

Proposal for Stage 1, AUTC Project

Learning Outcomes and Curriculum Development in Physics

Project Leaders: Dr. M. Sharma (U.Syd), Dr. D. Mills (Monash).

Steering Committee: Prof. A. Robson (AUTC), Dr. D. Mills (Monash), Assoc. Prof. B. James (Head, School of Physics, U.Syd), Assoc. Prof. L. Kirkup (UTS), Dr. M. Livett (U.Melb), Assoc. Prof R. Newbury (UNSW), Dr. J. Pollard (U.Adelaide), Assoc. Prof. M. Prosser (Institute of Teaching and Learning, U.Syd), Prof. M. Zadnik (Curtin).

Team Members: Ms. A. Binnie (UTS), Ms. S. Feteris (Monash), Dr. J. Furst (U.Newcastle), Dr. D. Low (UNSW-ADFA), Dr. J. O'Byrne (U.Syd), Dr. A. Rayner (U.Qld), Ms. M. Scoufis (UNSW), Dr. G. Swan (ECU), Assoc.Prof. W. Zealey (U.Wollongong).

Expert Advisors Panel: Prof. R. Gunstone (Professor of Science and Technology Education, Monash), Prof. B. Muddle (Head, School of Physics and Materials Engineering, Monash), Prof. J. Prescott (U. Adelaide), Prof. P. Ramsden (Pro-V.C. Teaching and Learning, U.Syd).

Introduction

As physics in Australia has experienced major changes this study is timely and should help revitalise tertiary physics education for the benefit of all stakeholders. Our team members have been involved in innovation and evaluation of teaching and learning, in developing curriculum for multidisciplinary environments, teacher training and in-service, and in the employer-industry aspects of Australian physics and can provide quality outcomes.

Proposed Approach and Methodology-timeline

The project team, with members from twelve institutions in five states and the ACT, will obtain an accurate and complete picture of the teaching and learning of physics in Australia. Given the breadth of the proposed project, we propose to have working groups for particular sets of tasks. (As a tentative plan, Working Party 1 will map the range of curricula, response to change including multidisciplinary areas and processes of innovation, Working party 2 on student satisfaction, expectations and attitudes, Working Party 3 – relations with industry, industry input to curriculum, graduate employability and professional preparation, Working Party 4 will seek out best-practice case studies from all the above.)

We envisage four phases within Stage 1 as outlined below. The Expert Advisors will provide expertise at critical points in the design and interpretation stages of the study. As well as the National Steering Committee meetings there will be Team Leaders meetings.

Work on Stage 1 is expected to commence in January 2004.

Stage 1, Phase 1 DESIGN (3 months)

This phase will identify the key issues in each of the specified tasks, and how to best obtain data which clearly reveals the key factors. We will draw on international and Australian studies including for instance, EUPEN (European Physics Education Network - a consortium of 130 Physics departments in over 30 different European countries, whose work is reaching maturity), the 2001 Institute of Physics (UK) Inquiry into Undergraduate Physics, and the recently formed National Task Force on Undergraduate Physics in the U.S., and the Australian Council of Deans of Science's report on science graduate destinations. Appropriate methodologies and international benchmarks will be drawn from these studies.

Design of questionnaires will be a key activity in this phase. These will be based on responses from individuals and focus groups targeted at each of the main areas. Obtaining information from employers and industry has been identified as requiring particular attention, based on the experience of the AUTC project on Information and Communication Technology and on the fact that there is no simply defined 'physics' industry.

