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Is There an Alternative to Exams?—Examination Stress in Engineering Courses*

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Examination stress is probably a factor in the poorer than expected performance of some engineering students. This paper presents some evidence of this connection from a specific third level electronics course together with descriptions of several strategies adopted to alleviate it and resulting changes in performance. The literature on examination stress and the effectiveness of strategies to alleviate it is then reviewed in the light of the above experiences, leading to the conclusion that it is likely that examination stress is a significant factor in the academic performance of some engineering students, and possibly more so for those from Asian backgrounds. Further the literature suggests that the following actions have potential value for alleviating the poorer academic results flowing from examination stress: 1) employing good teaching and well structured materials and study programs; 2) using a variety of styles of assessment with opportunity to practice those styles; 3) allowing memory support such as by allowing open-book assessments; 4) including opportunities for students to comment on the assessment experience either during the assessment or soon afterwards; 5) asking questions that are either individualized or have elements of choice about answers; and 6) relaxing the time pressure on assessment activities.

Keywords: examinations; examination stress; test anxiety; assessment; engineering courses

INTRODUCTION

ENGINEERING EXAMINERS frequently use examinations to assess students because they know of no other way to ensure that the students have sufficient knowledge and understanding to pass an exam without the risk that others have helped them excessively. However all examiners also know that examinations also cause serious stress to at least some proportion of students, probably to the extent that their performance is severely affected. Some degree of stress is however a normal part of the incentive to perform well, and is thus a good thing [1], but excess stress can be debilitating. For example, we as examiners have probably all spoken to students who complained after an examination that their work was poor because their mind went blank.

The author has had experience over recent years of teaching a third year electronics course called Electronic Measurement to large groups of students both on- and off-campus, involving both school leavers and mature students. During this experience, there has been an on-going perception that examination stress has been a problem for a small but significant proportion of the students. Further suspicions have been that such stress is more common among South-East Asian students and probably less common among the mature students who make up a large proportion of the external Australian contingent. There is also some anecdotal evidence that examination stress is higher in lower ability students who now make up a larger proportion of students than previously.

There is of course some argument that students who are inadequately prepared for the examination because of insufficient effort are more likely to suffer from such stress and should therefore not be given too much sympathy. This attitude appears to have been the dominant one among examiners for many years and still persists [1], but it seems from the literature that even this phenomenon of inadequate preparation can be attributed, at least partly, to examination stress. The current consensus also seems to be that it is the stress that causes the poor performance and not the other way around (see for example [2]). The current literature clearly shows that stress causes lower academic performance [3–7].

Quite apart from the severe stress described above, it is likely that the milder stress experienced by the majority of students, and in particular the stress caused by the fact that examinations are held at a specific time and over a quite short period, also causes some bias in performance. Logically it would seem that examinations like those described above cannot give good measures of student knowledge, let alone their ability. It seems therefore desirable to eliminate examinations altogether if

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it were possible to do so without jeopardizing the quality of graduates.

These perceptions have resulted in the motivation to develop less stressful ways of assessment. This paper describes teaching strategies in Electronic Measurement and how they have related to student performance. It then examines whether there is any evidence in the literature to support perceptions about examination stress, to critique the strategies already tried and to investigate what additional strategies if any may be used to alleviate it.

EXPERIENCE WITH EXAMINATION STRESS

Symptoms of stress

Anecdotal evidence of examination stress is plentiful in the author's experience, some instances being:

- Students explaining that during the examination, their mind went blank.
- Answer papers containing only very short responses to questions, the details of which peters out after a few lines.
- Otherwise quite high-performing students who seek out the examiner after a result is announced to explain, presumably for the sake of their own self esteem, that they suffered lack of concentration during the examination.
- Some students who contact the examiner frequently just prior to the examination with long lists of small questions to which they seek 'answers' or reassurance that they have it right.
- Students who request a deferred examination just prior to the examination by visiting a doctor complaining of stress or simply of feeling unwell.
- Students who are perfectionist by nature and who under stress in an examination waste time trying to write perfect answers.
- Students who openly state that they suffer from examination stress and find that reproduction of text from memory is the best way to ensure they at least write something 'correct' in the examination.

