Int. J. Engng Ed. Vol. 18, No. 4, pp. 472–478, 2002
Printed in Great Britain.

0949-149X/91 $3.00+0.00

Management and Assessment of Final Year Projects in Engineering*

JEFF JAWITZ
Faculty of Engineering and the Built Environment, University of Cape Town, Private Bag Rondebosch, 7701 Cape Town, South Africa. E-mail: jjawitz@eng.uct.ac.za

SUELLEN SHAY and ROB MOORE
Centre for Higher Education Development, University of Cape Town, South Africa.

The authors report on the first phase of a major study into the management and assessment of final year projects in engineering in the Faculty of Engineering and the Built Environment at the University of Cape Town. The results of a survey of assessment practice in final year projects across five departments are presented. The survey revealed a range of approaches and attitudes to the design, management and assessment of the final year projecst and the use of a variety of assessment methods. The authors make some preliminary comments on the implications of the lack of consensus in assessment practice on the key issues of the validity of the assessment system as well as the student perceptions of fairness.

INTRODUCTION

IT HAS BEEN standard practice for many years for engineering programmes in the Faculty of Engineering and the Built Environment at the University of Cape Town (UCT) to incorporate at least one major assessment exercise in the final (fourth) year of study in the form of a project. This final year project is viewed as the culminating learning experience of the engineering programme and the quality of student output is often used as an indicator of the quality of the programme as a whole.

This paper reports on the first phase of a research project to develop a systematic approach to the review and improvement of practice with respect to these projects. The study is divided into three phases:

- **Phase 1:** Survey the management and assessment practice of final-year projects in the departments of chemical, civil, electrical, mechanical and materials engineering at UCT;
- **Phase 2:** Develop a model to assist departments to address issues of validity in the design of their assessment system for the final year project;
- **Phase 3:** Study and evaluate the implementation of the assessment management model in two departments.

The development of the model and the evaluation of its implementation will be completed by the end of 2002 and will be reported on in future publications.

QUALITY ASSURANCE

In a recent national shift to outcomes-based education, the South African Qualification Authority (SAQA) Act of 1995 requires the establishment of a comprehensive quality assurance system at every educational institution in the country. As part of this new system institutions and programmes must demonstrate that their graduates have achieved a set of learning outcomes established in each discipline area by an appropriate accreditation agency.

In the case of a professional qualification, quality assurance procedures have traditionally been monitored by a professional body such as the Engineering Council of South Africa (ECSA) which, since 1980, has conducted accreditation visits to institutions offering engineering programmes every five years. ECSA recently adopted an outcomes-based accreditation process in line with several international engineering accreditation agencies in a move to standardise procedures across national boundaries. Having established a set of learning outcomes for engineering programmes (see Appendix) ECSA has shifted the focus of the accreditation process from an examination of content to the development and assessment of these outcomes [1]. This change is reflected by the key question that programmes are expected to answer as part of the accreditation process, namely [2]:

> *Does the assessment within the programme verify that every student satisfies the outcomes specified in PE-61 section 2?*

The importance being placed on student performance as an indicator of institutional provision places an unprecedented spotlight on assessment

* Accepted 17 February 2002.

and draws attention to the importance and significance of the final year project in engineering.

RELATED STUDIES

One of the earliest reported studies on the difficulties associated with the assessment of final year projects in engineering emphasised the importance of having well defined projects, good communication with students as to what is expected, and clear guidelines for assessment by staff [3]. Studies into the assessment of undergraduate projects in electrical engineering departments across 60 institutions in the UK [4] and at two universities in West Africa [5], found a wide variation in practice [4].

> Difficulties of assessment arise because of the wide range of topics studied, the extent of resources which can be made available to any individual student and, perhaps more importantly, the variation in the abilities, enthusiasm, motivation and powers of assessment of the relatively large number of academic staff involved as supervisors.

Divergent approaches adopted by academic staff assessing the same task have been frequently reported in studies of assessment practice in general [6, 7]. Two recent studies in the UK into the assessment of undergraduate theses, one surveying seven departments in Social Science and Law [8], and another investigating practice in a business school [9], revealed considerable ambiguity in the use, meaning and application of assessment criteria. Both studies found that academic staff was using subjective criteria that were not being made explicit. Academic staff who tried to use the published criteria in marking were found to not necessarily use all of them and often included criteria of their own [8].

> The analysis suggests that judgements are sometimes related to and influenced by the orientation of the assessor towards wider value systems. Thus some markers would have wanted dissertations to address empirical issues while others would like to see more theory.

