Physics Higher Education Conference 2008

PROCEEDINGS

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CONTENTS

The Higher Education Academy Physical Sciences Centre and the Physics Innovations Centre for Excellence in Teaching and Learning

The Physics Higher Education Conference 2008

Programme

Thursday 4th September

9.30 – 10.30	Registration and coffee
	Chair: *Derek Raine*
10.30 – 10.40	Welcome and introduction
10.40 – 11.30	Keynote Lecture - National Teaching Fellow 2007 'The Neuroscience of Teaching Physics' *Steve Swithenby, The Open University*
	Chair: *Bruce Sinclair* Oral Presentations
11.30-11.45	Towards a Conceptual Inventory in Quantum Mechanics *Simon Bates, Judy Hardy, Rachel Archer, University of Edinburgh*
11.45 - 12.00	Scientific Thinking; Insights from an Academic Game *Fatheya Al Ahmadi, University of Glasgow*
2.00 - 12.15	Student Attitudes to Physics at School and University *Jim Knowles and Karen Moss, Nottingham Trent University*
1	
2.15 - 12.30	Attitudes, Learning and Problem Solving in Physics *Rizwan Rana and Norman Reid, University of Glasgow*
12.30 – 13.30	Lunch
	Workshop
13.30 – 15.30	Understanding the Undergraduate Student Learning Experience in Physics *Mike Edmunds and Tina Overton, HEA Physical Sciences*

15.30 – 16.00	Tea
	Chair: *Sally Jordan*
	Oral Presentations
16.00 – 16.15	Building a Community of Physics and Astronomy Distance Learners *Dave Edwards, The Open University*
16.15 - 16.30	Supporting Level 1 Physics & Astronomy Undergraduates at the University of Glasgow *Morag Casey, University of Glasgow*
16.30 - 16.45	We've Solved our Maths Problem: Have You? *Kristel Torokoff and Simon Bates, University of Edinburgh*
16.45 - 17.00	Use of 3D Virtual Environments in Teaching Astronomy and Physics *Rob Lucas and Ulrich Kolb, PiCETL, The Open University*
17.00 - 17.15	Development of Learning Material for Formative Computer Based Assessment in Physics and Astronomy *Antje Kohnle, Tom Brown, Aly Gillies, Jane Greaves, Chris Hooley, Steve Lee, Bruce Sinclair and Graham Smith, University of St Andrews*
17.15 - 17.30	The Physical Sciences Question Bank – What Next? *Dick Bacon, University of Surrey*
19.00	Wine reception
19.30	Conference Dinner

Friday 5th September

	Chair: *Simon Bates*
9.00 - 9.15	Oral Presentations Being SUPA (Infrastructure) *Sean Farrell and Avril Manners, Scottish Universities Physics Alliance*
9.15 - 9.30	Being SUPA (Computer Mediated Activity) *Karon McBride and Avril Manners, Scottish Universities Physics Alliance*
9.30 - 9.45	Being SUPA (Video-Conferenced Lectures) *David Crooks and Avril Manners, Scottish Universities Physics Alliance*
9.45 - 10.15	Coffee
10.15 – 12.15	Workshop Interactive Screen Experiments: A New Resource for Experimental Physics *Paul Hatherly, Alan Cayless and Sally Jordan, piCETL, The Open University, and John Macdonald, PiCETL, The University of Reading* **Note:** If you have your own laptop it would be very helpful if you could bring it to this workshop.
12.15 – 13.15	Lunch
13.15 – 13.30	*Chair: Dick Bacon* Oral Presentations R1C12 Diagram Helping Educators Structuring Nucleons in Nuclei *Wajdi Ratemi, Alfateh University*
13.30 – 13.45	Undergraduate Student Perceptions, Views and Opinions of Laboratory Teaching of Physics *Peter Sneddon, University of Glasgow*
13.45 – 14.00	Problem-based learning labs in first year physics *Antje Kohnle, Cameron Rae, Tom Brown and Bruce Sinclair, University of St Andrews*
14.00 – 14.15	Closing remarks, tea and depart

