Book of Abstracts

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Cross-disciplinary issues in mathematics and science education

Dublin City University
11th-12th September 2008

Science and Mathematics Education Conference
(SMEC 2008)

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Conference Programme

				Venue
	Thursday 11.09.08			
8:30	**REGISTRATION**			Nursing Foyer
9:30	Opening Ceremony **Dr. Pauric Travers,** President of SPD **Dr. Odilla Finlayson,** SMEC08 Conference Chair			HG22
10:00	*Plenary Chair: Dr. Odilla Finlayson, CASTeL* Prof. Uri Zoller, Faculty of Science and Science Education – Chemistry, University of Haifa-Oranim, Israel *"Enhancing deep learning via Higher-Order Cognitive Skills (HOCS)-Promoting Teaching Strategies and Assessment"*			HG22
11:00	**COFFEE BREAK**			Nursing Foyer
11:30	*Plenary Chair: Dr. Joseph Kyle, University of Birmingham, UK* Prof. Norman Lederman, Illinois Institute of Technology, USA *"Inquiry: The Common Theme that Connects Disciplines"*			HG22
12:30	**LUNCH** *And Poster presentation setup*			
14:00	*Plenary Chair: Dr. George McClelland, University of Limerick* Prof. David F. Treagust, Science and Mathematics Education Centre, Curtin University, Perth, Australia *"Embedded/formative/diagnostic assessment in science to engender deeper conceptual understanding"*			HG22
15:00	**COFFEE BREAK**			Nursing Foyer
15:30	*Chair: Dr. Brien Nolan, CASTeL* **Focus on Strategies** **A.1** David Delany (CAPSL, TCD), *Enhancing deep learning and far transfer in science education: practical lessons from cognitive science*	*Chair: Dr. Michael Seery, DIT* **Focus on Multidisciplinarity** **B.1** Eilish McLoughlin (CASTeL) *A multidisciplinary approach - Recognising the relevance of all sciences in a first year science undergraduate course*	*Chair: Dr. Ann O'Shea, NUIM* **Focus on Maths transferability** **C.1** Joseph Kyle (University of Birmingham) *Breadth versus Depth in Mathematics: Upskilling or Dumbing Down?*	HG17/18/19
15:50	**A.2** David S. di Fuccia (Dortmund University of Technology) *Peer assessments in chemistry teachers' education "Learning by teaching" implies "teaching by examining"*	**B.2** Elizabeth Swinbank (University of York) *Perspectives on Science: a new course in history, philosophy and ethics of science*	**C.2** A.H. Mooldijk (University of Utrecht) *Coherent education in proportionality in Science and Mathematics*	HG17/18/19
16:10	**A.3** Richard Millman (University of Kentucky) *Role Modelling during the teaching of algebra by a cross-disciplinary team of STEM graduate students*	**B.3** Robert Toplis (Brunel University) *Teaching outside the discipline: case studies of trainee teachers' understanding of chemical reactions.*	**C.3** Michael Carr (DIT) *Alternative forms of continuous assessment in Mathematics*	HG17/18/19
17:00	Poster presentation & wine reception			Nursing Foyer
19:00	Conference dinner			1838 Club

	Friday 12.09.08			**Venue**
9:00	**REGISTRATION**			Nursing Foyer
9:30	*Plenary Chair: Dr. Janet Varley, CASTeL* Jenifer Burden, Twenty First Century Science, University of York, UK *"Twenty First Century Science"*			HG22
10:30	*Chair: Dr. Paul Van Kampen (CASTeL)* **Focus on Nature of Science** **D.1** Cliona Murphy (CASTeL) *Does teaching teachers about the Nature of Science matter?*	*Chair: Dr. Eabhnat Ni Fhlionn (DCU)* **Focus on Transition between 2nd and 3rd level education** **E.1** Ann O'Shea (NUIM) *A study of first year students' experience of the transition from second level mathematics to third level mathematics.*	*Chair: Dr. David Delaney (TCD)* **Focus on Construction of Knowledge** **F.1** Hugh Gash (CASTeL) *A meta-evaluation of constructivist science lessons*	HG17/18/19
11:00	**COFFEE BREAK**			Nursing Foyer
11:30	**D.2** Constantinos Phanis (Cyprus University) *Towards a New Biology Education for Future Scientists*	**E.2** Thomas Wemyss (CASTeL) *Improving the graphing literacy of undergraduate science students*	**F.2** Mansoor Vesali (Shahid Rajaei Teacher Training University) *Studying the mental patterns of Iranian high school junior students in kinematics*	HG17/18/19
11:50	**D.3** Michael Allen (Brunel University) *'Now this is what should have happened…': a clash of classroom epistemologies?*	**E.3** Simon Bates (University of Edinburgh) *"Diagnosing" the Maths Problem*	**F.3** P.A. Padmanabhan Nair (University of Johannesburg) *Shaping the future of Physics in South Africa- the way to go?*	HG17/18/19
12:15	**LUNCH**			
13:30	*Plenary Chair: Prof. Martin Henry (OVPLI)* Prof. Doris Jorde, University of Oslo, Norway *"The changing role of school science"*			HG22
14:30	Interim closing remarks **Prof. Martin Henry** (OVPLI) **Dr. Eilish McLoughlin** (CASTeL)			HG22
15:30	Depart for Dunsink			
16:30	*Plenary Chair: Dr. Maurice OReilly (CASTeL)* Dr. Niall Smith, Blackrock Castle Observatory, Cork *"21st Century Science in a 16th Century Castle"*			DUNSINK
18:00	Talk on Dunsink *Dr. Luke Drury, DIAS*			DUNSINK
19:00	Dinner & close of SMEC08			DUNSINK
22:30	Depart Dunsink for DCU			DUNSINK

Plenary Speakers

Enhancing deep learning via Higher-Order Cognitive Skills (HOCS)-Promoting Teaching Strategies and Assessment

Prof. Uri Zoller

Faculty of Science and Science Education – Chemistry, University of Haifa-Oranim, Israel

Given the current striving for sustainability and the corresponding paradigms shift in science, technology, R&D, environment perception, economy and politics; e.g., from unlimited growth-to-sustainable development, correction-to-prevention, option selection-to-options generation, disciplinary teaching – to inter/multi-cross disciplinary learning and passive consumption of “goods”, culture and education-to-active participation, all in the science-technology-environment-society-economy-policy (S-T-E-S-E-P) context, the corresponding paradigms shift in science and mathematics education is unavoidable. This means a shift from the currently dominating lower-order cognitive skills (LOCS) algorithmic teaching to "know", to HOCS-promoting deep learning to "think" resulting (if successful) in enhanced evaluative thinking and transfer capabilities. Our active research in STESEP-oriented science teaching has been targeted at the development of students’ HOCS such as critical system thinking, question asking, decision making, problem solving, and evaluative thinking within ongoing ‘traditional’ science and mathematics courses. Within a pre-post mixed methodology research design, our intervention focused on the implementation, in science courses, of HOCS-promoting teaching strategies and HOCS’ level examinations, selected representative examples of which will be presented and critically discussed. The main findings of our research, in the context of higher education chemistry/science instruction, are: (a) the capabilities of question asking and critical thinking, problem solving, system thinking and decision making, are enhanced (pre-post gains) via the tandem implementation of appropriate ‘HOCS promoting’ teaching strategies and HOCS-level assessment; (b) HOCS enhancement requires time; it is not achievable via a single-shot short exercise; and (c) assessment needs not only be consistent with the instructional objectives, but also capable of their enhancement in order to achieve them. The educational significance and implications are: (1) Deep learning through HOCS-level assessment is attainable, suggesting (2) generic-HOCS development is contextually-not discipline content-bound. Thus, deep learning, not only can be done; it should be done, across the board, in science and mathematics education.

