. and Simon, S. (1996) 'Primary Science: Past and Future Directions'. *Studies in Science Education*, 27: 99–147.

Osborne, J., Simon, S. and Collins, S. (2003) 'Attitudes towards Science: a review of the literature and its implications'. *International Journal of Science Education*, 25 (9): 1049-1079.

Osborne, J.F. and Collins, S. (2000) *Pupils' and Parents' Views of the School Science Curriculum.* London: King's College.

Pell, T. and Jarvis, T. (2001) 'Developing attitude to science scales for use with children of ages from five to eleven years'. *International Journal of Science Education*, 23 (8): 847–862.

Phanis, C. (2012) ‘Towards a New Biology Education for Future Scientists’. *SMEC Conference*. Dublin City University. Unpublished.

Reason, P. and Bradbury, H. (2006) *Handbook of action research: the concise paperback edition.* London: Sage.

Reason, P. and Rowan, J. (Eds.). (1981) *Human Inquiry: a Sourcebook of New Paradigm Research*. Chichester: Wiley.

Riquarts, K. and Hansen, H.K. (1998) ‘Collaboration among teachers, researchers and in-service trainers to develop an integrated science curriculum’. *Journal of Curriculum Studies*, 30 (6): 661-676.

Roberts, G. (2002) *SET for Success: The supply of people with science, technology, engineering and mathematics skills.* Available at: http://www.hm-treasury.gov.uk/d/robertsreview_introch1.pdf. (Accessed 20 October 2007)

Robertson, I.J. (1987) ‘Girls and boys and practical science’. *International Journal of Science Education*, 9 (5): 505–518.

Rocard, M., Csermely, P., Jorde, D., Lenzen, D., Walberg-Henriksson, H. and Hemmo, V. (2007) *Science Education Now: A Renewed Pedagogy for the Future of Europe*. Brussels: European Commission.

Roger, A. and Duffield, J. (2000) ‘Factors Underlying Persistent Gendered Option Choices in School Science and Technology in Scotland’. *Gender and Education*, 12 (3): 367-383.

Ryder, J. (2002) ‘School science education for citizenship: strategies for teaching about the epistemology of science’. *Journal of Curriculum Studies*, 34 (6): 637-658.

Schön, D. (1983) *The Reflective Practitioner: How Professionals Think in Action.* New York: Basic Books.

Schon, D. (1991) *The Reflective Turn: Case Studies in and on Educational Practice.* New York: Teachers’ College of Columbia Press.

Schoon, I., Ross, A. and Martin, P. (2007) ‘Science related careers. Aspirations and outcomes in two British Cohort Studies’. *Equal Opportunities International,* 26 (2): 129-143.

Shulman L. (1986) ‘Those who understand: Knowledge growth in teaching’. *Educational Researcher*, 15 (2): 4-14.

Simpson, R.D. and Oliver, J.S. (1985) ‘Attitude toward science and achievement motivation profiles of male and female science students in grades six through ten’. *Science Education*, 69 (4): 511–526.

Simpson, R.D. and Oliver, J.S. (1990) ‘A Summary of the Major Influences on Attitude toward and Achievement in Science Among Adolescent Students’. *Science Education*, 74 (1): 1–18.

Sinnes, A. (2006) ‘Three Approaches to Gender Equity in Science Education’. *NorDiNa*, 3 (1): 72-83.

Sjøberg, S. (2002) *Science and Technology Education in Europe: Current Challenges and Possible Solutions.* Available at:

Sjøberg, S. and Schreiner, C. (2008) *Young People, Science and Technology. Attitudes, Values, Interests and Possible Recruitment. Available at:*

Sjøberg, S. and Schreiner, C. (2010) *The ROSE project: an overview and key findings.* Available at:

Skoool (Intel Education website). Available at: http://www.skoool.ie/ (Accessed 23 October 2009)

SLO: Dutch National Curriculum Development Unit. Available at: http://www.slo.nl (Accessed 30 October 2008)

Smail, B. and Kelly, A. (1984) ‘Sex Differences in Science and Technology among 11 year old Schoolchildren: II – Affective’. *Research in Science & Technology Education*, 2: 87–106.

Smithers, A. and Robinson, P. (1988) *The growth of mixed A-levels.* Manchester: Department of Education, University of Manchester.

State Examinations Commission (SEC). Available at: http://www.examinations.ie/ (Accessed 15 April 2012)

Stringer, E.T. (1996) *Action Research, A Handbook for Practitioners*. Thousand Oaks, CA: Sage.

Stringer, E.T. (1999) *Action Research.* 2nd ed. Thousand Oaks, CA: Sage.

Susman, G. (1983) *Action Research: A Sociotechnical Systems Perspective.* London: Sage.

Taba, H. (1962) *Curriculum Development: theory and practice.* New York: Harcourt, Brace and World.

Taba, H. and Noel, E. (1957) *Action Research: A Case Study*. Washington DC: Association for Supervision and Curriculum Development.

Talton, E.L. and Simpson, R.D. (1985) 'Relationships between Peer and Individual Attitudes toward Science among Adolescent Students'. *Science Education*, 69 (1): 19–24.

The Research Business (1994) *Views of Science Among Students,* thesis. Dublin City University.

Tobias, S. (1990) *They're not dumb, they're different: stalking the second tier*. Tucson, AZ: Research Corporation.

Tobin, K. and Fraser, B. (1988) 'What Does it Mean to be an Exemplary Science Teacher'*? NARST Annual Conference*, San Francisco, 15-17 April.

urner-Bissett, R. (1999) 'The Knowledge Bases of the Expert Teacher'. *British Educational Research Journal*, 25 (1): 39–56.

van Kampen, P., Browne, W., Burke, M., James, P., Cotter, M.A., McGlynn, E., O'Kennedy, R., Smyth, P. and Whelan, G. (2004) 'A new science competition for secondary school students: the First European Union Science Olympiad (EUSO)'. *European Journal of Physics,* 25, 23-29.

