Proposal for Stage 2, AUTC/Carrick Institute Project
'Learning Outcomes and Curriculum Development in Physics'
Revised November 2004[1]

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

Steering Committee: Chairperson to be advised by the Carrick Institute.

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Team Members: Dr. 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), Dr. M. Hunt (UNSW), Dr. K.Wilson (ANU), Dr Alex Merchant (RMIT),

In addition, contact people at participating physics departments will form a wider network which enables this project to proceed.

Expert Advisors Panel: Prof. R. Gunstone (Monash), Prof. B. Muddle (Monash), Prof. J. Prescott (U. Adelaide), Prof John O'Connor (U. Newcastle)

Project Officer: Mr Alberto Mendez (U Syd and Monash).

Progress Report on Stage 1

All 34 Australian universities which have an identifiable group of academics teaching physics (henceforth called a 'department') are participating in the project. Data collection for this project is almost complete, the key findings identified for most areas, and the outline plan for the final report has been drafted. A progress paper was written in July for presentation at the October 2004 Uniserve Science conference at the University of Sydney.

All departments have completed a questionnaire covering all areas specified in the project brief. Based on the results of the questionnaire, nine institutions were selected, as representative of the range and geographical spread of departments, for an in-depth study to draw out how, in practice, departments decide, develop, and resource their academic programme. This in-depth study comprised an interview with Head of Department, interview with chair of academic programs or education committee, and focus groups with first year mainstream, first year service, third year and postgraduate students. Interviews with employers and recent graduates remain to be completed, along with two sets of focus-groups

The project and project representatives have been received enthusiastically and in each physics department there is one (or more) Physics Project contact person. A sense of ownership of the project has been fostered by returning a summary of their department's key points from the main questionnaire to each departmental contact person and Head of Department, along with a copy of the progress paper. Departments will be involved to a greater extent as we invite their input on the final report of Stage 1 and on the approaches to be taken in Stage 2.

Points of particular relevance from Stage 1 are noted below in the Stage 2 overview.

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[1] This version amended to include a budget of $85000, as advised by Carrick Institute.

2. Overview of Stage 2 – the Context, Opportunities and Goals

The proposal builds on the understanding of the current situation across departments in Australia, as identified by the research of Stage 1. Having recognised the dominant challenges, needs and opportunities, it will harness the good practices and resources, skills and experiences within our Australian and the international physics teaching community.

2.1 Time for Revitalising Australian Physics

Stage 2 of this project is at an ideal time for helping departments revitalise physics learning and teaching in Australia.

Stage 2 of this project would make significant contributions in all 6 objectives of the Carrick Institute in relation to physics. The project team has the understanding, experience, skills, and credentials (see Appendices A and B), and the following points show how the time is ideal for a Stage 2 project to bring about improved learning and teaching. A number of plans have been drafted at the annual Heads of Physics Departments meetings but have not succeeded in implementing the actions. The following points indicate the time is ripe for change.

a) There are a number of good practices in learning and teaching at individual institutions which would be of benefit to physics at other departments.

b) Departments are capable of creative change, as indicated by the number of initiatives to develop new programs in photonics, nanotechnology, space science, security technology, scientific imaging, and biomedical physics.

c) Other disciplines such as biomedical, environmental, and biological sciences, have an increased awareness of the need for supporting physics, perhaps coupled with an awareness that physics departments are increasingly able to undertake relevant and inspiring teaching.

d) There is an increase in higher year physics student numbers in many institutions in parallel with increased public awareness of the contributions of physics.

e) There is an opportunity to raise the profile of teaching experience in selecting for new staff as a number of institutions face replacements of retiring staff.

f) Departments are now open to collaboration and to adopting viable and successful practices as a result of financial and staffing pressure.

g) A collaborating network has been formed in Stage 1, directly involving about 50 key physics personnel.

2.2 Facing the Challenges of Dissemination

The project team recognises the inherent difficulties in disseminating good practice in general and those which are particular to Australian physics. It looks forward to the findings of the current AUTC projects on dissemination, and requests access to relevant reports at the earliest possible opportunity. The project team looks forward to working with the Carrick Institute in applying these as plans for 2005 are further developed. A substantial part of the early effort in Stage 2 will be the research to identifying effective ways of dissemination and adoption suited to the particular needs of tertiary physics in Australia (as per the final dot point of the AUTC Stage 2 Project brief, on further research, see Appendix C).

The stated Values of the Carrick Institute - Inclusiveness, Ownership, Long-term Change, Collaboration and Excellence – undergird the approaches described in this proposal.

The overall approach to developing good practice case-studies will be inclusive and affordable as all physics departments have identified understaffing and pressure on staff time, and resources, as major issues.

