European Journal of Engineering Education

Taylor & Francis
Taylor & Francis Group

ISSN: 0304-3797 (Print) 1469-5898 (Online) Journal homepage: http://www.tandfonline.com/loi/ceee20

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To cite this article: Andrew L. Guzzomi, Sally A. Male & Karol Miller (2015): Students’ responses to authentic assessment designed to develop commitment to performing at their best, European Journal of Engineering Education, DOI: 10.1080/03043797.2015.1121465

To link to this article: http://dx.doi.org/10.1080/03043797.2015.1121465

Published online: 15 Dec 2015.

EUROPEAN JOURNAL OF ENGINEERING EDUCATION, 2015
http://dx.doi.org/10.1080/03043797.2015.1121465

Students' responses to authentic assessment designed to develop commitment to performing at their best

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ABSTRACT

Engineering educators should motivate and support students in developing not only technical competence but also professional competence including commitment to excellence. We developed an authentic assessment to improve students' understanding of the importance of 'perfection' in engineering – whereby 50% good enough will not be acceptable in industry. Subsequently we aimed to motivate them to practise performing at their best when they practice engineering. Students in a third-year mechanical and mechatronic engineering unit completed a team design project designed with authentic assessment features to replicate industry expectations and a novel marking scheme to encourage the pursuit of excellence. We report mixed responses from students. Students' ratings of their levels of effort on this assessment indicate that many perceived a positive influence on their effort. However, students' comments included several that were consistent with students experiencing the assessment as alienating.

ARTICLE HISTORY
Received 10 January 2014
Accepted 20 October 2015

KEYWORDS
Engineering education; authentic curricula; integrity; assessment; feedback; competency formation

1. Introduction

Since the Second World War, engineering programmes have placed increasing focus on engineering science. However, a reoccurring theme globally has been a need for engineering educators to expand curricula to help students develop 'generic' skills (Grinter 1955; Johnson 1996; Sheppard et al. 2009). These skills (or competencies) may include communication (writing, speaking, presenting, etc.), teamwork, and other 'life skills' (Martin et al. 2005).

There is growing evidence that engineering practice is sociotechnical in nature (Faulkner 2007; Trevelyan 2007). Engineering science and generic professional competencies are not sufficient for engineering practice. Engineers must be capable of working on issues/problems that are social and technical in nature, within contexts in which social and technical factors interact, and on solutions for which engineers must engage technology and people. Because social and technical competencies interact in practice they should be developed and practised together in engineering education programmes (Male 2010; Trevelyan 2014). Understandably it has been acknowledged (King 2012) that introducing evidence of the social impact of engineering in the early years of the curriculum can assist in drawing in women and minorities who more readily appreciate and connect to the value of the profession. Jackson (2013, 783) notes that to improve non-technical employability characteristics in graduates, the learning context should involve 'authentic activities', 'learning whole tasks rather than component skills in isolation', 'performance feedback', 'setting

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learning goals and objectives', and 'collaborative learning, scrutinising, and building on the learning of others'. Put simply, 'engineers need to master much beyond engineering science to advance, branch out, and be most effective during their careers' (King 2012, 1). Hence, early in the curriculum there should be elements depicting what engineering actually is, and fundamentals should be integrated with engineering practice throughout the programme (King 2012).

Reflective practice is a competency that students need in order to learn and also that engineers need in order to become successful practitioners (Schon 1983; Carew et al. 2009). Smith and Trede (2013, 640) found 'asking questions, bouncing ideas off other colleagues, seeking validation for their decisions, making sense of their experiences, and drawing on others' ideas to incorporate into their own thinking' to be effective opportunities for reflective practice.

Although feedback is recognised as essential, it has been suggested that students disregard feedback if they perceive no potential gain to be obtained by responding to that feedback (Vardi 2012). This situation is common in traditional assessment tasks where feedback is often supplied too late (e.g. after the final exam) to be integrated into the current unit. Vardi (2012, 6) describes the features of effective feedback to improve performance. Attributes of effective feedback are 'focusing on the task, being specific, and elaborating on what the student needs to improve, in a straight-forward short and succinct way'. She also notes that feedback must be embedded in a course with 'clear goals, effective instruction, and sound learning activities and assessment tasks'. Some feedback and assessment must be formative, that is, provided during, rather than at the end of, semester when students have time to take account of the feedback to improve future assessments.

In response to the above pressures, the accreditation of engineering programmes across the world has evolved. In Australia, accreditation of engineering education changed from input- to outcomes-based, with an increased focus on generic attributes, including attitudinal competencies, as a result of the Johnson (1996) review of engineering education. This is evident in the programme accreditation criteria which stipulate that graduates of accredited programmes should have, among other competencies, 'commitment to ethical and professional responsibilities' and 'an appropriate professional attitude' (Bradley 2008, 13–14). Similar shifts in accreditation of engineering education programmes have occurred in the USA and Europe, among other locations (Scales et al. 1998; ABET 2004; ENAEE 2008). Multiple studies have shown that engineers are regarded as being honest and having strong moral principles; this 'integrity' is among the attitudes required by engineers. Integrity and commitment were rated highly important in two Australian surveys of competencies (Nguyen 1998; Male, Bush, and Chapman 2011), while integrity and quality orientations were found to be important in a USA survey (Brumm, Hanneman, and Mickelson 2006). Similarly, Ramadi, Ramadi, and Nasr (2015, 14) reported a significant skills gap in 'Acting with integrity' in a study of engineering graduates' skills in the Middle East and North Africa region. In their study on engineering students' competency formation, Walther et al. (2011) coded focus group responses about critical incidents and competency formation from 67 engineering students studying in four countries: Germany, Australia, the USA, and Thailand. The students were all recent graduates or final year students who had engaged in substantial work-integrated learning. The ability to take responsibility for the consequences of their engineering work, 'professional responsibility', was identified as an important competency category (718). Oliver (2013) notes that in developing graduate attributes, particularly attitudinal competencies, academic staff engagement and evidencing achievement of graduate attributes are major challenges. The development and assessment of competencies such as integrity are especially difficult and sensitive.