Waker, B. and Haslett, T. (2002) 'Action research in management – ethical dilemmas'. *Systemic Practice and Action Research,* 15 (6): 523-533.

Watanabe, T. and Huntley, M.A. (1998) 'Connecting Mathematics and Science in Undergraduate Teacher Education Programs: Faculty Voices from the Maryland Collaborative for Teacher Preparation'. *School Science and Mathematics,* 98 (1): 19-25.

Watts, M. and Bentley, D. (1993) 'Humanizing and feminizing school science : reviving anthropomorphic and animistic thinking in constructivist science education'. *International Journal of Science Education*, 16 (1): 83–97.

Weinburgh, M. (1995) 'Gender Differences in Student Attitudes toward Science: A Meta-Analysis of the Literature from 1970 to 1991'. *Journal of Research in Science Teaching,* 32 (4): 387–398.

Whitehead, J.M. (1996) ‘Sex stereotypes, gender identity and subject choice at A level’. *Educational Research,* 38 (2): 147–160.

Whitfield, R.C. (1980) ‘Educational Research & Science Teaching’. *School Science Review*, 60: 411–430.

Winter, R. (1989) *Learning from Experience: Principles and Practice in Action Research.* London: Falmer Press.

Winter, R. and Munn-Giddings, C. (2001) *A Handbook of Action Research in Health and Social Care.* London: Routledge.

Woolnough, B. (1994) *Effective Science Teaching.* Buckingham: Open University Press.

Yager, R.E. and Penick, J.E. (1986) ‘Perception of four age groups toward science classes, teachers, and the value of science’. *Science and Education*, 70 (4): 355–363.

Appendix A

First EUSO Constitution

This is a copy of the first EUSO constitution. It includes an introduction by Minister Noel Treacy, TD and an invitation to attend the first EUSO in Dublin in April 2002. The aims and objectives of the event are explained, as is the organisation and management structure. The rules governing the Olympiad are described and the duties and responsibilities of the participating members are elucidated. The competition itself is described in detail, including, the Tasks, the evaluation system and the method of allocating medals and awards. A registration form is included and a schedule for the week long event is provided.

1st European Union Science Olympiad
(EUSO 2002)

Dublin, Ireland. 1st - 8th April 2002

Official Version (Translations available in French, German, Italian & Spanish)

1st European Union Science Olympiad (EUSO 2002)

Dublin, Ireland. 1st - 8th April 2002

The Dawn of a New Millennium

The new millennium is here. Science Education will be a key factor in our continued technological development across the European Union. One of the ways of fostering greater participation in science at school level and future study and research at third level is to facilitate young science students in demonstrating their innovative capabilities through this European Union Science Olympiad.

The 1st European Union Science Olympiad (EUSO 2002) organised by the Department of Education & Science and Dublin City University will take place in Ireland on April 1st - 8th 2002. Participation in the EUSO will generate a renewed enthusiasm for science education within the European Union and will provide invaluable experience for students taking part in the International Science Olympiads which have been held for many years. Another positive outcome will be a closer relationship between the delegations for further collaborative research and related activities.

Minister Noel Treacy TD
Minister for Science & Technology
Department of Education & Science
Marlborough Street
Dublin 1

1st European Union Science Olympiad (EUSO 2002)

Chairman: Dr. Carl Ó Dálaigh
Director: Mr. Michael A. Cotter (michael.cotter@dcu.ie)

1. Introduction

The European Union Science Olympiad (EUSO) is an individual competition for EU second-level school science students who are 17 years of age or younger on December 31st on the year of the competition. Their skills in tackling science problems, and dealing with scientific experiments will be tested in the various competitions.

2. Objectives

In bringing together gifted science students the EUSO challenges and stimulates these students to develop their talents and to promote their career as scientists.

Participation in the EUSO will provide invaluable experience for students who may be taking part in the International Science Olympiads in future years.

The EUSO offers the opportunity to compare the syllabi and educational trends in science education within the EU Member States which could help improve science education at national level.

3. Organisation & Management

3.1 Aims of the Competition

The European Union Science Olympiad (EUSO) is an individual competition for seventeen-year-old second-level school students who are interested in Science. The aims of this competition are:

- to select the top young EU students in Biology, Chemistry, and Physics at the Annual EUSO
- to stimulate the active interest of students in the sciences
- to promote and reward the pursuit of excellence in scientific endeavour
- to foster a positive and high profile image of science and scientists
- to encourage an appreciation of the value of science and technology amongst the wider community
- to convey to students, schools and the community the importance of advanced study and progressive learning in science
- to exchange ideas and materials about science education
- to encourage greater contact and cooperation between second-level school students from the European Union
- to prepare EU science students for the International Science Olympiads

3.2 National Delegation

EU Member States are invited to send a delegation of not more than three students in each science discipline (Biology, Chemistry and Physics). They are accompanied by not more than one mentor for each discipline who is also a member of the Scientific Jury and the Country Coordinator who is a member of the Governing Body of the EUSO and Head of the delegation (Maximum number 13).

4. EUSO Bodies

4.1 Governing Body

The Governing Body (GB) of the EUSO is the committee of the Country Coordinators that meets annually during the EUSO competition. Each participating country must appoint one coordinator to represent the country in this committee. The GB elects one of its members as the chairman to chair it's meeting, to represent the GB at official functions and to keep in contact with the coordinating centre of the EUSO. A chairman serves a three-year term.