Keynote Lecture

1 National Teaching Fellow, 2007
The Neuroscience of Teaching Physics

Stephen Swithenby, The Open University

Keynote 1

National Teaching Fellow, 2007

The Neuroscience of Teaching Physics

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In the last few years, there has been increasing interest in the possibility that neuroscience in general and neuro-imaging in particular can contribute to making teaching and learning more effective. Recent funding is allowing both speculation and speculative early work. This should be of particular interest to physicists who have been deeply involved in developing methods of imaging the brain and in interpreting the complex data that is generated.

We are already influenced by models of learning derived from neuroscience. I will describe and critique some of these influences and suggest that some common approaches to teaching are misguided whilst others ignore fundamentals aspects of our understanding of the brain. The imaging methods that are central to contemporary cognitive neuroscience provide powerful ways of looking at brain functioning. I will introduce these methods and explain how I am using one of them, magnetoencephalography, to study the development of skills in symbolic mathematics. Failure to acquire such skills obstructs many students progress as physicists. Can we understand how the skills develop, be able to identify the student's stage of development and fine tune our approaches to catalyse individual or group progress. I don't yet know the answers to these questions but will welcome discussion about how to expand and develop the initial studies.

Oral Presentations

Oral 1	**Towards a Conceptual Inventory in Quantum Mechanics**
Oral 2	**Scientific Thinking; Insights from an Academic Game**
Oral 3	**Student Attitudes to Physics at School and University**
Oral 4	**Attitudes, Learning and Problem Solving in Physics**
Oral 5	**Building a Community of Physics and Astronomy Distance Learners**
Oral 6	**Supporting Level 1 Physics & Astronomy Undergraduates at the University of Glasgow**
Oral 7	**We've Solved our Maths Problem: Have You?**
Oral 8	**Use of 3D Virtual Environments in Teaching Astronomy and Physics**
Oral 9	**Development of Learning Material for Formative Computer Based Assessment in Physics and Astronomy**
Oral 10	**The Physical Sciences Question Bank – What Next?**
Oral 11	**Being SUPA (Computer Mediated Activity)**
Oral 12	**Being SUPA (Computer-Mediated Activity)**
Oral 13	**Being SUPA (Video-Conferenced Lectures**
Oral 14	**R1C12 Diagram Helping Educators Structuring Necleons in Nuclei**
Oral 15	**Undergraduate Student Perceptions, Views and Opinions of Laboratory Teaching of Physics**
Oral 16	**Problem-Based Learning Labs in First Year Physics**

Abstracts of Oral Presentations

Oral 1 - Towards a Conceptual Inventory in Quantum Mechanics

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In this talk we describe a pilot study that takes first steps towards the creation, deployment and evaluation of a concept inventory in quantum mechanics teaching at introductory undergraduate level in Physics.

The Force Concept Inventory and Mechanics Baseline tests, developed through years of research via the Physics Education Research effort in the US and Canada, have emerged as the 'gold standard' tests of students' conceptual understanding in classical mechanics. Inspired by the widespread use and usefulness of the tests, we have established a project to develop an equivalent test for student understanding of quantum mechanics.

Quantum mechanics is widely regarded as one of the most challenging topics in the undergraduate curriculum; it abounds with abstract and often counterintuitive findings, paradoxes and poses real conceptual challenges to students. The Nobel Laureate Richard Feynman, arguably the greatest physicist of his generation, famously quoted "I think I can safely say no-one *really* understands quantum mechanics". All too often, the teaching of the subject in early years of an undergraduate programme presents students with a barrage of information rather than focussing on understanding of concepts. Many students typically adopt the strategy that 'gets them through' courses, falling back on surface learning and memorisation rather than conceptual understanding.

This talk presents the initial findings from a final year undergraduate research project undertaken in Edinburgh between January and March 2008. It presents an initial attempt to try and identify the conceptual misunderstandings that students possess, via designing suitable questions and deploying them to students on a second year undergraduate course in Edinburgh. Examples of the questions will be presented, along with analysis of student responses and follow-up interviews from focus groups. We will also outline our plans for the future development of the test.