The literature on the subject extends this list of symptoms by adding the following:

- not turning up to exams [8];
- thinking about other things, staring into space, worrying [8], [9];
- working fast but inaccurately [8];
- working slowly and cautiously but accurately [8];
- procrastination about assignments and study generally [10]; and
- feelings of helplessness and depression often based on previous failures [3].

Strategies to alleviate stress

In response to all of the above issues, the author has tried several assessment strategies with mixed success. Briefly these have been:

- issuing assignments with more individualized tasks and giving more weight to those assignments compared with the final assessment;
- giving practice questions in early assignments of the types to be found in the final assessment;
- asking students to write reflections on their experiences during study and to articulate their attitude to their performance;
- giving the students ideas about how to prepare and how to go about answering examination questions; or example, answer the easy questions first or the easy parts of each question first and so build up confidence;
- writing examination questions in several parts with easier parts at the beginning to again build up confidence;
- giving choice of which questions to answer;
- individualising examination questions and writing them in such a way as to minimize the chance that answers can be simply found in other sources;
- speaking reassuringly when personally supervising an examination; and
- allowing plenty of time for answers.

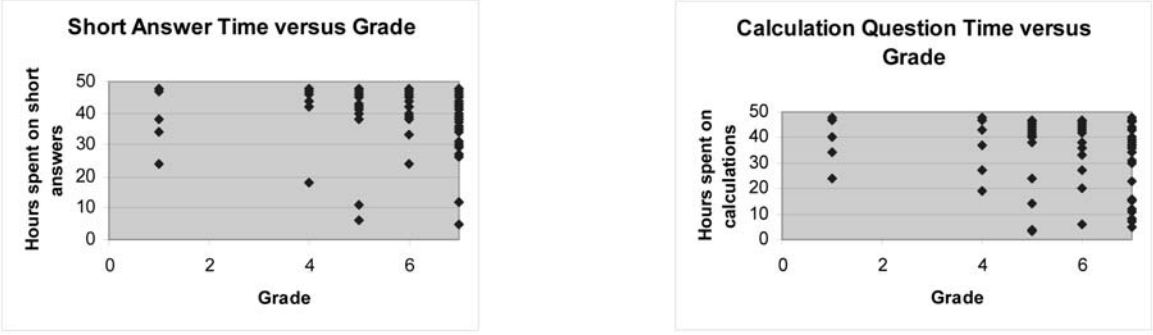
'Allowing plenty of time for answers' was achieved by giving an assignment comprising many short-answer questions and many short-calculation questions delivered via the internet and allowing 48 hours to provide the answers. Students could also choose the time of occurrence of this task within a time frame of about a week. It was estimated by the examiner that about 6–8 hours of work would have been more than adequate time to answer the questions. These were predominantly external students, who had all the expected pressures of time due to work, family, etc. and so many chose to take their 48 hours over a weekend. The lengths of times which the students chose to take before submitting their answers are given in Fig 1(a) and (b) for short answer and calculation questions respectively, plotted against the grade finally achieved by that student.

From Fig. 1 it can be seen that most students did not submit their answers until they had taken 30 or more hours to write and check their answers. However a significant percentage submitted in less than 20 hours and was still able to score good grades.

Results of changed strategies

Figure 2 shows the pass rates in the course of interest over the period 1999–2005. Many factors were at play in these results, notably a large and continuing proportion of international students starting in 2001 and resulting in a dramatic fall in pass rates. Figure 3 shows the pass rates for students from Australia, Malaysia, Singapore and other Asia-Pacific nations separately over the same period.

From the data in Figs 2 and 3 it seems that the strategies adopted have made an improvement to the pass rates as they were progressively adopted.



(a) (b)

Fig. 1 Time taken by students to answer short-answer test questions (a) and calculation questions (b) respectively versus grade finally achieved (with 48 hours being the maximum available).

Of interest is the fact that they have made little difference to Australian students but major differences to all others and it may be that part of this difference was the examination stress suffered by Asian students and the lower level of stress experienced by mature Australian students as mentioned above.

It has not however been possible to determine definitely whether and to what extent these strategies have achieved anything useful for students suffering examination stress, nor would it be possible to reach definitive conclusions without rigorous analysis because there are so many variables. Such an analysis has not therefore been attempted. Instead, the rest of this paper will examine the literature in the light of the above experiences, seeking evidence to support the strategies, to add to the range of strategies or to suggest that specific strategies are not useful.