The GB has the right to exclude students and teams from the competition in the case of a serious breach of the rules

4.2 Coordinating Centre

The coordinating centre (CC) of the EUSO, established at Dublin City University, serves as the headquarters of the EUSO. It fulfils its duties by:

- developing and maintaining the Web Site
- storing all relevant science material
- organising and reporting on the annual EUSO Advisory Board, Scientific Jury and GB meetings
- keeping records and membership updated
- functioning as the secretariat of the EUSO

In order to fulfil its function the coordinating centre of the EUSO will receive from each country participating a yearly contribution of €250, which should be paid before or at the start of the EUSO competition.

4.3 Advisory Board

The Advisory Board (AB) of the EUSO consists of the Director of the CC, representatives of the two previous host countries, the current host country and the two future host countries. It advises the host country on organising and running the EUSO.

4.4 Scientific Jury

A Scientific Jury (SJ) for each discipline is a committee formed for each EUSO competition. It is chaired by a distinguished scientist appointed by the EUSO organising country. Its members consist of the mentors from each competing country.

4.4.1 Duties of the Scientific Jury

- the SJ discusses and approves the tasks, the solutions and the marking scheme for evaluation submitted by the organising country
- the SJ has the right to check the procedure and results of the evaluation performed by the organisers. This includes verification of the marking processes and inspection of the scores of the students
- the SJ approves the final results of the evaluation, confirms the ranking and decides on prizes and awards for the competitors
- the SJ members are obliged to keep secret all information about the competition tasks, results and evaluation until the official final announcement
- the decision of the SJ is final

5. The Rules of the EUSO

The business of the EUSO meetings is conducted in English.

EUSO takes place during the Easter school holidays each year in one of the participating countries.

EUSO is organised by a nominee of the Ministry for Education of the host country.

The organiser of EUSO ensures equal participation of all delegations and invites all countries who have been accepted as members of the competition.

A country which has not participated in the competition for two consecutive years, or does not behave in conformity with the EUSO rules, loses its membership for at least one year.

Each country has to indicate within five years after its first appearance in the competition when it will organise the EUSO.

The GB decides all principal questions regarding EUSO

Decisions are taken on the basis of majority votes, in the presence of at least 75% of members. Each country has one vote. In case of equal votes, the chairperson takes the final decision.

Training or any other special instruction that is carried out for a selected group of 50 or fewer students, containing the EUSO team, should not be longer than two weeks in duration.

5.1 Syllabus

Topics should be chosen that will enable the competitors to exhibit not only their knowledge and skills, but also their ability to think independently and creatively.
The scientific content of the theoretical and practical parts of the competition must correspond, as far as possible, with the science syllabi in upper secondary education of the EU Member States

In the practical part no experiments should be carried out which cause deterioration of the living conditions of vertebrates. No handling of species protected by EU law is permitted.

5.2 Contestants

The contestants must be EU citizens in full time education in EU schools, be 17 years of age or younger on December 31st of the year of in which the EUSO is held and the winners of the national science Olympiad of the current school year.

All teams must have both male and female members.

Students may participate twice in an EUSO as a maximum.

5.3 Coordinators

In each participating country the Ministry of Education appoints an EUSO coordinator and informs the CC about the appointment. The country coordinator is the head of the delegation.

The main task of the coordinator is to ensure that:

- a mentor for each science discipline is appointed
- a national science Olympiad is organised
- information concerning the national competition and current textbooks and science syllabi are supplied to the CC
- participation in the EUSO is arranged
- the rules of the EUSO are upheld

5.4 Mentors

In each country the coordinator appoints a mentor for each discipline whose principal task is to ensure that the running of the EUSO is in accordance with the agreed procedures.

Mentors must be able to translate the text of the written competition questions from English to the students' native language, to evaluate competition tasks and to correct their solutions.

Duties of the mentor are:

- to take part in all SJ and moderation meetings
- to forward questions for the theoretical part of EUSO to the organizing country by a set date

6. Hosting the EUSO

6.1 The Host Country

The GB approves the appointment of the host country at least three years in advance.

At least two years in advance the nominee of the Ministry of Education sends confirmation to the CC that it accepts the responsibility for the organisation of the EUSO.

The organising country sends an official invitation to all country coordinators of the participating countries by a fixed date of the preceding year.

The invited countries have to confirm their participation by a fixed date.

The organiser sends out the preparatory tasks to all invited countries by a fixed date.

6.2 Duties of the Host Country

The organisers will ensure that:

- each country coordinators receives an official invitation to the EUSO
- suitable accommodation and subsistence is provided for each delegation
- the health and safety of the delegations is provided for
- laboratories, examination halls, materials and other requirements necessary for the competition in accordance with the rules are provided
- guides, translators and interpreters are available
- a cultural and social programme is in place

7. The Competition

7.1 Structure

The competition consists of two parts, theoretical and practical (experimental) examinations.

The recommended duration of each part is four hours with a break for refreshment.

There should be at least one-day interval between the examinations.

The organisers are responsible for the preparation of the competition. The competition tasks are prepared by specialists who also indicate solutions and criteria of evaluation.

The examination papers and laboratory tests become valid when approved by the SJ

The competitors receive all tasks in English and in their native language. The tasks should be constructed so that no extra verbal instruction or explanation about the testing procedure is necessary. All answers should be alphabetic or numerical.

7.2 Evaluation and Prizes

Each contestant will receive a certificate of participation in the EUSO

The maximum obtainable scores for the correct solutions of the theoretical and practical parts should be the same.

The individual scripts will be assessed and corrected by the authors of the tasks. The GB makes the final decision concerning classification of the results.

The marked and assessed original scripts will remain in the possession of the organisers who will archive them for a period of one year.

The chairman of the EUSO organising committee should announce the official results

- **Gold medals:** maximum of 10 % of the number of contestants
- **Silver medals:** approximately to 20 % of the number of contestants
- **Bronze medals:** approximately to 30 % of the number of contestants

In addition other prizes may be awarded at the discretion of the GB

The results will be proclaimed on an individual basis and not as a national team result.