Biography:

Uri Zoller is a Professor Emeritus in the Faculty of Science & Science Education, University of Haifa – Oranim, Israel. His research interests include:

- Environmental chemistry: detergents/surfactants and polycyclic aromatic hydrocarbons in surface and groundwater, surfactants-enhanced remediation of NAPL contaminated aquifers.
- Organic chemistry: synthesis and chemistry of strained, small rings.
- Science education: science, technology and environment in the social context: teaching, learning and assessment of higher-order cognitive skills.

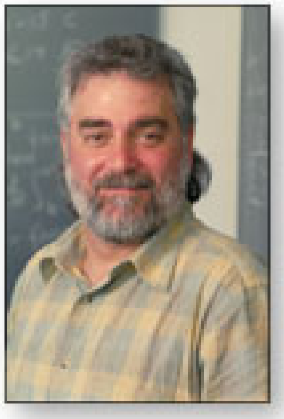
Inquiry: The Common Theme that Connects Disciplines

Prof. Norman Lederman

Illinois Institute of Technology, Chicago, USA

The disjointed nature of subject areas within educational systems throughout the world has perennially been cited as a serious concern. Students typically leave their public school education without any recognition of the connections that exist among the various subjects they have been asked to learn. More concretely, students do not see how the knowledge they have "absorbed" in school relates to their daily lives or society. The purpose of this talk will be to show how inquiry can be used to provide connections among the various subject matter disciplines (specifically science and mathematics) and make the current curriculum more relevant to the concerns of all citizens. A focus on inquiry changes the focus of school curriculum from the memorization and recall of facts and algorithms to thinking skills that can be applied to personal and societal decisions. Orienting the science and mathematics curriculum to an inquiry perspective has significant implications for teacher education and professional development. The challenges that must be confronted and solved in these areas will be discussed.

Biography:



Dr. Norman G. Lederman is currently Chair and Professor of Mathematics and Science Education at the Illinois Institute of Technology. Before arriving at his present position, he was Professor of Science and Mathematics Education at Oregon State University since1985, Assistant Professor of Teacher Education, SUNY/Albany (1984-85) and Assistant Professor of Science Teaching, Syracuse University (1983-84). Dr. Lederman taught high school Biology at Eureka (IL) High School (1974-79) as well as college level biology at Onondaga Community College (1979-82) and Illinois Central College (1976-79). He has received the Illinois Outstanding Biology Teacher Award (1979), a Presidential Citation for Distinguished Service from the Association for the Education of Teachers in Science (AETS, 1986), the Burlington Resources Foundation Faculty Achievement Award for Excellence in Teaching and Research (1992), the AETS Outstanding Mentor Award (2000), and the National Association for Research in Science Teaching Award for Outstanding JRST Paper (2001).

Dr. Lederman is internationally known for his research and scholarship on the development of students' and teachers' conceptions of nature of science and scientific inquiry. He has also studied pre-service and in-service teachers' knowledge structures of subject matter and pedagogy, pedagogical content knowledge, and teachers' concerns and beliefs. Dr. Lederman has been author or editor of 10 books, including an elementary science teaching methods textbook. He is editor of the recently published Handbook for Research on Science Education. He has written 15 book chapters and published over 200 articles in professional refereed journals. In addition, Dr. Lederman has made over 500 presentations at professional conferences and meetings around the world.

Embedded/formative/diagnostic assessment in science to engender deeper conceptual understanding

Prof. David F Treagust

Science and Mathematics Education Centre, Curtin University of Technology Perth, Australia

Of great concern in many western nations is the reduced interest and low participation rates of students taking science, especially the more conceptually demanding calculus-based options in the last two years of secondary school that lead to university science and engineering courses. Indeed, the success, and even the continuation, of science programs in universities are dependent on foundational improvements in science education in secondary schools.

Science teachers can incorporate formative assessment as part of their teaching in such a way that they not only gain feedback about students' progress but also provide information to students about their own progress in a non-threatening manner. In this presentation, I describe research using embedded assessment of various types that also includes a range of two-tier tests in science that help students question and understand the underlying science concepts. In the two-tier tests items, the first tier is a content response and the second tier is an explanation response. The items are designed so that alternative conceptions and scientifically acceptable responses are readily identified. Through this teaching and assessment, students are encouraged to think about the concepts and consider more appropriate explanations rather than memorise basic facts for a test or examination.

Biography:

David Treagust is Professor of Science Education in the Science and Mathematics Education Centre at Curtin University in Perth, Western Australia. He taught secondary science for 10 years in schools in England and in Australia prior to working in universities in the USA and Australia.

David is the author of over 240 science education articles in refereed journals as well as several books and chapters in books and has presented over 250 papers at international and Australian conferences. His research interests are related to understanding students' ideas about science concepts, especially chemistry concepts, how these ideas contribute to conceptual change and can be used to enhance the design of curricula and teachers' classroom practice. David is a member of the Australian National Advisory Committee for PISA since 1998, was President of the National Association for Research in Science Teaching (1999-2001), and is currently Managing Director of the Australasian Science Education Research Association. He has experience teaching and consulting in a number of countries in South-East Asia and Europe.

Twenty First Century Science

Jenifer Burden,

Twenty First Century Science, University of York, UK

The term 'scientific literacy' has been increasingly used in recent years to characterise an important aim of school science. A major national project in England and Wales, *Twenty First Century Science*, implements a flexible approach to the curriculum for students aged 14-16. At the centre of the programme is a core Science course to develop students' scientific literacy. Alongside this core students are offered a range of additional courses, tailored to meet their diverse science education needs and aspirations. The development of a detailed teaching programme for the core Science course has been an important tool for clarifying the meanings of a scientific literacy approach, and highlighting implications for both the assessment of these ideas and teacher training.

The development of *Twenty First Century Science* was initiated by the Qualifications and Curriculum Authority for England and Wales. Following a pilot phase in 78 schools from September 2003, the project led to a revision of the National Curriculum for students aged 14 – 16. Launched nationally in September 2006, over 1000 schools currently use *Twenty First Century Science* courses, with over 250,000 students being awarded final grades in August 2008.

Biography:

Jenifer Burden spent thirteen years as a teacher and Head of Science in several comprehensive schools in the North West of England. In 2001 she joined the Association for Science Education as Director for the *Science Year* project, moving to the Centre for Innovation and Research in Science Education (University of York) in 2002. Jenifer is currently Co-director for *Twenty First Century Science*, an innovative curriculum for GCSE science, which was highly influential in shaping the 2006 Programme of Study for Key Stage 4 science (England and Wales), in particular the increased focus on the nature of science. Jenifer is an experienced trainer and examiner, and is the author and editor of a range of school science resource materials, including print, interactive, and film

The changing role of school science

Prof. Doris Jorde,

University of Oslo, Norway

Scientific and technological developments happen quickly in a modern society, influencing the lives of all citizens. Challenges of global warming, climate change, disease, energy and food supplies are topics on the forefront of scientific research and of importance to all people in the global community. At the same time reports within the EU indicate that modern youth are less interested in careers in science than their predecessors. So we look to science teaching in schools to help us understand if there is any remedy to the situation at hand. Is school science outdated? Should we be looking more critically at the connections between academic science and school science?

In this talk I will present what I consider to be the challenges to science education at schools and in teacher education, including the changing roles of the teacher, student and curriculum. Examples of teaching sequences from viten.no (a web based science curriculum now in English) will be used to illustrate some of the new ways we are thinking about teaching science.

Biography:

Doris Jorde is a professor in Science Education at the University of Oslo, Norway. After completing her doctorate at the University of California, Berkeley, she moved to Oslo, Norway where she has worked with developing science education as a research field.

Her research interests have centred on curriculum development and classroom practice in teaching and learning science. She was the project leader of the net based curriculum Viten.no; conducting research on the uses of ICT in science teaching. She is currently the Vice Dean (Studies) at the Faculty of Education, University of Oslo.