A recent study by Hand and Clewes found that guidelines produced to assist academic staff were not valued or used consistently [9]:

> It seems wrong that students worked towards common guidelines for producing the dissertation yet staff appeared to have freedom to choose their own guidelines. . . Faced with the challenging, qualitative, and significant task of marking a dissertation [tutors] are bringing a great deal of *themselves* to the task . . . Just how tutors come to understand their own beliefs about criteria is an intriguing question for reflection emerging from our study.

It is clear from the literature that the variation in assessment of final year projects within departments and institutions raises the questions of how one manages such projects to ensure a valid assessment system.

METHOD

In the first phase of this study we examined course documentation and interviewed at least one final-year project co-ordinator in each of the five engineering programmes in the faculty. Additional data was drawn from in-depth interviews with staff in one department by one of the authors. The course documentation examined included course handouts, marksheets, support material for students (e.g. guidelines to writing the thesis) and the list of project topics. Particular attention was paid to the forms of assessment used and the weighting given in the final marking procedure.

RESULTS

The five programmes differed in terms of size (Table 1). Two had large numbers of students (C and E) while one had only a handful (D). Student numbers was raised as a major limiting factor in the type and form of assessment offered by project coordinators. All academic staff in each

Table 1. Final year projects in engineering at UCT

Programme	Title of course	Course Credits#	Size of class*	Project type (ref Table 2)	Key tasks
A	Engineering Project	8	Medium	I	Thesis & poster (in pairs)
A	Engineering Design	7	Medium	II	Individual report, group oral
B	Thesis	9	Medium	I	Individual thesis & poster
B	Design Project	6	Medium	II	Individual report, presentation, group report
C	Thesis Project	12	Large	I/II/III	Individual thesis
D	Laboratory Project	10	Small	I	Individual thesis
D	Design Project	3	Small	II	Group report
E	Individual Research Project	10	Large	I/III	Individual thesis, poster and hardware
E	Design	3	Large	II	Group report & presentation

Notes:
* class size: Small < 20; Medium from 20 to 60; Large > 60

Table 2. Project types

Objective	Examples
I. Assessment of research skills	Experimentation, literature review
II. Assessment of professional skills	Design project
III. Assessment of specific skills—	Software simulation, construction and testing of prototype, reverse engineering

programme were required to be involved in supervising and marking with staff: student ratios ranging from 1:4 to 1:16.

The organisational culture in some departments was relatively formal with regular staff meetings and clear guidelines issued on most aspects of academic life (A and B) while in others, such as programme C, there was minimal evidence of departmental guidelines and each staff member was left to develop their own ways of working with very little organised support or discussion.

Project definitions and learning outcomes

The documentation from the small and medium programmes included relatively clear definitions around the type of projects set in the final year. Three different project types were identified namely those that focused on research skills, professional skills and discipline-specific skills such as hardware design or programming (Table 2).

Most of the programmes surveyed had students do two separate projects in final year, usually a thesis, which focused on assessing research skills, and a design project to assess professional 'readiness' (see Tables 1 and 2).

In general project definitions in these programmes made explicit links with the overall programme outcomes. For example:

- '. . .to evaluate how well you can apply much of the knowledge gained during your university career in solving a real life engineering problem.' (E—Individual Research Project)
- '. . .to demonstrate the ability to independently design and conduct a research project and to effectively communicate the research process and results in a professional, written form.' (B—Design Project).

In contrast, in programme C students only did one final year project with topics varying across all three types. Interviews with staff in programme C, a discipline with several distinct sub-disciplines, revealed a variety of views about the nature of the final year project and what it should be assessing. Different specializations within the department favoured different kinds of projects, some with a significant design component and others with no design requirement at all. While all projects were linked in some way to a supervisor's particular research interest, some supervisors intentionally used the project to identify future postgraduate students for their research groups. Other supervisors had defined projects in close consultation with industry. These projects thus had as objectives (often unstated) the professional apprenticing of students to a particular industrial working or research environment. It is clear that these different project definitions have inevitably resulted in the application of different (often implicit) assessment criteria. In the interviews some staff raised concerns as to the fairness of this situation.

Assessment tasks

A wide range of assessment tasks was evident across the projects. At the one extreme, such as in the case of programme C's thesis project and programme E's individual research project, students were assessed on the basis of a final written report only (Table 3). In contrast, in programmes A, B and D, students were assessed both summatively and formatively using a range of methods throughout the project (Table 3).