7.3 Financial Matters

The country organising the competition will expect each participating country to pay a contribution of €4000. This contribution should be paid by a fixed date before the start of the EUSO.

In addition each participating country has to pay the travel expenses of their delegation to the competition site in the host country.

The cost of running the EUSO is borne by the host country

7.4 Conclusion

The countries taking part in the competition are obliged to observe the EUSO rules.

Countries infringing the rules without adequate explanation may be issued a warning and, if the infringement continues, will be suspended from the competition for at least one year.

Changes in these rules can be made only at a GB meeting that become valid after the completion of the current EUSO.

The GB will decide upon any matter that is not included in the rules.

8. Communication

Address:
Mr. Michael A. Cotter
Director,
EUSO Centre,
Dublin City University,
Dublin 9, IRELAND.

Telephone: +353 1 700 8807
Mobile: +353 87 239 4043
Fax: +353 1 2845721
E-Mail: michael.cotter@dcu.ie
URL: http://webpages.dcu.ie/~cotterm

THE 1ST EUROPEAN UNION SCIENCE OLYMPIAD COMMITTEE

Chairman: Dr. Carl Ó Dálaigh
Director: Mr. Michael A. Cotter
Members: Professor Richard O Kennedy *(Biology)*
Dr. Paraic James *(Chemistry)*
Dr. Paul van Kampen *(Physics)*
Mr. George Porter *(Science advisor)*
Secretary: To be appointed

Registration

Form 1 EUSO country coordinator

Name of Country: ....

EUSO Country Coordinator: ....

Full contact address: ....

....

....

Telephone: .... Fax: ....

Email address: ....

Number of persons who are expected to attend:

Science Discipline	Number of Contestants	Number of Mentors
Biology	☐	☐
Chemistry	☐	☐
Physics	☐	☐

Total number in delegation including country coordinator:.................. (Max: 13)

Visitors who wish to accompany the delegation are welcome. They must obey the rules of the EUSO. They will receive similar accommodation to the mentors and may join any excursions arranged. They may not attend the business meetings. The host country will decide the fee for visitors.

Return to:
Michael A. Cotter, Director EUSO Centre, Dublin City University, Dublin 9, Ireland
Telephone: +353 1 700 8807 Fax: +353 1 2845721 E-Mail: michael.cotter@dcu.ie

THE 1ST EUROPEAN UNION SCIENCE OLYMPIAD (EUSO 2002) PROGRAMME			
DATE	CONTESTANTS	MENTORS	COORDINATORS
Monday 1 April	Arrival Orientation meeting	Arrival Scientific Jury Meeting	Arrival Governing Body Meeting
Tuesday 2 April	Opening Ceremony Social / Cultural Activities	Opening Ceremony Scientific Jury Meeting Test 1	Opening Ceremony Governing Body Meeting
Wednesday 3 April	Theoretical Test Afternoon Meet Mentors	Excursion Afternoon Meet Contestants	Excursion
Thursday 4 April	Excursion	Scientific Jury Meeting Test 2	Governing Body Meeting
Friday 5 April	Practical Test	Moderation - Test 1	Advisory Board Meeting
Saturday 6 April	Social / Cultural Activities	Moderation - Test 2	Determination of Awards
Sunday 7 April	Closing Ceremony Presentation of Medals Dinner Evening Departure	Closing Ceremony Presentation of Medals Dinner Evening Departure	Closing Ceremony Presentation of Medals Dinner Evening Departure
Monday 8 April	Departure	Departure	Departure

EUSO

European Union Science Olympiad

Further details:
Michael A. Cotter, Director, EUSO Centre, Dublin City University, Dublin 9, Ireland
Telephone: +353 1 700 8807 Fax: +353 1 2845721 E-Mail: michael.cotter@dcu.ie

Translations provided by: DCU·LS language services

Appendix B

First EUSO Promotional Document

This is a copy of the first document produced to promote the EUSO. This six sided “flyer” gave information on the proposed first EUSO to be held in Dublin in 2003. It included the contact details of the Director, Michael A. Cotter, a welcome address by the patron, Minister Noel Treacy TD, The organising committee, the EUSO governing body, a pre-registration form and information on the aims and objectives, delegation membership and the rules governing the event.

EUSO

European Union Science Olympiad

First EUSO
Dublin Ireland
6th – 13th April 2003

The First European Union Science Olympiad (EUSO 2003) is a team competition for EU second level school science students who are 17 years of age or younger on June 30th 2003. Their skills in tackling science problems and dealing with scientific experiments are tested.

Mr. Michael A. Cotter
EUSO 2003 Director
Dublin City University, Dublin 9, IRELAND

Telephone: + 353 1 700 8807
Mobile: + 353 87 239 4043
Fax: + 353 1 2845721
E-Mail: euso2003@dcu.ie
URL: www.euso2003.dcu.ie

DCU

Minister Noel Treacy TD (Minister for Science & Technology) &
Mr. Michael A. Cotter (Director EUSO 2003)

Welcome address by Minister Noel Treacy TD

The new millennium is here. Science education will be a key factor in our continued technological development across the European Union. One of the ways of fostering greater participation in science at school level and future study and research at third level is to facilitate young science students in demonstrating their innovative capabilities through this European Union Science Olympiad.

The 1st European Union Science Olympiad organised by the Department of Education & Science and Dublin City University will take place in Dublin, Ireland from the 6th to the 13th April 2003. All fifteen EU member states are welcome to send delegations of Students and Mentors.

Participation in the EUSO will generate a renewed enthusiasm for science education within the European Union and will provide invaluable experience for students taking part in the International Science Olympiads, which have been held for many years.

Another positive outcome will be a closer relationship between the delegations for further collaborative research and related activities.