Doris Jorde is leading the project “Mind the Gap” – a European initiative recently funded by the EU to improve the teaching of science through inquiry based teaching strategies.

21st Century Science in a 16th Century Castle

Dr. Niall Smith,

Blackrock Castle Observatory, Cork, Ireland

The continued decline in the number of young people taking science and technology subjects at second level is a concern for any society which aspires to be knowledge-based. Reversing the trend may be vital to future economic success, but experience shows it is by no means a trivial matter. This talk will outline the rationale underlying the project at BCO, the reaction of visitors to date, the advantages of integrating research and public outreach in a science centre and the challenges of making the facility relevant from a curriculum point of view. It will also explore how astronomy can be used as an educational vehicle that crosses disciplinary boundaries in a package that has general appeal to all ages. The BCO website is www.bco.ie

Biography:

Niall Smith has held the position of Head of Research at Cork Institute of Technology since 2005. He is also Principal Scientist at Blackrock Castle Observatory (BCO). The Observatory was opened in 2007 and presently houses a robotic observatory alongside Ireland's first interactive science centre based on the theme of Life in the Universe. Dr. Smith's research interests include optical searches for extrasolar planets using telescopes on a number of sites in both the northern and southern hemispheres. As a central figure in developing and implementing the concept at BCO, he is very interested in encouraging more of the population, young and old, to gain a better insight into the scientific method and its importance to society. Dr. Smith has co-authored over 30 papers and conference proceedings, 1 book chapter and has supervised 15 postgraduate students. He is also a member of the International Astronomical Union.

Oral Presentations

Group A: Focus on Strategies

A.1 Enhancing deep learning and far transfer in science education: practical lessons from cognitive science

David Delany[1] and Lorraine Boran[2]
[1]Centre for Academic Practice and Student Learning (CAPSL), Trinity College Dublin, Dublin 2, Ireland
[2]Department of Psychology, University College Dublin, Belfield, Dublin 14

We describe a novel cognitive science-based thinking skills theoretical framework and related methodologies designed to reliably enhance teaching, learning and research performance. This metacognitive accelerated learning approach is currently being used within TCD to enhance the thinking skills of academic staff and postgraduates across the sciences and humanities.

Expert-novice performance differences are overwhelmingly due to differences in the quality of domain-specific knowledge structures [1]. To facilitate meaningful learning that promotes expert 'connected understanding', we developed Knowledge Engineering, a skilled meaningful learning technique for explicitly constructing integrated, hierarchical, expert-like knowledge structures using the fundamental thinking skills of abstraction, analysis, synthesis, and inference.

The motivating assumption behind Knowledge Engineering is that the ideal goal of education is to promote the development of adaptive expertise i.e. the ability to apply meaningfully learned knowledge in a flexible and creative manner [2]. Elite performers invariably exhibit adaptive as opposed to routine expertise.

The use of the advanced Knowledge Engineering techniques of Deep Structure Analysis and Heuristic Analysis to 'reverse engineer' the deep-level understanding and adaptive problem solving strategies of elite experts is discussed.

The potential of the Knowledge Engineering approach to enhance the quality of science teaching and learning, and levels of uptake, performance, and retention within science courses is also considered.

References:
1. Ericsson, K. A., & Charness, N. (1994). Expert performance: Its structure and acquisition. American Psychologist, 49(8), 725-747.
2. Hatano, G. (1982). Cognitive consequences of practice in culture specific procedural skills. The Quarterly Newsletter of the Laboratory of Comparative Human Cognition, 4, 15-18.

A.2 Peer assessments in chemistry teachers' education "Learning by teaching" implies "teaching by examining"

David S. di Fuccia

Dortmund University of Technology, Dortmund, Germany.

Abstract:

The motto of "learning by teaching" was presented in various forms in schools during the last decades as well as a success was proven. Many open teaching methods, which achieved good results especially in chemistry lessons, make use of the model "learning by teaching". An example for this is the so called jigsaw. Here, students become experts of a special topic and then return to their original group to provide information and instructions for the other members of their group. At this point expert-students take over the teacher's role in their group.

Knowledge transfer at universities has applied the motto of "learning by teaching" – although not having a special name for it – for a longer period of time. Primarily scientific seminars are based on lectures by students for students.

But most implementations of "learning by teaching" on a school and even on a university level can only be seen as an information flow or an instruction. The current discussion about teacher's "diagnostic skills" reveals that the observance of student's previous knowledge as well as special conditions of motivation and interest are the key to a successful learning process.
According to this, it is reasonable to establish a basis for this "more complete" teaching concept in terms of "learning by teaching". Not only possible but necessary is the inclusion of diagnostic questions in the area of university's teacher education. Performance appraisal and examinations are fundamental and important elements of a teacher's work routine. This is often accompanied by particular pressure for teachers. Consequential, university's teacher traineeships' examinations and its designs should involve a "learning by teaching" concept and their effects should be studied. Precise forms and its effects up to now are to be reported.

References:

1. Schäffner, N. (2008). "Lernen durch Lehren im Fachbereich Chemie am Beispiel der Thematik ‚Rund um den Wein'", München: GRIN-Verlag.
2. Prokoph, K. (2005). Lernen durch Lehren in der Chemie, MNU. 58,231 - 236.
3. Eilks, I., Leerhoff, G. (2002). „Die Einführung des differenzierten Atombaus - ein Gruppenpuzzle" in: „RAABits Grundwerk Chemie Sekundarstufe I", Stuttgart: Raabe.
4. Di Fuccia, D.-S. (2007). „Schülerexperimente als Instrument der Leistungsbeurteilung", Berlin: uni-edition.

A.3 Role Modelling during the teaching of algebra by a cross-disciplinary team of STEM graduate students

Richard Millman[1] and Xin Ma[2]
[1]*Mathematics Department, University of Kentucky, Lexington KY, USA*
[2]*Curriculum & Instruction, University of Kentucky, Lexington KY, USA*

The ALGEBRA CUBED program is a three year project involving 650 children per year in which a total of 39 STEM graduate students participate as co-teachers 10 hours a week in a middle (12-15 years old) or high school (15-18 years old) in two poor, rural counties of Kentucky in the United States. The early results of this cross-disciplinary approach to the teaching of algebra have been quite positive.

We hypothesize that STEM graduate students in mathematics classrooms can impact student attitude and achievement in mathematics, based on the premise of the theoretical framework of role models within social learning theory of Bandura (1977). Central to this framework is that significant others can inspire and motivate students to work harder as well as pursue higher educational and occupational goals. The cross-disciplinary group of advanced graduate students of ALGEBRA CUBED come from the areas of mathematics, biology, statistics, and engineering. Their participation as significant others offer unparalleled advantages as models in that they are much closer in age to the school students than are the teachers and are clearly dedicated to their STEM discipline.

The ALGEBRA CUBED program will be described and results of the first year of this project will be discussed. We will use descriptive and inferential statistics on indicators of role model effects to show that for high school students there is significant improvement pre- to post-survey on indicators of role model effects and boys and girls benefited equally from the role models. However, for middle school students, there is less significant change and it appears that boys benefited more than girls cognitively (i.e. achievement) while girls benefited more affectively (i.e. acceptance as a role model).

Group B: Focus on Multidisciplinarity

B.1 A multidisciplinary approach - Recognising the relevance of all sciences in a first year science undergraduate course

Odilla Finlayson and **Eilish McLoughlin**
CASTeL, Faculty of Science and Health, Dublin City University, Ireland

First year undergraduate science students (particularly in Chemical and Biological programmes) generally attend lecture and laboratory modules in introductory Chemistry, Physics, Biology and Mathematics, regardless of their ultimate degree programme. Students don't see the links between these subject areas and in some cases, even question the relevance and importance of some disciplines. In this project, students were facilitated to work in small multidisciplinary science groups to tackle specially devised problems that spanned the borders from Physics-Chemistry-Biology, such as nuclear energy, brewing, water treatment and environmental issues. The benefits to the students are that they develop the ability to work as a part of a team of experts from different disciplines and how to collate, communicate and discuss information with their peers so that they operate as an effective team. As a result of this module, students can at least see relevance of other science disciplines and their understanding of concepts in physics, chemistry and biology is reinforced. Devising suitable problems for 1st year students was challenging where the context was particularly important. Detailed analysis of student feedback, over two year implementation with over 300 students, will be presented in this paper.