A specific problem facing engineering educators is that students can develop misleading perceptions of engineering practice and competencies required by engineers, and professional or unprofessional practices (Trevelyan 2011). Walther et al. (2011) developed a model of intended and accidental competency formation that explains how this can arise as a result of students' competency development being influenced by multiple aspects within the learning environment. Formal assessment was identified as part of the learning environment that contributes to competency formation. Even aspects of the curriculum, over which educators might assume they have control, can have unintended consequences for student development. Walther et al. compare students' competency formation in an environment in the USA, where they experienced much formative assessment, with an environment in Germany where students' assessment was entirely summative, being a single examination. Students' responses to the German experience included enhanced capability to direct their learning and, at the other extreme, increased development of a habit of responding to deadlines by working hard at the last minute. These examples demonstrate that assessment design can influence students' competency development. Sambell (2012, 186–187) describes a model of 'assessment for learning' rather than assessment for measurement alone, to encourage students to engage in assessment rather than experience alienation:

> [Assessment for learning] is rich in formal feedback … ; is rich in informal feedback … ; emphasises authentic assessment tasks; offers extensive low-stakes confidence building opportunities and practice; develops students' abilities to evaluate own progress, direct own learning; uses high stakes summative assessment rigorously but sparingly.

In addition to the engineering education research trends identified above, it is important that industry's needs and recommendations be considered as part of designing engineering curriculum. At the University of Western Australia (UWA), the School of Mechanical and Chemical Engineering engages members from industry to provide input into the curriculum. The School's Industry Advisory Panel (IAP) comprises approximately 10 professionals representing companies that employ the School's graduates. An example of how feedback received from an industry-based adjunct research fellow and members of the mechanical engineering IAP was used for this purpose is given by Guzzomi and Miller (2013, 719–720):

> Feedback from industry professionals indicates that one thing that is very different in engineering practice as compared to the student university experience is that in engineering analysis '90% correct' is not acceptable. At the university, marks of 60–70% are common and incorrectly convey the message that performance to such a standard [i.e. to aim to achieve a pass or any other mark other than 100%] is sufficient.

The work of Walther et al. (2011), combined with the importance of integrity for engineering and the above industry advice, led us to the conclusion that authentic assessments should be designed to help engineering students understand the importance of integrity, and to practise performing at their best. By this we mean understanding the need to take effort to ensure that their work is optimal for the situation. For example, they should check that their work is compliant and correct. The intervention reported in this paper involved a new assignment marking protocol. This innovation was first undertaken in 2011 (Guzzomi and Miller 2013) in an urban Australian research-intensive university. The intervention was made in the third-year core mechanical and mechatronic engineering unit (elsewhere known as a 'course' or 'paper') Mechanisms and Multibody Systems. In the unit, students learn about high-level kinematics and dynamics of spatial and planar mechanisms and machines. In previous years the topics were marked using a traditional marking scale from 0% to 100%. Students were able to pass with any mark greater than or equal to 50%. The above quote was used as the preamble to the assignment and accompanied by the following text (Guzzomi and Miller 2013, 713):

> To emulate engineering practice, this assignment will be marked on a simple scale: very good = 100%, not very good = 0%. In engineering practice feedback is sought from many sources. To emulate this process there will be tutorials devoted exclusively to provide feedback on the assignment.
> Also if errors are found in the analysis, engineers have time to correct them. To emulate this process, if the report submitted by the first deadline is considered to be not 'very good' (and therefore attracts a mark 0%, detailed feedback will be provided at this stage) resubmission by the second deadline is allowed. Reports considered 'very good' submitted by the second deadline will attract the mark of 70%.

The assessment also had all of the components identified by Jackson: students' self-reported effort on this and previous assessments, and their ratings of the positive influence of factors that influenced their effort are reported. In the first implementation of this scheme, despite students initially agreeing, in principle, to the 100%, 70%, and 0% mark scale, a number of concerns began to be voiced.

These concerns are consistent with students potentially feeling alienated as described by Mann (2001). She proposed the method of conceptualising learning approaches in terms of engagement or alienation experienced by students in higher education as an alternative to the well-known framework of surface and deep approaches to learning that have been found to be encouraged or discouraged by various curriculum features (Ramsden 2003, 47). Mann (2001, 14–15) describes how assessments have the potential to create alienating experiences for students in higher education. When 'examined', in a broad sense of the word, students can be made visible and judged in an unbalanced relationship where the other has power over the marking system, and the students are consequently compared with other students. Below is an example of a voiced concern from a student taking the unit:

> This 70% mark for everyone who resubmits with an acceptable level, … is plaguing us. We accept that our initial submission was not worthy of full marks. However, it is also clear to us that our initial submission was orders of magnitude better than others who are in the same boat as us. I am sure there are plenty of other groups who feel similarly. No distribution in the mid-range of submissions seems to be promoting free-loading and slackness. I am not sure these are qualities that should be encouraged. For argument's sake, if we take a cut-off mark of 80% and two groups scored 79 and 81% respectively, then these two groups who would usually be separated by 2% would now be separated by 30%. This is clearly not an accurate representation of the difference in the quality of the two reports.
> Can the second submission assignments please be remarked and, if the marks will still not be distributed, could some extra marks be awarded to help compensate for the errors in marking the first submission? (Guzzomi and Miller 2013, 715)

The above concern from a student is consistent with the student experiencing alienation. The student felt that he/she would be ranked unfairly among other students based on a submitted piece of work. Given the concerns of students, the authors decided that second submissions that were below the threshold of a 70% mark would be ranked accordingly: submissions which fell below the threshold achievement level were marked and assigned numeric values from 50% to 70% in 5% increments with very bad reports receiving 0 (Guzzomi and Miller 2013, 715). By acknowledging and responding to the student concerns, this potentially alienating circumstance became a mutually engaging process.

A qualitative analysis of students' reflections and comparison of first and second submissions indicating that students responded to feedback is given by Guzzomi and Miller (2013). This initial attempt was used to inform ways to improve the implementation of the authentic assessment.

The second implementation of the assessment, reported here, occurred in 2012, when 257 students were enrolled in the unit. Working in groups, the students wrote a program to aid in the design of a mechanism for a particular task and facilitate the investigation of coupler curves generated by four-bar mechanisms. They wrote a report explaining their chosen design and how the program could be used. The assessment is novel in its design to encourage and help students to see the importance of performing at their best,[1] and in the authentic grading scheme. In implementing this innovation we address the following questions:

(1) Is it feasible to implement an authentic grading scheme that encourages students to perform at their best? If so,
(2) How might students respond to this? In particular
    - Which factors would they perceive to influence their effort positively? and
    - Would students report other responses to assessment?

Similar to the work by Martin et al. (2005), due to the global nature of the engineering profession, and that UWA's teaching aligns with the Bologna Process (3 + 2) and Melbourne Model (King 2012), it is expected that the findings would be applicable to other similar education contexts. In particular, the approach may be adopted within the degree in units/courses that tackle real-world challenging technical design problems not run by industry representatives.