Ownership and collaboration will be crucial to developing or transferring sustainable and effective approaches. Collaboration will be fostered by means of having working groups of interested persons with the support of their home department, working together to enable similar practices and resources to be transferable. In the diversity in physics departments nationwide there will be good practices identified as suitable for some but not all local contexts. The local distinctives in fact can assist in developing a sense of ownership; for instance workshops will be on topics which are identified by the local department as a priority area.

We will seek to ensure long-term changes in learning and teaching firstly by creating a supportive climate of interaction among our peers in physics departments, and secondly by collective experience to underpin a confidence that improved teaching and learning is achievable and beneficial within the given staff and budget constraints. We note this against our collective memories of the hope that the computer-based approaches of the early to mid 1990's would save staff time whereas the opposite was often true.

Excellence in learning and teaching arise from staff who have developed the necessary awareness and skills. The project will seek to facilitate this in ways which are appropriate on a national level, using physics education research and good practice case studies.

3. Components in Stage 2 Dissemination

3.1 Strategies for publicising key findings and good practices

Six strategies are proposed for disseminating the project outcomes including good practice materials which will be refined early in Stage 2.

a) Meeting with Heads of Physics Departments at their occasional meeting held in conjunction with the AIP Congress in Canberra late January 2005, as a way of further deepening their sense of ownership and inviting input in the ongoing process of reinvigorating our discipline.

b) Publishing a summary in *The Physicist* (magazine of the AIP and NZAIP) as a means of informing members of the professional body which represents Australian physics academics.

c) Printing an attractively designed overview booklet or catalogue (for instance in the style of *Assessing Learning in Australian Universities* commissioned by the AUTC), as a way of providing the majority of academics with responsibility for learning and teaching decisions and quality with ready access to good-practice examples.

d) Presenting colloquia by a project leader at departments or in cooperation with local regular Australian Institute of Physics meetings as a direct method of engaging a significant fraction of physics academics in a situation where there can be questions relating to implications for their own institution(s). (Colloquia of this nature were successfully presented at several capital cities by one of our team-leaders, Marjan Zadnik, in his capacity as a National Teaching Fellow of the CAUT scheme.)

e) Opportunity for further discussion with key staff in departments following the colloquium, as a means of helping them to relate the project outcomes to their situation.

f) Maintaining an on-going project website, as a readily accessible host for various resources (see below) ideally in co-operation with the well-established UniServe Science clearing-house website.

3.2 Workshops - equipping tomorrow's departments

Workshops are seen as an effective means of equipping change-agents.

The model envisaged involves about 20 physics educators in hands-on and small group interactive learning and is based on the successful 'Chautaqua' workshops which were offered in various centres in Australia in 1996 and 1998. The latter contributed to teaching improvements in several departments and are widely and effectively used in the large US based American Association of Physics Teachers' Winter and Summer meetings. Our team has experience in running such workshops, for example for the CUTSD project on Developing Workshop Tutorials in Physics (Sharma, Wilson, Newbury), and by Zadnik, across several states with participants from physics, sciences, engineering, and teaching and learning units.

Workshops would be run in major centres (Qld, NSW, ACT, Vic, SA, WA) with funds for subsidising attendance by participants at regional universities and Tasmania. Topics offered would be drawn from areas identified in Stage 1, including good practice case-studies, physics resources accessible via the Uniserve Science clearing-house, and effective use of teaching resources (doing more with less), and the local departments would decide on the particular workshop topics.

Workshops would ideally have about 30% of participants as active contributors, and draw together teaching staff responsible for the areas identified above. The workshop aims are to:

- enable teaching staff to discover elements that enhance learning, and analyse the fundamental reasons for their success (not just show and tell of what has worked in different places);
- assist staff embarking on teaching and learning development to identify the opportunities which could lead to research publications;
- to synthesise the elements which suit the unique features and meet the individual needs of each department;
- discuss the challenges likely to arise during implementation and explore the role of evaluation in sustaining and further developing good practice.

3.3 Capacity-building for a Physics Educator Network

Building the capacity of a network of experienced and inspiring physics educators to equip is essential to the long-term future of good physics learning and teaching in Australia.

The project team sees the need for the current Physics Education Group of the AIP to become, or be part of, a national entity to promote and resource Australian physics education. This would be a desirable effect of Stage 2 of the Project, and provide for ongoing equipping and provision of resources. At an appropriate time in 2005 we will seek discussions with the Carrick Institute as to how this may be best achieved. At this point the idea has had endorsement from the present and incoming President of the AIP and 8 Heads who were able to respond to a straw-poll.