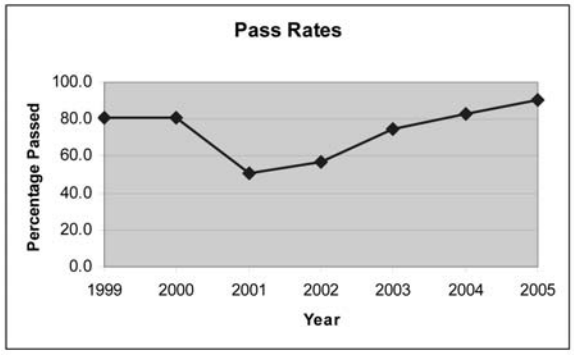


Fig. 2. Pass rates in the Electronic Measurement course over time.

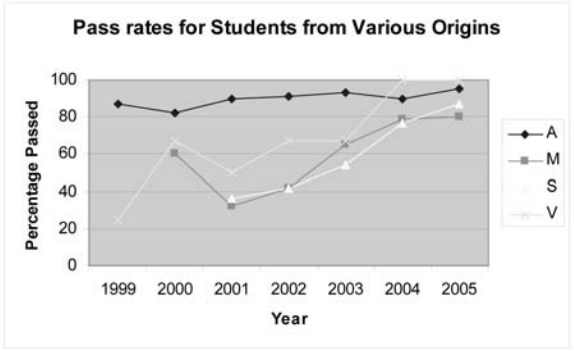


Fig. 3. Pass rates over time for students from Australia (A), Malaysia (M), Singapore (S) and other Asia-Pacific nations (V).

THE SIGNIFICANCE OF STRESS IN TERTIARY STUDENTS

As outlined above, there is significant evidence that examination stress does in fact cause poor performance. The main source of stress in educational assessment is the fear of failure and the consequent loss of self-esteem [11], [12]. Stress impairs performance in a wide range of cognitive functions such as 'attention, memory, concept formation and problem-solving . . . less thorough acquisition of the information to be examined, a lack of basic domain-specific skills, interference in the retrieval of prior learning, difficulty using or transferring knowledge, difficulty demonstrating knowledge on tests, being self-conscious in performance settings' [11].

There are in fact several psychological test scales that specifically measure various aspects of examination stress, such as the Test Anxiety Inventory and the Revised Test Anxiety Scale [11]. Indeed fear of failure is explicit in some psychology inventories used to assess students learning styles. Entwistle's 1983 Approaches to Study Inventory (ASI) includes it as a component of the reproducing orientation study strategy where rote-learning is common and there is extrinsic motivation and fear of failure. Fear of failure is also explicit in the more recent (1991) Motivated Strategies for Learning Questionnaire (MSLQ) [1].

Interestingly for those who teach mature engineering students, Entwistle and McClune [1] also suggest that there may be room in their test anxiety inventories for a scale measuring 'vocational and concrete' factors for students in professional programs. There is a hint here that those mature

Table 1. Grade point averages of the 5% of students with the lowest test anxious scores and the 5% of students with the highest test anxious scores (from [15])

	GPA (0 to 5 scale)	
	Lowest 5% test anxiety	Highest 5% test anxiety
Female	3.40	3.08
Male	3.31	2.93

students studying to achieve progression in well-established careers in engineering bring another dimension of motivation and practicality to their study and maybe also suffer less from examination stress as observed above.

Examination stress (a term used essentially interchangeably with test anxiety in this paper) is thus common and has an impact on the academic performance of those affected either through their learning or their assessment performance. Estimates are that of the order of 20% of tertiary students are significantly affected. Zeidner [13] and Chapell *et al*. [15] cite studies that showed that 61% of high test anxious students (across all levels of education) would fail compared with only 39% for the low test anxious students. Indeed, many researchers in other areas have used exam stress as a conveniently-available test situation for studies of the impact of stress as medically conceived, without explicitly considering its impact on the academic performance of students.

