Final Year Engineering Thesis

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Executive Summary

To address concerns raised by students about inconsistency in final year thesis within and between Schools of the Faculty of Engineering, a committee was convened to review practice and make recommendations to ensure validity and consistency of approach.

The committee recognises the desirability of flexibility of approach to allow for the needs of particular disciplines, and the differing resource availability and emphasis in different schools. Nonetheless there is a need that the different thesis courses be educationally equivalent.

Accordingly, two types of recommendation are made with regards to thesis course design and delivery: "Required", which should be considered as compulsory across the Faculty, and "Recommended" which should be seen as examples of good practice. Additionally, notes have been made in relation to matters that might be worthy of further work. The main recommendations are summarised below.

Required Practice

- Alternatives to thesis be allowed, however students undertaking the alternatives shall not be eligible for the award of Honours

- Students be permitted to undertake thesis work in groups, but that assessment tasks (especially written tasks) must be undertaken and assessed individually. The thesis must be assessed by more than one marker, with additional marker(s) in case of marking discrepancies greater than 10%

- An advanced or extended thesis option may be offered, but it must have significant additional assessment which requires conceptually more of the student than does a standard thesis – typically, the preparation of a manuscript for submission to a research journal

- Thesis courses must require the individual writing and submission of a written thesis, and some form of individual oral presentation and defense of the work by the student

- Thesis projects must be complex, open-ended problems that allow room for student creativity, and the acquisition, analysis and interpretation of results. There must be multiple possible solutions or conclusions at the outset and sufficient complexity to require a degree of project planning from the student.

- Expectations of schools, supervisors and students (beyond the intended learning outcomes, detailed in the body of this report) must be specified explicitly in the course outlines

- All thesis course outlines and project advertising must explicitly allow the possibility of projects and (co) supervision from outside the student's home school

- All thesis courses must allow students substantial choice of topic and supervisor

Recommended Practice

- Assessment for theses and other work such as presentations should be weighted on multiple criteria that address the course learning outcomes. Suggested tables have been provided in the body of the report for assessment criteria that match the provided learning outcomes

- All Thesis A courses should be 6UoC, and should then articulate into a 6UoC standard Thesis B or extended thesis option

- Students failing Thesis A should be required to start again with a new topic and supervisor

- Students failing Thesis B should be allowed to develop the work and re-submit the work after a period of 6-8 weeks (supplementary assessment) if they are potential graduands.

- Recommended Learning Outcomes have been provided in the body of the report.

- Any project / supervisor allocation process should ensure an equitable workload across academic staff within a School. A maximum of 8 thesis students per staff member is suggested.

Recommended Further Work

- The Faculty and Library should allocate resources to the development of an extended ELISE type course suitable for 4th year thesis students. Successful completion of such a course should be a required component for the Thesis A courses.

- Consideration be given to selecting the best posters from across the faculty each year and bringing them together for an industry sponsored showcase event which might include cash or other prizes.

- The Faculty should re-examine the way that OH&S training is run for 4th year thesis students with a view to its being completed in the first half of the first semester of thesis work.

Final Report on Final Year Research Thesis
Faculty of Engineering, UNSW
28/04/10

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Introduction

The final year research project undertaken by most engineering students is probably one of their most important academic experiences at UNSW. The thesis courses are also among the most expensive courses run by the faculty and so it is important that they run well, from the student experience and well as from a faculty resourcing point of view.

The rest of this report is segmented by topic, with, in each case, a description of the range of current practice or observations followed by Required and Recommended practice, where appropriate.

Alternatives to Thesis

All engineering programs within the Faculty require students to undertake a final year thesis project with the following two exceptions.

The BE in Petroleum Engineering program contains the courses PTRL4010 Oil&Gas Field Eval. Thesis "A" and PTRL4011 Oil&Gas Field Eval. Thesis "B" in which students work individually to complete a feasibility evaluation for an oil and gas field development proposal. The assessment for the courses is a series of reports and a presentation. Students in these courses do not have a choice of study topics.