B.2 Perspectives on Science: a new course in history, philosophy and ethics of science

Elizabeth Swinbank[1], Ralph Levinson[2], Michael Hand[2] and Ruth Amos[2]
[1]*Science Education Group, University of York, York, UK*
[2]*Institute of Education, University of London, UK*

Perspectives on Science (POS) is a unique research-based post-16 course which addresses the historical, philosophical and ethical aspects of science. The inter-disciplinary skills and knowledge which students have to draw on are likely to be unfamiliar. There are two components to the course: a case-study discussion-based component which is taught in the first part of the course followed by a written research project which includes an oral presentation. Emphasis on discussion skills, individual and sustained research and an oral presentation of the research which is subject to scrutiny by teachers and peers set POS apart from other post-16 subjects. POS is about to be incorporated as an Extended Project.

In studying POS we were focused (i) on the extent to which the course promotes high quality discussion and the factors which influence this, and (ii) how the research project is managed by teachers and students.

To address these questions we studied the dimensions of knowledge and understanding, procedural skills and dispositions necessary for fruitful discussion. Our study of the management of the course focused on the quality of supervision, selecting research projects, use of resources and assessment arrangements which support sustained individual study. Through a multi-methods approach and inductive analysis of data we were able to identify those factors which promoted good discussion, particularly teacher input, the role of diversity and conflict, use of knowledge and characteristic blocks for discussion. In the management of the course we identified support leading up to identification of the research question as critical.

B.3 Teaching outside the discipline: case studies of trainee teachers' understanding of chemical reactions.

Robert Toplis
School of Sport and Education, Brunel University, Uxbridge, UK

Misconceptions in chemistry have been widely reported in the literature, largely with learners up to the age of eighteen. In contrast, this presentation reports case study research into chemistry understanding by six trainee teachers of secondary science (training to teach science to the 11 – 16 age group) with higher education backgrounds in the biological sciences and physics. It combines innovative trainee-generated computer animation models, using *ChemSense* software, with interviews to probe trainees' understanding of four common chemical processes met in schools with 14 to 16 year old pupils. Findings indicate that the trainees possess misconceptions in depicting free atoms, ionic and covalent bonds and bond angles. They exhibit some confusion with ionic and covalent bonds, limit their models to two-dimensional representations and produce animated models as a series of episodes that closely follow written reaction equations. However, they balance the numbers of atoms and engage with, and discuss, construction of models over extended periods of time. The study concludes that misconceptions may arise due to limited access to prior knowledge and trainees' use of multiple frameworks to explain new ideas. The *ChemSense* software is discussed as a tool for encouraging discussion and the development of knowledge in chemistry.

Group C: Focus on Maths transferability

C.1 Breadth versus Depth in Mathematics: Upskilling or Dumbing Down?

Joseph Kyle and Michael J Grove
University of Birmingham, Birmingham, UK

Our paper presents recent findings from the UK university sector and offers a new perspective on several long-standing questions in the teaching of mathematics:

- How do we design a well-balanced mathematics curriculum?
- How do we resolve the tensions between breadth and depth?
- Is there such a thing as an irreducible minimum core content?

In many discussions the debate concentrates on the "upward interface" - typically as students move from school, say, to further or higher education. In this paper we concentrate on, inter alia, how best to prepare students as they leave (in our case higher) education and enter the workplace, or engage with further study. After all, there is a well-documented expectation from Government and employers that Higher Education courses should provide graduates with enhanced competencies alongside the traditional subject knowledge and understanding.

Our discussion will give an introduction to the current skills agenda that may well begin to drive higher education in the future. It will look not just within mathematics itself, but will compare and contrast the position with other near-cognate disciplines and identify practice from which we all may learn. The data in this paper are drawn from recent (2006, 2007 and 2008) surveys and reports in the UK and the conclusions will offer a contemporary perspective on the "Breadth versus Depth" debate.

C.2 Coherent education in proportionality in Science and Mathematics

A.H. Mooldijk
Utrecht University, Utrecht, The Netherlands

Traditionally school subjects deal differently with relationships between variables and teaching approaches on this topic are specific for each subject. Pupils often have difficulties to recognize the relation between these approaches. In the Dutch SaLVO-project an effort is made to develop coherent education in reasoning from data and in working with mathematical functions by linking different school subjects. A learning path was developed for this topic with teaching materials for a variety of forms and various school subjects. The teaching approach is made more coherent with the aim that pupils experience and appreciate the relation between the ways teachers of different subjects deal with the same topic.

We start in form 2 with Mathematics lessons on `proportionality` just before the Science lessons deal with the concept of density. Students usually find the concept of density difficult because it is abstract. In the Netherlands hardly any attention is given to proportionality in form 2 Mathematics classes. We place more emphasis on proportionality and expand it to square and inverse proportionality. At the end of form 4 the students should be able to work with a diversity of proportionalities, find mathematical relationships in experimental data and think about the possible underlying theory of relations between variables in science lessons.

After 3 years of working with the SaLVO-materials, teachers have observed improvements in pupils dealing with proportionality and relations between variables. Their experiences suggest that pupils are more likely to choose Science subjects in senior secondary school after working with the new materials.

C.3 Alternative forms of continuous assessment in Mathematics

Michael Carr[1] and Eabhnat Ní Fhloinn[2]
[1]School of Electronic and Communications Engineering, Dublin Institute of Technology, Kevin Street, Dublin 8, Ireland
[2]School of Mathematical Sciences, Dublin City University, Dublin 9, Ireland

In Dublin Institute of Technology, there has been a recent move to semesterisation, with an increased emphasis on continuous assessment. In mathematics, this would traditionally mean that students would sit a number of short, written assessments during the course of each semester, in conjunction with an end-of-module exam. However, it was decided to combine these usual assessments with presentations on mathematics for certain cohorts this semester.

As part of their continuous assessment mark, students were required to work in groups of three, to prepare and deliver a short presentation to their classmates. Two techniques were employed: in one instance, third-year Engineering students gave presentations revising one of a selection of fundamental mathematical topics studied in previous years; in the second instance, second-year Product Design students explored possible applications of the mathematics they had studied to their other modules or future careers.

The aim of the first technique was to ensure that students were familiar with core mathematical concepts, which would be necessary for the new topics they would meet in the coming year. It also allowed them to experience the challenge of presenting this material in a clear and interesting fashion, giving them a new appreciation for the position of the lecturer. The second technique was employed to encourage students to consider the relevance of mathematical topics to their area of study, providing them with an opportunity to discover the importance of fundamental mathematical concepts in the design process. In both cases, the students developed an important skill for the workplace in which they may often be required to give presentations on technical matters.

Every group in the class was required to anonymously award a mark out of ten to each presentation, and these marks were combined to produce the final mark. The lecturer also awarded a mark to each group, and this was compared to the mean mark awarded by the students, to examine the difference between this and the peer-marking system. Arising from this, some possible issues associated with peer marking are discussed.

In addition to the presentation itself, students were required to complete a reflective survey on WebCT. The purpose of this was two-fold: to encourage the students to reflect on their own learning experience and how the presentations had contributed to this; and also to provide valuable feedback to staff as to students' perceptions of this learning methodology. The results of this survey are provided in the paper.

Group D: Focus on the Nature of Science

D.1 Does teaching teachers about the Nature of Science matter?

