

Is it Possible to Break-even in Undergraduate Engineering Education? A Cost Analysis and Costing Model*

SCOTT D. SNYDER

Senior Lecturer and Acting Head, Department of Mechanical Engineering, Associate Dean for IT, Faculty of Engineering, Computer and Mathematical Sciences, Adelaide University, Adelaide, South Australia 5005, Australia. E-mail: scott.snyder@adelaide.edu.au

The purpose of this study is to examine the cost of undergraduate student education in a specific mechanical engineering department. While the numbers will be precisely correct only for the institution under examination, the trends will be relevant to most engineering departments. Of particular interest is the derivation of a relationship between absorption cost per student and student numbers, marginal cost of students in the degree programs, and explicit documentation and costing of activities in the program. A detailed costing model is developed with three different costing. The results clearly show that undergraduate teaching activities in small and medium sized departments can easily lose money.

INTRODUCTION

UNDERGRADUATE ENGINEERING education is an expensive business. This observation is often made by engineering educators, particularly in the presence of central administrators who are looking for that last sliver of ‘non-essential’ activity to trim from an institution’s expenses. The problem for many engineering educators lies in converting the qualitative observation into a quantitative argument: just exactly *how* expensive?

The purpose of this study is to examine the cost of *undergraduate* student education in a specific mechanical engineering department. While the numbers will be precisely correct only for the institution under examination, the trends will be relevant to most engineering departments. There are three specific objectives:

1. To derive a relationship between the absorption cost per student, both average throughout the courses and on a year-level basis, as a function of the number of students in each year of the degree. The data can then be assessed against the common levels of funding and student numbers to make some assessment about the profitability or otherwise of undergraduate education.
2. To derive the variable cost per student on a year level basis. This data is useful in a number of circumstances, such as the assessment of scholarship levels (which will effectively reduce the income per student).
3. To explicitly document the main cost drivers in the degrees. This will then provide the input for

explicit assessment of value in some form of balanced scorecard exercise [1], the outcome of which can be used to shape teaching-related behaviours and practices in the department.

The approach taken here to derive a detailed costing model capable of supplying the required information is to employ an activity-based costing (ABC) methodology. In the last decade, ABC approaches have been advocated for providing accurate costing models *in general* [2–9]. Recently, practitioners [10–14] and government reports [15–18] have advocated the application of ABC methodologies to the higher education sector. The strategic benefits offered by this are both numerous and obvious, and are spelled out in detail in [18]. Such an approach was not unheard of prior to these publications; for example, Deakin University used ABC methods to cost mixed mode course delivery as early as 1986 [19]. However, most expenditure control systems in universities at that time failed to effectively link expenditures with outputs [20], a problem which is still common. A report by the Higher Education Funding Council for England [15] provides a procedure for deriving ABC models in different university operational units, including academic departments. However, the majority of published examples, including [13, 14, 21], are concerned with non-academic support units. The goal here will be to derive a model for an academic activity.

It should be noted that the costing exercise is being undertaken from the departmental standpoint, and so only those costs which must be borne by the department providing tuition are considered. Therefore, faculty-level costs, such as the salary of a registrar and dean, and centre-level

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costs, including administrative staff salaries and various infrastructure components (buildings, central IT, etc), are not included. It is reasonable to expect that these additional costs would more than double the total price of the package.

Finally, all costs are given in Australian Dollars (AUD\$). While exchange rates fluctuate regularly, notionally using AUD\$1 = US\$0.60 will typically be within 10% of the current market rate.

DESCRIPTION OF THE DEPARTMENT

Costing practices across the higher education section vary markedly, which is to be expected given the individuality of institutions and the range of requirements for costing. Universities in Australia, like most service organisations [2], typically manage operations through budgetary control of cost centres: faculties, departments, etc. In regard to undergraduate education in Australia, funding comes in to the University from two main sources: from the federal government for domestic students, and from the private and individual bodies for full fee paying overseas students (FFPOS) and fee paying domestic students. While fees and dispersion methods vary from university to university, at the time of writing the fees charged by Australian institutions to fee paying undergraduate engineering students was of the order of \$15,000, with the departments receiving less than half of this.

The department explicitly under consideration

here is the Department of Mechanical Engineering at the Adelaide University. While staff numbers vary, they are typically 12–15 academic staff members involved in teaching, approximately the same number of general staff members who support teaching, approximately 180–200 equivalent full time student units (EFTSU) of Australian government (DETYA)-funded undergraduate student load and approximately 40–50 EFTSU of overseas full fee paying student load. These numbers make the Department small-to-medium sized for an Australian institution. The two main income sources to the Department, teaching revenue and research funding, are typically of the same order of magnitude of dollars.

APPROACH TO MODEL DERIVATION

The approach to model derivation used here is common to most ABC model developments. Using the terminology of [15], the steps are:

- Step 1. Determine the cost objectives. (These have been described previously in the Introduction.)
- Step 2. Identify activities which contribute to cost objectives.
- Step 3. Assign resource costs to activities.
- Step 4. Link activities to cost objectives.
- Step 5. Analyse and report results.

These steps are shown in the sketch in Fig. 1. Steps 2 through 5 will be discussed in detail in the sections that follow.

