Executive Summary

Goals and Methods

The project's brief was to evaluate how teaching and learning in physics was responding to several factors including multidisciplinary areas, new technologies, student backgrounds and expectations, employment, career advice, industry input to the curriculum, teaching for engineering and the biosciences, staffing, and inputs to teacher training. This report identifies strategic directions and instances of good practice in relation to these factors.

The project was conducted by a team representing 13 universities, drawn largely from the Physics Education Group of the Australian Institute of Physics. International studies in the UK and USA and a recent comprehensive review of physics teaching practice in a leading international journal provided benchmarks.

A questionnaire on issues for mainstream, multidisciplinary and service teaching, changes, challenges and responses, new initiatives and strengths, the interface with employment, staffing and teacher training, was completed by all of the 34 groups or departments who teach tertiary physics in Australia. Its format was largely open-response to enable a clear description by each department. At nine selected departments, interviews with heads of departments and leaders of academic programs, and focus groups of students, were conducted to gauge how curricula are responding to change, what approaches are effective, how departments plan for teaching, and what they expect and need for their future. Expert advisors were consulted regarding employment and future directions.

Key Findings

Pressures from loss of staff, loss of service teaching, increased student to staff ratios and the necessity to provide numbers of new subjects, dominate the landscape and have determined most departments' limits to teaching quality and responsiveness to change. Departments are endeavouring to teach well, continuing to place high value on laboratory work, adopting or seeking sustainable approaches for their student to staff ratio, and at the same time improving their research output. In most cases they cannot do justice to all of these dimensions.

Multidisciplinary and other creative initiatives have been pursued by many departments, particularly in nanotechnology. Photonics, biomedical physics, medical radiation, space and astrophysics have been developed over a longer time-frame. Larger departments have tended to keep their traditional breadth and many departments have capitalised on their research-teaching nexus.

Departments have widely adopted on-line resources, primarily as a course delivery tool but with on-line assessment frequently used. Australian innovations using new technologies are isolated, perhaps reflecting the lessons learnt from the 1990s about the costliness of developing software and questions of efficacy in some cases.

Physics education research has guided several developments in introductory physics teaching in Australia, which have in turn increased awareness of learning and teaching issues through conferences, and provided valuable resources such as the CUTSD Workshop Tutorial Project.

A broader cross-section of the tertiary student cohort is now studying physics in an increasingly wide range of subjects. The project reports on different learning styles and changed expectations of Generation Y students, as well as their weaker background in mathematics and physics which ranks high on the list of challenges reported by departments. Departments' responses include remedial materials and adjusted expectations and styles of teaching in both service and mainstream physics, but concerns about these changes remain.

Generic skills have increasingly featured in the physics curriculum, and learning outcome statements are more widely implemented, with departments looking for effective practices in developing generic skills. Graduate employment opportunities with mainstream physics are, as in the past, very broad. While departments generally have strategies for informing students of physics-related careers, students in some departments found this information to be inadequate. Some departments do not have an effective industry interface but new degree programs tend to have better industry contribution to their curricula. Outside professional experience is not a strong feature of physics degrees but projects are now a significant component. The relationship between curriculum design and factors such as graduate and employer satisfaction is to be further explored in Stage 2 of this project.

Service teaching provides a large fraction of teaching income in many departments. The loss of service teaching, particularly for engineering, has been substantial in many departments, though this is partly offset by emerging areas including the biomedical and health sciences, and physics for agricultural industries. Departments report that they maintain the same quality in service teaching as for mainstream physics.

Many departments contribute to teacher education, both pre- and in-service, but innovation and further involvement are constrained by their workloads and the complexities of working across faculty boundaries and with state education departments. There is scope for departments to consider how their own courses could best contribute to the education of future physics teachers.

The quality and commitment of physics academics is recognised as a great strength by many departments. Reliance on sessional staff offers a short-term solution to staffing and financial pressures but comes at a long-term cost and conveys an impression that the discipline is not sustainable. Good training, support and mentoring are particularly needed for staff teaching in multidisciplinary areas, for sessional demonstrators and tutors, and for academics new to teaching.

The project has begun to identify good practice in the many areas addressed above. It was notable that many departments described their strengths and features of their teaching and learning in a student-centred holistic way rather than by focusing on a single special approach. With the help of the originating departments, good practices will be disseminated and showcased in Stage 2.