This phase will identify what physics is taught and the structure within which the teaching occurs in all Australian universities including a wide range of multidisciplinary and specialised degree programs. Data to be collected will encompass:

- content, assessment, learning outcomes, the scope of information available to students;
- the extent of adaptation to changes (in the student body and in the increasing multidisciplinary study, work environment) and adoption of physics education research and innovative practice;
- physics in multidisciplinary contexts and disciplines especially engineering and biomedical sciences, including the alignment of graduate attributes in those disciplines, and the extent of consultation and responsiveness to the client department or faculty;
- mechanisms for evaluation and the extent of and response to student feedback;
- advice to students about careers and the multidisciplinary nature of physics;
- graduate employability and employment trends, employer satisfaction;
- extent and type of industry involvement in teaching and curriculum development;
- professional and industrial experience and its evaluation;
- revitalising 'main-stream' physics in the midst of other changes;
- identifying probable future developments and other issues of significance to the tertiary physics sector;
- student backgrounds, expectations and attitudes.

Stage 1, Phase 2 ANALYSIS (4 months)

In this phase data collection will be completed and data analysed in order to identify the major features of physics training, how it has adapted to the various changes and how it meets the needs of all stakeholders.

Questionnaire(s) designed in Phase 1 will be administered to all Australian universities teaching physics. The working group will follow up in more depth (e.g. by focus groups, 1:1 interviews with industry representatives, associate deans for teaching and others with specialist knowledge) those initiatives which have been successful in addressing issues such as

- effectively communicating multidisciplinary career opportunities to students, and effective ways of equipping students for such careers;
- the involvement of industry in curriculum development and the teaching and learning process;
- academic staff development which fosters an ethos of innovative teaching and learning, and ways of providing effective teaching in understaffed situations;
- ways in which physicists contribute to the training of teachers for physics in schools; ways of fostering cooperation across states and with faculties of education.

Stage 1, Phase 3 TOWARDS BEST PRACTICE (3 months)

This Phase will develop criteria and identify best (or excellent) and innovative practice in the key tasks specified in the project. A set of guidelines and suggestions for improving teaching practices will be developed, focussing on the four areas outlined in the Project brief (assessment of student and employer satisfaction, relationship between course design and various indicators, incorporation of industry expertise in the curriculum and academic staff

development). Scenarios or case-studies will be developed showing the incorporation of new developments in physics into curricula and the teaching program, with particular reference to features that have led to successful assimilation. These scenarios will serve as a model for the incorporation of future developments.

To achieve this, working groups will interpret results from Phase 2, use comparisons with international standards and findings (such as EUPEN and ABET for physics in Engineering in the USA), and formulate criteria for best practice and guidelines for improvement. These criteria and guidelines will be validated by reference to relevant members of the Expert Advisors Panel and to experienced senior academics and leaders in physics industries outside the team.

Stage 1, Phase 4 REPORTING (2 months)

A report will be prepared for AUTC as specified in the Project Description. It will include current practice, best practice cases and guidelines. During this phase a detailed proposal for stage 2 of the project will be prepared.

Cases of best practice and innovative practice identified in Phase 3 will be refined in collaboration with the relevant academic staff.

Stage 2

Resource material incorporating the guidelines and suggestions for improvement described in stage 1 will be developed. Innovative solutions to specific problem areas will be developed with a view to facilitating their implementation. During this stage the team will divide into sub groups depending on their expertise to develop and disseminate resource materials.

In stage 2 we envisage we will provide a website, a series of workshops across Australia, and a small publication. The web site would ideally be updated beyond the life of the project to provide a national physics teaching resource containing ‘excellent practice’ teaching material and case studies of innovative practice in relation to issues of importance to the physics community. We believe that it is possible to extend the existing sharing of teaching resources on a ‘goodwill’ basis to become the norm provided there are efficient mechanisms. Publication of a print resource similar to the booklet *Assessing Learning in Australian Universities* commissioned by the AUTC would be desirable since it would serve as a reminder to academic staff that improvement is achievable.

Workshops in Stage 2 would be cost-effective, particularly by having them hosted in states by team members’ institutions in conjunction with the Physics Education Group (PEG) Conference (formerly known as OzCUPE) at the AIP Congress in February 2005, etc. Dissemination to the broader higher education scientific community will also be made through presentations at the UniServe Science Annual Conference.