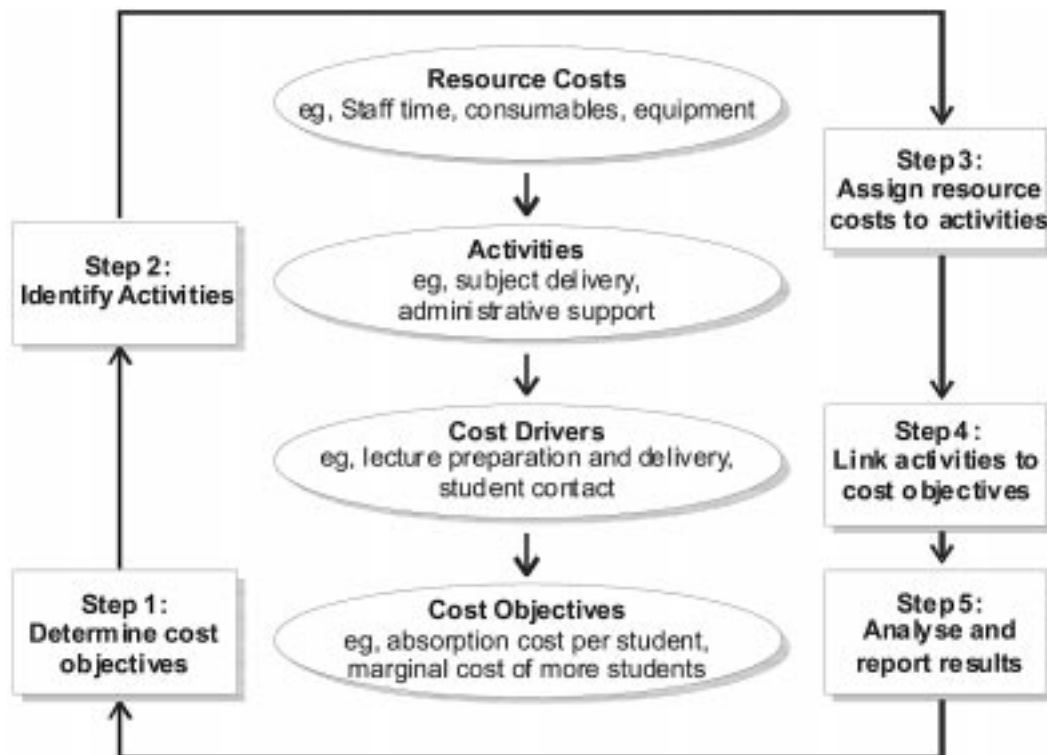


Fig. 1. Steps in the costing process, adopted from the HEFCE report (1997a).

STEP 2: IDENTIFY ACTIVITIES WHICH CONTRIBUTE TO THE COST OBJECTIVES

The purpose of this work is to examine the cost, both absorption and marginal, of undergraduate education for two Bachelor of Engineering degrees offered by the Department of Mechanical Engineering: Mechanical Engineering and Mechatronic Engineering. The rationale for studying two programs together is that there is a large degree of commonality in the cost drivers: the administration of the degrees is shared within the Department, a high percentage (over 50%) of the subjects are common, and the overall structure of the degree program is similar. Of the 78 subjects on offer over the four years for the two degrees, 43 are common to the two degrees, and 28 are taught by departments other than Mechanical Engineering (service courses). In developing the cost model, no distinction will be made between the subjects taught by the Department and service courses. While this will lead to some underestimation of administration costs, as some administration costs are borne by other departments, it is felt that the error will be small. It should be noted that the Department also offers service teaching to other departments, and no attempt has been made to separate the cost of administration of these subjects from the Mechanical and Mechatronic Engineering costs. The two errors tend to balance to some degree.

Each year level is allocated 24 points, with subjects allocated a certain point value based upon the number of lectures and tutorials encompassed. The most common point value, assigned to 40 of the 78 subjects under consideration, is 1.5. A 1.5-point subject will have 2 hours of lectures per week over a 13-week period. The next most common point value is 2, assigned to 24 of the 78 subjects. A 2-point subject is allocated 3 hours for lectures and tutorials per week.

Referring to Fig. 2, there are a range of activities that contribute to the cost of education:

- Overall administration-related drivers, which include both *process level activities* and *facility level activities* [23], such as the cost of having a head-of-department and administrative staff, and the hours staff spend in committee meetings, promotional activities, formal meetings with student groups outside of teaching, and the support of workshop infrastructure.
- Drivers related to the number of academic staff required to teach in the program, or *product/service level activities* [23], such as computer infrastructure and office furniture.
- Drivers related to administering a given year level, which are *batch level activities* [23], including the cost of lab setup for the year, the time required to collating the grades for a given year level and the time required to compile student manuals.
- Subject level cost drivers, which are *batch level activities*, such as the time required to set final exams and the time required to review textbooks.
- Lecture-hour cost drivers, which are *batch level activities*, which include the time required to develop and deliver each hour of lecture material.
- Student-number cost drivers, or *unit-level activities* [23], associated with the time required to answer individual student questions and supervise student project work.

Details of these drivers will be given in subsequent sections. However, before doing this it important to discuss how a typical academic divides his or her time, covered in Step 3, as the assumptions made here impact upon the derived model.