2. Methodology

In light of the above literature, the study was designed with recognition of the potential for accidental competencies, that is, competencies that result although not consciously designed by the curriculum designer, and the importance of authentic curriculum design to motivate and support engineering students in developing competencies required for engineering practice. The authentic assessment design was also informed by increasing literature on the sociotechnical nature of engineering practice. The specific aspects of the theoretical framework that shaped the research methods are identified below.

2.1. Competency formation and accidental competencies

In the study referred to above, Walther et al. (2011) developed a model of competency formation for engineering students. In the model, formal assessment is an example of the learning environment that can contribute to accidental competency and incompetency development. Aware of these aspects, we designed the assessment and survey questions accordingly to be authentic.

2.2. Authentic engineering curricula integrate social and technical competencies

We engaged students in a sociotechnical problem on the topic of coupler curves and the technical design of a real (level luffing) crane. Sociotechnical aspects include working in teams on the engineering project, preparing a technical report, and commenting their code so that others could follow and understand their logic and decisions, and the requirement to seek or provide peer assistance to improve the second round of submissions.

2.3. Other curriculum design principles

Other curriculum design principles that are authentic to engineering practice that were employed in the assessment included *deep approaches to learning* and *student engagement* and *reflective practice* and *teamwork*. Our assessment was consistent with the principles identified by Sambell (2012, 186–187) and Smith and Trede (2013, 640) and identified above. As extensive low-stakes confidence-building opportunities exist in early years in the mechanical engineering programme and this intervention was in a third-year unit, the level of challenge was deemed appropriate. Palmer (2007) similarly placed challenging authentic assessments in senior years of an engineering programme rather than in junior years.

Teamwork is a competency required by engineers (Male 2010) and the assessment was a team project. In the assignment brief, we identified reasons students should work in teams during the course and the assignment was purposely designed to ensure students worked in teams (Appendix 1).

Effective feedback can be valuable in supporting reflective practice and hence, formative, authentic feedback from teachers and peers was a design feature of the assessment.

2.4. Assessment of competencies

Although we aimed to encourage students to develop and understand the need for integrity, we do not advocate any assessment of or effort to change students' personalities. As noted by Bary and Rees (2006, 74–75) in their study on self-directed learning for engineers, 'training does not seek to change the personality of students but to help them acquire knowledge and know-how'. Competencies interact and cannot be measured directly but through their manifestations in people's responses to demands within contexts (OECD 2002). The assessment in this study was designed to assess the formation of interacting sociotechnical competencies as demonstrated by students' responses to the assignment.

2.5. Approaches to data collection and analysis

We have previously reported, qualitative investigation of how students responded emotionally when we analysed students' reflections (Guzzomi and Miller 2013). As discussed above, this previous study explored the range of students' responses, especially emotional responses such as alienation. The current study complemented and built on the earlier investigatory study. In this study we were interested in how the authentic assessment influenced the extent to which students performed at their best. A quantitative approach was used to facilitate comparison between students' effort in previous assessments and this authentic assessment. Data were collected in the form of students' ratings of their efforts and the influence of features of the assessment. The study was designed to be non-intrusive and respectful of students' time. Therefore participants were anonymous and questionnaires were short. An open question was used to collect any comments students wished to make about the assessment. The qualitative responses were analysed for evidence of students experiencing the assessment as engaging or alienating (Mann 2001).

3. Method

Here we describe the assignment exercise, marking protocol, and feedback process. We then outline data collection and analysis methods implemented to investigate students' responses to these.

3.1. Assignment design

The full assignment brief is included in Appendix 1. The novel grading scheme was supported by the following key features of the assignment.

(1) It was based on a real engineering problem.
(2) The assignment problem was defined sufficiently openly to have multiple possible valid solutions.
(3) It was given to the students in a manner in which tenders might be called. For example, the students received a briefing document early in the semester and then a scheduled information tutorial similar to a tender brief, where the assignment outline was described and students could ask questions about expectations.
(4) The students were required to respond as if they had won the tender, in that the solutions had to be fully documented such that each component could stand alone.
(5) Consistent with a tender process, there was an enforced deadline for submissions with no late submissions accepted.
(6) Students worked in teams.
(7) Students received concise generic feedback and standardised common errors, and a good assignment was made available to the whole class. Students were encouraged to ask students with higher marks to give them advice on how to improve their submissions. To aid in this process, the high-achieving groups were identified to the class.
(8) The feedback and assessment structure encouraged reflective practice required for self-directed lifelong learning.
(9) The exercise was challenging, expecting a high level of effort from the students.

We sought to encourage a deep approach to learning and engagement rather than alienation. The high stakes, level of challenge, teamwork, and encouragement to seek feedback from peers were features expected to support this.

The assignment was worth 25% of the unit mark. Two per cent of this came from the individual report in which each student highlighted and evaluated their contribution to the group (approximately 0.5 page), separately submitted (before the first deadline only), along with a copy of the student's technical diary. In the assignment brief we explained why keeping a technical diary is important (Appendix 1). It was not acceptable for a group member to be, for example, an excellent coder – a professional engineer needs also to be an excellent reporter (and hence a good diary keeper).

As peers and teaching staff may not know students well enough to gauge whether a student has reached his or her full potential, we used the individual reports and technical diaries to note where the contributions of individual group members were significantly different. We then adjusted marks where individual efforts varied. The marks of the more active contributors were raised to compensate for marks that might have been gained if all members had worked to their full potential, that is, if all members had performed at their best. However, all group members would also receive some penalty on the basis that their teamwork had not been well managed.

Feedback was given in the form of academics answering questions raised at tutorials. As occurs in a tender process, the general answers were made available to the whole class in the lectures and at the start of the tutorials (Appendix 2). At these sessions, groups that were required to resubmit because they received a grade below 70% were encouraged to seek feedback from groups that were not required to resubmit.

3.2. Research approach

Based on the findings from the literature, two anonymous questionnaires were designed specifically for this study to measure the student responses (Appendix 3). Questionnaire design principles including clear instructions with sufficient to be specific but otherwise as few words as possible, shading and fonts to make the questionnaire easy to read and complete, a simple question numbering, and starting with a simple question that demonstrates the topic and the participants' importance as knowledgeable stakeholders were followed (Foddy 1993; Dillman 2000; Mertens 2005). These were completed by students in the second and final lectures of the semester. The assignment was set in the lecture following completion of the first questionnaire. Before implementation, the questionnaires were pilot tested (Mertens 2005) with two engineering students who were not taking the unit. This was to test that the students understood the questions, found the questionnaire clear, and were able to respond to the questionnaire to their satisfaction and in a short time. The students indicated that there was insufficient opportunity to indicate discrimination between item ratings. Hence the number of points on the response scales increased from five to seven.