There are some 80 current members of the Physics Education Group of the AIP, about 50 of whom are active tertiary physics academics (others are secondary teachers and active retirees). This group has provided helpful interactions for over a decade, starting from OzCupe (Computers in Physics Education - Australia). The project would see as an achievable target, expanding the network to at least 110 tertiary academics (more than that number would be currently involved in some teaching innovations or have major learning and teaching oversight in a department). Having two or three participants from medium sized departments would mean that materials from workshops and the resources described above are likely to be adopted.

This wider network would be launched at a one-day Physics Education workshop (tentatively late September 2005). Strategies will be devised to ensure that younger academics are linked into this network.

3.4 Resources Clearing-house

Heads have identified making good use of available resources which do work in the contexts of Australian departments as one immediate way to help.

The main questionnaire asked, "Can you identify resources which could be developed cooperatively by the physics teaching community?" The following summarises the most frequent suggestions:

- Universally applicable laboratories for 1st year students;
- Sharing of specialist laboratory equipment for higher years;
- Biophysics/biomedical physics teaching materials including lab experiments;
- Joint development or pooling of interactive and multimedia materials; and
- Assistance to staff in identifying resources suitable to their context and implementing teaching-learning strategies.

In addition some smaller institutions commented on the possibility of shared teaching for honours courses. Some of these suggestions may only work in a two- or three-way partnership. All of them express a strong need for effective methods and accessible, cost-effective teaching resources. Some Heads of departments have stated what they could offer.

The Accreditation process of the Australian Institute of Physics (AIP) currently gathers together laboratory experiment scripts and manuals with the purpose of making them available to departments, but there is no mechanism for informing potential users (departments) of their availability or contents. Uniserve Science clearing-house, hosted by the University of Sydney, provides a suitable platform for indexing resources; the AIP website is an option for large volume storage.

Our strategy in this area is first to catalogue the available resources identified in Stage 1, and second, for the project officer to work with the source department or academic to document the resources in a suitable format (issues of whether directly downloadable, or whether available by negotiation with the author). Finally, we aim to publicise the resources at several levels (including the AIP Congress and other means mentioned above) so that academics would always think 'Physics Education Network' for physics teaching resources.

3.5 Fostering learning and teaching excellence within the physics community

A recently completed study on undergraduate physics in the USA [1] identified essential elements in all thriving physics departments: a well-designed and resourced curriculum, good staff-student interactions fostering a strong sense of community and providing mentoring, commitment to this program by all staff, and strong and sustained departmental leadership.

The inaugural AIP Medal for Excellence in Physics Education is to be awarded in 2005 at the AIP Congress (the winner being a member of the project team, Prof M Zadnik). The team together with the wider Physics Education Group, has been instrumental in raising the profile of physics education in the AIP, departments and institutions, and will seek tangible ways of recognising and rewarding excellence for a wider group.

In recent interviews with Heads of Departments, a sense of belonging to a physics community has been identified as an important need in Australia. The project will to look at the affective factors in this regard, and endeavour to assist departments and the AIP in matters where the image of physics needs updating, such as promoting physics at secondary school, giving a lead on graduate employability in particular the multidisciplinary opportunities and student satisfaction.

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4. Further Development of Stage 2 plans.

At this point the proposal indicates the purpose, scope and basic method for each component in the dissemination, and the team will seek advice on the dissemination details from the Carrick Institute, other expert advisors and the wider international and national physics teaching community. The project team also seeks advice regarding the operation of a Steering Committee. Many members of the team will be in Canberra for the AIP Congress 31 January - 4 February 2005.

The project team will be widened to strengthen the sense of ownership and to further facilitate local learning and teaching initiatives, as well as to begin extending the envisaged Physics Education Network, in the first instance by inviting all departmental Physics Project contact persons to be part of the project network.

Completing the analysis of physics teaching good practices and drafting the recommendations for Stage 1 will enable us to inform Heads of Departments of the collective needs and requests, inviting their department's participation and preferred choice of topics, and begin the process of detailed planning for the colloquia and workshop components. It is intended that Stage 2 be widely promoted at the AIP Congress in Canberra.

4. Notional Budget – Stage 2

This amended budget is for a total of $85000 as advised by letter of 19 October 2004 from Professor John Hay, Chair of The Carrick Institute.

Project Officer (research-only Level A Step 2 12 months F/T, Monash)[(a)]	$66000
Colloquia and workshop travel & accommodation[(b)].	$8000
Nation-wide workshop[(c)]	$9000
Printing and preparation of 'catalogue'/booklet, 280 copies[(d)]	$1500
Administrative costs	$500
TOTAL Stage 2	$85000

Notes

(a) The salary component has increased by almost $10000 compared to Stage 1, due to EB salary increases and an annual increment. The Carrick Institute's increased funding by $10,000 above the amount in the original project brief is appreciated.