Notional Budget – Stage1

Project Officer (research-only academic at middle of Level A e.g. minimum salary for a person with PhD of \$48,554 plus on-costs for 1 year full-time, or a higher level salary at for instance 0.7 fraction)	\$56,810
Travel to 4 meetings of Steering Committee and Team Leader (assumed to be in Sydney)	
Airfare Mel-Syd-Mel \$200, ground transport \$60, (Mills & Livett)	\$2,080
Airfare Ade-Syd-Ade \$280, ground transport \$60, accomodation \$130 (Pollard)	\$1,880
Airfare Per-Syd-Per \$600, ground transport \$60, accommodation \$130 (Zadnik)	\$3,160

Interstate travel for Project Officer and accommodation (may include Team & Steering Committee meetings if Project Officer not based in Sydney).	\$4,000
Other costs of meetings (meals, etc)	\$880
Consultants e.g. employer groups	\$2,800
Miscellaneous including data entry, preliminary construction of website	\$3,400
TOTAL Stage 1	\$75,000

The Project Officer will require a working knowledge of evaluation techniques and appropriate data analysis methodologies as well as excellent interpersonal skills to support the collaboration. The project will be labour intensive, with much of the data collection and analysis happening in parallel in the various working parties in the first year. We propose to use consultants sparingly, in cases where this will expedite the design of the methodology and interpretation of key issues. The heads of departments/schools at U.Sydney and at Monash have offered to provide accommodation for the project officer.

We propose to hold two National Steering Committee Meetings and two Team Leader Meetings in Stage 1, with the Project Officer attending these meetings. These face-to-face meetings will be pivotal in keeping the many aspects of the project moving.

Addressing the Selection Criteria

Demonstrated understanding of the issues involved in teaching and learning in physics

The project team leaders and members have extensive experience and understanding of issues relating to the teaching and learning of physics, the use of educational research-based strategies and innovations, and the interface with industry and the physics teacher community. Most are members of the AIP (Australian Institute of Physics) Physics Education Group which hosts a biennial conference during the Australian Institute of Physics Congress. Leaders have collaborated and spent sabbaticals with prominent physics education groups including R. Thornton (Tufts U.), L. McDermott (U. of Washington), E. Redish (U. Maryland), D. Zollman (Kansas State) and A. van Heuvelen (Ohio State U.)

All team members have experience of physics in multidisciplinary environments and have developed curricula for courses such as Biomedical Sciences, Marine Science and Food Sciences, Medical Imaging and Radiography, Materials Science, Astronomy, and have adapted physics specifically to the modern demands of Engineering courses. All have experience and success in striving to teach better with fewer staff, and strategies for improving academic teaching.

Capacities of the methodologies proposed to deliver appropriate outcomes

The team has had preliminary discussions with the leader and education evaluation expert of the AUTC project on Information and Communication Technologies to identify areas of potential difficulty and has been offered the full benefit of their experience.

The capacity of our methodology to collect, analyse and interpret appropriate data from across Australian universities and employers is the first key to success in this project. This depends on our ability to identify key issues, effectively use focus groups and design surveys. Our extensive network of contacts within universities and in industry boost our ability to be able to actually collect data.

For convenience we have numbered the task dot-points given in the project brief to confirm that all outcomes are deliverable. The data and analysis enable us to describe and evaluate (1) the impact of new multidisciplinary areas on teaching and learning, (3) ways in which universities assess and respond to the changing nature of industry and graduate employment, (4) ways in which the processes of curriculum development and review are varied in view of

changing circumstances, (6) the role of professional experience and its management within the curriculum, (7) graduate employability and employer/industry satisfaction, (8) methods of assessing student and employer satisfaction and its role in curriculum review and enhancement of teaching and learning, (9) relationships between course design and indicators such as enrolment and employment trends, graduate satisfaction and graduate employability. Information collected in phase 2 will enable us to describe and evaluate how the teaching and learning of physics has evolved to face changing circumstances, (5) how information about opportunities in multidisciplinary areas can be disseminated and managed, (10) how industry can be involved in curriculum development and teaching and learning process, and (11) strategies for academic staff development and resolving staff shortages.