Students in the Civil and Environmental Engineering programs have a choice between an individual thesis project (CVEN4030 Honours Thesis A and CVEN4031 Honours Thesis B) or a team based design project (CVEN4002 Design Practice A and CVEN4003 Design Practice B) which appears to be similar in scope to PTRL4010 and PTRL4011. Within the School of Civil and Environmental Engineering, students require a WAM of 63 or higher to be eligible for entry into the Honours Thesis courses. Lower WAM students are streamed into the CVEN4002 / CVEN4003 alternative and are not eligible for honours. The presumption here appears to be that students with WAM less than 63 are not going to bring their average mark over 65 in their final year and hence would not be eligible for honours anyway. Although this will usually be true, a more satisfactory way to guarantee this might be desirable.

Note the the ability for students to take non-thesis alternatives might complicate accreditation processes for the schools concerned.

Required Practice

Enrolment into Thesis courses *may optionally* be restricted on the basis of student WAM, in which case alternative courses which achieve similar learning outcomes must be available. **Students not completing thesis courses must not be awarded honours, regardless of eventual WAM.** (See notes under External Requirements).

High WAM students should have the option of enrolling into any alternative to thesis that is offered to lower WAM students, on the understanding that they will not be eligible for honours.

Assessment

Thesis course assessment varies considerably in detail across the faculty, but varies little in principles. All thesis courses require the submission of a substantial written thesis which accounts for the bulk of the Thesis B course. All thesis courses contain a significant component of assessment which requires students to present and defend their work orally, typically either a seminar presentation, open day or poster session.

The thesis courses are in most cases split between a "Thesis A" and "Thesis B" course. The way that assessment is divided between the two courses varies: e.g. Chemical Engineering formally assesses (and reviews) the literature review, research plan and specified preliminary work; Mechanical and Manufacturing Engineering requires the submission of a brief report graded satisfactory / unsatisfactory by the supervisor. Schools include their oral presentation component in either or both of Thesis A and Thesis B.

A perceived problem across the faculty is the difficulty in getting students to do enough work in the "Thesis A" half of the research, with assessment for Thesis A intended to encourage this as well as offering feedback.

Another possibility for the assessment is to not return a grade at all for Thesis A, but to hold it open as "Grade Pending" or similar until an overall mark that includes the thesis can be computed at the completion of Thesis B. This overall grade would then be entered for both Thesis A and Thesis B. Such an approach *might* encourage students to work harder in Thesis A, as their efforts would have a larger effect on their overall WAM and hence honours grading.

Individual vs Group Work

Most thesis courses require the submission and assessment of individual student work, with the following exceptions:

In Electrical Engineering, students are permitted to work and submit theses in pairs if they will not be candidates for Honours (presumably determined from student WAMs).

In Computer Science and Engineering, students sometimes work together on projects, which sometimes means the submission of a group thesis with attendant group mark allocation and workload equity problems. Some staff within CSE have indicated a preference for individual theses to avoid these problems.

The committee recognises the potential benefit of students working collaboratively in research projects, not least because this mirrors professional research practice. However, given the equity problems which arise when some students work individually while others work in groups, as well as potentially serious conflicts over mark allocation within teams and given such a large assessment weight, we strongly recommend that assessment for thesis projects be on an individual basis. When students work together on projects, the individual theses must clearly identify which work was completed by each member of the group.

Thesis Assessment Criteria

Theses are assessed holistically in some schools, and according to categories (quality of discussion, overall presentation, validity of analysis etc.) in others. The assessment can be norm referenced (usually to an internal norm through the use of vague terms like "superior", "very good", "adequate" etc. for example MMAN4020, CVEN4031); criterion referenced (whether or not the student provides intellectual input to the discussion; whether or not research results are meaningfully linked back to the literature review, whether or not the student has done anything thoughtful and original; for example CEIC4003); or not explicitly referenced to anything at all (for example ELEC4121).

In all cases the thesis is to be assessed by the supervisor and one other assessor. A third assessor is usually involved in cases where the first two cannot agree to within a nominated range, usually set at 10%.

The clarification and specification of criteria is generally seen as a useful way of communicating expectations to students; and in helping staff to assess consistently and avoid the need for third assessors. The comment has been made in more than one forum that assessors and supervisors often agree on what was done or not done and that more often than not apparent marking discrepancies are due to a difference in expectations or applied grading norms than any disagreement over the work.

Assessing criteria in relatively coarse bands helps to make disagreement less likely, while the inclusion of multiple assessment criteria is valid because there are multiple intended learning outcomes. The inclusion of multiple assessment criteria helps provide more differentiation in final grade while retaining the coarse and easy-to-use grading banks. Accordingly, suggested assessment criteria are given under Recommended Practice. These are essentially a composite of ideas taken from across the faculty thesis courses.