Cliona Murphy
CASTeL (SPD), St. Patrick's College, Drumcondra, Dublin 9

Research has indicated that providing students at all levels, with opportunities to develop contemporary NoS conceptions can result in improved understanding of scientific concepts and inquiry, a greater interest in science and a greater appreciation of science's role in contemporary culture (Mc Comas 1998; Matthews 1994; Lederman, 1998; Lederman and Abd-El Khalick, 1998; Driver et al., 1996; Solomon, 1994). This paper reports on a longitudinal study, which explored the effects that explicitly teaching about NoS, as part of the Irish Primary Science Curriculum (DES, 1999a) have had on primary teachers' approaches to and perceptions of teaching science and on their pupils' reflections of school science. Findings are based on data gathered from written reflections from beginning primary school teachers and questionnaires and group interviews from primary school children. This paper presents some of the positive outcomes the employment of these explicit reflective approaches has had on beginning primary teachers' approaches to teaching science. The effects these approaches have had on enhancing primary pupils' attitudes towards and interest in science are also considered.

This has implications for teacher education in terms of building primary teachers' confidence in teaching science and increasing Irish students' interest in science.

D.2 Towards a New Biology Education for Future Scientists

Phanis Constantinos

Cyprus University, Nicos, Cyprus

This presentation elaborates on observations from the European Science Olympiad (EUSO) which was organised in Cyprus and took place in May 2008. We attempt to address the issue of the degree to which knowledge from physics, chemistry and biology could coexist in an integrated manner at the upper secondary level of education.

Twenty two European countries participated in EUSO 2008. The students were under 17 years old and each country had the opportunity to participate with two teams of three students. Each student was representing a team for one science topic: Physics, chemistry or biology.

For the first time in the EUSO, one of the examination tasks included a field trip theme, which represented an attempt to undertake a holistic, transdisciplinary approach to the study of an ecosystem.

The field trip experiment included:
observation, description and explanation of scientific phenomena
skills of handling simple apparatus, team cooperation and initiative
knowledge, understanding and critical thinking.
Specifically, there were five sections in the ecological study/examination entitled “light energy”. In section 1 there were general science questions. In section 2 there was a question testing the ability of the students to classify a specific plant species. In section 3 the students were required to observe the xeromorphic adaptations of a specific plant. In section 4 the students were asked to draw the reproductive organs of a specific flower which was present in the ecosystem. In section 5 each team was expected to *plan an investigation* in order to be able to estimate the density of two specific plants (*Convolvulus oleifolius and Thymus capitatus*) that are present in “ATHALASSA PARK” ecosystem.

In an educational context, where there is an increasing need to encourage students to enjoy science so that they become interested and curious, so that they develop knowledge building skills, such examination formats can be very useful.

D.3 'Now this is what should have happened…': a clash of classroom epistemologies?

Michael Allen
Brunel University, Uxbridge, UK

Current school science curricula attempt to reflect contemporary constructivist-provisionalist related epistemologies as accepted by professional science. It is argued that conversely, the effect of science education is the creation of pupils holding naïve-realist epistemological beliefs, largely inductivist-positivist absolutists who chase an irrefutable 'right answer'. This outcome has unwelcome consequences:

Encouraging positivist mind-sets during school science practical work that trigger confirmation bias and other deviant evidential attitudes.
Philosophical inconsistency creating epistemological confusion with a tendency towards positivism that continues into higher education, and perhaps beyond. This forms a significant barrier to science learning and impacts on the quality of scientists within the workforce.

Solutions are offered but as things presently stand, significant change is deemed unlikely. Discussion of these issues is timely in the light of the recent introduction into English secondary schools of a teaching scheme that articulates a post-positivist view of the nature of science, in the form of a *How Science Works* strand.

Group E: Focus on the Transition between 2nd-3rd level education

E.1 A study of first year students' experience of the transition from second level mathematics to third level mathematics.

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[2]*Department of Mathematics, St Patrick's College, Drumcondra, Dublin*
[3]*Department of Mathematics, Department of Mathematics, IT Tralee.*

It has been widely recognised, both in Ireland and internationally, that the transition from second level mathematics to third level mathematics is a difficult one for many students (see [2], [4], [5]). Students who fail to make the transition are at risk of performing poorly at third level; or even of dropping out. Since most Science and Engineering students take compulsory mathematics modules in first year and are required to transfer their mathematical skills to their other subjects, the problems with mathematics can lead to higher failure rates and lower retention rates in these programmes ([6]). It is therefore important to investigate the reasons for students' difficulties in order to identify initiatives that could help them succeed at third level (this was recognised by the Irish Universities Association in [3]). Mathematics educators have been writing about the gap between school and university for decades ([1]), but the views of students themselves are not always sought. In a study carried out in 2006 and 2007, over 300 students in three different third level institutions were asked to describe the differences between second and third level mathematics, how they found the transition between second and third level and what they liked about third level mathematics. In this paper, particular attention will be paid to the responses of Science, Engineering and Education students.

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E.2 Improving the graphing literacy of undergraduate science students

Thomas Wemyss, David Smith, and Paul van Kampen
CASTeL (DCU), Dublin City University, Dublin 9

Graphs have a widespread importance in science as their role is both communicative and functional. We believe that it is necessary that undergraduate students should have a strong graphing literacy. The new first year physics labs for general science students were developed with a guided inquiry approach with an emphasis on transferrable skills. Students within the framework of guided inquiry, covered different aspects of graphing, throughout the course. The talk will focus on the misconceptions that students bring to the labs from second level, the progress that we have made and the work that needs to be done. We also discuss an approach to introducing and developing graphing in inquiry based labs.

E.3 "Diagnosing" the Maths Problem

Simon Bates and Kristel Torokoff
University of Edinburgh, Edinburgh, Scotland

This talk will describe out efforts to try and diagnose and address “the maths problem”; the widely-acknowledged decline in the ability of entrant undergraduates’ ability in mathematical proficiency and fluency. This is a common problem across all undergraduate science courses, particularly chronic in physics. We describe the design, implementation and evaluation of a new second year course for Physics students (in the Scottish HE system) entitled Problem solving in Physics.

The course was introduced in the first semester of the 2007-8 academic year, with a small pilot cohort of students chosen on the basis of their examination results at the end of the first year. These were students we identified “at risk” of failing part or all of second year, having got between 40 and 55% at the end of first year. The pass rate of the course in the first examination diet was 75%, comparable with that obtained in our other Physics courses (which comprise a far wider spread of student ability).

The instructional design of the course will be described, and its use of a very tutor-dense working environment. The relatively small cohort size allowed us to perform a detailed evaluation of the course, affording not only a unique opportunity to study the nature of the maths problem in detail, but also to understand the students background knowledge in both maths and physics, their study habits, as well as their expectations regarding learning, teaching and examination. Finally, we will present details of future plans for this course, and the consequent developments that it introduction has precipitated.

Group F: Focus on the Construction of Knowledge

F.1 A meta-evaluation of constructivist science lessons

Hugh Gash[1], Thomas McCloughlin[2] and Sinead O'Reilly[1]
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[2]*Education Department, St. Patrick's College, Drumcondra, Dublin 9*

This project concerns the enhancement of the constructivist approach to science teaching and learning in upper primary and lower secondary schools. There are many facets of a constructivist approach, and the one we addressed is the use and quality of dialogue between the teacher and child whereby the teacher and child negotiate a shared understanding of an idea or of an explanation of an observation. Modules of work for school children were designed and training modules for teachers were designed to accompany this. They were trialled in schools first by the facilitator of the project, and redesigned based on an evaluation of the trial. Evaluations were analysed according to a ranking rubric devised by the facilitators with Brockbank and McGill (2007) in mind but rather than ranking sorely on the basis of the quality of reflection, the rubric takes account of specific constructivist actions on the part of the teacher that may coincide with a deeper level of reflection such as 'reflection-in-action'. The overall concern of the project is to facilitate constructivist practice in science teaching.