Oral 2 - Scientific Thinking; Insights from an Academic Game

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Scientific thinking is often considered as an important set of skills in science courses even at school level but there is little clarity about exactly what is involved, how such skills can be developed and how to measure them (Al-Ahmadi, 2008)
The academic game, called Eloosis, was first described by Zieglar in 1974 and has been used in higher education science courses over many years. The game claims to model the key elements of scientific thinking but its use is perhaps greater when seen as a way to initiate discussion about how the sciences work in developing ther understandings of the world around (Matuszek, 1995).

This paper describes a series of experiments using the game Eloosis, these being used to explore the extent of scientific thinking with three very different groups of learners in Scotland: a group of science qualified school leavers; two large groups of students who had recently completed degrees in physics, chemistry or biology; a group of highly able third year students not following a course remotely related to the sciences. The results were compared to outcomes from several groups of younger school students (Reid and Serumola, 2007).

It will be argued that scientific thinking is only accessible above a certain age (about 15-16) and, for its full development, undertaking courses in a science subject are important This will be set in the context of the development and measurement of scientific thinking with students of physics.

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Oral 3 - Student Attitudes to Physics at School and University

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The HEFCE funded Stimulating Physics Project has run a Teacher Fellows scheme organised through the Institute of Physics. As part of a teacher fellow secondment at Nottingham Trent University, a research study has been undertaken with first year undergraduates and ‘A’-level students.

The aim of the study was to investigate reasons behind why students chose not to continue to study physics for example after GSCE, or after completing AS-level or A2 level physics.

Using questionnaires (designed using the Osgood method of measuring attitude and based on previous work by Reid), and interviews, the following groups of students were surveyed:

- 1st year undergraduate Physics students,
- 1st year undergraduate Chemistry students
- Year 13 Physics students.
- Year 12 Physics students, and
- Chemistry and Maths students in Years 12 and 13.

The survey looked at their attitudes towards the teaching & learning of physics, their perceptions of the career potential of the subject and the challenges presented by studying physics. It also investigated reasons why students stopped studying physics.

Initial findings suggest that not only do students perceive physics to be one of the hardest subjects to study they actually find it the hardest of all – this included students who were also studying maths as well. Those who had stopped studying physics also felt that it offered less career opportunities than other STEM subjects.
This study offers some insight into possible ways of increasing numbers of students studying physics at a range of levels.

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Oral 4 - Attitudes, Learning and Problem Solving in Physics

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It has been argued that most of the early research in physics education focussed on students’ conceptual understanding in physics, their problem-solving ability and investigative skills (May, 2002). May went on to argue that effective problem-solving skills required more than knowledge and understanding of physics but was also dependent on less easily defined skills and attitudes (Hammer, 2000; Schommer, 1990). Indeed, there have been numerous studies which show the interrelationships between attitudes and physics learning (Domert et al., 2007; Stathopoulou & Vosniadou, 2007; Perkins et al., 2006) and Adams et al., (2006) and Perkins et al., (2006) noted this as an active area of research in the field of physics education.

This paper will describe an exploration of students' attitudes relating to physics and learning physics in higher education which involved 200 students in four universities in Lahore, Pakistan using a refinement of an established survey. The response patterns were analysed using Principal Components Analysis which looked for underlying factors. Although set in Pakistan, the outcomes are of much wider significance and, perhaps, define part of the agenda which might contribute to better understanding and problem solving skills in Higher Education Physics.

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Oral 5 - Building a Community of Physics and Astronomy Distance Learners

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The challenge of maintaining and even boosting student retention through a whole programme of study, especially in light of the government's ELQ policy, is an important issue for the Open University and its distance learners.