Required Practice

Students may work together on suitable thesis projects, or on interfacing thesis projects, but must be assessed on individually prepared theses and oral presentations.

All thesis course pairs (Thesis A / Thesis B) must require the submission of an individually written thesis document, and must contain some kind of oral presentation or defense component in the summative assessment.

The thesis document must be assessed by at least two markers, one of whom is normally the supervisor. When the two markers cannot agree to within 10%, a third assessor must be appointed to resolve the disagreement.

Recommended Practice

The following assessment criteria are provided as a recommendation. Note that each assessment criterion has a table, and corresponds directly to the intended learning outcomes. Each criterion would have a different weight towards the final overall mark.

A thesis document might be assessed by a weighted combination of Engagement with

Literature (Table 1), Quality of Written Communication (Table 2) and Intellectual Input (Table 3), where an oral presentation such as a seminar or poster presentation might be assessed by Engagement with Literature (Table 1), Intellectual Input (Table 3) and Oral communication (Table 5).

Engagement with Literature / Prior Knowledge (Learning Outcome B)	
F / 0.2, ±	Something has been submitted but it is not recognisably a literature review.
E / 0.4, ±	Some information has been extracted from the literature and presented, without any apparent understanding of how or whether it relates to the project.
D / 0.6, ±	The literature review substantially only covers one of the aspects important to the research.
C / 0.7, ±	The literature review has substantially addressed (extracted and presented information) more than one aspect important to the research
B / 0.8, ±	As for credit, but the student has linked the different literature areas and the research plan together in a meaningful way that demonstrates real understanding of the problem.
A / 0.9, ±	As for distinction, but the student has brought in a meaningful area of literature that had not previously been seen as relevant, or synthesised a novel perspective or theory, i.e., they have done something thoughtful and original.

Table 1 - Suggested assessment criteria for a Literature Review

Quality of Written Communication (Learning Outcomes B and D)	
F / 0.2, ±	The document is barely readable. After reading and re-reading, some sections of text still don't make sense. There is probably no discernible structure to the document.
E / 0.4, ±	Nominal document structure exists but the content is all over the place. Unacceptably poor formatting, failure to label and reference figures, etc. The document is probably difficult to read – some text may require re-reading.
D / 0.6, ±	The document is readable but poorly formatted and structured. Communication in terms of conveying ideas and argument is laboured.
C / 0.7, ±	Formatting and document structure is acceptable but not at a professional standard. The document can be read without too much difficulty and the ideas within it are clear enough.
B / 0.8, ±	High quality document presentation with clear formatting that might not be consistent across the document. Clear structure and easy to read, though some poor decisions have been made with document layout or the way in which graphical information has been presented. Some arguments made are not very well supported.
A / 0.9, ±	Clear and consistent document layout and formatting, complete, consistent and correct referencing to literature, figures, tables etc. Document structure leaves you in no doubt where you are, where you have been and where you are going as a reader. Clear and logical text flow with well supported arguments, clearly explains the research. Graphics and figures wisely formatted and clear in meaning. Work of a professional standard.

Table 2 - Suggested assessment criteria for Written Communication

Intellectual input / Quality of the Work (Learning Outcomes A, C, D)	
F / 0.2, ± (FL)	The submitted work is not recognisable as a thesis project.
E / 0.4, ± (FL)	The submitted work is clearly incomplete as measured against the minimum project scope.
D / 0.6, ± (PS)	Minimum project scope has been addressed. Research results have been acquired and presented. Intellectual input is largely absent from the discussion, which is equivalent to a restatement of the results.
C / 0.7, ± (CR)	As for pass, but research results have been presented and analysed. The analysis and discussion interprets the results in terms of theory.
B / 0.8, ± (DN)	As for credit, but the student has interpreted the meaning of the research results by linking them back to the literature in a meaningful way. The research aims, literature review, results and discussion form a coherent intellectual whole.
A / 0.9, ± (HD)	As for distinction, but the student has connected research results in a way that had not previously been seen as relevant, or synthesised a novel perspective or theory. Ie, the student has done something surprisingly thoughtful or original.

