Research-Based Fourth Year Hypersonics Elective

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Broad discipline area:
Engineering and Related Technologies
- Mechanical Engineering: Hypersonics

Year level:
- Fourth year undergraduate

TRN strategy:
- Designing learning activities around contemporary research issues
- Building a small scale research activity into undergraduate assignments

Teaching and learning context:
- Assessment item
- Practical experiments

Brief description of the initiative:
Hypersonics[ii] a fourth year elective, with a typical enrollment of 16, is designed to develop students' understanding of, and ability to carry out, research. Students:
- experience how research leads to knowledge creation;
- learn about current hypersonics research and methods;
- discover how hypersonics research is organised and funded;
- carry out an independent research project;
- are assessed by methods resembling research procedures in the discipline.

This academic links teaching and research in a range of ways:
- Lectures draw on the academic's own (and others') research. Students are exposed to the latest plans, developments and attitudes in relation to technical, strategic and political issues.
    - International experts from academia, government and industry conduct guest lectures.
    - This academic delivers recent international conference presentations of his own research.
- Research-based assessment tasks (outlined below).

- Students participate in research-based learning. For example, students brainstorm methods to overcome a critical propulsion system issue, and perform online computational fluid dynamics (CFD) simulations in class.

Research-based assessment tasks:
Literature review (30% of course mark)
Students conduct a literature review on a current hypersonics research and development topic. The purpose of this task, which involves a balance between technical activity and independent learning, is for students to:

- gain experience in uncovering, summarising and reporting existing knowledge;
- achieve additional learning beyond the lecture material;
- develop research skills prior to preparation of their final year honours theses.

Primary Research Project (50% of course mark)
Working in teams, students conduct research using CFD software from a list of topics (provided by the lecturer) relevant to key hypersonic technology issues. The topics:

- are open-ended i.e. the likely outcomes are not known ahead of time;
- allow for the possibility of the unexpected to occur.

Students submit this task in three stages:

- Qualitative analysis of the topic including a preliminary concept of the phenomena expected in the simulations and the computational mesh necessary to obtain the results.
- Electronic submission of the mesh, including a description of its key aspects.
- Analysis and discussion of the results generated by the simulations.

The progressive submission of the assignment makes it possible to provide students with feedback, giving students the opportunity to alter their focus to accommodate unexpected developments.

Evidence of effectiveness and impact:
Student feedback collected via questionnaire were positive. Students found the course motivating, engaging and exciting and attributed this to the research-led teaching approach and the style of the assessment activities.
Students reported that the inclusion of latest research issues and guest lecturers:

- made the course cutting edge and gave them insight into future technological developments;
- spurred their interest, making them keen to learn and understand the real life practical issues/examples presented;
- made them realise that hypersonics is a complex, uncharted field, and that much of the research occurs by trial and error.

Students perceived the demonstration of CFD calculation and assessment tasks as:

- highly engaging, giving them freedom to learn and research their own areas of interest;
- enabling insight into the research process, fundamental phenomena and concepts;
- empowering; motivating them to think critically rather than memorise.

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[i] Professor Boyce was in the School of Aerospace, Civil and Mechanical Engineering at the University of New South Wales at the Australian Defence Academy (UNSW@ADFA) when undertaking the activities described in this example. He will be implementing the same approach at UQ later in 2008.

[ii] Hypersonics is the study and application of complex aerodynamics and propulsion phenomena encountered when flying at speeds in excess of five times the speed of sound. These phenomena are described using the mathematics of partial differential equations. Research and development is conducted in three ways: direct experiment in specialized ground-based high-energy wind tunnels; high performance computer simulations based on the mathematics that describes the flowfields; and flight tests.