F.2 Studying the mental patterns of Iranian high school junior students in kinematics

Mansoor Vesali and Noushin Nouri
Shahid Rajaei Teacher Training University, Tehran, Iran

In this research we have tried to find out mental patterns of first- and second year high school students in kinematics and show it's importance in physics education. We have used the schema theory to probe student understanding. We have conducted interviews with 40 students and have used think-aloud techniques. The questions used in this research were mainly selected from similar researches done in US. But, since in Iran, in contrast to US, physics is taught in early years of high schools we, considering the age and experiences of our students, had to modify the questions to meet goals of our work.

The early analysis of this work, which is an M.S dissertation, has had some interesting results. For example, we have noticed a diSessa p-prim regarding the students' conception of moving objects having the same speed; when, in a diagram showing the position of two objects in different mutual times, they were asked whether the objects had the same speed in any times, many said that two objects moving in the same direction have the same speed when they have the same position in the same time. However, when they were asked about a real life situation they showed that they had no difficulty in considering the problem correctly. We consider this as 'the same position means the same speed' p-prim. As another result, we noticed that students while successful in solving an equation in mathematics context, were practically unable to do it in physics context.

F.3 Shaping the future of Physics in South Africa- the way to go?

P.A. Padmanabhan Nair[1] and A. Wilkinson[2]
[1]*University of Johannesburg, South Africa*
[2]*University of the Free State, South Africa*

The future of physics and physics-associated developments do not appear to be too exciting in South Africa unless an immediate intervention with an action plan is put in place. Of the three major sciences taught in secondary schools, physics is probably the most neglected wing to its difficult conceptual nature and therefore there is a dwindling interest among students taking physics as a major in the higher education sector. Physics has more misconceptions associated with its principles than any other science, not to mention an undeserved reputation for difficulty. Yet physics is the foundation of modern technology and a key requirement for millions of highly paid careers in engineering, computer science and medicine. This research aims to gain some consensus of opinion among stakeholders for making recommendations in order to put physics in its rightful place, so that South African physicists may compete globally in a developing world. In this paper the author has presented some propositions that have the potential to guide those who develop educational policies and reforms as well as those who are tasked with implementing them.

Poster Presentations

In alphabetical order

1. *Lab experiments as a tool of an everyday assessment*

Dr. David-S. di Fuccia
Dortmund University of Technology, Germany

Since 2004 a research project is running investigating in which ways pupils' practical activities can be used as a tool for diagnosis and assessment.

Looking at the development of school chemistry education in the last years one can see that the way of teaching has changed and the variability of teaching methods has increased considerably. In spite of these changes assessment tools used at school remain mostly the same as before: paper and pencil tests which often focus on encyclopaedic chemical knowledge. Thus, currently we have to complain a gap between the quality of teaching and the ways of testing of what have been taught. It seems therefore feasible to us to develop new assessment tools that focus on diagnosis.

Practical activities can be expected to be useful as a suitable assessment instrument: they offer possibilities for learning in many important fields of competence and have a great importance in school chemistry teaching.
To realise an assessment by the pupil's lab work instruments were developed and tested which can be produced by the teachers themselves and which are suitable for everyday chemistry lessons. Some of the instruments used in the project will be presented, the experiences that were made using them will be reported and selected results about the attitudes of pupils and teachers towards experimenting before and after participating in the project will be presented to get an idea of the effects of using pupils' lab work as a tool for diagnosis and assessment.

2. *Teaching engineering modules within an interdisciplinary biotechnology degree program – the role of workbooks*

Dr. Greg Foley
School of Biotechnology, Dublin City University, Dublin, Ireland

Biotechnology has been defined by the European Federation of Biotechnology as the application of scientific *and* engineering principles to the processing of materials by biological agents (cells, enzymes etc.) to provide goods and services. The BSc degree program in DCU is consistent with this definition in that it incorporates about 55% biological sciences, 35% biochemical engineering and 10% mathematics. The profile of our student intake is such that the majority of students are naturally attracted to the seemingly more dynamic and topical areas of modern molecular biology. Generating enthusiasm for engineering and mathematics and developing student skills in these areas is always a challenge.

In recent years, we have begun to adopt a more active approach to the teaching of engineering modules in the Biotechnology degree program. Our aim is for the students to become competent in, and even enjoy, their engineering subjects by 'doing' rather than 'learning'. In this paper, a pilot workbook-based approach to teaching a second year module in Fluid Flow is described. Students were provided with a complete set of course notes and a workbook which they completed in parallel with the notes. The module was taught over a six week period, with one formal lecture and two hands-on workbook sessions per week. The module was marked on the completed workbooks (50%) and with a short end-of-semester, in-class exam (50%). There was a zero failure rate in the module. Anecdotal evidence gathered in subsequent modules suggests that the hands-on approach to learning has improved the students' basic engineering skills, especially in the area of computation.

3. The Significance of Mathematical Conceptualisation in 2nd Year Students' Ability to Transfer Their Mathematical Knowledge to A Chemical Context, Where it Is Applied

Richard Hoban[1], Odilla E. Finlayson[1] and Brien Nolan[2]
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In the Science Education Community, there appears to be a dearth of literature concerning students' ability in transferring mathematics from one discipline to another. Certain studies have been undertaken by some researchers in trying to quantify *transfer in learning*. However, understanding the nature of the process itself and the variables that affect the extent to which it occurs has been advocated as needing further exploration. Previous studies have somewhat investigated the 'transfer ability' of students' mathematics capability concerning algebraic and graphical thinking from mathematics to chemistry. In light of the issues raised from these endeavours, the findings conveyed in this poster portray whether the whole idea of 'graphicacy' and 'conceptual understanding' of mathematics are flagship variables in students' proficiency, with regard to transferring their mathematical wherewithal from one domain to another— in this case from mathematics to chemistry.

The design of *diagnostic tools* to assess 2nd year undergraduate students' 'procedural' and 'conceptual' understanding of mathematics pertinent to kinetics and thermodynamics both in mathematics and a chemistry context is described. The findings seek to provide insight as to whether graphical and conceptual mathematical awareness are key determinants in the ability of students to transfer their mathematical knowledge to a chemistry context requiring the same underlying mathematics.

Results-to-date suggest that a majority of students are inept at visualising a mathematical concept both in a mathematics domain, stripped of any practical context and also in the chemistry context where the same mathematics is applied. Whether or not this skill correlates with an ability to transfer from mathematics to chemistry for students who scored favourably in the diagnostic tools is discussed; the suggested consequent impact on the teaching regimen of mathematics to chemistry students is also articulated.

4. Selggog Abbey – a context laboratory for 1st year undergraduate science students

James Lovatt[1], Edelle B. Mc Crudden[1], Sonia Ramírez-García[2], Odilla E. Finlayson[1], Patrick O'Malley[2].
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Many authors have criticised the 'recipe' style chemistry laboratory as not providing a full learning experience and have made a case for the modification of laboratories tasks and the introduction of different teaching strategies including Context and Problem Based Learning (CBL/PBL) [1,2]. A difficulty using CBL/PBL in laboratories is designing an appropriate problem for students with limited background in the subject area and in problem solving. (some examples are available [3, 4]).

This work provides an example of a CBL task that has been used successfully over the last two years in a first year undergraduate chemistry course as part of a redeveloped laboratory module [5, 6]. The problem task developed involved groups of students working on behalf of an environmental protection agency who have been asked to determine the water quality in the rivers in a fictitious area called Selggog Abbey. Students were asked to (a) provide general information of the water quality (b) identify and quantify any pollutants present and their possible sources (if any) (c) discuss the implications of their findings and to make appropriate recommendations.

Due to the nature of the problem, the exact scenario can easily be altered each year e.g. focussing towards particular analyses. Evaluation of the task was carried out through surveys and interviews with both the students and tutors involved. Both were positive about the task, indeed many of the advantages of PBL were mentioned including, motivation, consolidation of understanding, working independently to mention a few.