Minister Noel Treacy TD
Minister for Science & Technology

EUSO2003 Organising Committee

Chairman: Dr. Carl Ó Dálaigh
Director: Mr. Michael A. Cotter
Members: Prof. Richard O Kennedy (Biology)
Dr. Paraic James (Chemistry)
Dr. Paul Van Kampen (Physics)
Mr. George Porter (Science advisor)

Delegation

EU member states are invited to send a delegation of three teams with three science student in each team (nine students in total). They are accompanied by one Mentor for each discipline (Biology, Chemistry and Physics) who is also a member and the Scientific Jury. The Country Co-ordinator who is the member of the Governing Body of the EUSO is Head of the delegation. The Country Co-ordinator may also be one of the Mentors (maximum number 13).

Objectives

- to challenge and stimulate gifted science students to develop their talents and promote their career as scientists
- to offer the opportunity to compare the syllabi and educational trends in science education within the EU member states.

Aims

- to select the top young EU science student teams at the annual EUSO.
- to stimulate the active interest of students in sciences.
- to promote and reward the pursuit of excellence in scientific endeavour.
- to foster a positive and high profile image of science and scientists.
- to encourage an appreciation of the value of science amongst the wider community.
- to convey to students, schools and the community the importance of advanced study and progressive learning in science.

Pre-Registration Form

First EUSO
Dublin, Ireland: 6th – 13th April 2003

Name of Country: ....

Country Coordinator(s):..

Full contact address:...

....

Telephone: .... *Fax:* ....

Email address:...

Expected number of Participants

The EUSO 2003 Organising Committee wishes to know the expected number of persons in your delegation. Please mark the expected number in each category.

CATEGORY	NUMBER
Country Coordinator *	
Number of Teams **	
Biology Mentor	
Chemistry Mentor	
Physics Mentor	
Number of Observers	
Number of Visitors	
Total number expected in delegation	

(may also be one of the mentors)*
*(** maximum number: 3 teams with 3 students in each)*

Observers and visitors who wish to accompany the delegation are welcome. They must obey the rules of the EUSO. They will receive similar accommodation to the Mentors and may join any excursions arranged. Observers may attend the business meetings. Observers and Visitors will be expected to pay a fee.

Return as soon as possible to:

Michael A. Cotter,
EUSO2003 Director, Dublin City University, Dublin 9, IRELAND

Telephone: +353 1 700 8807 Fax: +353 1 2845721
E-Mail: euso2003@dcu.ie URL: www.euso2003.dcu.ie

Summary

The Rules

- EUSO 2003 will take place from 6th to 13th April 2003

- Decisions will be taken on the basis of a simple majority in the presence of at least 75% of members. Each country has one vote. In case of equal votes, the chairperson takes the final decision.

- Training or any other special instruction that is carries out for a selected group of 50 or fewer students, containing the EUSO team members, should not be longer than two weeks in duration.

Contestants

- The contestants must be17 years of age or younger on June 30th 2003 and have been in full time education in EU schools for at least one school year prior to the competition.

- It is not necessary for the students to have been winners at a national science competition created specifically for the EUSO. Existing science competitions or exhibitions may be used for the selection process.

Structure

The EUSO lasts for one week. The two-part competition is spread over two days with at least a one day interval between each part. A social/cultural/educational programme forms part of the week.

Tasks

Each task will be a practical activity incorporating elements of Biology, Chemistry and Physics in approximate equal proportions.

Constitution

The complete EUSO constitution is a available at www.euso.dcu.ie

First EUSO GB Meeting
Dublin, Ireland. May 9th – 12th 2002

L-R (back): Michael Cotter, Ireland; Gèrard Cobut, Belgium; Edouard Ries, Luxemburg; Carlos Romero Aires, Spain: (front) Kostas Kampouris, Greece; Eckhard Lucius, Germany

EUSO Governing Body (Country Coordinators)

COUNTRY	EUSO COORDINATOR
Austria	Dr. Maria ZADRAZIL
Belgium	Mr. Gèrard COBUT
Denmark	Mr. Mikkel BOHM
Finland	Mr. Eero NURMINEN
France	Mrs Jacqueline BLOAS-GONIN
Germany	Dr. Wolfgang BUENDER
Greece	Dr Christos RAGIADAKOS
Ireland	Mr. Michael A. COTTER
Italy	Mrs. Sandra PERUGINI CIGNI
Luxemburg	Mr. Edouard RIES
The Netherlands	Mr. Hans MORELIS
Portugal	Prof. Manuel FIOLHAIS
Spain	Ms. Maria GASPAR
Sweden	Mr. Jan SYDHOFF
United Kingdom	To be Appointed

Appendix C

French, German, Italian and Spanish Constitution Covers

The first EUSO constitution was produced in five languages. This appendix shows the cover page of the French, German, Italian and Spanish versions

Premières Olympiades de Sciences de l'Union européenne (EUSO 2002)

Dublin, Irlande 1 – 8 Avril 2002

Version Française

Disponible en anglais, allemand, italien et espagnol

EUSO

Erste Naturwissenschaftliche Olympiade der Europäischen Union (EUSO 2002)

Erste Naturwissenschaftliche Olympiade der Europäischen Union

Dublin, Irland, 1-8 April 2002

Deutschsprachige Version

Auch auf Englisch, Französisch, Italienisch und Spanisch erhältlich

EUSO

Le prime olimpiadi scientifiche dell'Unione europea (EUSO 2002)

Le prime olimpiadi scientifiche dell'Unione europea

Dublino, Irlanda   1° – 8 aprile 2002

AN ROINN OIDEACHAIS AGUS EOLAÍOCHTA | DEPARTMENT OF EDUCATION AND SCIENCE

DCU

Versione italiana

Disponibile anche in inglese, francese, tedesco e spagnolo

EUSO

Primera Olimpíada Científica de la Unión Europea (EUSO 2002)

Primera Olimpíada Científica de la Unión Europea

Dublín (Irlanda), del 1 al 8 de abril de 2002

DCU

Versión en español

También disponible en francés, alemán, italiano e inglés

Appendix D

2002 EUSO Constitution

Following the first EUSO Governing Body meeting in Dublin in May 2002 the EUSO constitution was revised and reprinted. This is a copy of the 2002 EUSO Constitution. It is similar in many ways to the first EUSO constitution. The significant difference is that the EUSO became a team competition as distinct to an individual one and it became a totally experimental Olympiad with no theory examination.