Only programme C did not include a group work component as part of final year project. Where group work was included, assessment appeared to focus on the product rather than on

Table 3. Weighting of assessment items in final year engineering projects

			Assessment item								
Programme—Title	Class size	Students work	Prop-osal	Literat. Review	Work plan & method	Super's mark	Draft report	Seminar	Oral	Poster	Report
A—Engineering Project	Med	in pairs	5%			5%		5%	10%	10%	65%
A—Engineering Design	Med	indiv									65%
		group							5%		30%
B—Thesis	Med	alone		10%	30%		10%			10%	40%
B—Design Project	Med	indiv							25%		25%
		group							25%		25%
C—Thesis Project	Large	indiv							DP	DP	100%
D—Laboratory Project	Small	indiv				10%		10%	10%		70%
D—Design Project	Small	group									100%
E—Individual Research Project	Large	indiv							DP	DP	100%
E—Design Project	Large	group							15%		85%

Note: DP—required but not included in summative assessment the process and a variety of mechanisms were evident for allocating marks to individuals based on the group work product. Nowhere did we find evidence that any of the programmes attempted to assess student ability to work in groups, as explicitly required by the new ECSA engineering graduate outcomes (Appendix A).

In programmes C and E, while both an oral presentation and poster were required as well as a written project report, only the written project contributed to the final mark.

Assessment criteria

In most cases marking schedules were found to exist but it was unclear whether they were used in any consistent way. These marking schedules consisted of a grid specifying the different areas that marks need to be allocated to e.g. literature review, practical work, results and conclusions, etc. Interviews with project coordinators and staff revealed that some staff felt at liberty to decide whether or not to use the marking schedule. We found a range of oral presentation mark schedules which prioritised different criteria and there was no clarity on how or whether these were used.

While staff in programme C perceived themselves as sharing a broad common understanding of what a 'good' thesis was, evidence from interviews suggested that this understanding was not as 'common' as it was thought to be. In 2000, over a third of the projects had more than a 10% discrepancy between the first and second markers.

A number of reasons were given for this discrepancy. While both the first marker, which in the case of programme C was the supervisor, and the second marker mark the same written project, they have access to different contextual information about the project. The supervisor knows the student, has watched the student's progress, knows the project and so on, whereas the second marker may have little information other than the written project itself. Some assessors felt strongly that only the written product should be assessed while others felt that the related contextual information inevitably influenced the final assessment.

The interviews also revealed that the lack of a clear assessment criteria or guidelines was felt most acutely by new staff, both those new to academe as well as those coming from other tertiary institutions or industry, as they had to adjust to a new set of social practices. None of the departments surveyed had any explicit way of helping new staff learn how to assess these projects. The expectation in most of the departments was that new staff would simply 'learn by doing', as everyone else had done. One junior member of staff related to the authors how the trial and error method had resulted in him feeling uncomfortable when his marks were found to be 'out of line' with more senior staff. He had found no help in his repeated requests to senior staff members to advise him on how to assess the final year project.

Student support and formative assessment

Another issue that was dealt with differently across the programmes was the level of support given to students during the final year project. This included being given clear details of what the end product should look like, information on how to tackle unfamiliar tasks or help with writing the report.

In programmes A and D students were given detailed notes on how to write the final report, what a poster should look like, or how to go about ordering the materials required or finding the equipment needed for particular experiments. In the remaining programmes students were left to fend for themselves and expected to draw on their experiences and resources obtained from other courses. In some departments students had received a handbook on how to write a thesis as part of a Professional Communications course taught earlier. However there was conflicting evidence on whether the formats used in this handbook were in line with what was expected by staff.

Some programmes incorporated formative assessment elements. For example, students were encouraged to hand in drafts of their work to their supervisors and were given feedback on discipline-related as well as language and communication issues. In most cases the levels of support were left to the discretion of the supervisor. In programme B however, students were required to hand in a draft of their thesis. It was marked and formed part of the assessment plan (Table 3).

In the case of the Individual Research Project in programme E the submission of a draft thesis to the supervisor was explicitly discouraged as the entire final year project was regarded as examinable. This view was shared by some staff in programme C who argued strongly that the thesis was to be treated as an examination script and therefore drafts should not be reviewed by staff. However as there was no official departmental position on the matter some staff accepted drafts and gave extensive feedback, whilst others refused to do so. This variation in practice across and within programmes raises a potential serious problem of fairness from the students' perspective.