Recommendations

Chapter 3: The Changing Nature of Students: Implications for Teaching

Recommendation 3.1:
That physics staff include in the curriculum learning activities that cater for a variety of learning styles and contemporary technology. (§ 3.2.2)

Recommendation 3.2:
That physics staff recognise and value diversity of student background, such as previous physics and maths studies, work experience, gender and cultural background in designing the curriculum. (§ 3.2.5)

Recommendation 3.3:
That physics staff acknowledge the competing demands on students' time, including part time work, when designing learning and assessment tasks. (§ 3.2.3 & 3.4)

Recommendation 3.4:
That physics staff communicate their expectations of students clearly and explicitly. (§ 3.2.5)

Recommendation 3.5:
That physics departments involve younger academics and consult students in teaching and learning decision-making. (§ 3.4)

Chapter 4: Skills, Capabilities and Employment

Recommendation 4.1:
That physics departments and the AIP seek to identify and utilize effective methods to ensure that graduates are highly competent in the key generic skills.

Recommendation 4.2:
That physics departments and the AIP together with industry develop resources to help inform students of physics and future careers.

Recommendation 4.3:
That physics departments consult with, and take advice from industry and employers in developing their curriculum.

Chapter 5: What are we Teaching?

Recommendation 5.1:
That departments and the AIP pursue strategies to ensure that service teaching to engineering, biomedical sciences and other disciplines, is valued and promoted, by means which include effective inter-faculty or inter-departmental teaching liaison groups, dialogue with Deans of client faculties, sharing of good practice teaching syllabi and materials between physics departments, engaging in or having representation at engineering education conferences, and discussion with professional societies.

Recommendation 5.2:
That departments and the AIP consider how they may more effectively contribute to the training and ongoing professional development of physics and junior science teachers.

Chapter 6: How are our Students Learning and How are we Teaching?

Recommendation 6.1:
That Physics departments and the AIP through the Physics Education Group support and undertake research into the effectiveness of learning and teaching strategies such as the use of IT / e-learning, the contexts and benefits of undergraduate research projects, and opportunities for optimising our investment in and commitment to laboratory experience.

Recommendation 6.2:
That the Carrick Institute provide support for further research into effective physics learning and teaching in the Australian context, with particular attention to Generation Y.

Recommendation 6.3:
That heads of physics departments and the Australian Institute of Physics cooperate in establishing improved mechanisms for promoting and sharing good practice, such as supporting academic exchange visits and contributing to UniServe Science.

Recommendation 6.4:
That the AUTC project team identify academic staff with an interest in physics for biological and medical sciences, and encourage them to collaborate in the production of common course materials appropriate for the Australian context.

Chapter 7: Staffing Challenges and Responses

Recommendation 7.1:
That departments provide time, and resources for staff who contribute substantially to innovative and quality teaching, recognise their contribution to retaining students, and support their promotion based on their teaching.

Recommendation 7.2:
That Heads of departments and institutions ensure academic staff appointments address teaching capabilities alongside research, that new appointees have a good induction to teaching and learning, and that ongoing support is provided for physics-specific teaching and learning practices.

Recommendation 7.3:
That departments value the contribution that demonstrating, tutoring and sessional staff have on students and should ensure adequate training and support, both in terms of physics content and teaching and learning issues.

Recommendation 7.4:
That the AUTC project team in Stage 2 highlight and disseminate good practices and available resources for demonstrator and tutor training.

Chapter 8: Future Directions

Recommendation 8.1:
That the Heads of departments and the AIP consider means by which they can more effectively support tertiary physics education in Australia, including obtaining strategic government funding and strengthening the AIP Accreditation guidelines.

Recommendation 8.2:
That the Physics Education Group of the AIP play a more prominent role as a network which provides effective mechanisms for promoting and sharing good practice. To achieve this, it should invite a wider membership, have representatives from all departments and support for its activities from Heads of physics departments and the Australian Institute of Physics.

Recommendation 8.3:
That the AUTC project team, Heads of departments, and the AIP cooperate in establishing an effective means of sharing teaching resources and providing a database containing evaluations of and advice regarding resources.

Recommendation 8.4:
That the AUTC project team and Heads of departments work together to prioritise areas for evaluation or provision of teaching resources, with special attention to resources adapted to an Australian context.