In the future, there will be fewer opportunities for face-to-face meetings for students, especially on higher level courses. Personal interactions play an important role for many students as they select future courses, and maintain their motivation to study. The University is making increasing use of the Moodle VLE for its courses, and is shifting towards encouraging programme-based studies

The Physics and Astronomy Department offers a complex mix of qualifications and courses, interfacing with qualifications and courses from other parts of the University. Our introductory astronomy courses are studied by thousands of students each year – many of whom do not see themselves as physical scientists

Recent websites providing information about subject programmes and qualifications have proved popular with students.

The Physics and Astronomy student website is currently under development. It is built on Moodle to be familiar to students – and aims to become a site that students will return to regularly throughout their studies, with a community aspect. It should encourage students to take further courses in physics and astronomy, and help them succeed in their study and career goals.

The site includes video statements by students describing their experiences and plans. There is material on study skills, and opportunities for activity on an astronomical observation wiki. Plans include links to material to help students cross the gap between courses (to help improve progression through to a qualification) and careers materials.

Oral 6 - Supporting Level 1 Physics & Astronomy Undergraduates at the University of Glasgow

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It is generally accepted that the retention and associated completion rates for first year classes are an area of concern for UK universities, and physics and astronomy classes at the University of Glasgow are no exception. Classes are often large and, as result, student integration on academic and social levels can be difficult to achieve; some students perceive a lack of personal interest and support in what can sometimes be a stressful transition from secondary to tertiary education.

In common with some other Scottish universities, the University of Glasgow grants students entry to a faculty rather than an individual course; there are benefits and detriments to this system. As well as allowing students to study a broad-based curriculum, one benefit of the faculty entry system is that it allows students to change course at the end of their first year. The detriment to this system, from the perspective of individual departments, is that some students *do* decide to change course at the end of their first year.

In order to address these issues, the author has been employed in a new departmental post, *Director of Learning Support for First Year.* The remit of this post is primarily the implementation of an improved personal contact and academic monitoring and support strategy for first year undergraduates. Therefore, a number of new initiatives were introduced:

- Contact of students by SMS text messaging.
- Provision of optional drop-in tutorials.
-

Secondly, a longitudinal cohort analysis was performed in an attempt to ascertain the effects or otherwise of studying first year physics on students' long-term degree intentions.

The purpose of this paper is to present, firstly, the ways in which the role of *Director of Learning Support* has had a positive impact during the present academic year and, secondly, the results from a longitudinal cohort analysis of the first year Physics classes.

Oral 7 - We've Solved our Maths Problem: Have You?

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This talk will describe our efforts to try and address 'the maths problem'; the widespread and widely-acknowledged decline in the ability of entrant undergraduates' ability in mathematical proficiency and fluency. We describe the design, implementation and evaluation of a new second year course (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 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 its introduction has precipitated.

Oral 8 - Use of 3D Virtual Environments in Teaching Astronomy and Physics

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We have developed several 3D graphics applications to support our teaching some of which create virtual environments. In particular a telescope simulator has been used to initiate students in the controls of a particular telescope that they will then subsequently use at an observatory.

At the beginning of each observing session the students have to align the telescope with a known star in order to allow the automatic tracking of stars. Most course students have never used a telescope before and find this task rather challenging. As a result, the aligning procedure often takes up too much of the precious dark time needed for data acquisition.

The simulator is a C++ program using the OpenGL library and the glut API. A finite state automata models the handset whose transitions were carefully plotted by interaction with the actual controller. This gives a near perfect recreation of the interface, the only differences being: only a limited set of features are implemented and that the user clicks with a mouse rather than actually presses buttons.

The user can move forward and away from the telescope and can rotate around it in order to obtain the view needed. In particular, when aligning on a star, a rough alignment along the tube of the telescope can be performed before using the finder-scope feature (this shows the finder-scope view with cross-wires centred on the screen).

The stars are modelled using a single star texture mapped to the relevant size depending on apparent magnitude. They are coloured according to their spectral type. The night sky as it will appear when they are actually at the observatory is plotted. This allows them to become familiar with the bright stars that they will commonly use for alignment.