We will prepare a report on (2) national and international developments in teaching and learning in physics which will assess the quality of teaching and learning of physics across Australian universities and suggestions for improvement as specified in the Project Description (12-15). In particular best (or excellent) practice and innovative practice will be identified (12) and appropriate staff will be invited to contribute a section for a book or web-book to be distributed to all Australian universities teaching physics. From the findings, (13) recommendations will be made for the effective dissemination and take-up of examples of best practice and innovative practice. Comparison of results from across Australia and with international benchmarks will allow us to carry out (14) an overall assessment of the quality of teaching and learning and to place the examples of best practice in this context.

Experience and demonstrated capabilities of the project team in relation to the tasks

The team has extensive experience in educational innovation and evaluation. CUTSD grants have been successfully led by Sharma and Newbury (*Tutorials in Physics*), Pollard (*Studio Physics*) and Livett (*Real-World Physics*), Kirkup (*Experimental Methods in Physical Sciences*), and by Zadnik. Ability to collaborate was a key to the *Tutorials in Physics* project involving team members from three institutions. This project is also an example of successful dissemination through national and international workshops and has made a significant contribution to teaching at other institutions.

It is noteworthy that innovations have been based on solid physics education research findings which have meant that the benefits have been long-lasting and have spread to other institutions and to secondary teaching (eg Mills & Feteris' *Conceptual Understanding in Physics* cooperative learning approach, Feteris' research on learning in laboratory, Kirkup on experimental method, Zadnik on studio-physics). Most members have had institutional teaching grants for teaching improvements and innovation. By necessity innovation has targeted effective means of learning for large student:staff ratios, for example interactive web-based materials (Livett), a 3-semester physics software package for engineering (Mills & Feteris), rotational dynamics (Swan), IT for active learning in large classes (Sharma).

Our collective responsibilities reflect the fact that most physics teaching is at the introductory level. We also have extensive experience at upper level physics where change is inevitably slower (e.g. Grant, Feteris in developing higher level laboratories) and have led curriculum change through departmental undergraduate education committees and at faculty level (eg. Newbury, Zadnik, Mills, Feteris, Pollard, Grant). This means we are very much in touch with changing student backgrounds and their future directions. Several members are in departments which are quite different from traditional physics departments (e.g. Furst, Low, Swan). Our team is well placed to evaluate globalisation and internationalisation (through teaching developments off-shore as well as in our international collaborations) and gender-related issues.

Prosser, Ramsden, Gunstone and Scoufis bring expertise of national and international standing in evaluating teaching and learning in a range of contexts, including particular topic

areas in physics, the whole physics learning environment, broader issues of science and maths curricula, and physics teacher training. Gunstone (with Mills) and Zadnik have ARC large-grant research in physics teaching and learning and Prosser has had three ARC grants since 1990 looking at various aspects of teaching and learning in university studies.

The team has wide knowledge of the industry and employer interface; O'Byrne in particular maintains an alumni data-base. Expert Advisors provide more specialist knowledge: Prescott has for some decades provided a continuing survey of overall Australian employment in physics; Muddle is strongly involved with industries which employ physicists and also brings the perspective of Engineering (both education and industry) as a stakeholder.

The team has extensive cooperation with faculties of education and with physics and science teachers, their pre-service and in-service training, reviewing, advising and providing resources for state physics curricula and for national science initiatives (Livett, Gunstone, Binnie, Zealey, Feteris, Mills and others).

Value for Money

Our team has a mix of senior and young academics with a demonstrated commitment to enhancing the teaching and learning of physics. We have the advantage of already having worked together in various capacities and have already extensively shared resources and experience which is significantly changing the face of physics education in Australia. We are already familiar with much of the territory to be investigated. Our team's proven ability to disseminate the benefits of this project widely through our involvement and activities within existing frameworks of state and national physics communities is a major advantage, for without it the project will have little long-term impact.