STEP 3: ASSIGN RESOURCE COSTS TO ACTIVITIES

The third step in the ABC model derivation is assigning resource costs to the activities identified

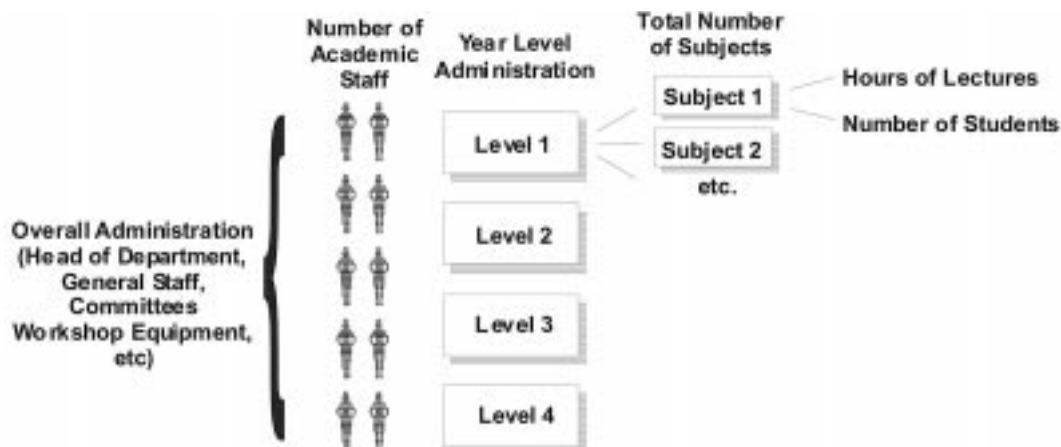


Fig. 2. Categories of cost drivers in the courses.

in Step 2. As outlined in [15], there are three common ways of approaching this:

- direct attribution
- estimation, or
- general apportionment.

Direct attribution requires detailed measurement of actual usage. While being the most accurate in terms of capturing the volume and cost of resources used by activities, is also the most complicated and time consuming. It is questionable whether the increase in accuracy justifies the means [15].

An alternative to direct estimation is estimate the volume of resources used by interviews and surveys of staff members. This approach will be used in conjunction with general apportionment of staff time between research and teaching activities to develop the model here. The interview and survey results will be averaged to derive a simple model that is both useful and *usable* (i.e. the number of cost drivers will be limited to less than 10). Output from the derived model will be compared to actual numbers to provide a reality check. If the model proves inaccurate, direct attribution can be pursued.

Apportioning academic time

An important question to answer here relates to apportionment of academic time: how *does* an academic staff member spend his or her time?

Academic staff members in the School of Engineering at Adelaide University have four discipline-specific promotion criteria categories: teaching, research, administration (aka, 'service'), and consulting. In practice, teaching and research

are the drivers of academic activity, being the most important of the promotion criteria. Because of this, the activities of the typical academic staff member can be considered as split between these activities, with administrative tasks allocated to support of these activities. In this split, 'teaching' refers purely to undergraduate education, as in Engineering the education of postgraduate students typically supports research activities. Consulting work is modelled as co-existing with research activities. This reflects actual practice, where staff members either consult at the expense of basic research and/or consult outside of the standard 37.5-hour week (i.e. these staff members work 'overtime'). The notional model is depicted graphically in Fig. 3.

An important question that follows on from this model is: how much time must be spent on research activities to sustain a program of the calibre expected at the University? The answer to this question impacts upon the number of staff required to teach a given number of subjects. Based upon staff interviews, an average value was of the order of 15 hours of research-related activity per week *minimum* was required to sustain an internationally competitive program during the teaching year, with greater periods of time available outside of the normal teaching period. It should be noted again that this 15 hours includes the time spend in supervision of postgraduate students, considered here to be a research-related activity. It will be argued later that each hour actually lectured per week corresponds to approximately 4.7 hours of teaching-related work. Looking ahead and taking into account the additional time required for teaching-related tasks, and the



Fig. 3. Academic staff members typically split their time between research-related and teaching-related activities.

time spent in supervision of level 4 projects, it can be concluded that 4–5 hours of lectures per week are the maximum possible for a single staff member who is also an active researcher. This corresponds to approximately two regular subjects per semester of 1.5–2 point value, or approximately four subjects per year. Therefore, the number of staff required to teach a given course will be set by: (number of subjects)/4. This is an upper limit on the standard teaching load.

It should be pointed out that this teaching load is significant *less* than that suggested elsewhere; reference [26] suggests approximately 2/3 of the academic's total time should be spent in teaching and teaching-related administration. However, based upon staff interviews, this is viewed as too high for a world-class research university, and would be a deterrent to potential staff.

Costing academic time

In later discussion, lecturer time will be costed at an 'average' hourly rate that includes 36% centrally charged on-costs (this are set by central administration). The academic ranks and salary ranges at Adelaide University are outlined in Table 1.

In regard to the hourly rate, the question now arises, what hourly rate should be applied to the teaching activities of academic staff members? If the hourly rate of \$43.30 is applied to teaching activities, the implication is that the University is only going to fund part of an academic salary. This is clearly not aligned with practice, as academic staff are hired on the assumption that they will be given a full year's wages for a 'full' teaching load. Therefore, it is reasonable to expect that an *academic staff member's* salary should be fully covered by the money received from the government for teaching-related activities.