EUSO

European Union Science Olympiad

EUSO Constitution

2002 Edition

EUSO Coordinating Centre
Dublin, Ireland

www.euso.dcu.ie

AN ROINN OIDEACHAIS AGUS EOLAÍOCHTA | DEPARTMENT OF EDUCATION AND SCIENCE

DCU

European Union Science Olympiad

Contents

1. Introduction

The European Union Science Olympiad (EUSO) is a team competition for EU second level school science students who are 17 years of age or younger on June 30th of the year of the competition. Their skills in tackling science problems and dealing with scientific experiments are tested.

2. Objectives of the EUSO

- to challenge and stimulate gifted science students to develop their talents and to promote their career as scientists
- to provide invaluable experience for students who may take part in the International Science Olympiads
- to offer the opportunity to compare the syllabi and educational trends in science education within the EU member states which could help improve science education at national levels

3. Organisation & Management of the EUSO

3.1 Aims of the Competition

The European Union Science Olympiad (EUSO) is a team competition for secondary school students who are interested in science. The aims of this competition are:

- to select the top young EU science student teams at the annual EUSO.
- to stimulate the active interest of students in the sciences.
- to promote and reward the pursuit of excellence in scientific endeavour.
- to foster a positive and high profile image of science and scientists.
- to encourage an appreciation of the value of science amongst the wider community.

• to convey to students, schools and the community the importance of advanced study and progressive learning in science.
• to exchange ideas and materials about science education among EU states.
• to encourage greater contact and co-operation between secondary school students and teachers from the EU.
• to prepare EU science students for the International Science Olympiads.

3.2 National Delegation

EU member states are invited to send a delegation of three teams with three science student in each team (nine students in total). They are accompanied by not more than one Mentor for each discipline (Biology, Chemistry and Physics) who is also a member and the Scientific Jury. The Country Co-ordinator who is the member of the Governing Body of the EUSO and Head of the delegation may also be one of the Mentors (maximum number 13).

4. EUSO Bodies

4.1 Governing Body

The Governing Body (GB) of the EUSO is the committee of the Country Co-ordinators that meets annually during the EUSO competition. Each participating country must appoint one Co-ordinator (who may also be one of the Mentors) to represent the country on this committee. The GB elects one of its members as the chairman to chair its meeting, to represent the GB at official functions and to keep in contact with the Co-ordinating centre of the EUSO. A Chairman serves a three-year team and may be re-elected for a further three-year term. A Chairman may serve for a maximum of two consecutive terms.

The GB has the right to exclude students or teams from the competition in the case of a serious breach of the rules.

A country that has not participated in the competition for two consecutive years must send an Observer to the EUSO on the year prior to full participation.

4.2 Coordinating Centre

The Co-ordinating Centre (CC) of the EUSO, established at Dublin City University, serves as the headquarters of the EUSO. It fulfils its duties by:

• developing and maintaining the EUSO Web Site.
• storing all relevant EUSO material.
• organising and reporting on the annual EUSO Advisory Board, Scientific Jury and GB meeting.
• keeping records and registration of members updated.

4.3 Advisory Board

The Advisory Board (AB) of the EUSO consists of the Director of the CC, representatives of the two previous host countries, the current host country and the two future host countries. It advises the host country on the organisation and running of the EUSO.

4.4 Scientific Jury

The Scientific Jury (SJ) is a committee formed for each EUSO competition. A distinguished scientist appointed by the EUSO Host Country chairs it. Its members consist of the Mentors from each participating country.

4.4.1 Duties of the Scientific Jury

- The SJ discusses and approves the tasks, the solutions and the marking scheme submitted by the Host Country.
- The SJ has the right to check the procedures and results of the evaluation performed by the Host Country. This includes verification of the marking processes and inspection of the scores of the teams.
- The SJ approves the final results of the evaluation, confirms the ranking and decides on prizes and awards for the teams.
- The SJ members are obliged to keep secret all information about the competition tasks, results and evaluation until the official final announcement.
- The decision of the SJ is final.

5. The Rules & Regulations of the EUSO

5.1 The Rules

The business of the EUSO meetings is conducted in English.

EUSO takes place during April each year in one of the participating countries. The date has to be fixed at least on year in advance

EUSO is organised by a nominee of the Ministry (ies) for Education of the Host Country.

The organiser of EUSO ensures equal participation of all delegations and invites all countries who have been accepted as members of the competition.

Each country is expected to indicate as soon as possible when it will organise the EUSO.

The GB decides all principal questions regarding EUSO.

Decisions are taken on the basis of a simple majority in the presence of at least 75% of members. Each country has one vote. In case of equal votes, the chairperson takes the final decision.

Training or any other special instruction that is carries out for a selected group of 50 or fewer students, containing the EUSO team members, should not be longer than two weeks in duration.

5.2 Programme

Topics should be chosen that would enable the competitors to exhibit not only their knowledge and skills, but also their ability to think independently and creatively.

The topics for the competition must correspond as far as possible with the science syllabi for seventeen-year-old students in the secondary education system of the EU member states.

In the tasks no experiments should be carried out which cause deterioration of the living conditions of vertebrates. No handling of species protected by EU law is permitted.