Table 3 - Suggested assessment criteria for intellectual input

Research Manuscript (Advanced Thesis option). (Learning Outcomes A, C and D). *This might be assessed as the average from a panel of postgraduate reviewers imagining that they are reviewing for an international journal.*	
F / 0.2	Reject outright – the work ought not be re-submitted
D / 0.4	Reject – full revision and re-review required
C / 0.6	Accept with major revisions acceptable to reviewer
B / 0.8	Accept with minor revisions acceptable to editor
A / 1.0	Accept as is

Table 4 - Suggested assessment criteria for Research Manuscript as a result of a peer review process (probably postgraduate peers)

Oral communication or defense. (Learning Outcome D). *This would normally be assessed by several academics or postgraduates in a venue such as a seminar, open day or poster session.*	
F / 0.2	Very poor communication – the audience is confused.
D / 0.4	Poor communication – the audience has an idea of what the project is about but had to work hard because of inappropriate aides, mumbling, lack of eye contact etc.
C / 0.6	Clear enough presentation, the main ideas have been communicated but the student might have appeared confused or unprepared at times.
B / 0.8	Professional presentation, clear speaking, good engagement of the audience including listening and appropriate response to questions and answers. It is not apparent that the student has mastery of the topic.
A / 1.0	Professional presentation, clear speaking, good engagement of the audience including listening and appropriate response to questions and answers. The student clearly has mastery of the topic.

Table 5 - Suggested assessment criteria for oral communication

Extended Projects / Advanced Thesis

Currently most thesis courses across the faculty have adopted the uniform structure of a 6 Unit of Credit "Thesis A" course followed by a 6 UoC "Thesis B". The School of Computer Science and Engineering has been running thesis courses with a variety of units of credit and is currently reviewing their practice to achieve a uniform approach consistent with the rest of the Faculty.

Some schools run an extended or advanced thesis course as an option in place of a final year professional elective. Chemical Engineering offers CEIC4006 Thesis Advanced (12 UOC) which may be taken in place of CEIC4003 Thesis B (6 UOC) and one professional elective. Entry into the advanced thesis course requires the consent of the project supervisor and at least a DN grade for the pre-requisite CEIC4002 Thesis A. CEIC4006 Thesis Advanced requires in addition to the submission of a thesis, the preparation of a research manuscript in the style that would be submitted to a journal appropriate to the work.

Civil and Environmental Engineering offers in addition to their standard thesis courses CVEN4032 Higher Honours Thesis A (12 UOC) and CVEN4033 Higher Honours Thesis B (12 UOC). From the handbook description, CVEN4032 appears not to be greatly different in scope from CVEN4030 except that it requires the completion of a literature review whereas CVEN4030 does not. CVEN4033 includes the assessment requirements of CVEN4031 plus additionally a research seminar and a submission-ready research manuscript.

Offering advanced thesis options would appear to be a useful way to allow capable students to take on a more challenging project. One of the central issues with doing this is student equity. The advanced thesis with more units of credit needs to be clearly distinguished from the

ordinary thesis – to remove the possibility of having students doing essentially the same thing for differing units of credit. The argument that the workload equity issue exists within a thesis course anyway is in our view a fallacious one because students vary a lot in their strengths and weaknesses and have a significant level of choice in the project and supervisor that they select. Differentiating the advanced thesis course by requiring the prepration of a research manuscript is an unambiguous way of "requiring more" of both the student and the project. It also has an institutional benefit in facilitating the conversion of high quality undergraduate research into research publications.

Required Practice

Schools *may optionally* offer an advanced thesis option. This might take the form of a 12 UOC replacement for the ordinary "Thesis B" course, or might be a 6 UoC "Thesis C" course for which the 6 UoC Thesis B would be a co-requisite. **Where an advanced thesis option is offered, it must have significant additional assessment which requires conceptually more of the student's performance in the project than does a standard thesis.** The preparation of a journal manuscript is consistent with current practice and would appear to be an ideal way to achieve this.

Recommended Practice

A 6 UoC Thesis A that articulates into either the standard or advanced thesis option appears to be an administratively simpler and more flexible arrangement than is currently proposed by Civil and Environmental Engineering. It would delay the decision to take on the advanced thesis until both the student and the supervisor have been able to make some assessment of research capabilities and project scope and avoids the somewhat undesirable situation of a student dropping back from Higher Honours Thesis A to standard Honours Thesis B.