Moderation

All programmes used some form of moderation by an external examiner from another institution. Moderation refers to the re-marking of a sample or all products by another examiner to strengthen reliability of marks awarded, both to individuals, and across cohorts. While practices varied significantly two main systems were evident:

- the supervisor marks the projects and refers to an external examiner;
- the supervisor and one other internal staff member mark the projects independently and these marks are forwarded to an external examiner.

Where marks differed, an arithmetic mean was often used. Programme C took this system a bit further. Where the difference between first and second marker was greater than 10%, the thesis was marked by a third internal marker. The three markers then met and tried to reach agreement on a suggested mark before submitting to an external marker.

In the case of the smallest programme, D, all staff assessed and allocated a mark for each project report before it went to the external examiner.

Staff on all programmes appeared to be happy with their current system of external moderation although the issue of who had the final say in the event of a disagreement was not fully resolved in some cases.

Evaluation

Only one programme had a formal system of evaluating the final year project using student evaluations. Feedback on the final year projects from the external examiners, annually, and ECSA, every five years, appeared to be the major source of confidence for programmes in the quality of the final year project and by implication of their graduates. The ECSA accreditation teams have in the past paid particular attention to the final year project as an indicator of the quality of the programme.

DISCUSSION

Final year projects are complex performance-based assessment events which have a major influence on decisions about a student's readiness to graduate and on the perceptions of the quality of the engineering programme offered by departments.

While most departments appear to have met the formal requirements for a reliable assessment system, i.e. external examiners, the study revealed large variation in managing and assessing final year engineering projects within the same faculty. The variation found in the actual practice of assessment is consistent with that found in similar studies elsewhere in higher education [4–9].

No general consensus was found as to what constituted a legitimate assessment task and whether or not it was acceptable to provide formative assessment at this level, for example in the form of feedback on draft reports. Much of the variation at this level would appear to result from a lack of general discussion and agreement within the faculty on issues of educational task design and assessment. In almost all cases staff in one programme in the faculty were unaware of what decisions their colleagues in the other programmes had made around many of the key aspects of the organization of the final year projects.

At the time of the survey, departments were in the early stages of re-thinking their course and programme design along outcomes-based lines. Only in a few cases was a clear relationship found between the stated objectives of the final year project and the overall programme outcomes. Given the need to link assessment criteria directly to course objectives for sound educational design, the lack of clear objectives in some of the projects raises questions regarding the nature of the criteria used for assessment.

Furthermore the lack of explicit marking criteria raises concerns around the issues of inter-marker reliability i.e. the degree to which different markers agree in their assessment of the same product. This, together with the variation in the practice of giving feedback to students in the draft stage, could potentially give rise to perceptions of unfairness from the students' point of view.

In most cases there was an overall sense of confidence in the existing practice around the final year project which probably explains the lack of attention being paid to evaluate the process on an annual basis as is done with all other courses.

CONCLUSION

Reliable and valid assessment practices are central to the integrity of the qualifications offered at a university, and are thus a legitimate focus for quality assurance procedures. Engineering programmes in South Africa face the challenge of developing curriculum design and assessment practices that satisfy requirements of the outcomes-based procedures that make up the new accreditation process. This will require that a programme's assessment system, in particular the various assessment events in final year, cover the range of performances specified in ECSA's engineering graduate outcomes.

Of these assessment events, the final year project will always be central, requiring (as it should) students to demonstrate the more complex of the learning outcomes. However, this study has revealed a great unevenness in approach to the design and assessment of final year projects at one institution.

Two key issues are raised by our findings. Firstly, the educational purposes of the final-year project need to be more clearly defined—as much for staff as for students. An outcomes based approach to curriculum design requires a systematic alignment between outcomes, assessment practices, and the learning opportunities provided by the curriculum. Our study shows that the balance between formative and summative purposes is differently weighted across contexts, raising questions about educational design. For example if a project is conceptualised entirely as an examination (as in one case reported above), and students may thus not approach staff for support, then when in the curriculum do these students have the opportunity to develop these skills with guidance from staff? Although it is appropriate for different programmes to have differing approaches to developing competence in students, there nevertheless needs to be roughly equitable levels of cognitive demand made of students on the one hand, and of educational support provided by the programme on the other.