APPENDIX: INDICATIVE TIME-LINE – STAGE 1

Time	Tasks for PO	Tasks for Team	Result
Month 0	Appoint Project Officer (PO)	Form 4 working parties (WP), establish leader for each WP.	Appoint PO and establish WP.
Phase 1 Month 1/2	<p>Assist WPs in designing questionnaires.</p> <p>Design database for the project, in consultation with team.</p> <p>Research EUPEN, IoP and US projects, and other relevant material.</p>	<p>Use focus groups, existing survey tools and local expertise to design instruments such as questionnaires, questions for focus groups and interviews. Start to collect data on trends.</p> <p>WP1: Instruments on courses, student numbers, multidisciplinary t&l. Gather data on trends in students numbers, service teaching, and how t&l has adapted.</p> <p>WP2: Instruments on student satisfaction, attitudes, views and backgrounds. Possible focus groups with students.</p> <p>WP3: Instruments on employer satisfaction, needs, involvement in course development. Review data on employment trends. Initial interviews with employers.</p> <p>WP4: How to identify obtain best practice case studies, including data on how effectiveness is measured. Initial interviews with staff.</p>	<p>Steering committee meeting</p> <p>First version of questionnaires.</p> <p>First version of database (accessible to all team members)</p> <p>Begin collection of data on trends</p>
Phase 1 Month 2	Enters test data from to trial the database.	Instruments are trialled and modified appropriately.	Final version of questionnaires

Phase 1/2 Month 3-4	Finalises database. Questionnaires distributed and data gathered.	Assist PO with data gathering, and administering of instruments to students and employers in their states.	Basic data collection complete
Phase 2 Month 5-7	Data entry and collation. Work with WP on data analysis and interpretation.	Work with PO on data analysis and interpretation.	Leaders Meeting Data entered into database.
Phase 3 Month 8-10	Work with WP on writing a report for each section. Work with all team members and WP4 on developing criteria for best and innovative practice and incorporation of new developments.	Work with PO on writing a report for their section. All team members work with WP4 and PO on developing criteria for best and innovative practice and incorporation of new developments.	Steering Committee Meeting Reports from each working party.
Phase 4 Months 11 to 12	Work with WP on journal papers and the report for AUTC.	Work with PO on journal papers and report. Prepare Stage 2 proposal.	Leaders Meeting. Stage 1 report and Stage 2 Proposal to AUTC Journal papers.

APPENDIX: BRIEF DETAILS OF TEAM

Team Leaders

Dr. Manju Sharma is Head of the Sydney University Physics Education Research (SUPER) group; her investigations range from cooperative learning strategies to the use of IT to promote active learning in large lecture classes. She led a successful CUTSD *Tutorials in Physics* project resulting in a 3-volume book, 2 refereed papers, 13 conference presentations and 4 workshops in Australia and one in the US.

Dr. David Mills is Director of First Year Physics at Monash, oversees off-shore teaching, is national convenor of the AIP Physics Education Group, developed the *CUP* cooperative learning strategy, a 34-module interactive physics software package, has reviewed Victorian secondary physics courses on several occasions.

Assoc. Prof. Brian James is Head of School of Physics, Sydney University, and has been Associate Dean for Postgraduate Coursework and Research. He has extensive experience in the evaluation and enhancement of teaching ranging from third year physics labs to specialised medical science courses and has received Sydney University grants for the improvement of teaching and learning

Assoc. Prof. Les Kirkup has led the development of enquiry based physics laboratories for Engineering and Biomedical sciences at UTS since 1996 and has published in this area. He currently leads a group at UTS, funded by University grant, to look into issues linked to Cross-Faculty teaching of Physics and Mathematics

Dr. Michelle Livett is Director of First-Year Studies in the School of Physics, University of Melbourne, had a major role in several CUTSD and University of Melbourne projects, co-ordinates biomedical physics, and contributes to professional development of physics teachers.