External Requirements

Neither EAust nor the IChemE explicitly require engineering programs to contain a research thesis. EAust requires that students have the opportunity to engage with a "complex, open-ended problem", with multiple possible solutions and without a unique criterion for evaluation of the solution. Both the research thesis and senior year design projects address this requirement.

UNSW requires the completion of a thesis for the award of honours. The following comments were noted in the minutes of the Academic Board, June 2007 in relation to research and the award of honours in the LLB:

> The ... model provided for: (i) Honours to be based on the student's WAM ... and (ii): research through achievement of at least a credit result in either LAWS2423 or LAWS2422 or in three research papers of a least 3000 words each taken over three courses.
> ....
> During discussion the following comments were made ....
> • The comment was made that the principle behind Honours was to allow students with the interest and capability to gain an appreciation for research. Ideally, the independent research component would be strengthened.
> • It was noted that the research essay component required independent and analytical

research and that many students elected to complete the large research essay of 12,000 words.

All engineering programs currently meet these requirements, with the exception of 3045 Petroleum Engineering.

Required Practice

All programs must meet University expectations for the award of honours, ie a component or components that require independent and analytical research, with individual problem definition and synthesis of conclusions. Such a requirement would ordinarily be met through thesis courses.

Failure

In almost all cases across the faculty, the final year thesis project is a 6 unit of credit "Thesis A" course which generally consists of problem formulation, research plan, literature review and / or preliminary work followed by a 6 unit of credit "Thesis B" course. Although not common, students do sometimes fail either or both of these courses.

Recommended Practice

Students failing the Thesis A course should not be permitted to continue under the same project and supervisor.

Students passing Thesis A but failing Thesis B will often be eligible for supplementary assessment as potential graduands. In this case the student should be given the opportunity to address any shortcomings and re-submit their thesis after a further 6-8 weeks. Passing after re-submission should result in 50 PS. Students failing after re-submission of Thesis B will have to re-enrol in Thesis B with the same project and supervisor or have the opportunity to re-take Thesis A with a new project and supervisor.

Information Literacy

Some schools in the faculty offer formal training in research techniques and information literacy as part of the thesis courses and others do not. Such training was seen by the committee as useful

Recommended Practice

The Faculty and Library should allocate resources to the development of an extended ELISE type course suitable for 4th year research students. Successful completion of such a course should be a required component for the Thesis A courses.

Learning Outcomes

The following Learning Outcomes are recommended as a composite yet short (hence useable) list, mapped to the UNSW graduate attributes

Intended Learning Outcomes		
Outcome	Schools (inspired by)	UNSW graduate attributes **Addressed in a maior way** Addressed in a minor or project-dependent way
A. Plan and execute a research project	SSIS ChSE CVEN MMAN	**1. the skills involved in scholarly enquiry** **3. the capacity for analytical and critical thinking and for creative problem-solving** 6. the capacity for enterprise, initiative and creativity
B. Engage with the relevant discipline knowledge, synthesise and report a view on what is known, unknown and controversial	ChSE MMAN	**1. the skills involved in scholarly enquiry** **2. an in-depth engagement with the relevant disciplinary knowledge in its interdisciplinary context** 3. the capacity for analytical and critical thinking and for creative problem-solving **5. information literacy - the skills to appropriately locate, evaluate and use relevant information** 7. an appreciation of, and respect for, diversity **12. the skills of effective communication.**
C. Identify, acquire and apply any knowledge and skills required to prosecute the project	SSIS ELEC MMAN	1. the skills involved in scholarly enquiry **4. the ability to engage in independent and reflective learning** **5. information literacy - the skills to appropriately locate, evaluate and use relevant information**
D. Synthesise and report research outcomes orally and in writing. Demonstrate understanding of the signficance of the outcomes by integrating it with other work in the field.	SSIS ChSE CVEN ELEC MMAN	**1. the skills involved in scholarly enquiry** **3. the capacity for analytical and critical thinking and for creative problem-solving** 8. a capacity to contribute to, and work within, the international community 9. the skills required for collaborative and multidisciplinary work **12. the skills of effective communication.**

The only attributes not really addressed at all through the thesis courses are

10. an appreciation of, and a responsiveness to, change; and
11. a respect for ethical practice and social responsibility

Marketing

It was noted that several schools include as part of their assessment something similar to a poster session or open day. There might be an opportunity to select the best posters from across the faculty and bring them together for an industry sponsored showcase event which might include cash or other prizes. This could be implemented in a similar way to the postgraduate research showcase event.