Secondly, the large number of staff involved in supervising and assessing projects within a single programme highlights the need for agreement on project objectives, assessment criteria and how these are used to assess students' products. The procedures for achieving such consensus (e.g. regular workshops to design assessment tasks, and to train and coordinate marking) are essential to ensuring the fairness, validity and reliability of assessment, and are amongst baseline standards of professional conduct for academics. We may increasingly be held publicly accountable for the assessment decisions we make, given the high stakes attached to the attainment of tertiary qualifications.

One of the implications of these recommendations is a need for consistent forms of educational management within, and across, programmes in a faculty—a potentially vexed issue in contexts where autonomy is prized. But as we have illustrated above, such collegial management is essential if we are to ensure fairness and defensible standards of academic professionalism in our educational programmes. This would require some careful and extensive discussion across programmes in the faculty about educational goals, curriculum and assessment. Agreement is unlikely to be easily achieved, but the ongoing debates will provide an important platform for professional development.

REFERENCES

1. ECSA, *Standards for Accredited University Engineering Bachelors Degrees*, Document PE-6, Rev 1, Engineering Council of South Africa, 20 July 2000.
2. ECSA, *Documentation Requirements for Accreditation visits to Universities*, Document PE-73, Rev 0, 21, Engineering Council of South Africa, August 2000.
3. J. Black, Allocation and assessment of project work in the final year of the engineering degree course at the University of Bath, *Assessment in Higher Education*, **1**(1), September 1975, pp. 35–54.
4. J. Allison, and F. A. Benson, Undergraduate projects and their assessment, *IEE Proc. A*, **130**(8), 1983, The Institution of Electrical Engineers, UK, pp. 402–419.
5. E. Jackson, The importance and assessment of final year projects: Case studies from Africa, *Assessment and Evaluation in Higher Education*, **12**(2), 1987, pp. 83–93.
6. D. Tribe and A. Tribe, Assessing law students: lecturers' attitudes and practices, *Assessment and Evaluation in Higher Education*, **13**(3), 1988, pp. 83–93.
7. M. Yorke, P. Bridges, and H. Woolf, Mark distributions and marking practices in UK higher education, *Active Learning in Higher Education*, **1**(1) 2000, pp. 7–27.
8. F. Webster, D. Pepper, and A. Jenkins, Assessing the undergraduate dissertation, *Assessment and Evaluation in Higher Education*, **25**(1), 2000, pp. 71–80.
9. L. Hand, and D. Clewes, Marking the difference: an investigation of the criteria used for assessing undergraduate dissertations in a business school, *Assessment and Evaluation in Higher Education*, **25**(1), 2000, pp. 5–21.

Jeff Jawitz is the Educational Development Officer in the Faculty of Engineering and the Built Environment at UCT. He is responsible for co-ordinating academic development in the Faculty with specific responsibilities in the department of Electrical Engineering. His current research interests include assessment of learning, curriculum development and women in engineering.

Suellen Shay is joint co-ordinator of the Assessment and Evaluation Project in UCT's Centre for Higher Education Development and is programme convenor for the Higher Education Studies Programme. She is currently researching assessment practice in the higher education context.

Rob Moore is joint co-ordinator of the Assessment and Evaluation Project in UCT's Centre for Higher Education Development. His interests are in curriculum, assessment and evaluation, and he is currently researching the implementation of curriculum restructuring policy in South Africa.

APPENDIX

ECSA standards for accredited university engineering bachelors degrees (pe 61)
A B.Sc.(Eng.) graduate is competent to:

1. Identify, assess, formulate and solve convergent and divergent engineering problems creatively and innovatively.

2. Apply knowledge of mathematics, basic sciences and engineering sciences from first principles to solve engineering problems.
3. Perform creative, procedural and non-procedural design and synthesis of components, systems, works, products or processes.
4. Apply research methods, plan and conduct investigations and experiments using appropriate equipment and analyse, interpret and derive information from data.
5. Use appropriate engineering methods, skills and tools and assess the results they yield
6. Communicate effectively, both orally and in writing, with engineering audiences and the community a large, using appropriate structure, style and graphical support.
7. And is critically aware of the impact of engineering activity on society and the environment, and the need to bring into the analysis and design considerations of the impact of technology on society and the personal, social, cultural values and requirements of those affected by engineering activity
8. Work effectively as an individual, in teams and in multidisciplinary environments showing leadership and performing critical functions.
9. Engage in lifelong learning through well developed learning skills.
10. Exercise judgement commensurate with knowledge and experience and critically aware of the need to act professionally and ethically and to take responsibility within own limits of competence.