There are two obvious way to model this. One way is to assign an hourly rate of \$86.60 per hour, which effectively says that the centre will fund one hour of *research-related* activity for every hour

Table 1. Taking the Department of Mechanical Engineering academic mix as average, and working on 52 weeks of 37.5-hour duration, the average hourly rate for an academic staff member is found to be \$43.30 per hour. The cost of laboratory demonstration, which is commonly done by postgraduate students, will be calculated at the going rate of \$22.00 per hour. External lecturing staff are costed at \$110 per hour of lecture. Academic ranks at the Adelaide University. It should be noted that salaries attract 36% on-costs, which is factored in to the analysis in the paper. A complete description of the Adelaide University payscale can be found on the HR website: www.adelaide.edu.au/HR

Staff Grade	Lecturer Level	Salary Range (AUD\$)
Tutor	A	\$34475–\$46786
Lecturer	B	\$49249–\$58484
Senior Lecturer	C	\$60329–\$69564
Associate Professor/Reader	D	\$72642–\$80028
Professor	E	\$93572

spent in *undergraduate* teaching. Implicit in this is the capture of 'overtime' by staff members, where additional cost is assigned to teaching loads above 50% of the normal working hours (the assumption is that academic staff members will have to work longer than 37.5 hours per week on average to support a research program if more than 50% of their normal week is consumed with teaching-related activities).

An alternative approach is to simply assign one academic staff member salary per every 4 subjects on offer, and ignore the allocation of academic staff time. While this approach fails to capture the need for overtime to support research activities if the teaching load exceeds 50% of the normal working week, it does have two important advantages from the standpoint of cost centre budgeting:

- It is simpler to use, as the use of staff hours replaces the need to estimation of hours spent in teaching and teaching preparation (these latter values would be open to debate by external bodies).
- It provides incentive to develop and implement efficient teaching practices. Under an hourly system, the cost centre would be funded more if, for example, all staff members walked more slowly between the office and classroom, or graded assignments more slowly. If staff numbers are funded, then the staff member must do a certain (reasonable) amount of work, regardless of how long it takes; walking slowly or taking a long time to grade will simply impact upon how much research time is available. The trade-off between quality and quantity will be made by the academic in consultation with various department-level committees and the head of department.

In this alternative approach, administrative staff costs would still be partitioned between research and teaching. Lecture hour costs would disappear, with the exception of laboratory demonstration and tutorial costs that are attributed to post-graduate students and other external members.

In the work that follows, three cost models of undergraduate teaching will be derived: one based upon \$43.30 per hour, one based upon \$86.60 per hour, and one based upon a full salary being paid for each four subjects taught.

No mention has yet been made of non-academic (support and general) staff salaries. In days past it would have been reasonable to expect the centre to pay full non-academic staff salaries to support both teaching and research. However, this no longer equates with practice. Therefore, in the models to be derived, non-academic salaries will be partitioned into teaching and research-related activities, with only the teaching component including in the costings. Implicit in this is the assumption that research-related activities will cover the cost of approximately 50% of the general staff salaries in the Department.

Detailed consideration of the cost of activities

Detailed consideration of the cost of activities is given in the Appendix.

STEP 4: LINK ACTIVITIES TO COST OBJECTIVES

Step 4 in the model derivation process is to link activities to cost objectives. Again, direct attribution, estimation or general apportionment can be used in this process. However, as noted in [15], direct attribution is 'rarely feasible' because of the large number of outputs, and general apportionment provides only broad insights. An estimation approach, based upon staff surveys and interviews, is used here.

Valid range

The values assigned to cost drivers described in this section is based upon data from academic and general staff surveys and interviews. The data has been derived on the assumption of an 'average' class size of 35 BE (Mechanical) students and 35 BE (Mechatronic) students. Staff were asked to describe the range of student numbers over which they considered their responses valid; the most common response was in the range up to 50 BE (Mechanical) and 50 BE (Mechatronic). These correspond to the maximum capacity of the current lecture venues, and roughly the maximum capacity of laboratory facilities, given student group sizes and number of weeks available to expose students to each laboratory class. To move above this number would require some capital expenditure in laboratories, which would have to be costed, and a change of teaching venue. The end result would be an increase in absorption cost, which mirrors trends published elsewhere [24].

The main exception to this range is in technical staff support. With the current nominal class levels sizes of 35 and 35 for the two degree programs, the technical staff are working to, and in some cases

above, maximum capacity to support the teaching and research programs. It is likely that if the student class sizes were to expand to 50 and 50, then two additional technical staff members would have to be employed to maintain the current program, principally to support student project work. In the simulations given later in the paper, it will be assumed that one additional technical staff member will be required if average student numbers exceed 65, and two additional staff members if the student numbers exceed 85.

Summary of results

Detailed costings can be found in the appendix. A summary of results is provided in Table 2.

STEP 5: ANALYSIS AND REPORTING

Shown in Fig. 4 is the absorption cost per student for the three models, with the assumptions that each year level has the same number of students and that one additional technical staff member will be hired when average student numbers exceed 65 per year, and a second hired when average numbers reach 85. The line at \$7000 is of the order of, but slightly less than, 50% of the fees charged to non-residents engineering students by Australian universities. It can be expected that many engineering departments will receive of the order of \$7000 per student (on average).

There are two interesting points to note. First, the fact that the \$86.60 hourly rate costing exceeds the full salary model implies that staff members spend more than half their time in undergraduate teaching-related activities, and so must work 'overtime' if they are to maintain their research careers. Second, if a department *does* receive of the order of \$7000 per student, then a department receive of the order of 100 students (total) in each year level to simply break-even.

The question now arises, is this sensible? The Department under consideration here has significantly less than 100 students in each year level;

Table 2. Summary of cost drivers and rates for the three different costing approaches.