The talk will describe the program, how the students have been using it, and the feedback we have obtained.

Oral 9 - Development of Learning Material for Formative Computer Based Assessment in Physics and Astronomy

Antje Kohnle, Tom Brown
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Formative computer based assessment (CBA) has a great potential for enhancing student learning: it can be used to quickly and efficiently diagnose areas of difficulty and to enhance student motivation and learning. Amongst its advantages are high flexibility in delivery and prompt feedback that can be tailored to connect assessment and learning. Formative CBA is student-centred and can lead to higher levels of student engagement and student motivation.

In the framework of a Higher Education Academy 2007/08 development project, we have developed material covering a large number of core physics and astronomy areas ranging from 1st to 4th year undergraduate physics. Topics covered include stars and elementary astrophysics, solar system, waves and optics, properties of matter, oscillations, electricity and magnetism, special relativity, thermal physics, quantum mechanics, and nuclear and particle physics. We have focused on material requiring higher-order cognitive skills and have attempted to tailor feedback to be particularly useful to students. The material is now available to you all in the DUMP and PSSC question banks. In this presentation, we will give examples of questions produced and show some ways of using questions to enhance physics and astronomy teaching.

Oral 10 - The Physical Sciences Question Bank – What Next?

Dick Bacon
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The Physical Sciences Question Bank was released earlier this year and is being used by a growing number of academics. This paper will describe the existing system, briefly discussing the various decisions that had to be made during its construction. The various uses of the questions will be considered, together with the need for more questions and the properties they would require to be suitable for these or other uses. It is clear that for maximum utility the question bank will need to develop, partly as new target systems are developed or current ones are modified, but also because a number of excellent suggestions for new question bank features have been received. Some of these suggestions will be described against the background of the design decisions described above, and ways in which such question bank developments could be undertaken will be explored.

Oral 11 - Being SUPA (Infrastructure)

Sean Farrell & Avril Manners
SUPA, the Scottish Universities Physics Alliance.
SUPA comprises the Physics departments of Edinburgh University, Glasgow University, Heriot-Watt University, St. Andrews University, Strathclyde University and Paisley University.
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The Scottish Universities Physics Alliance, SUPA, is founded on a Scottish graduate school in physics and a coordinated approach to research under a single management umbrella.

SUPA includes academics with expertise across a broad range of physics themes. The aim of the SUPA Graduate School is to make best use of this expert knowledge base within SUPA. To this end, the SUPA Technology Team works with lecturers to develop and extend their use of learning and teaching technologies to maximise the physics expertise available to their students, both postgraduate and final year undergraduate.

This physics expertise is made available to PhD students through video links between dedicated teaching rooms, computer mediated resources and tools, practical activities (e.g. programming labs), tutorials and discussion classes as well as lectures by distinguished visitors. The key elements in the provision of SUPA technology are:

- infrastructure
- video-conferenced lectures
- computer mediated activity

This session, one of three related but independent presentations, concentrates on the SUPA infrastructure. We outline some of the factors to be considered when providing computing infrastructure in an inter-institutional pooling context and report on the solutions we have adopted to manage the flow of information and data within SUPA and to provide accessible storage and online tools to our geographically distributed users.

This subject will be of particular interest to those involved with other pooling initiatives, especially those at the planning stages, who may benefit from our experience.

Oral 12 - Being SUPA (Computer-Mediated Activity)

Karon McBride and Avril Manners
SUPA, the Scottish Universities Physics Alliance.
Email: david.crooks@supa.ac.uk

The Scottish Universities Physics Alliance, SUPA, is founded on a Scottish graduate school in physics and a coordinated approach to research under a single management umbrella.

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(e.g. programming labs), tutorials and discussion classes as well as lectures by distinguished visitors. The key elements in the provision of SUPA technology are:

- infrastructure
- video-conferenced lectures
- computer mediated activity

In this presentation, one of three related but independent sessions, we describe the ways in which we exploit the opportunities afforded by computer technology to the benefit of the participants in the SUPA Graduate School and the wider SUPA research community. In particular, we report on our implementation of a Moodle as a virtual learning and research environment in an inter-institutional pooling context.