5.3 Contestants

The contestants must be 17 years of age or younger on June 30th and have been in full time education in EU schools for at least one school year prior to the competition. Younger age categories may be included with the approval of the GB

It is not necessary for the students to have been winners at a national science competition created specifically for the EUSO. Existing science competitions or exhibitions may be used for the selection process.

Students attending "Schola Europaea" may represent their home country (the country of which they are a citizen) but not the country in which the school is located.

Students may participate only twice in an EUSO.

5.4 Country Co-ordinators

Each participating Country must appoints an EUSO Country Co-ordinator and inform the CC of the appointment. The Country Co-ordinator, who may also be a Mentor, is the head of the delegation.

5.4.1 Duties of the Country Co-ordinators

The main duties of the Country Co-ordinator is to ensure that:

- a Mentor for each science discipline is appointed.
- participation in the EUSO is arranged.
- the rules of the EUSO are upheld.

5.5 Mentors

Each country appoints a Mentor for each discipline (Biology, Chemistry and Physics). Mentors must be able to translate the text of the competition tasks from English to the students' native language, evaluate the tasks and correct their solutions.

5.5.1 Duties of the Mentor

The main duties of the Mentor is:

- to take part in the SJ and moderation meetings.
- to forward model / example tasks to the Host Country by a set date.

6. Hosting the EUSO

6.1 The Host Country

The nominee of the Ministry of Education confirms to the CC at least two years in advance that it accepts the responsibility for the organisation of the EUSO.

The Host Country sends an official invitation to all Country Co-ordinators of the participating countries at least six months prior to the EUSO.

The invited countries must confirm their participation four months prior to the EUSO.

In the event of more than one country offering to host the EUSO in any particular year the GB will evaluate the proposals and make the final decision.

6.2 Duties of the Host Country

The Host Country must ensure that:

- each Country Co-ordinators receives an official invitation to the EUSO.
- suitable accommodation and subsistence is provided for each delegation.
- the health and safety of the delegations is provided for.
- laboratories, examination halls, materials and other requirements necessary for the competition in accordance with the rules are provided.
- team guides are provided.
- a cultural and social programme is in place.

7. The Competition

7.1 Structure

The two-part competition is spread over two days with an interval of at least one day.

The recommended duration of each part is four hours.

The EUSO is a week long event.

7.2 The Tasks

The Host Country is responsible for the preparation of the tasks for the competition. Science experts who also indicate solutions and criteria of evaluation prepare the competition tasks.

Each task must be a practical activity incorporating elements of Biology, Chemistry and Physics in approximate equal proportions.

The tasks become valid when approved by the SJ.

The student teams receive all tasks in English and in their native language. Translation from English to the native language is the responsibility of their Mentors.

The tasks should be constructed so that no extra verbal instruction or explanation about the testing procedure is necessary.

7.3 Evaluation

Answers should not be language dependent. Responses should be alphabetic, numerical, graphical, illustrative or a box tick.

Each Task must be designed so that the team can achieve a number of milestones or stage results. The task evaluator will judge and mark these achievements according to agreed procedures.

7.4 Prizes and Awards

Each contestant will receive a Certificate of Participation at the EUSO.
The chairman of the EUSO organising committee should announce the official results.

Gold medals: approximately 10% of contestants
Silver medals: approximately 30% of contestants
Bronze medals: all remaining contestants

Additional prizes may be awarded at the discretion of the GB or the Host Country.

The results will be proclaimed on an individual team basis and not as a national team result.

The original scripts will remain in the possession of the Host Country for a period of one year during which time they can be viewed by the GB. They are then destroyed.

7.5 Financial Matters

Each participating country must pay the travel expenses of their delegation to the nearest Port, Airport or Bus/Rail Station to the competition site in the Host Country.

Observers and Visitors must pay an amount to be determined by the Host Country

The cost of running the EUSO is borne by the Host Country.

7.6 Conclusion

The countries taking part in the competition are obliged to observe the EUSO rules.

Countries infringing the rules without adequate explanation may be issued a warning and if the infringement continues will be suspended from the competition for at least one year.

Changes to the constitution can be made only at a GB meeting, in the presence of at least 75% of members and on the basis of a simple majority. They become valid only after the completion of the current EUSO.

The GB will decide upon any matter that is not included in these rules.

Contact Address

Mr. Michael A. Cotter
Director
EUSO Coordinating Centre
Dublin City University
Dublin 9
IRELAND

Telephone: ++ 353 1 700 8807
Mobile: ++ 353 87 239 4043
Fax: ++ 353 1 284 5721
Email: euso@dcu.ie
URL: http://www.euso.dcu.ie

EUSO

European Union Science Olympiad

Further details:
Michael A. Cotter, Director, EUSO Centre, Dublin City University, Dublin 9, Ireland
Telephone: +353 1 700 8807 Fax: +353 1 2845721 E-Mail: euso@dcu.ie

Appendix E

Diary Entry 6th July 1999

This is a copy of the diary entry of the researcher of Tuesday 6th July 1999 following a meeting of the EU member states attending the International Biology Olympiad (IBO) in Uppsala 4-11 July 1999. All seven EU countries attended. The researcher proposed the concept of a Junior Biology Olympiad for EU countries with a view to promoting Biology in EU schools. He also introduced the idea of a Junior Science Olympiad fro EU member states.

JULY 1999

M	T	W	T	F	S	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

6 Tuesday

Uppsala Sweden.

All seven EU members attended. Belgium, Finland, Germany, Ireland, Netherlands, Sweden and UK.

Richard Chaired. Welcomed everyone.

I explained purpose of meeting. Looking for ways to promote Biology and Science in schools and encourage young students to study Science. I proposed that we look at the possibility of establishing a Junior Biology Olympiad for EU countries. Only seven of the fifteen EU members attended the IBO in 1998 and again this year. We now had the Euro in 8 countries and European Parliament elections in 15. This was the time to do something EU wide for Science Education.