Cost Drivers	Costing Basis		
	\$43.30 hourly rate	\$86.60 hourly rate	1 staff member per 4 subjects
General Administration	\$612,800	\$612,800	\$612,800
Staff Numbers (\$ per staff member)	\$6230	\$10560	\$86335
Year Level Costs (\$ per year level)			
Year 1	\$866	\$1732	\$0
Year 2	\$2866	\$3732	\$2000
Year 3	\$4866	\$5732	\$4000
Year 4	\$11732	\$12785	\$10000
Subjects (\$ per subject)	\$1600	\$3200	\$0*
Lecture Hours (\$ per lecture hour)	\$204	\$408	\$0*
Student Numbers (\$ per student)			
Year 1	\$1035	\$1540	\$530
Year 2	\$990	\$1495	\$485
Year 3	\$960	\$1465	\$455
Year 4	\$2770	\$4620	\$825

* These costs are now included in the staff number costs.

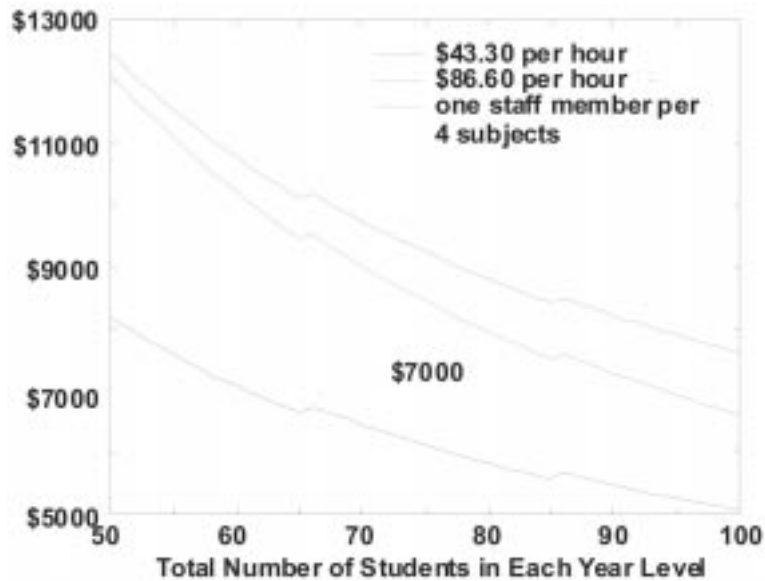


Fig. 4. Full absorption cost per student for the three models, assuming an equal total number (Mechanical and Mechatronic) of students in each year level.

total numbers (Mechanical + Mechatronic) range from approximately 50–70 across the year levels. The results illustrated in Fig. 4 imply that the teaching activities of the Department are running at something of the order of a 20% loss. How is this possible?

In fact, the Department currently covers approximately one-third of the total administrative costs with research-related funds, instead of the one-half actually. However, two full and two part academic positions are paid for by external funding sources, no money is set aside for laboratory and workshop infrastructure replacement, staff support costs (computers, books, etc) are covered by research income, and staff *do*, on average, work more than 37.5

hours per week to support research activities (effectively, unpaid overtime). So, in fact, research activities *do* partially support teaching activities. The extent of the support will be examined more shortly.

Illustrated in Fig. 5 is the (full absorption) cost per student divided into year levels, using the \$86.60 academic hourly rate model and assuming an equal total number (Mechanical and Mechatronic) of students in each year level. Note that it is the final year of study costs significantly more than the first three, owing principally to the significant increase in variable cost per student which accompanies the final year student project. There is also an increase in the fixed and variable costs associated with the CET (laboratory) subject, owing to

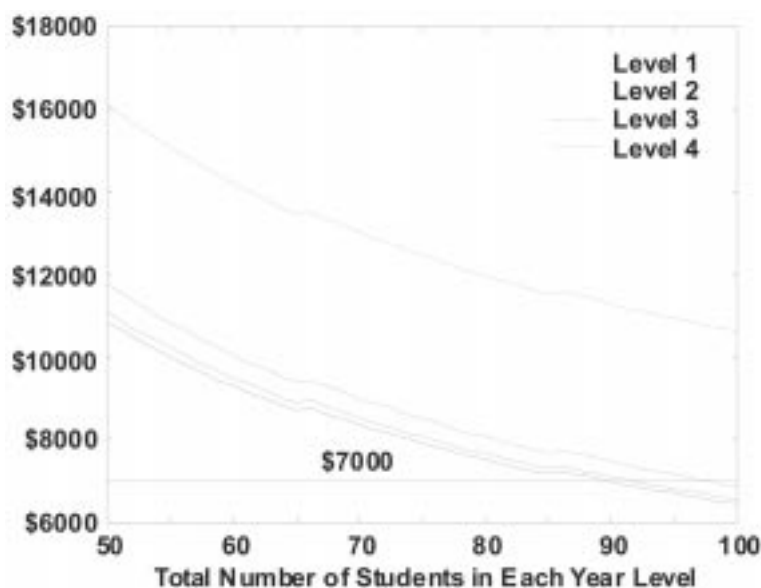


Fig. 5. Full absorption cost per student for the four year levels, using the \$86.60 academic hourly rate model and assuming an equal total number (Mechanical and Mechatronic) of students in each year level.

the use of more expensive equipment and the doubling of laboratory session (time) lengths.