This subject will be of particular interest to those involved with other pooling initiatives, especially those at the planning stages, who may benefit from our experience.

Oral 13 - Being SUPA (Video-Conferenced Lectures

David Crooks and Avril Manners
SUPA, the Scottish Universities Physics Alliance.
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The Scottish Universities Physics Alliance, SUPA, is founded on a Scottish graduate school in physics and a coordinated approach to research under a single management umbrella.

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This physics expertise is made available to PhD students through video links between dedicated teaching rooms, computer mediated resources and tools, practical activities (e.g. programming labs), tutorials and discussion classes as well as lectures by distinguished visitors. The key elements in the provision of SUPA technology are:

- infrastructure
- video-conferenced lectures
- computer mediated activity

In this session, one of three related but independent presentations, we describe the video conference systems used to enable the SUPA graduate school lecture portfolio. We report on the multilayered approach required to support these systems effectively across a geographically distributed graduate school. We also report on our experiences of working with students and staff during the first two full years of operation.

This subject will be of particular interest to those involved with other pooling initiatives, especially those at the planning stages, who may benefit from our experience.

Oral 14 - R1C12 Diagram Helping Educators Structuring Necleons in Nuclei

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Electronic configuration of atoms was easily figured out using the Aufban principle [1] which explains that the orbits of lower energies are first filled up with electrons, therefore, a well known diagram (Aufban diagram) is used world wide to develop the electronic structure of atoms. In this work, the author reviewed the shell model theory for the structuring of neutrons and protons in nuclei [2], and developed a new diagram for the nucleonic structure of nuclei. It is named R1C12- Diagram because the arrows representing the state energies of the harmonic oscillator $h\omega 0$, $h\omega 1$, $h\omega 2$,…etc. start from the first raw R1 and ends up in columns C1 and C2 alternatively of a matrix extension of Aufban diagram (see the general diagram structure in figure 1 below). The diagram with the orbital (ℓ) and spin (s) coupling can be easily used to develop the neutron and proton shell structuring in nuclei , and an example of the proton and neutron structuring of Tin nucleous ($^{116}_{50}Sn$)is demonstrated. The diagram is recommended to be used for teaching in nuclear physics courses.

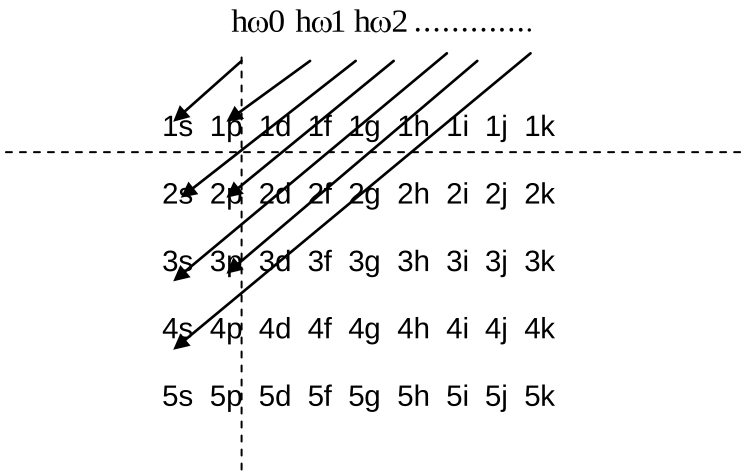

Figure (1)
The general form of the R1C12- diagram for the nucleonic structure of nuclei

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Oral 15 - Undergraduate Student Perceptions, Views and Opinions of Laboratory Teaching of Physics

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The physics laboratory has long been a distinctive feature of physics education. It has been given a central and distinctive role in the teaching and learning of physics at school and undergraduate levels in the universities. This is certainly the case at the Department of Physics and Astronomy at the University of Glasgow, the department where the idea of laboratory teaching was originally developed in the 1800s by the future Lord Kelvin.