Assoc. Prof. Richard Newbury is Director of Studies in First Year Physics at UNSW and is overseeing a comprehensive review and redevelopment of first year physics teaching at the School, had a major role in successful CUTSD and UNSW Learning Enhancement projects and contributes to regular outreach and high school teacher training programs.

Dr. Judith Pollard is Co-ordinator of Physics I at the University of Adelaide, had a major role in CUTSD projects related to staff development for tutors and demonstrators, and to teaching innovation, and co-edited a review of assessment in the Faculty of Science.

Assoc. Prof. Michael Prosser is Director of the Institute for Teaching and Learning at Sydney University, has expertise in the design of evaluation tools and analysis of data, and has had 3 ARC grants since 1990 looking at various aspects of teaching and learning in first year university physics.

Prof. Marjan Zadnik has received numerous of awards and nominations for teaching excellence, including being a CAUT National Fellow. He has published over 120 papers and abstracts and has been co-investigator on over 30 competitive research and development grants and awards on T&L (totalling over \$1M), including a large ARC and 5 CAUT and CUTSD grants. He is also Vice-Chair of the Australian Institute of Physics Education Group.

Team Members

Ms. Anna Binnie is a lecturer at UTS, a former physics teacher, writer for NSW HSC Physics curriculum, former Chair of NSW Branch of AIP, recently retired from Board of RTA Science Olympiad.

Ms. Susan Feteris coordinates the laboratory programmes at Monash, is engaged in a study of learning in laboratory from introductory through to third year, and has experience in developing multidisciplinary biomedical and radiological physics and astronomy courses

Dr. John Furst is a physicist in the multidisciplinary School of Applied Sciences, University of Newcastle, and covers areas ranging from marine science to food technology.

Dr. David Low is level one laboratory convener at the Australian Defence Force Academy, teaches in a context-driven curriculum across Science, Engineering and Technology streams, has developed curricula for ADF's requirements, and online enhancements to active learning.

Dr. John O'Byrne is the Director of First Year Physics Studies at Sydney University and has expertise in astronomy education. He has extensive experience with physics alumni in industries ranging from insurance, business and software development to biomedical research.

Dr. Anton Rayner (University of Queensland) teaches students of physiotherapy, science and engineering, has developed and evaluated context-based interdisciplinary courses, and is Acting Director of RTA Science Olympiads.

Ms. Michele Scoufis, Office of the PCV-Education, evaluates strategic learning and teaching initiatives at UNSW, has successfully led a CUTSD project, has led UNSW learning and teaching funding awards and VC's Award for Teaching Excellence.

Dr. Geoff Swan teaches engineering, aviation, education, and science students at Edith Cowan University, and has expertise in teaching generic skills and the use of interactive technologies in learning.

Assoc. Prof. William Zealey, former Head of Physics, Wollongong University, authored a secondary physics text, initiated a B.Sci.Ed.(Physics) program, and is involved in medical imaging and environmental physics.

Expert Advisory Panel

Prof. Richard Gunstone, Professor of Science and Technology Education at Monash, internationally renowned researcher in science education, has participated in several overseas and international studies in science curriculum and teacher education, and led ARC funded research in *Teaching and Learning in Tertiary Science* with R. White (1994-1996).

Prof. Barry Muddle, Head of School of Physics and Materials Engineering at Monash, and Director of two CRC's and Nanotech Victoria, has extensive experience with industry.

Prof. Paul Ramsden is the PVC, Teaching and Learning at Sydney University. His research is of international standing, and has provided a fundamental understanding of the evaluation and assessment of teaching and learning in Australian Universities.

Prof. John Prescott has supplied the AIP with physics-related employment data for over two decades and has an in-depth knowledge of the career directions of physics graduates.