It is quite clear that the costs of teaching the final year of the course will *never* be met by the income attributed to the year level, barring a significant change in funding model or student numbers (the latter would require a change to the model, as more academic staff members would have to be appointed simply to cope with the increased final year project load). It is important for the Department to balance the cost of the final year with the quality of the degree, and while it is beyond the scope of this paper to develop a balanced scorecard for the Department's teaching activities, it is worth briefly mentioning quality of education in light of the final year level costs.

In terms of teaching, the Department has two sets of 'customers': the students themselves, and their employers. Quality of education must in part relate to expectations of these two groups. Considering the first customer group, the (government collected) graduate satisfaction ratings for the Department under consideration were equal top for Mechanical Engineers in 1999. When students are surveyed internally about likes and dislikes, the overwhelming comment is the value of hands-on work and interaction with lecturing staff. It is not surprising that schools that rank lowest in graduate satisfaction surveys go to lengths to limit student access to academic staff members.

While this is a way of reducing costs, it is also a way of reducing both satisfaction and quality. In regard to employers, comments from the Department's industry advisory board indicate that a high value is placed upon the skills acquired in the student project. Indeed, the final year capstone design project is a highlight of most high quality engineering degrees [27], and removal or restriction of the project would have ramifications that go well beyond the financial bottom line.

SOME CONCLUSIONS

Having derived an ABC model that can be used to look at both absorption and marginal costs, three important conclusions can be drawn.

1. At present, the undergraduate teaching activities in small to medium sized Mechanical Engineering departments in Australia are likely to be losing money.

Given the levels of funding per student commonly found in Australia, the above model indicates that combined Mechanical/Mechatronic Engineering student numbers of the order of 100 per year level would be required to break-even, or an increase in funding per student. As the average student numbers in the Department under consideration here are of the order of 65–75 in each level, the model predicts a shortfall of the order of 20%. In reality, research activities in the Department are supporting teaching: two full

and two part academic positions are paid for by external funding sources, no teaching-related money aside for laboratory and workshop infrastructure replacement, research grants are used to cover *all* basic staff costs (computers, books, etc). In addition, staff *do*, on average, work more than 37.5 hours per week to support research activities (effectively, unpaid overtime).

2. The final year level of the degree is far more expensive than the other three years.

The variable cost of students in level 4 of the degrees is of the order of three times as high as in the other years, which results in a significantly higher absorption cost per student. This main reason for this the high level of student/academic contact associated with project work. Given that this form of project work is a worldwide accepted component of a high quality engineering degree, it is unlikely that this time could be removed without seriously impacting upon teaching quality. Other contributing factors are the offering of course options in level 4, where students choose six specialist subjects from a list of 12–15, and more intensive laboratory work.

3. Level 1 students are no less expensive than Level 2 and 3 students

There has been a notion in many engineering faculties in Australia that level 1 students are the least expensive to teach, owing to the large number of subjects (statics, dynamics, mathematics, etc) that are common to all engineering degrees. The findings here show that the marginal cost of level 1 students is, in fact, higher than the marginal cost of level 2 and 3 students. This is because of the high number of tutorial sessions associated with level 1 courses, which are driver by student numbers.

A FINAL COMMENT

The title of this paper poses a question: is it possible to break-even with undergraduate engineering education? To someone outside the field, it may seem an incredible question: surely engineering education can't be running at a *loss*. In fact, undergraduate engineering education is a money losing task in small and medium size department. These departments need either more students, or more funding, or both. It is the research activities of many engineering departments that simply keep them afloat, that let them operate undergraduate programs with some degree of quality. It is a pity that not all areas of the university are so self funding!

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APPENDIX: DETAILED CONSIDERATION OF COST DRIVERS

Lecture hour calculations

It is straightforward to calculate the number of lecture hours required for a given subject, level and course. However, for each hour of lecture given there is a range of background activities. These activities are most easily and logically represented by a multiplying factor (hours of preparation per hour of lecture delivery). Based upon staff interviews, the following is taken as average:

- For a subject in its first year of development, 10 additional hours of material development are required for each hour of lecture. (This number varied from 6 to 20 hours, depending upon the nature of the subject and the habits of the lecturer. A value of 10 hours is roughly average. As many of the staff members interviewed have been employed at the University for less than 5 years, and so are currently involved in subject material development, this average is considered reliable.)

- For a subject in its second year of development, 1 additional hour of material development is required for each hour of lecture.
- The average life of a given subject is approximately 5 years. (This number varied from 6 to 20 hours, depending upon the nature of the subject and the habits of the lecturer. A value of 10 hours is roughly average. As many of the staff members interviewed have been employed at the University for less than 5 years, and so are currently involved in subject material development, this average is considered reliable.) After that time it is likely that the lecturer would have changed for some reason, or the course will be completely re-vamped. Therefore, the 11 additional hours per lecture considered in the first two dot points can be depreciated over a 5 year period, giving 2.2 hours per lecture per year.
- For any subject, for each one hour of lecture there is (on average) approximately one hour of preparation for the 'presentation', plus 15 minutes setting up and 15 minutes packing up. Questions asked by students immediately after the lecture are included in the packing up time. Travel time to and from the lecture venue is included in the 1 hour lecture time (50 minutes actual speaking, 10 minutes travel).
- Based upon the above, each 1 hour of lectures represents (1 hour of lecturing + 2.2 hours of depreciated subject material development + 1 hour of basic preparation + 0.5 hours of setup and packing up =) **4.7 hours of work per 1 hour of lecture**. This is the multiplying factor that will be applied to lecture hour calculations. Based upon a staff hourly salary, this corresponds to a cost of $(4.7 \times \$43.30 \text{ or } \$86.60) =$ **\$204 per 1 hour of lecture at the \$43.30 costing and \$408 per 1 hour of lecture at the \$86.60 costing**. The alternative approach is to assign a full staff salary for every 4 subjects offered, which will be discussed under the subject drivers heading.