During the second semester of the academic year 07/08, the Department joined with the University of Glasgow's Centre for Science Education to try and judge the perceptions, views opinions of undergraduate students across the first, second and third years of their degrees. This presentation will summarise the key conclusions from this work, highlighting the common factors across the years, as well as the differences.

The broad view of students is that Physics labs are an enjoyable experience that do make a valuable contribution to their studies. They are not, though, perfect. In addition to highlighting the strengths of laboratory teaching from the students' point of view, this presentation will point out the "traps" to avoid by those involved in running undergraduate teaching labs in their own institutions.

Oral 16 - Problem-Based Learning Labs in First Year Physics

Antje Kohnle, Cameron Rae, Tom Brown, Bruce Sinclair
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With the aim of enhancing problem-solving skills and student motivation, we have introduced three short problem-based learning labs at the end of the second semester of our 1st year physics lab. We focussed on problems relevant to everyday student experience that would enhance the development of core lab skills.

In the first lab, students were given the scenario that they were to test the claims of a rival manufacturer that their sunglasses block all the harmful high-energy radiation from the sun. This required students to work together in groups to design an experiment and to then ask staff for apparatus for their experiment. Most of the types of apparatus likely to be requested were available in another room, and brought in on request to each group. The students then had to design their experiment and carry it out, essentially measuring the wavelength-dependence of the transmission of a provided pair of sunglasses. At the end of the session, students visited one of our research labs and were shown how such a measurement would be carried out in a research environment using a spectrophotometer.

The second lab was centred on ultrasound technology used in assisting parking in cars. The third lab focused on the possible hazards of mobile phone radiation and how to reduce exposure to this radiation.

The presentation will give details of our experience and will summarize the outcomes and future plans.

Workshops

Workshop 1 **Understanding the Undergraduate Student Learning Experience in Physics**

Workshop 2 **Interactive Screen Experiments: A New Resource for Experimental Physics**

Workshop 1 - Understanding the Undergraduate Student Learning Experience in Physics

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During 2007/8 I have been the consultant for the HEA Physical Science Centre "Review of the Student Learning Experience in Physics". A draft report and initial results will be ready by September, and I would like to run a 2 hour Workshop on interpreting the results. It is very important that the correct interpretations (or range of interpretations) are made from the data before publication of the final report. I also believe that university teachers will gain a great deal of insight from an interactive session where the raw results from student, staff and other surveys carried out under the review are presented in suitable combinations, and then analysed/commented on/discussed by the audience (in appropriate groups, with reporting). This discussion can then also inform writing of the final report, which should be completed by late October/early November. The Review covers a wide range of student learning and staff teaching experience in the 45 UK universities that currently offer Physics (and Physics-related) degrees.

Workshop 2 - Interactive Screen Experiments: a New Resource for Experimental Physics

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ISEs (Interactive Screen Experiments) are being developed by piCETL (Physics Innovations Centre for Excellence in Teaching and Learning) at the Open University and the University of Reading. ISEs are based on photographs of real experiments and are presented to students in a way that enables them to collect data for themselves.

This hands-on workshop will explain further what an ISE is – and what it is not – and explore some of the philosophies behind their development.

ISEs are already in use in Open University residential and non-residential modules. They are used to supplement rather than to replace laboratory work, and to support students in experiments conducted at home. Evaluation of the ISEs in use is seeking to ascertain the effectiveness and usability of the ISEs so as to enable improvements to be made for the future. Early evaluation findings will be presented.

Workshop participants will have an opportunity to try a range of ISEs for themselves and will be encouraged to consider situations in their own teaching environment in which they might use ISEs to enable students to derive maximum benefit from their laboratory work.

The workshop will be organised as follows:
What is an ISE? (Presentation)
Have a go! (Hands-on)
OU use of ISEs (Presentation)
How would you use ISEs in your own teaching? (Group discussions)
Outcomes of our evaluation (Presentation)
Discussion