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5. Implementing a Key Skills in Mathematics Initiative

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The drive towards mass education, and the year on year fall in popularity of technical based subjects in Ireland (and other western countries), has created cohorts of students in many technical courses who are ill-equipped to succeed on those courses. Compounding this problem is the fact that most students in Ireland are now on semesterized courses, which seems to encourage students to learn enough for the regular examinations, without necessarily taking time to reflect on what they have learnt.

Whilst addressing the needs of these students is multi-faceted, we would like to describe the construction of a Moodle-based initiative at IT Tallaght called Key Skills Testing in Mathematics. Using the Moodle platform, Key Skills consists of:

1. creating many categories of multi-choice question which we believe our cohorts of students MUST be able to do. Each question comes with feedback and reference to a book chapter and an electronic resource.
2. creating tests which draw randomly from particular categories of questions. These tests may be repeated several times over a semester and only a high mark is rewarded with credit.
3. different tests run for different groups and in different semesters, reflecting the Key Skills of previously taught material required for that semester.

The aim is for students to expect Key Skills in each semester, re-enforcing and repeating their learning.

We would like to describe the development process and to present our material as a reusable learning object. A detailed examination of student performance so far will be presented.

6. The development and evaluation of second level chemistry lessons, central to the cognitive acceleration through science education methodology

Lorraine McCormack[1], Odilla E. Finlayson[1] and Thomas J.J. McCloughlin[2]
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[2]CASTeL, St. Patrick's College, Drumcondra, Dublin, Ireland

The CASE (Cognitive Acceleration through Science Education) programme was developed in the UK for the 11-14 year age group to encourage higher level thinking, in order for them to better attain the objectives of the curriculum. In this longitudinal study the successful CASE programme was implemented and its effects were monitored across the primary and second levels in Ireland. The effectiveness of the programme on cognitive development was tested by the CSMS (Concepts in Secondary Mathematics and Science) tasks, assessing Piagetian levels. The results of both programmes show increases in formal-operational thought. The core test results were analysed by residual gain score analysis, a method used to predict the post- test results for the experimental group as if he/she were part of the control group.
This work now concentrates on the development and implementation of second level science lessons, central to the CASE methodology- *Thinking Science through topics*. Increasing the relevance and density of the use of the CASE methodology beyond stand- alone activities to use within entire topics demanded development of additional resources. Six chemistry and physics topics on the Junior Certificate science course were chosen, materials and lessons were designed in accordance with the CASE methodology- to promote higher order thinking- and subsequently used by five teachers, trained in the use of the cognitive acceleration tools. Preliminary results from the cohort indicate that the cognitive levels of the experimental group were much greater than that of the control group, with mean residual gain scores of 3.9 and 0.0 respectively. Detailed results will be available at SMEC 2008.

7. Analysis of Leaving Certificate Chemistry Examination

Edelle B. McCrudden and Odilla E. Finlayson
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Assessment at both second and third level has come under immense scrutiny over the last decade with particular emphasis placed on the role it can play in student learning. Good assessment strategy should be preformed in such a way that is justifiable and allows all students to achieve their maximum potential [1]. Assessment should also reflect the stated objectives and leaning outcomes of a curriculum [2].

The revised Irish second level national syllabus (Leaving Certificate) in Chemistry was implemented in 2000 and first examined in 2002.

This syllabus will be assessed in relation to its objectives which include:

- an ability to interpret experimental data and assess the accuracy of experimental results.
- an ability to organise chemical ideas and statements and write clearly about chemical concepts and theories. [3]

This new revised syllabus has received criticism due to the implementation of mandatory experiments without the proper equipping of all Irish Secondary and Vocational Schools, and also the failure of the terminal exam to provide adequate assessment for the shift in emphasis to the applied aspects of chemistry. [4,5] This study aims to assess the level of questioning used in the Leaving Certificate examination and how well the final examination assesses students competence of the stated outcomes.

While there are issues in relation to the use of Blooms Taxonomy [6] in determining question type, in this study it is being used purely as a tool in order to compare the examination questions from 2000 to 2008, for the higher level examination papers. Questions have been identified as knowledge, comprehension, application, analysis, synthesis or evaluation using a devised rubric, and this has revealed that the predominant question type is of lower order with only a small percentage of higher order questions appearing in each examination.

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8. Application to Initial-Value 2nd Order Ordinary Differential Equations & Aliasing

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Several commercial software packages to solve Differential Equations (DEs) are available off the shelf. A selling point of many programs is their compatibility with MS Excel©, others come as an Add-In to MS Excel©. The assumption, sometimes stated, is that Excel© can not solve DEs. This paper presents a friendly method for solving initial-value DEs analytically on a MS Excel© workbook without the need for additional software. Upon entering the constant coefficients and boundary conditions, the type of solution is highlighted and the user can visualize the full solution accompanied by a graphical representation. Parameters can be varied and equations of interest, with solutions, saved on a separate worksheet for future use. The solver can be customized to adopt user's terminology. This first version has been restricted to equations of the type:

$$ay''+by'+cy = RSin(\omega t + \phi)$$

where a, b, c, R, ω and ϕ, are all constants and b or R can be zero.

Graphical artifacts and data misrepresentation (aliasing) have been explored and remedial procedures recommended. This tool is intended for widening participation in advanced mathematics from non-mathematics students, a help to academics wishing to generate DEs for teaching and assessment purposes, and an aid to simulation and development scientists/engineers.

9. Novel Approaches to Refresher Courses in Basic Mathematics

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The poor core mathematical skills of many students entering a wide range of Further and Higher Education programmes continue to be a cause for concern for many mathematics educators. Some universities have responded by offering short "refresher courses" in basic mathematics to incoming first-year students in service-taught mathematics modules. However, traditional approaches to teaching these basic skills may simply echo students' previous unsuccessful attempts to grasp the concepts involved. By introducing the material in a different way, students may be more engaged with the learning process, hopefully improving their ability to understand and retain the information involved.

As a result, the possibility of using novel approaches, such as inquiry-based learning or other techniques, in these refresher courses is currently being investigated by the authors, with a view to producing sample refresher sessions on common problem areas in basic mathematics. The resulting material will be trialled by the Maths Learning Centre in Dublin City University (DCU) in the coming year and will be freely available from the sigma CETL (http://www.sigma-cetl.ac.uk/). In this paper, we discuss our findings and give details of the refresher material produced.

10. Introducing systems engineering concepts into the education of physics students

Aidan O'Dwyer
School of Electrical Engineering Systems, Dublin Institute of Technology, Kevin St., Dublin 8

In 2005, the School of Physics at Dublin Institute of Technology introduced an innovative honours degree (Level 8) programme in Physics with Medical Physics and Bioengineering. A major objective of this programme is to provide students with an appreciation of the interdisciplinary nature of modern science and technology. The author was tasked with the development and instruction of a module covering basic concepts in feedback systems and control, with particular reference to physical and biological sciences. This module was first delivered in Semester 1 of the 2007-8 academic year. In the presentation, the author will outline how students learned that negative and positive feedback concepts are central to the understanding of homeostatic applications such as temperature regulation of the body, the control of breathing, diabetes and blood glucose control and how the human eye works. In practical work, students created a plot of their personal eye-brain-hand motor response, and deduced their reaction time. Students were also required to prepare an individual PowerPoint presentation on how feedback concepts are required for the understanding of blood pressure control, human behaviour and global warming. The author will contend that feedback concepts are a good vehicle for interdisciplinary transfer of knowledge in science and technology education, both at third level and second level (at the senior cycle), where relevant experience from the US education system will be reported.