The degree of significance is however less than clear. Zeidner [13] suggests that the impact is major but a recent study by Chapell *et al*. [15] with a large number of North American undergraduates, (70% of whom were of European ancestry), gave the results shown in Table 1. These figures suggest that the difference between performance of low and high test anxious students is less than a grade point average overall. The data also show that females perform marginally better than males at both ends of the anxiety range.

THE MECHANISMS OF EXAMINATION STRESS

There are many different reasons for students experiencing examination stress that, according to Zeidner [13], include the following, where the overlap with the symptoms described above will be apparent:

- those with poor study skills (poor organization and retrieval skills for example) who know they are not prepared;
- those who experience blockage and retrieval problems during exams;
- those who have become accustomed to failure because of their personal history (which may of course be because they have low ability);
- those whose primary concern is to avoid failure and thus avoid being seen to be failures either in their own eyes or in the eyes of others;
- those who deliberately indulge in examination stress as an excuse for failure—so they can blame examination stress rather that their ability or lack of hard work for their failure; and
- those who want to do very well—perfectionists—and whose anxiety comes from worrying that they will not do as well as they would like.

VARIATIONS OF STRESS AMONG DIFFERENT GROUPS OF STUDENTS

Students with personal problems

Studies have found that there is no correlation between academic performance and psychosocial adjustment of *young* tertiary students. That is, poor performance is not biased towards those with personal problems in handling university life or those lacking social support [12]. It seems to be recognized that there are many different specific forms of anxiety among the general population and that, for example, a student can suffer from a quite specific form (such as maths anxiety) without suffering from others. That is, it should not be assumed that only those who appear to be generally an anxious type of person will suffer from examination stress.

Low achieving students

Low achievers are particularly likely to suffer from examination stress [11].

Social class

Among school students there seems to be a small bias towards more test anxiety among students from lower socio-economic groups—presumed to be due to the different socialization and training they have received as regards study and related matters[13].

Gender

The evidence here is somewhat mixed with Halamandaris and Power [12] on one hand claiming that there is no evidence that this stress factor varies with gender but Zeidner [13] suggesting a small difference in the level of test anxiety between women and men due probably to socialization differences rather than to inherent behavior. Chapell *et al*. [15] cite other studies showing that females have a greater tendency to suffer from examination stress but achieve higher grades (as shown in Table 1). There also seems to be a difference in the response of the genders to time pressure as described below.

Cultural background

There is no evidence that this stress factor varies with culture [12]. Research has found only small variations in test anxiety among students from different areas with the highest being those from

Islamic countries, relatively high in those from South America and Eastern Europe relative to Asia, Western Europe and North America [13].

Ethnic group

Based on groups in USA, there is no difference between anxiety in university students of European and African ancestry, whereas there is a difference between those of European and Asian background with Asian culture students being more anxious, due presumably to the family pressure to succeed [13]. This detail seems to confirm the suspicion that Malaysian students in the course taught by the author do suffer more from examination stress than do the Australian students.

Age

This factor is of interest to the author because of the high proportion of mature students in the student population taught and the fact that the predominantly older Australian students reported above did not seem to suffer the same problems as other students. Chapell *et al*. [15] collected data on age together with their study of test anxiety but their brief reported data seem to suggest very little correlation between age and either test anxiety or grade point average.

METHODS OF ALLEVIATING STRESS

Strategies to alleviate examination stress suggested in the literature are many, with the research on the effectiveness of each being patchy.

Treating the student

Most earlier efforts were simply to help students cope with their stress, but there is some evidence that susceptibility to test anxiety is a personality characteristic that is fairly inherent and resistant to change. Hence current thinking seems to be that it is better to look at providing help to cope with the detailed situations of stress rather than try to change the students' reactions to stress [6].

Some students suffer examination stress but persuade themselves continue as if nothing had happened. This personal psychological tool seems to help them [12] but little practical advice is given in the literature about how such an attribute might be cultivated by those who suffer such stress.

There are some claims that medical treatment including alternative medicines can help but Jorm *et al*. [16] review the literature on alleviating examination stress from a medical point of view and conclude that the only individual treatments with some evidence of effectiveness for examination stress are movement therapy and relaxation therapy. Powell [17] claims that progressive muscle relaxation helped medical students to pass a licensing examination after failing it initially, and Hembre [6] also suggests this approach.