The questionnaires were designed to encourage students to reflect on their approaches to completing assessments. Students were advised that participation was voluntary and anonymous and would in no way influence their enrolment or assessment. Demographic questions referred to gender, whether students were repeating the unit, and whether they had 'previous engineering work experience'. Consent was indicated by completing the questionnaire. Students were given 10 minutes to complete each questionnaire.

3.2.1. Questionnaire 1

The first questionnaire included seven quantitative questions designed to collect a baseline of students' effort in completing assessments and their perceptions of factors influencing this. Factors corresponded to the features designed into the assessment: the weighting, authenticity, feedback, teamwork, and intrinsic factors related to the authenticity – namely professionalism and desire to learn. The option to enter 'other' was effectively an open question that collected qualitative responses indicating additional factors that were important to the students. The question about effort was,

Last semester in assignments I usually did, with endpoints 'Enough to pass' and 'The best I could' on a seven-point scale. On all rating scales, anchor descriptors were used only at the endpoints in order to assume that participants spaced the points on the scales evenly.

The question about factors influencing effort was

The quality of my work for assessments last semester was influenced positively by:
Weighting
Being in a team
My professionalism
Desire to learn
Feedback from teachers
Other

where each factor was rated on a seven-point scale with endpoints 'Hardly at all' and 'Very much'. 'My professionalism' was included in the questionnaire because we expected it to be an intrinsic factor that could be activated in an authentic assignment. Descriptive statistics from the first questionnaire were to be reported to students in a lecture.

3.2.2. Questionnaire 2

Six questions in the second questionnaire were adaptations of questions in the first questionnaire, now referring to the assignment in the unit rather than previous assignments.

In Questionnaire 2, the question about effort was adapted from Questionnaire 1 by modifying the item stem to

In the main assignment in this unit I tried to do.

The question about factors influencing effort was adapted by modifying the item stem to

The quality of my work for the main assignment in this unit was influenced positively by.

Additionally, the two open questions below and space for 'any further comments' were added:

The most valuable feature of the feedback on the assignment was: ____________
The feedback on the assignment would have been more valuable if: ___________

The questionnaire responses were transcribed. In the process the quantitative responses were coded in order to facilitate analysis in SPSS™ V22. The 7-point rating scales were coded from 0 to 6 for analysis. As noted above, anchor descriptors were identified at the endpoints of the scales only, so that it could be assumed that participants mentally spaced the points on the scale evenly.

The responses to the open questions were coded inductively (Miles, Huberman, and Saldana 2014) by the second author, who was not part of the teaching team. The themes that emerged were verified with the first author who was a member of the teaching team. The themes were analysed for insights into students' responses to the authentic assessment, applying Mann's framework of engagement and alienation.

4. Results

Valid responses were received from 146 students in the first survey and 97 in the second, representing response rates of 56.8% and 37.7%, respectively.

4.1. Participant demographics

The responses to the demographic questions are presented in Table 1. Although the sample for the second survey was only approximately two-thirds that of the first, evidence was not found to suggest that the samples in the surveys were different based on the demographic variables. The null hypothesis that the demographic variables were independent of the survey was not rejected at the 95%

Table 1. Survey participants' responses to demographic questions ($N_1 = 146$, $N_2 = 97$).

		Survey 1		Survey 2			
		n	%	*n*	%	χ^2 (1)	*p*
Gender	Female	17	11.6	5	5.2	2.90	.088
	Male	129	88.4	91	94.8		
Previous engineering work experience	No	111	76.0	71	73.2	0.25	.618
	Yes	35	23.4	26	26.8		
Repeating	No	133	91.7	87	89.7	0.29	.590
	Yes	12	8.3	10	10.3		
Required to resubmit assignment	No	–	–	35	36.1	–	–
	Yes	–	–	60	61.9	–	–

confidence level by the χ^2 test for any of the collected demographic variables: independence for gender, whether the student had engineering work experience, or whether the student was repeating the unit (Table 1).

Eighty-four (33%) of the 257 students enrolled in the unit were not required to resubmit their assignments because they received 100%. Of the 97 students who participated in Survey 2, 36 (37%) reported that they were not required to resubmit their assignments, a figure that was not significantly different from the population percentage of 33% ($t = 0.772$, df = 94, $p = .442$, excluding two responses with no indication of whether the student was required to resubmit).

4.2. Analysis

In addition to descriptive statistics, we undertook independent sample *t*-tests to compare mean ratings of effort and the reported influences on this between the two questionnaires. Matched sample tests were not used because it was more critical to maximise voluntary participation by maintaining simplicity and anonymity. The test for significant difference between means was less sensitive than if the samples had been matched. In regard to the open question responses, all comments were coded under at least one and sometimes two themes each.

A primary purpose of the authentic assessment was to increase the students' effort to produce high-quality work. To start to understand if this was achieved, we analysed the students' ratings of these factors on influence on the quality of the students' work (Table 2 and Figure 1). A significant increase between the mean students' perceived effort in assignments in the previous semester and that in the main assignment in this unit was found.

In response to the question about the most valuable feature of the feedback on the assignment, 34 responses identified a valuable feature. Of these, 17 were general comments, 13 comments referred to specific information in the feedback, and 3 comments referred to the most valuable

Table 2. Descriptive statistics and independent samples *t*-test results for survey participants' ratings of their effort and the influence of factors on the quality of their work.

	Survey 1 (referring to assignment in the previous semester)			Survey 2 (referring to the main assignment in this unit)			Independent samples *t*-test results		
Variable	*n*	*M*	SD	*n*	*M*	SD	*t*	df	*p*
Effort (0 = *Enough to pass*; 6 = *The best I could*)[a]	144	4.4	1.5	97	5.4	1.2	−5.7	233	.000
Positive influence of weighting on quality of work (0 = *Hardly at all*; 6 = *Very much*)	145	3.8	1.7	97	4.6	1.7	−3.3	240	.001
Positive influence of being in a team on quality of work (scale as above)[a]	143	3.8	1.6	97	4.6	1.2	−4.3	237	.000
Positive influence of my professionalism on quality of work (as above)	145	3.9	1.4	96	4.4	1.3	−2.7	239	.007
Positive influence of desire to learn on quality of work (as above)	143	4.1	1.2	96	4.4	1.1	−2.1	237	.036
Positive influence of feedback from teachers on quality of work (as above)	143	2.4	1.8	96	2.7	1.8	−1.5	237	.144

[a]Levene's test of equal variances failed and equal variances not assumed.