11. Teaching complex number manipulations as part of an introductory module in electrical engineering

Aidan O'Dwyer
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Complex numbers and their manipulation are central to electrical engineering practice. However, it is difficult to motivate students to master this area in a pure mathematics class, particularly at Level 7, where students enter third level education with a modest prior attainment in mathematics. The contribution will report on the author's experiences of student learning of complex number manipulations as an integral part of the learning of how alternating current (AC) circuits work. Teaching is done by means of lectures and laboratories, where the mathematics is a natural part of the understanding of the technology; active student learning through problem solving is employed. Four hours (or 45% of the lecture time in this topic) was devoted over six weeks to this active learning in the 2007-8 academic year. Evidence of increased student understanding compared to previous student cohorts, as measured by performance in associated examination questions, will be presented in the contribution. The electrical engineering module taught by the author is the foundation stone for further student learning in the career discipline that they have chosen. The author has observed that linking complex number manipulations (together with other mathematical concepts such as scientific notation and trigonometry) directly to the engineering application demonstrates the direct usefulness of those topics to students who are increasingly questioning the relevance of the material that they are learning.

12. Factors influencing the take-up of physics within second level education in Ireland —the students' perspective

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An analysis is presented of the main factors militating against the take-up of physics at second level in Ireland in recent years, from the perspective of students who undertook the subject for the Leaving Certificate examination. The analysis is based on a survey of student opinion conducted in December 2006. The sample comprised 529 university freshmen from NUIG and UCD who were attending courses that attracted students with a mathematical and/or scientific/technical aptitude. The instrument used was the self-administered questionnaire, which had been refined *via* a pilot survey. The study complements a previous study of teacher opinion on the same issue, conducted in December 2004 [1].

Comparative analysis of both teachers' and students' responses revealed a clear consensus that physics is perceived to be both a difficult subject and a male-dominated subject; that it is more difficult to obtain high grades in physics than in other subjects in the Leaving Certificate; that the level of mathematics required for the study of physics for the Leaving Certificate is higher level; and that students are not aware of the wide range of employment opportunities associated with a physics training. On the other hand, teachers and students adopt opposite positions in relation to the following: satisfaction with the content of the current Leaving Certificate physics syllabus (teachers agree); satisfaction with the balance between theoretical and practical work (teachers agree); satisfaction with the teaching and learning resources available in schools (teachers agree, whereas students are evenly split).

References:

1. Politis et al., 2007, *Irish Educational Studies* **26**(1), 39–55).

13. E-learning resources to support Maths for Chemistry

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Computers are increasingly a part of the mathematics syllabus in tertiary level chemical science degrees and particular emphasis on the handling, statistical analysis and/or graphing of data is now common-place. The poster describes the development and Implementation of an online module (webcourses-Blackboard) providing resources for the use of MS Excel in graphing data, statistical analysis and extracting information of scientific relevance from experimental data. Resources include video screen captures of Excel tasks such as plotting data, completing t- and f-tests and importing and analysing experimental data, lecture notes with audio and an online discussion forum to deal with queries. An assessment programme was incorporated in the module which aimed to develop students' mathematical manipulation skills in Excel and develop their ability to learn how to learn, by providing scaffolded support in unseen tasks. Student feedback and access statistics indicated that the screen capture videos and podcasts were extremely popular. Engagement in the course, usually delivered in a classroom setting was much higher in previous years. Ongoing developments of the module will be outlined, in particular to expand the role of online discussion forum.

14. Teaching Electric Circuits in First Year Undergraduate Laboratories

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This project involves the development of electric circuits curriculum for first year undergraduate non-physics students. A framework of guided inquiry is used, which focuses on the understanding of students and their ability to conceptualise physics. The limiting nature of first year undergraduate laboratories required that we focussed on the key elements and that the curriculum was efficient in conveying the relevant concepts.

These labs follow the same order as that outlined in Physics by Inquiry curriculum [1], thus students first discover the need for a complete circuit, which makes the assumption of current plausible using simple two-bulb series and parallel circuits. The concept of resistance is also introduced using simple circuits where students make conclusions based on the change in bulb brightness and then make inferences on changes in resistance. The introduction of voltage is more quantitative than the previous two concepts where students base their development on a combination of observations and measurements.

The laboratories commence in February 2008 and will continue for three successive weeks. Pre-test data is collected through an online survey which challenges students understanding on upcoming concepts and highlights their misconceptions. Post-test data is collected through two in-class exams, carried out half way and at the end of the semester. This presentation will highlight some of the key findings from the data and discuss the approach in developing the curriculum.

References:

1. McDermott, L.C. (1996). *Physics by Inquiry Volume II*. Canada: John Wiley & Sons, Inc

15. Enhancing Cognitive Development through Physics Problem Solving: Example of Thinking-Skills Curriculum

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Numerous research studies in the last 30 years have highlighted the inadequacy of traditional physics courses. It has been shown that students who leave such courses tend to have incoherent physics knowledge and mediocre problem solving skills. Moreover, they have difficulties when engaged in higher-level thinking, and their appreciation towards science improves little. At GW University we designed a "thinking skills" curriculum that trades "breath by depth" by focusing on slight fewer topics while addressing such issues. We used parallel conceptual and procedural learning progressions that have been created based on a taxonomy of physics problems being developed by Teodorescu et al. (TIPP: Taxonomy of Physics Problems). Our course emphasises concept formation in various procedural context fostered by different curriculum units. This approach allows us to explicitly link physics problems and exercises to the higher-order thinking skills we want the students to develop, while addressing the common student complaint that the various course elements, such as textbook readings, lecture materials, homework problems and lab exercises, appear disjointed and unrelated to each other. Our framework can easily be adapted to many curricular settings and can be continuously adjusted throughout the semester. We will present preliminary results on improving students' thinking ability and their problem-solving proficiency. We will also discuss patterns of student problem solving behaviour that we discovered.

16. Student understanding of P-V diagrams and related conceptions about integration

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As part of ongoing research into upper-level undergraduate student understanding of thermal physics at the University of Maine, we report on student understanding of thermodynamic work, internal energy and the associated mathematics.

Students were given a P-V diagram and asked to answer qualitative questions pertaining to work (PdV) and internal energy changes during two processes represented on the diagram. The physics questions were paired with equivalent qualitative mathematics questions asking about signs and comparisons of magnitudes of various integrals.

Our previous work was restricted to written data from physics majors in a thermal physics course. Recent work includes interviews of physics students, as well as written data obtained after Calculus III instruction.
Analysis of the data reveals student conceptions about integration that might otherwise be interpreted as conceptual difficulties with the physics.

Interview findings include student reliance on the length of the integration path, and/or symmetry of the paths when comparing the magnitude of two integrals, rather than area under the curve to answer questions requiring integration. The data suggest that students' application of the state function concept to thermodynamic work may be due in part to incorrect conceptions regarding integration. We also have evidence that students lack the correct mathematical foundation of the state function concept, which may be a factor in its indiscriminate application.

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17. MatCid - mathematics in the city: a project with elementary pre-service teachers and student

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One of the most features in mathematics education in this century is the lake of scientific culture and curiosity of young people. This happens in short anywhere around the world, but in particular at Portugal, that the recent international studies (TIMSS, PISA) have shown that Portuguese students have low Mathematics results. These students' low mathematics skills translate themselves into lack of motivation for learning this subject traditionally identified as a hard task. When students enter in school they carried, with them, a negative attitude towards mathematics, subject about they already hear, most of the times in an inexact way, but of which have a limited knowledge. This situation provokes in the teachers despondency, lack of motivation and alternatives strategies for break with this vicious cycle in which have been transformed the mathematics teaching. It is our strong belief that only with action that conducted to a great awareness of people in general and students in particular, that mathematics it is accessible everybody and it is present everywhere around us, it is possible recover the general lack of motivation. It is important to show the invisible face of mathematics. In this presentation we present an overview of this ongoing project that its first objective is to promote the mathematics culture of elementary pre-service teachers and students through the observation and exploration of the urban environment while designing mathematics curriculum for elementary education. At same time we create opportunities for pre-service teachers to explore their worlds and discover that math is everywhere, connecting mathematical ideas to real world interests, experiences, and empowerment.

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