(b) To effectively engage the academics who are the potential change agents and to include the smaller departments across the nation requires face-to-face workshops and/or meetings, which incur travel costs. Colloquia and workshops in main centres incur costs when presenters or participants are required to travel. Most will be held at minimal cost in major centres. The figure allows for 16 participants or presenters travel and accommodation, enabling involvement by departments in Tasmania, regional Queensland and NSW, and the NT.

(c) One Australia-wide workshop in October 2005 is seen as a key ingredient in ensuring ongoing momentum in the changes aspired to by Australian physics departments, and by the AUTC and Carrick Institute. The nation-wide workshop includes travel and accommodation subsidy for 32 anticipated participants coming to Sydney and a nominal facilities and meals cost.

In the absence of guidelines from the Carrick Institute regarding Steering Committee meetings, there has been no funding allocated for a Steering committee meeting apart from those which coincide with the AIP Congress in Canberra 31 January- 4 February 2005, and the proposed national workshop.

This amended budget does not include any teaching relief for team members who have given enormous thought, time and energy to this project.

References

[1] AAPT (2003) *Strategic Programs for Innovation in Undergraduate Physics* [Online] Available: http://www.aapt.org/Projects/ntfup.cfm [2004, August 25]

Appendix A. 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. Collaboration between universities and departments, and successful dissemination has been a hallmark of several initiatives mentioned here.

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 motion (Swan), IT for active learning in large classes (Sharma).

We have extensive experience at teaching in all levels of physics, and almost all members have led curriculum change through departmental undergraduate education committees. At the senior echelons, we have several Heads and former Heads of departments, Deans and acting Deans, and associate Deans (Teaching) and have helped guide or implement systemic changes. We are closely in touch with changing student backgrounds and their future directions. Several members are in departments which are quite different from traditional physics department. Our team is well placed to evaluate globalisation and internationalisation (through teaching developments off-shore as well as in our international collaborations) and has specialised physics education experience in laboratories, on-line learning, workshop tutorials and gender issues.

Prosser, 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).

Importantly, the team has several younger academics and will seek to engage more younger academics through invitations to be contact (or 'network') persons at the local institution.

APPENDIX B: BRIEF DETAILS OF TEAM

Team Leaders

Dr. David Mills is Director of First Year Physics at Monash, is national convenor of the AIP Physics Education Group, developed the *CUP* cooperative learning strategy, a 34-module interactive physics software package, and initiatives in flexible learning, and has been a tertiary reviewer for Victorian secondary physics courses on several occasions.

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.

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 Associate Dean Academic Programs in the Faculty of Science, and 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, has co-ordinated biomedical physics teaching, 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 is Dean Teaching and Learning, Division of Engineering, Science and Computing at Curtin University, has numerous of awards for teaching excellence including the 2005 AIP Excellence in Physics Education Medal and CAUT National Fellow, and is Vice-Chair of the AIP Physics Education Group. He has published over 120 papers and abstracts, been co-investigator on over 30 competitive Teaching & Learning grants and awards on (over $1M), including a large ARC and 5 CAUT and CUTSD grants.

Team Members

Dr Anna Binnie is a lecturer at University of Technology Sydney, 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, as developed curricula for ADF's requirements, and online enhancements to active learning.

Dr Alex Merchant has been a lecturer at RMIT University for 5 years, with particular responsibility and interest in service teaching and a constructivist approach to 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 teaches in the Grad Cert in Ed(Higher Education) for beginning university teachers.

Ms. Michele Scoufis, Office of the PCV-Education, evaluates strategic learning and teaching initiatives at UNSW, has successful 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.

Dr Kate Wilson, First Year Coordinator, Department of Physics and Theoretical Physics, Australian National University and Physics Program Director for the Rio Tinto Science Olympiads; she was Project officer for the ‘Workshop Tutorial Project’, and an Innovative Teaching and Educational Technology Fellow at the University of New South Wales.

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, recently stepped down as Head of School of Physics and Materials Engineering at Monash, and Director of two CRC’s and Nanotech Victoria, has extensive experience with industry.

Emeritus 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.

Professor John O’Connor, Head, School of Mathematical & Physical Sciences, University of Newcastle, former President, Australian Institute of Physics, Secretary of the Federation of Australian Scientific and Technological Societies.

Appendix C. AUTC Project Brief – Extract for Stage 2

Stage 2 of the project should result in practical outcomes for students and university staff, as well as having an impact across the sector.

This stage of the project will include:

- development of resource materials for use by staff and students;
- implementation and evaluation of innovative solutions to problems identified;
- preparation of case studies of innovative practice;
- conduct of forums and workshops across the sector to raise awareness and enhance staff expertise; and
- analysis of the relationship between course design and indicators such as enrolment and employment trends, graduate satisfaction and graduate employability.