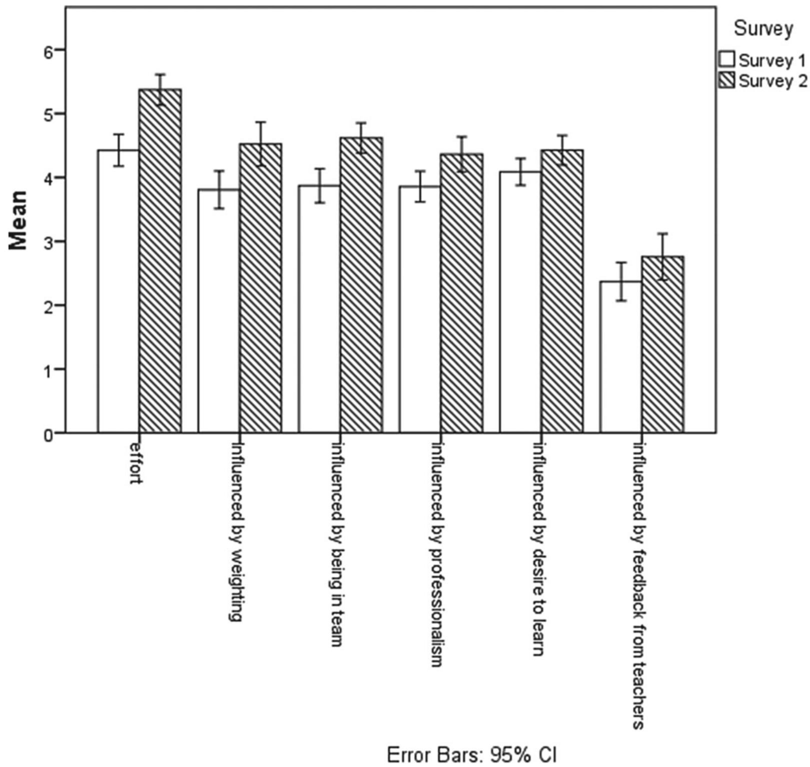

Figure 1. Students' reported effort on previous assignments (Survey 1), and the current authentic assignment (Survey 2) (0 = *Enough to pass*; 6 = *The best I could*); and students' reported extent to which factors positively influenced the quality of their work on previous assignments (Survey 1) and the current authentic assignment (Survey 2) (0 = *Hardly at all*; 6 = *Very much*) (N_1 = 145, N_2 = 97).

source of feedback. Examples of the general comments are 'what was missing', 'what we needed to include in the report', and 'it showed some obvious flaws'. Examples of the specific information are 'does not work for square mechanisms', 'add a diagram', and 'include crank angle limits'. The sources of feedback identified included 'talking to tutors', 'being able to ask peers', 'the sheet in the tute', and the 'perfect submission shown in lectures'.

In response to the question about what would have made the feedback on the assignment more valuable, the main theme in the comments was about the comments written on their work being brief and generic rather than specific ($n = 17$). (Numbers in parentheses indicate the number of responses, each from a different student, coded under each theme. In no case was one student's response separated into two comments coded under the same theme.)

The second main theme ($n = 15$) regarding students' recommendations for making the feedback more valuable was the request for more comprehensive feedback on the students' submission. Examples were 'if every imperfection was given', 'we were told all the problems we encountered', and 'if they looked at all our stuff and gave feedback'.

Comments coded in the third theme ($n = 8$) indicated frustration that the assignment requirements were not more specific (e.g. 'more detail given initially'), consistent with frustration noted above in response to the first open question. This theme recurred in the survey responses.

In response to the final request for any other comments, 31 responses were received, 5 of which were 'none' or similar. Emotion coding (Miles, Huberman, and Saldana 2014, 75), which was useful for our interest in student responses, identified the following:

(1) *Desire for more specific instructions* ($n = 7$), for example, 'it would be better if there were very specific points which needed to be addressed for assignment to be "perfect" e.g. the report should have … '; 'I hope assessment criteria can be more specific in the future so that my marks better reflect the effort I put in and the knowledge I gained from the unit'; 'discouraging to be penalised for hidden requirements';
(2) *frustration due to harshness of the scheme* ($n = 6$), for example, 'Yeah hard'; 'Hope I don't have to repeat'; 'too stressful'; 'assessment system of the this unit is not fair'; 'I, at first, enjoyed the assignment, but felt ripped off by the mark';
(3) *satisfaction* with the assessment or the unit despite reservations ($n = 4$): 'it was an interesting assignment, but more time would have helped/proved useful'; 'interesting unit. Better than most in terms of content'; 'the assignment was good. I liked it. I worked very very hard on it and it paid off'; 'enjoyable content, everything else a little frustrating';
(4) *concern about working in the team rather than individual marks* ($n = 3$), for example, 'any project that involves coding in a team means that generally only one / two member/s writes the code therefore only one member benefits. Coding is not a team job. Either this or smaller groups 5 people is a joke for coding, 2 max'; 'member's contribution should be inspected in the assignment'; 'make individual assignments so that leaders don't complete others' contributions';
(5) *desire for more examples* ($n = 2$): 'more worked examples', 'It could've been more helpful if a proper solution had been handed out in class';
(6) *desire for more specific and timely feedback* ($n = 2$), for example, 'an individual slip stating what was tested on the code would be very helpful';
(7) *other aspects of the unit*, namely the unit outline, the website, tutors, management of the unit, and feedback and marks from laboratories ($n = 4$), and weighting ($n = 1$): 'due to 50% exam requirement to pass other assessments were significantly depreciated in the value I placed on them'.

5. Discussion

5.1. *Reported influences on quality of work*

Figure 1 and Table 2 reveal several results about the students and their experience of the assessment. Possible reasons for the significant increase between the mean students' perceived effort in assignments in the previous semester and that in the main assignment in this unit are discussed below. It should be noted that measures of effort are very subjective and based mainly in past personal experiences, which in some cases may be limited.

All of the factors were rated as significantly more influential by students on their quality of work in the current assignment than in assignments in the previous semester. Factors indicating design features of the assessment were weighting and being in a team, which were both rated as having a stronger influence in the current assignment than in previous assignments. This is consistent with the literature that informed the design of the assessment as described above.

When rating the positive influence of factors on assignments in the previous semester, the factor with the strongest influence was intrinsic, namely the desire to learn. It is possible that the intrinsic factor was more dominant in the students' minds when recalling past events, while factors related to the specific assignment were more easily recalled during the current assignment.