Facts: at IBO 1998 2 EU Countries won 3 gold medals out of 12. 4 EU Countries won 7 Silver medals out of 29 and 6 EU Countries won 14 Bronze out of 14.

Eckhard was very supportive. He was first in to support the idea. He pointed out that many of the Gold & Silver Medals last year went to China, Asia and the Soviet Bloc. He said that the idea of an EU olympiad for younger students was excellent. The Netherlands and Belgium were also supportive. The big problem they saw was funding.

I said that I'd be around for the week to answer any questions. I think it went well. Richard and Eckhard were pleased.

Appendix F

List of Interview Questions

This appendix is a copy of the list of questions used by the researcher during the semi-structured interviews with selected EUSO country coordinators to find out how the EUSO was run and managed in those countries.

This example is for Estonia

ESTONIA

Since joining the EUSO in 2005 Estonia has won **six gold** medals and been in **1st place on two occasions**.

- What kind of EUSO organisation do you have in your country?

    Who is responsible for the EUSO?

    Is there an EUSO Office / Organization/ Building

        Full time members

        Part time members

        Budget

        Who do you select the mentors

- How important is the EUSO in your country

To Whom

Not Important   Very important

Is it a recognised part of the school year

Do schools /Teachers know about it

Does the Ministry know about it

How involved is the Ministry

Do you give reports to the Ministry?

Is there publicity in the papers or TV & Radio?

- How do you select your teams? (the procedure)

    Letter to schools

    What do you send to schools? Posters etc

    Do you have a Website

    Why do students take part?

- are they **school teams** or **individuals** from different schools
- How many rounds

- How many students take part in the early rounds?
- Do you pick a Biologists, Chemists and Physicist on each team?
- What kind of training do you do with them?

    How long

    What is covered?

    Individual subjects of Integrated Science

- Is it **Integrated** /Combined/ Parallel/ Individual Training

    The EUSO is a Theme (Integrated) Competition

    Is it possible to have The EUSO more Integrated?

- Is the A Team better than the B Team

IN SCHOOLS

- Do all students do team-work (projects in teams) in schools

  What does TEAMWORK mean

  (Individual/ Collaboration/ Side-by-Side?)

  Male/Female or single sex

    Size of teams

    Supervision

- Do all students do a lot of practicals (experiments) in schools

- Do students do practicals (experiments) and theory and how much time is allocated to each?
- Are the practicals just repeating recipes from the textbook or are they real experiments?

    How many Science lessons for the 12 - 15 years olds

    Quality of Laboratories

    Equipment

    Technicians

    What is their job?

    Prepare Labs for Lessons

Clean up after

Length of a Lab session

- Is it examined & graded (is lab work part of the Exam System?)

  In what way

- Has the Old Soviet System helped you to do well at the EUSO
- What is it about the Old Soviet System that was good in teaching Science
- You have along tradition of Olympiads. In what way does this help?
- In the past five years nearly all the EUSO Gold medals have gone to countries the former Soviet Bloc. Why is this??
- Do you have a policy of taking girls, Boys or Mixed teams
- What is the main aspect of your education system that helps you do well at the EUSO
- Early Intervention, What kind of science is taught in Primary schools???
- How is science education organised for student's age 11-12 and age 13-15. It seems to be natural science in the 10-12 age group and for the 13-15, Natural Science, Biology, Chemistry and Physics as separate subjects.
- What teaching methods are used? How is science taught to the different age groups?
- Are the school science books (Sc. Bio, Chem & Phy) and teaching materials good or bad?

  Who writes the books

- The Curriculum…When was it last revised
- Do students do a lot of **EXAMS** in Science (end of term, end of year etc)
- What is the average class size
- Do students do Extra Curricular Science projects outside school hours

  Is this taken seriously?

- Do students work in Groups or individually?
- Is there a decline in the numbers of students taking **Science, Biology, Chemistry and Physics** in secondary school?
- In what age groups is there a decline?
  How big a decline
- If yes what is the reason?
- Do students think the Sciences (Bio, Chem & Phy) are too difficult?
- Do Girls think that Physics is for MALES?
- Is there a difference between boys and girls?
- If boys or girls are not doing science, what is the reason?
- Is science taught as an Integrated subject or as three/four separate

Subject	**Stage 1 (age 7-9)**	**Stage 11 (age 10-12)**	**Stage 111 (age 13-15)**
Natural Science			
Geography			
Biology			
Chemistry			
Physics			

- Do you have a shortage of Natural Science Teachers?
- Do you have a shortage of Biology Teachers?
- Do you have a shortage of Chemistry Teachers?
- Do you have a shortage of Physics Teachers?
- Do Science Teachers have high status in Estonia
- Do Teachers have high status in Estonia
- Do males want to be teachers in secondary schools
- What qualifications do Science teachers have?
- What teaching qualifications do the have?

- Do they (the teachers) spend much time in re-training, up-skilling etc (continuing professional development -CPD).
- In the teaching of Science influenced by the exam system (do teachers mainly prepare students for exams)
- Are the facilities for teaching the Sciences in the school good or bad?
- Are there enough Laboratories?
- Are there Technicians in the Laboratories to lay out the equipment and tidy up after the lesson?
- Is the image of Scientists good or bad in society?
- What is the attitude of Parents to science and scientists?
- What is the attitude of the wider community to science and scientists?
- What is the attitude of Girls to science and scientists?
- Are parents involved in their children's education?
- Is Science, or Biology or Chemistry or Physics a requirement for entry to University.

  What courses What subjects
- Do teachers use Information Technology in preparing lessons?
- Do teachers use Information Technology in teaching?
- How important is the Olympiads (IBO, ICHO & IPhO) in Estonia.