Cognitive techniques that, for example, teach students to recognize certain aspects of their own behavior and exercise some self control are also claimed by some such as Hembree [7], Tuncay [18], and Powell [17] to be successful. There is however the need here to understand properly the difficulties being experienced by each individual student and tailor activities to suit. Group counseling to help cope with examination stress is not effective for this reason.

Training to make a study plan, manage time and effectively use study materials can give moderate improvements in performance [3]. Gulek [19] recommends training in time management skills and Tuncay [18] suggests that the treatment of test anxiety using skill-focused approaches has been quite successful in reducing the test anxiety level of school level students.

Preparation for assessment

- Good teaching. Onwuegbuzie and Wilson [10] (in the context of statistics anxiety) recommend performance assessments that involve evaluating what students can do as well as what they know—a relatively un-contentious idea in engineering, even though perhaps not always practised. They should therefore be meaningful and interesting and relevant to what the student perceives will be their professional role, or even just to everyday life. Practical elements of such performance assessment should include selecting assessment tasks that:
  - are clearly connected to what has been taught;
  - have clear scoring criteria;
  - are backed up by clear models of what is expected;
  - encourage students to undertake self assessment of their work; and
  - interpret students' performances relative to those of other students as well as to the course objectives and standards
- Generally increasing students' motivation is another way to help overcome test anxiety, although the literature does not seem to address the question of the extent to which this helps all students as opposed to test anxious students. Suggestions to this end but without specific evidence for tertiary students include [19]:
  - making connections between the content and the personal experiences of students;
  - making content interesting; and
  - providing useful and complimentary feedback

Examination contexts

- Providing supervisor support. Students report less stress when supervisors of exams are congenial and respectful of those taking the exam, rather than tense and serious. There is some evidence that support from supervisors does counteract the negative reactions of highly anxious students [13].
- Use of humor in the examination. The evidence is that humor affects different people in different ways and while some students may find it relieves anxiety, others find it distracting and

increasing of anxiety. Jorm *et al.* [16] did not find any convincing evidence that humor helps with examination stress.
- Background music. There is evidence that this helps some students but probably only during preparation stages rather than while actually doing the examination [13]. Jorm *et al.* [16] reviewed the literature and concluded that more evidence was needed on this issue.

Examination formats
- Test instruments should be well organized and structured because this removes any ambiguity and uncertainty and gives high anxiety students more feelings of control and they perform better. (This may explain why engineering students often prefer well structured but autocratic classroom methods such as good lectures, to class discussions and tutorial activities). Part of good structuring is of course clearness of marks allocated and grading schemes, etc.
- Gulec [19] recommends assessment using a variety of formats to cope with the variety of student learning styles but at the same time ensuring that students have adequate opportunity to practise these formats during their preparation.
- Some formats such as multi choice rather than problem solving questions may be seen as easier, but again there is little evidence that this helps test anxious students [13].
- Computer-administered testing. In spite of the fact that claims of less anxiety-producing conditions exist here (non-competitive environment, individualization of questions, own pace and timing, immediate feedback, student control of order of answering) reviews of the research literature do not show any less anxiety compared with conventional paper examinations [13].
- Providing choice among questions. This does seem to help students and to create less anxiety but it does so for all students, not just those suffering high levels of anxiety [13].
- Put easier questions first in examinations to help students gain confidence during the examination. However there is little evidence that this really helps [13].
- Free choice questions. The most evident form of assessment would seem to be major individualized assignments that demanded significant effort and about which examiners would feel confident they could judge whether work was really the student's own rather than that of, say, a paid substitute. The individualized nature of the assessment would also avoid the issue of students collaborating excessively. There are however problems here because of the need for reliability in assessment and there is no specific evidence that they specifically benefit high anxiety students