The second of the two intrinsic factors listed in the questionnaire was 'my professionalism'. The students' rating of the influence of this factor on the quality of their work was higher in Survey 2 than Survey 1.

Most clearly apparent, the factor rated as having the smallest positive influence on the students' quality of work in both surveys was feedback from teachers. Furthermore, this was the only factor for which no significant difference was identified between the mean ratings in Survey 1 and those in

Survey 2. A possible explanation, despite the extensive effort applied to providing feedback, is that 37% of Survey 2 participants reported that they were not required to resubmit their assignments and therefore did not have an immediate opportunity to use feedback. Other possible explanations and motives become evident from the responses to the open questions.

5.2. Responses to open questions

The 34 responses to the question about what was valuable indicate that many students effectively used the feedback system. However, concerning language was used by the participants; the students referred to 'failing': 'It told me why I failed'; 'where I failed'. It is possible that the use of the word 'fail' arose from the binary marking scheme for the first submission. These responses contrast with examples from students who received 100%, who reported that the most valuable feature of the feedback was ($n = 7$), for example: 'Ego boost' and 'Good news'. The potential for the marking scheme to polarise the students, especially if students feel they failed, should be minimised through the reminder that there is an opportunity to recover. A sense of failing would be consistent with students feeling alienated, as discussed by Mann (2001) above.

In response to the question about the most valuable feature of the feedback, seven students' comments indicated that the student felt disgruntled with the feedback. These comments were consistent with the students feeling alienated because they did not receive sufficient or fair attention (e.g. 'the feedback provided was brief and indicated a rushed marking effort with little interest in the content', 'harsh feedback') or because the student felt that the assignment was not sufficiently specific and the details only became apparent in the feedback ('being told the assignment question is not complete and they expected more than specified in the question'). The latter was even more apparent in response to the second open question.

The comments about what would have made the feedback on the assignment more valuable were consistent with Vardi's (2012, 6) recommendations on what students want in feedback, quoted above. As described above and recognised in responses to the first open question, explanations for these comments were provided in detail in the tutorials. This was a feature of the assessment design.

The responses to the invitation for 'any other comments' that were coded as *frustration due to harshness of the scheme* ($n = 6$) reflect a frustration consistent with potential alienation, and contrast with the responses from participants indicating *satisfaction*. This polarisation is similar to that evident in the responses about the value of the feedback.

Many comments referred to students finding designed authentic aspects of the assessment disconcerting. Comments indicated that students would have liked more specific instructions but the assessment was designed as a high-level unit in which students should use initiative. Comments indicated that students were frustrated by receiving a team mark when one person did the work, yet teamwork was another designed authentic feature of the assessment. Similarly, the desire for more 'worked examples' suggested that the students assumed there were correct solutions, when the assignment was intentionally open with no one correct solution. Baillie and Johnson (2008) identified fear of uncertainty as troublesome for engineering students. The students' responses in this study are consistent with Baillie and Johnson's finding and support the need for assessments that are authentically open with multiple solutions. Nonetheless, the students' comments about specific and timely feedback directly reflect Vardi's (2012) recommendations for effective feedback discussed above, and a balance between authenticity and effective feedback would be ideal.

Many possible authentic features of assessment could be introduced. For example, students could be encouraged to follow procedures and policies for version control, task allocation, design checks, holding and recording team meetings, and cost control. Indeed, Foley and Willis (2013) have started to develop and test an engineering management system for this purpose. We conclude from the results that as educators we tread a fine line between challenging students with authentic assessment features designed to build competencies they will require in engineering practice, and alienating students. In this study there is evidence of students responding to authentic features of the assessment in both ways. The challenge is to stretch students such that all students develop and no one student is left feeling alienated. An indication that any student felt alienated is concerning. In hindsight, Sambell's (2012, 186–187) recommendation for low-stakes confidence-building assessments could reduce students' alienation, despite the unit being in the third year. With careful design, these could also help the students understand the expectation of the main assignment that students perceived as 'hidden' requirements.

6. Limitations and future studies

As noted, the sample size in the second survey was approximately two-thirds that of the first. It is possible that the sample in the second survey was not completely representative of that in the first. The main factor that affected the response rates was the attendance at the lectures in which the surveys were implemented. Lectures are automatically recorded and available to students online. The decrease in response rates reflected a decrease in lecture attendance rates between the two lectures. The majority of university students in Western Australia where the study was undertaken do not live on campus but in the suburbs of Perth. The city does not have a dense population and public transport is infrequent. Therefore, students' commutes can be up to an hour long. Furthermore parking on campus is scarce. Additionally, students have conflicting demands on their time such as teamwork, clashing classes, assignment work, and part-time work. Taking advantage of the flexibility to watch recorded lectures rather than attend face-to-face could as easily represent a busy student making efficient use of time as an uncommitted student. Given also that neither survey was compulsory, it is reasonable to assume that the second sample is representative of the first.

Given the context of recorded lectures and students' travel times, the likelihood that the sample in the second survey was not representative of that in the first is minimal. This is because choosing not to attend a recorded lecture in face-to-face mode is not an indication that a busy engineering student is not committed to studies. However, a recommendation for future studies is to implement the questionnaires online in order to collect responses from students regardless of whether they attend live lectures.

In addition to sample limitations, there are other potential threats to the validity of the survey results. As noted, in the first survey participants were asked to make recollections of a general nature: 'Last semester in assignments I usually did'. This contrasts with the cognitive processes involved in responding to questions about a specific current unit. Similarly, as discussed, the relative significance ratings given to factors in memories of past events are likely to be different from those in thoughts of current events. Additionally, contextual factors could threaten the validity. For example, potential confounding factors are which tutorial groups students attended and whether students were international or domestic. Changes in students between last semester and the current semester could also confound the results. It is possible that some students had transformational experiences, such as undertaking vacation employment in engineering, between the semesters. Further investigation in the form of interviews or focus groups could be helpful in investigating potential modifications to minimise alienation of students.

7. Conclusions

Engineering educators have a responsibility and opportunity to help students develop not only engineering science knowledge and skills, but also sociotechnical and attitudinal competencies that are required in engineering practice. The latter might be difficult to teach and sensitive to assess.

To contribute to addressing this problem, we implemented an assessment that is authentic to engineering practice, which includes a novel marking scheme, and is designed to encourage students to be aware of the need for, and to practise, performing at their best. Students reported that their efforts in this assessment were higher than typical in the previous semester. Students also reported that the quality of their work was more heavily influenced positively in this assignment than previously influenced by weighting, being in a team, professionalism, and desire to learn. Qualitative comments by students drew attention to the need for sensitivity to the potential identified by Mann that assessments can be experiences as alienating by students.