Drivers related to student numbers

The main activities that have a duration directly related to the number of students in a given class are:

- the time spent marking assignments;
- the time spent marking exam papers;
- the time spent compiling grades on a mark sheet;
- the time spent meeting with students outside of the normal lecture period (the normal lecture period is taken to include the 10 minutes immediately after the lecture, where the majority of student questions are typically fielded);
- student expenses for IT for teaching.

In regard to the first point, academic staff members typically use a combination of 'self' marking and marking by postgraduate students under supervision. There are typically 3–4 assignments that must be marked per normal subject. A typical assignment will take, on average, 5 minutes to mark. Given the mix of postgraduate and academic staff labour, and the fact that postgraduate students are paid at approximately one-half the academic hourly rate, an average of 10 minutes of academic staff time will be costed per student for assignment marking for a given subject.

In regard to the second point, based upon staff responses, an average of 20 minutes per exam marked will be costed. For the third point, also based upon staff responses, an average of 4 minutes per student for grade compilation will be costed.

For the fourth point, academic staff members spend time out-of-class with students in a variety of ways, including answering informal questions, training student leaders for peer-lead tutorial exercises, and maintaining formal consultation hours. Despite this range of activities, the deviation amongst staff was relatively small: 16 minutes per student was approximately average. There is some difference between the 1.5 and 2 point subjects, as the 2 point subjects encompass more lectures and therefore more questions. However, this error will be ignored here.

For the last point, the School of Engineering has a centrally-run IT facility, the use of which is charged to departments on the basis of use and student numbers. On average, the cost to departments is \$285 per student.

Adding the above numbers, the total academic time spent per student per average subject is (10 minutes assignment marking + 20 minutes exam marking + 4 minutes grade compilation + 16 minutes consultation) = **50 minutes per student per 'average' subject**. On average, students will take 14 of these 'normal' subjects per year level, plus some 'special' subjects that are costed separately (discussed shortly). Therefore, each student consumes, on average, 700 minutes of staff time per year. At the hourly rate of \$43.30, this corresponds to \$505 dollars per student per year level, and \$1010 at the hourly rate of \$86.60. Adding this to the \$285 IT cost, **each student costs \$790 at the \$43.30 hourly rate, and \$1295 at the \$86.60 hourly rate**.

Subject-related activities

The main tasks which are driven by subject are:

- setting final exams;
- additional tasks, such as reviewing textbooks, background reading, communicating with overseas twinning partners, recruiting and training postgraduate student markers, and communicating with guest lecturers.

Note that the setting of assignments is not included here. This is considered to be part of the lecture material development and preparation.

Based upon staff interviews, an average of 12 hours is spent setting final and supplementary examinations, and 25 hours in additional tasks. Therefore, **37 hours** of staff time will be allocated against each subject. This corresponds to **\$1600 per subject for the \$43.30 hourly rate, and \$3200 per subject for the \$86.60 hourly rate.**

Special subjects

The above model of lecture hours is applicable to the range of 'normal' subjects. There are, however, several subjects or subject components that must be costed separately: For several level 1 subjects, such as statics, dynamics and design graphics, tutorial and 'special' tutorial groups run. These incur costs above the normal subject, lecture hour and student drivers. The number of groups is driven by student numbers on a step basis, with a typical group size ranging from 15 to 50, depending upon the subject and whether the tutorial group is 'special' or normal. Taking an average, there are approximately 6.25 hours of tutorial per student. Tutorials are typically run by trained postgraduate students or other external persons, and are paid at a rate of \$39 per hour of tutorial given (no additional money is given for preparation). Therefore, **for level 1 students**, and additional cost of $(6.25 \times \$39 =)$ **\$245 per student** must be allocated.

In year levels 2, 3 and 4 there is a subject Computational and Experimental Techniques (CET), which is basically a series of laboratory exercises. Each academic staff member is responsible for developing and maintaining the laboratory material related to his or her area of expertise. One academic staff member is given overall responsibility for running the subject, scheduling the laboratories, recruiting and training postgraduate students who supervise the individual classes and collating the material and marks. There are two additional cost drivers that must be assigned to the CET subjects above and beyond the normal subject costs: the cost of laboratory equipment that is actually purchased, and the cost of postgraduate time. Much of the laboratory equipment is made in-house; for this, the hours spent in construction will be captured in the administrative cost section, while the material is costed under the basic infrastructure section under the heading of 'lab maintenance'.

In regard to the cost of purchased equipment, much of the 'expensive' laboratory equipment serves a dual teaching/research role. For these pieces, the costs are assumed as being split evenly between the two activities. The calculation here will be based upon the assumption of a 10 year straight line depreciation for the laboratories currently undertaken, which is longer than suggested elsewhere [25] but in line with actual practice. Using this, the basic equipment cost that must be assigned to each year level for the CET program is **\$2000 for level 2, \$4000 for level 3, and \$10,000 for level 4**. Equipment that is more than ten years old is assumed to have depreciated to zero value.