Assessment structures
- Repeating the examination. The evidence here is that this improves the scores for all students and so does not really compensate the high anxiety group of students.
- Providing positive or negative feedback to students during the exam, which is probably only possible when using certain formats such as computer-based multi-choice questions. As expected negative feedback (Incorrect) tends to increase anxiety and positive feedback (Correct) tends to decrease anxiety, but overall the research is inconclusive in this area and results vary with other variables such as difficulty of questions [13].
- Take home examinations. These give students more control and also allow retrieval of information to be done in a leisurely non-stressful way. The evidence is that they benefit only some high anxiety students. Take home examinations allow more feelings of control but the evidence for effectiveness in helping highly anxious students is not clear.
- Providing memory support. High anxiety students suffer most in examinations that rely heavily on memory. Thus techniques that provide memory support can help these students. Example techniques are open book exams, notes, summaries, etc.
- Provide the opportunity to comment on test items. There is evidence that if students are encouraged to comment on questions (perhaps in a separate space from their answers) then they tend to do better on subsequent questions. This apparently allows emotional release and reduces emotional build up during the exam [13]. Journal writing in which students self-express about their experiences during study and assessment seems to reduce anxiety [10].
- Time pressure. The research suggests that time pressure is undoubtedly a source of stress in examinations with high anxiety students responding either by rushing or by being over cautious and slow, both producing lower quality answers. Extra time can be used to correct answers and thus reduce feelings of stress. This technique does work and allows high stress students to reach the levels of other students [13]. Hill and Eaton (cited in [8]) found that highly anxious (school) students did quite badly when placed under time pressure compared with low-anxiety students. When the time pressure was removed, these same highly anxious students performed nearly as well as low anxiety students. The conclusion was that their poor performance under pressure of time was caused by examination stress or similar factors, not to learning-cognitive problems. Onwuegbuzie (cited in [10]) found that open-book examinations that are not limited in time are reported by most students to cause the least amount of stress, to increase levels of performance, and to promote higher-order thinking. If more time were to be allowed for a mathematics type examination, the authors above found that an increase of 50% in time allocation was sufficient

to make the improvements described. In the above study, there was an interesting gender difference in the results. Under time pressure, low anxious boys and girls performed better than high and middle anxious students. When time pressure was removed however, a gender difference emerged. High and middle anxious boys performed just as well as the low anxious boys. For girls however, the removal of the time pressure did not bring the results of high, middle and low anxious students closer together, and in fact made the results of the high anxious girls even worse. No explanation for this phenomenon was offered.

Another issue on which the literature is strangely silent is that of the impact of the time of occurrence of examinations relative to a woman's menstrual cycle. Anecdotal evidence would suggest that a significant proportion of women suffer from some physical stress for some days in their cycle to the extent that it seems highly likely that they would perform less than optimally should an examination occur at that time. There is probably an argument here for flexibility in the timing of major assessments such as examinations, as was done in Electronic Measurement.

DISCUSSION AND CONCLUSIONS

There is substantial evidence that examination stress is a factor in the poor performance of many students because of both resulting poor preparation and problems during examinations, the causes of which are quite complex. This means that there is probably no simple solution to the problem. However if examiners are aware of the range of student responses and attempt to take them into account in their teaching and assessment strategies, this will at least be a step in a useful direction.

There is however some absence of research data on the impact of examination stress on mature students, who are a major component of the student cohort of interest to external engineering educators, for whom the impact of examination stress may be different from that on younger students.

Overall it seems that treatment of individual students for stress is not a realistic option except in extreme cases, but providing explicit training in study skills ought to be a normal part of engineering degree courses. More promising actions are the structural ones taken by the examiner or university and there may be some evidence in the experiences reported in this paper that certain strategies can help improve student performance. Predominantly they simply involve good teaching and well structured materials and study programs, but may also include other strategies.

Several of the strategies that have been part of the teaching strategies for Electronic Measurement over the last few years are supported by the literature, whereas several others are either not supported or require further evidence. Specifically, on the question of large assessments, the possibilities that are encouraged by the literature or judged to have potential by the author as having greatest potential for helping those suffering examination stress include:

- a variety of styles of assessment with opportunity to practice those styles;
- allowing memory support such as by allowing open-book assessments;
- including opportunities for students to comment on the assessment experience either during the assessment or soon afterwards;
- setting questions that are either individualized or have elements of choice about answers; and
- relaxing the time pressure on assessment activities.

By combining the arguments for the points above, there is some argument for moving away from traditional examinations towards un-timed and individualized assessments in order to provide more equitable assessments for those students who suffer from examination stress.

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