Note

1. It is acknowledged that although performing at one's best does not always correspond to the best performance, success and effort are highly correlated.

Acknowledgements

The authors thank the students for completing the reflections on their assessments and the anonymous reviewers for their constructive comments.

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Appendix 1. Assignment

Coupler curves and design of a level luffing crane
(25% of the total mark)

Form groups of five (groups of four are acceptable, groups of six are NOT). One submission per group is required.

Your report should be no longer than 300 words + well documented program listing and a disc with a working program.

Each of you will need to keep a professional diary and submit a copy separately with the group report.

Each of you will also need to submit half-a-page summary of your individual contributions to the project.

The feedback from industry professionals indicates that one thing that is very different in engineering practice as compared to the student university experience is that in engineering analysis '90% correct' is not acceptable. At the University marks of 60–70% are common and incorrectly convey the message that performance to such a standard is sufficient. Therefore, to emulate engineering practice, this assignment will be marked on a simple scale: very good = 100%, not very good = 0%.

In engineering practice feedback is sought from many sources. To emulate this process there will be tutorials devoted exclusively to provide feedback on the assignment work.

Also if errors are found in the analysis, engineers have time to correct them. To emulate this process, if the report submitted by the first deadline is considered to be not 'very good' (and therefore attracts a mark 0%, detailed feedback will need to be sought from successful groups at this stage) resubmission by the second deadline is allowed. Reports considered 'very good' submitted by the second deadline will attract the mark of 70%.

The aim of this project is to practice analytical methods of kinematic analysis of mechanisms, as well as reinforce computer programming skills.

Problem – Coupler curves and design of a level luffing crane:
I. Write a Matlab^{TM} (other programming languages are permitted) program to draw coupler curves. It should contain the following components:

1. Input dimensions of the linkage, assembly mode and position of a coupler point
2. Find motion limits ($Theta2_{min}$, $Theta2_{max}$)
3. Compute the position of the coupler point for Theta2 running from $Theta2_{min}$ to $Theta2_{max}$, and plot the result.

Remember to document your code carefully, so that other people can use (or check) it!
Additional programming resources can be found here: http://www.mathworks.com/academia/student_center/tutorials/intropage.htmlGood primer in Matlab programming is here: http://www.mathworks.com/moler/chapters.html
II. Choose dimensions for the four-bar linkage of the level luffing crane (you may use a 4-bar software to help you in the design). Your linkage should produce a coupler curve, which contains a substantial horizontal straight line, needed to shift heavy payloads ['Kinematics, dynamics, and design of

machinery' K. J. Waldron, G. L. Kinzel, Wiley, 1999, or course notes]. Using your program, show that the coupler point from which the load is suspended indeed moves approximately along a horizontal straight line.
III. Your program should be able to deal with all four-bar linkage types. It should also give appropriate warning messages when user input data is incorrect.
IV. It is very important that your program is well documented so that other people (e.g. your marker) can run and/or check it.

Guide for Project Work:

The project work is an important component of this course. Working in teams on projects prepares you for professional work in any engineering discipline.

The most important unpredictable factor that affects nearly all engineering work is human behaviour, particularly behaviour within an engineering team. Learning how to manage this factor is the key to a successful engineering career. This project is intended to help you with necessary practical experience in team skills.

You are free to form groups as you wish. Five-member groups are preferable. Four-member groups are acceptable. Three- or six-member groups are NOT acceptable. You need to remember that the main constraint is the timetable: you must be able to spend time working with your fellow team members.

Your project work will be assessed based on your group's report, your individual technical working diary, and your individual short summary of your contributions to the project.

1. Project Assessment

The marks for the project will be made up as follows (25 available marks, or 25% of the unit):

Project final report	23%
Main (group) report, including the specification, code testing, test results, details of time spent, crane design process, final design.	
Documentation of the code. A reasonably computer-literate person should be able to run your code without your help. A person reasonably knowledgeable in theory of mechanisms should have no problem understanding what your code does.	
If the report is considered near-perfect, the full 23% mark will be awarded.	
If not, a tentative 0% mark will be given, and an opportunity to submit before the second deadline offered.	
If a near-perfect report is submitted by the 2nd deadline, a mark of 16% will be awarded.	
Individual report on your contributions to the project and time spent (approx. ½ page), separately submitted (before the 1st deadline only), (copy of your technical diary must also be submitted, no additional marks).	2%

2. Technical Project Diary

You must write a technical project diary while you are working on your project. This can be requested at any time. You must record the times you work on your project in your diary.

Why keep a diary?

First, your diary will record all your ideas, code specification notes, implementation notes, and test results. This is normal professional practice. All professional engineers must work on the assumption that a replacement engineer may need to take over their work at short notice. No one is indispensable in any properly managed engineering project. Your diary is the key to this. It will enable another person to take over your work at any time.

Second, your diary will record the time you spent working at every aspect of this project.

Third, your diary will help you remember your mistakes and successes. Many ideas developed for a project end up being discarded. Sometimes they are not feasible, sometimes they are too expensive. However, they can come in useful in later projects, so you need to keep a record.
Ideas

Write your ideas down as they occur to you. Write the date and time at the top of every page or the start of a new section. Your ideas will develop with time: keeping records helps this development.

Implementation Notes

Record names of source code modules and record changes made as you write the code. Changes that do not reflect the specification are unfortunate, but inevitable while learning. Note these changes and variations on the original specification.

Test Results

For software, write test modules that generate the test data inputs and display the results. Record the source files for these test modules in your diary and keep backup copies. Note test results in your diary. If the tests fail and the reason is not immediately apparent, note the results and print out your source code. Leave the problem diagnosis for a later session. Instead of trying to fix the problem immediately, get on with another code module.

Some hours, or days later, return to the problem. Review the test results, and follow through the design (or code) to understand why the tests returned unexpected results. If the problem is not apparent, do n't keep trying. Design extra displays of the intermediate results and run the tests again. Compare these results with your predictions. By following this routine, you will spend minimal time diagnosing problems.

Is it worth all the time to write this down? Surely it is quicker just to get on with the work!

As an engineer, your skills may be needed elsewhere for something more important at a moment's notice. Therefore it is essential that you document your work so someone else can take over when needed. Also, you need to prepare for future maintenance and enhancements. Documenting what you do is essential if you want to come back and improve it later. All this is 100% standard engineering practice.