In regard to instruction, each year level is divided into groups of 4 or 5 students which form the basic building blocks of the laboratory program. For some laboratories, only one group can undertake the exercise at a time, with all groups rotating through on a scheduled basis. For other laboratories, 12 groups can undertake the exercise at one time. For levels 2 and 3, postgraduate students are paid for 3 hours of direct supervision and 1 hour of marking per laboratory class session, while for level 4 they are paid for 6 hours of direct supervision and 2 hours of marking. Working with the current laboratory schedule, and dividing the total direct cost up amongst the student population, the cost of CET supervision is **\$200 per student for level 2, \$170 per student for level 3, and \$540 per student for level 4** using the postgraduate rate of \$22 per hour.

In level 4 of both the Mechanical Engineering and Mechatronic Engineering courses, students undertake a major research, design and development project. Students are typically grouped in pairs for this exercise, although single- and three-student groups are also allowed. Based upon staff surveys, the average time required to supervise a two-person group for the year's work is: (40 hours direct supervision + 6 hours background work + 10 hours grading reports + 2 hours marking seminar presentations + 4 hours grading the final presentation) = 62 hours. This implies a final year project workload of **31 hours per student** (it is assumed that the extra time spent on single person groups is averaged out when combined with the time savings from the three person groups). There is also \$100 made available to each student for basic project support (larger projects obtain support from research or external funds). Therefore, the cost per student of the final year project is $(31 \text{ hours} \times \text{hourly rate} + \$100) =$ **\$1440 per student at the \$43.30 rate and \$2780 per student at the \$86.60 rate.**

Year level administration

Year level administration tasks include compiling grades, producing student manuals and answer curriculum-specific questions. For years 1–3, this amounts to approximately 20 hours, or **\$866 at the \$43.30 rate and \$1732 at the \$86.60 rate**. For level 4 there is additional time involved, as the year level administrator must also organise the final year projects; level 4 is costed at 40 hours, or **\$1732 at the \$43.30 rate and \$3464 at the \$86.60 rate.**

Basic staff costs

Each staff member requires a minimum level of infrastructure for teaching support, including a PC, books, office furniture and a staff allocation for miscellaneous purchases. Assuming \$1000 per year depreciation on a computer, \$200 per year for texts, \$200 per year for furniture and \$500 (actual) for allocation, basic staff support costs are budgeted at **\$1900 per year per staff member**.

Administration overheads—personnel

Precise allocation of administrative and general staff costs, as well as head of department costs, to the teaching and research programs is a difficult and time-consuming exercise. After interviews with staff, it appears that simply allocating one-half of the staff costs to research and one-half to teaching is reasonable as well as simple. At present, the Department has the minimum complement (i.e. one of each) of support staff required to maintain operation: one receptionist/secretary, one senior secretary who is also in charge of ordering, one administrator, one lab manager, one instrumentation technician, etc. It is also clear that any increase in teaching or research load would require additional hiring of support staff, as these staff work at full capacity. Technical staff have a project waiting list of several months. The overall situation is typical for Australian institutions for some time [22, 26], where reductions in real funding levels have resulted in a falling average cost per EFTSU, suggesting an increase in efficiency.

If one-half of the (budgeted Department of Mechanical Engineering) general support and administrative staff salaries are allocated to teaching, then this overhead is \$371,000. In addition, there are \$14,000 of general staff support costs, half of which will be applied to teaching activity costings.

The Head of Department position is basically one-half administration, one-half academic staff. Noting that the Head of Department position is paid at a higher rate than most academic staff members, and applying half of the administrative load to teaching, then the allocated overhead for this position is \$29,300.

Additionally, all academic staff members participate in committees, student focus groups, publicity activities, general student supervision and course advice. Conservatively, this requires 100 hours per year per staff member. The cost of this is \$4330 per staff member at the \$43.30 rate, and \$8660 at the \$86.60 rate.

Summing, the total administrative load (personnel) is **\$407300 + \$4330 per staff member at the \$43.30 rate, and \$407300 + \$8660 per staff member at the \$86.60 rate.**

Administrative Overheads—Infrastructure

Basic infrastructure support includes a number of components: workshop consumables, workshop depreciation, teaching consumables, basic laboratory maintenance. Workshop consumables of \$55,000 per year are charged to the Department by the central facility; half of this will be applied to teaching-related activities (this is conservative, as additional costs are charged against research grants for construction activities). Much of the workshop equipment is 'old', and so effectively depreciated to zero. Depreciation of equipment is therefore limited to the newer NC equipment. Assuming a 10 year straight-line depreciation split equally between teaching and research activities, depreciation costs are of the order of \$50,000. General maintenance and consumables for teaching are budgeted at \$128,000. While this number would obviously change if student numbers were to increase, it will be assumed here to be constant. Therefore, basic infrastructure overhead is conservatively set at **\$205,500**.

Total infrastructure costs are therefore \$612,800 + \$4330 per staff member at \$43.30 per hour, and \$612,800 + \$8660 per staff member at \$86.60 per hour.

Scott Snyder is a Senior Lecturer in the Department of Mechanical Engineering, lecturing on control systems. He performs a number of additional administrative roles: Deputy Head of Department, coordinator for the Mechatronics program, Associate Dean in the Faculty of Engineering, Computer and Mathematical Sciences, and Project Manager for a new School of Petroleum Engineering. Dr Snyder is also halfway through an MBA, something that was unexpected several years ago.