OH&S Considerations

All students completing a laboratory-based thesis are required to undertake a full-day safety training course run by the faculty OH&S coordinator. These courses are heavily subscribed, such that students often cannot complete the course until in some cases after the completion of their first semester of thesis. The difficulty in receiving timely training is compounded by the fact that is offered only as a whole-day session, which isn't compatible with student timetables.

This represents a significant bottleneck in student progress for lab-based thesis projects (most of them) and is one of the reasons for the universal complaint that students don't achieve enough in the "Thesis A" course.

Required Practice

The Faculty should re-examine the way that OH&S training is run for 4th year thesis students with a view to training being completed in the first half of the first semester of thesis work.

Project Specification

The types of projects offered in thesis courses vary enormously across the faculty and even within a given thesis course code. Thesis projects encompass laboratory or field investigations including but not limited to industry projects, design work, numerical or computational work and model development. This diversity is seen as a positive thing. All of these projects should, and generally do, satisfy certain basic criteria that allow students to demonstrate the required Learning Outcomes for thesis courses.

Required Practice

A thesis project must have a minimum scope of work specified. It must be a complex, open-ended problem that allows room for student creativity and the acquisition, analysis and interpretation of results. There must be multiple possible solutions or conclusions at the outset and sufficient complexity to require a degree of project planning from the student.

Projects must be adequately resourced.

Requirements of Students

Students are sometimes unsure of exactly what is expected of them in the thesis courses.

Required Practice

The following expectations of students should be highlighted in the thesis course outlines in addition to the Learning Outcomes. Students must:

- have been confmed in a project by the end of week one

- comply with UNSW guidelines on ethical scholarship (see student code of conduct)

- compy with UNSW OH&S requirements

- write an individual thesis and speak to it (see Assessment)

Requirements of Schools

One of the recurring sources of student complaint is supervisors who disappear for extended periods during the course of the thesis. It was considered that there ought to be a minimum standard for supervision and student service across the faculty.

Required Practice

- All students can have a supervisor who is based in their 'home' school.

- All thesis students should have face-to-face access to their supervisor or nominated deputy at least fortnightly. This expectation should be made explicit on all thesis course outlines. Deputies should be formally nominated before a supervisor takes planned leave.

- Necessary OH&S and related training will be provided, without delaying the project.

- All assessment will be timely.

- Adequate resources will be made available to complete the project which will allow demonstration of the learning objectives.

Topic and Supervisor Choice

Across the faculty, with the exception of 3045 Petroleum Engineering as noted under "External Requirements", students have a level of choice in their selection of research topic and supervisor. The mechanism by which this is achieved varies. The most common model, employed by Electrical and Civil Engineering and others is a "First in First Served" model, in which students select from a published list of projects and supervisors and then meet with the supervisor to sign up to the project. Students selecting a project that already has a student or students will need to select again. Any students not having a project by the nominated deadline (end of week 1) are dis-enrolled from the course.

In Chemical Engineering, students nominate project / supervisor preferences via email to the course coordinator, who assigns students to projects in a way that ensures all students have a project. An attempt is made to optimise the allocation so that the highest overall preferences are met. This system represents a significant workload for the course coordinator, but has the advantage that academic workload is more easily managed and that all students are assigned a project.

Students in most schools have the freedom to choose projects outside the school including industry projects although this is not widely known and only occurs when students display particular initiative.

Required Practice

All thesis courses must allow students substantial choice of topic and supervisor.

All thesis courses must include in the course outline and in their project advertising explicit comments indicating that projects and supervisors may be selected from outside the school, including from industry. When students locate a suitable external project, a co-supervisor from within the student's own school must be appointed to ensure appropriate project scope (see Project Specification) and that the appropriate procedures (such as assessment procedures) are followed.

Recommended Practice

Any project / supervisor allocation processes should ensure an equitable workload across the academic staff within a school. It is suggested that an academic cannot sensibly supervise more than 8 undergraduate thesis projects at any one time, and that this should be set as an upper limit.