Importance of a Diary in Commercial Engineering Practice

In a commercial setting, your diary records would form the basis for auditing project accounts and expenditure records. If you have no evidence that you have spent time working on a specific project, your client may not pay you for the work completed. The records of design decisions, and testing results provide a *traceable* record of design and testing that forms an essential part of any quality assurance program.

Final Report:

Part A – Group Report
A single report is required from each group of students. This must be submitted as a printed report on paper, with the Mechanical Engineering cover sheet signed by the authors. CD-ROM with the code must be included.

Part B – Individual Report

This must be submitted separately by each individual group member. This is a report on your contributions to the project and the time you spent (1/2 page maximum). A copy of individual technical diary should also be included.

From the demonstrations, individual reports, and technical diaries, we note where the contributions of individual group members have been significantly different. If you think that some group members made far greater contributions than others, this is your opportunity to tell us.

We adjust marks where individual efforts vary. The marks of the more active contributors are raised to compensate for marks that might have been gained if all members had worked to their full potential. However, all group members receive some penalty on the basis that their teamwork has not been well managed.

Other Important Issues:

Back-Up Your Work

It is your responsibility to back-up your own computer work, both in the university laboratories and at home. Keep two separate backups on high-quality diskettes, CD-ROMs, or Zip discs. One backup should be taken daily: the other should be taken weekly and kept in a safe location.

Failure to keep adequate backups will not be allowed as an excuse for late work.

Sharing Designs and Software

We encourage students to share design work and software. This is normal industrial practice. However, as the copyright always rests with the original author, the permission of the original author must be obtained and the work of the original author must be clearly marked. The original author must be clearly shown everywhere it is used: in code comments, in final report, in the list of references. A precise reference is required giving the original source of the code, not just the name of the person from whom it was obtained.

However all software code must be thoroughly tested, and the testing fully documented in the technical project diary.

Karol Miller (based on ideas by James Trevelyan, with input from Andrew Guzzomi) July 2012 http://www.mech.uwa.edu.au/courses/MMS305/ass5-coupler-curve.html

Appendix 2. Assignment feedback

GENERAL:

Documentation of the code and clear instruction for running the code.

Appropriate message is not given by the code when the input is out of range …

COMPLETELY WRONG:

Just because a mechanism is susceptible to reassembly mode changes and singularities, does not mean it does not have a coupler curve …

DESIGN SOLUTION

- The final design in the report must be compatible with what we get from the code.
- No diagram: A design is not complete without a diagram (with correct labelling of the links and dimensions in meters or at least dimensional ratios) … .
- Bad design AND NOT OPTIMISED, (i.e.: the straight line mechanism is NOT generating a straight line portion but it is curved). …

PRESENTATION

The design process presented in a logical order (also in the code) …

WHAT TO DO NOW:

REVISE YOUR ASSIGNMENT USING THIS FEEDBACK AND HELP FROM ‘GOOD’ GROUPS

HAND IN YOUR REVISION TOGETHER WITH YOUR FIRST ATTEMPT

Appendix 3. Questionnaires

Questionnaire 1

Reflection on Assessments

- Please complete this questionnaire to give us feedback for improving the unit and to help you reflect on motivation for quality in your assessments.
- **Do not** write your name on the questionnaire.
- For each question tick **one** box only.

Q1. Last semester in assignments I usually did:	*Enough to pass* ☐	☐	☐	☐	☐	☐	*The best I could* ☐	
Q2. In this unit I aim to:	*Learn enough to pass* ☐	☐	☐	☐	☐	☐	*Learn as much as I can* ☐	
	Never or hardly ever						*For all or almost all of my submitted work*	
Q3. Last semester I received feedback on my work:	☐	☐	☐	☐	☐	☐	☐	
Q4. Last semester I used feedback to improve my work:	☐	☐	☐	☐	☐	☐	☐	
Q5. Last semester the average quality of my assignment work was	*Very poor* ☐	☐	☐	☐	☐	☐	*Excellent* ☐	
Q6. The quality of my work for assessments last semester was influenced positively by:								
	Hardly at all						*Very much*	*N/A*
a). Weighting	☐	☐	☐	☐	☐	☐	☐	
b). Being in a team	☐	☐	☐	☐	☐	☐	☐	☐
c). My professionalism	☐	☐	☐	☐	☐	☐	☐	
d) Desire to learn	☐	☐	☐	☐	☐	☐	☐	
e) Feedback from teachers	☐	☐	☐	☐	☐	☐	☐	
f). Other:								
Q7. Were any of your assessments last semester authentic (i.e. similar to tasks performed by engineers)?	*None or hardly any* ☐	☐	☐	☐	☐	☐	*All or almost all* ☐	*Don't know* ☐
Q8. Gender :	*Female* ☐			*Male* ☐				
Q9. Do you have previous engineering work experience?	*No* ☐			*Yes* ☐				
Q10. Are you repeating this unit?	*No* ☐			*Yes* ☐				

Questionnaire 2

Reflection on Assessments

- Please complete this questionnaire to give us feedback for improving the unit and to help you reflect on motivation for quality in your assessments.
- **Do not** write your name on the questionnaire.
- For each question tick **one** box only.

Q1. In the main assignment in this unit I tried to do:	*Enough to pass* ☐	☐	☐	☐	☐	☐	*The best I could* ☐
Q2. In this unit I aimed to:	*Learn enough to pass* ☐	☐	☐	☐	☐	☐	*Learn as much as I can* ☐
Q3. In the main assignment in this unit I received:	*0-49%* ☐	50-59% ☐	60-69% ☐	70-79% ☐	80—89% ☐	90-99% ☐	*100%* ☐
Q4. The feedback received on the assignment was:	*Of no or hardly any use* ☐	☐	☐	☐	☐	☐	*Extremely valuable* ☐
Q5. The most valuable feature of the feedback on the assignment was:							
Q6. The feedback on the assignment would have been more valuable if:							
Q7. The quality of my work for the main assignment in this unit was influenced positively by:	*Hardly at all*						*Very much*
a) Weighting	☐	☐	☐	☐	☐	☐	☐
b) Being in a team	☐	☐	☐	☐	☐	☐	☐
c) My professionalism	☐	☐	☐	☐	☐	☐	☐
d) Desire to learn	☐	☐	☐	☐	☐	☐	☐
e) Feedback from teachers	☐	☐	☐	☐	☐	☐	☐
f) Other:							
Q8. Gender :	*Female* ☐			*Male* ☐			
Q9. Do you have previous engineering work experience?	*No* ☐			*Yes* ☐			
Q10. Are you repeating this unit?	*No* ☐			*Yes* ☐			
Q11. Any further comments?							