

Problem-based Learning: a case study in Assessment and Evaluation in the University of Manchester

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Introduction

This paper looks at the issues of appropriate assessment and evaluation for innovative programmes of study, in particular examining the circumstances of units using problem-based learning (PBL). A number of inter-related course units have been run at the University of Manchester over the last ten years. Their linking theme has been that of global societal responsibility and they have all featured a significant element of PBL. The initial under-graduate unit was Interdisciplinary Sustainable Development and a recent Masters' unit was in Managing Humanitarian Aid Projects. Another link between these units has been the nature of the learning outcomes – spanning personal skills as well as factual knowledge. The prompt for these course units was a talk given by Professor Charles Engel in 2002.

The Ultimate Challenge (Engel et al 2004; Brundtland 1987)

The future of the world faces a number of significant challenges:

- Economic burden of large national debts;
- Reduction of biodiversity;
- Pollution of air, soil and water, with detrimental influences on the environment;
- Growth of the world's population, accompanied by increasing poverty in the developing world;
- Competition for limited water supplies, resulting in threats of armed conflict;
- The threats and consequences of climate change.

These developments stimulate extremism, terrorism and migration that affect social stability

Governments and Businesses have too short a time horizon, therefore the professions need to take responsibility for:

- Expert, non-partisan support to governments;
- Underpinning research as well as ameliorative interventions;
- Collaborating on exploring the causes and consequences of major global problems;
- Working in outward-looking, collaborative, proactive, inter-professional and inter-sectoral ways.

In support of this, Universities need to provide scholars, researchers and graduates who can meet these requirements and Higher Education needs to promote:

- Active learning, inter-disciplinary thinking and creative problem-solving;
- Teachers as enablers of learning rather than as knowledge-givers;
- Learning in context; not isolated from the real world.

So, what educational approaches are most relevant to providing scholars with these attributes? A Delphi study in 2008 (Tomkinson R et al, 2008) suggested that student-centred learning methods, in particular role play and case studies, were most appropriate to embedding sustainable development

in the engineering curriculum but in order to achieve all of the requirements mentioned above it was felt that problem-based learning would be the most appropriate student-centred approach.

Problem-based learning (PBL) operates with groups of students researching a complex problem. The particular way that it operates can vary from unit to unit, but usually the learning starts with a complex problem scenario. Each group is facilitated by a post-doctoral researcher or PhD student who is trained to help students to maximise their learning but not to ‘teach’. Sometimes facilitators may also take part in assessment.

Table 1 Comparison of PBL with traditional teaching

Traditional Didactic teaching:	Problem Based Learning:
<ul style="list-style-type: none"> • “I’m the expert - listen to what I tell you and follow my instructions” • “Absorb my knowledge – learn these facts and principles...” • “This is the right or wrong answer / approach.” 	<ul style="list-style-type: none"> • “Here is a complex situation - What do <u>you</u> think you need to know to understand or tackle this?” • “I don’t know the solution – you will have to find that out for yourselves” • “There is no single right or wrong answer – you must <u>justify</u> your reasoning and approach” • What did you learn from this experience?

Wicked problems

Introducing an element of complexity into the curriculum, rather than simplifying problems so that students can come to an easy resolution of them, means facing up to the challenges of ‘wicked’ problems. Independent of Engel’s arguments, at an informal meeting of academics in Graz in 2008 Rietje van Dam, Vice-Rector Magnificus of the University of Leiden, suggested that a major issue for universities was that they tended to reduce the complexity of issues in order to make them simpler for students to tackle, particularly in the sciences and engineering. Added to this are the problems of mono-disciplinary approaches that educate students to think narrowly and not to look at what other disciplines might bring to a problem. Rather than giving students the tools to face complex challenges, higher education had taken the easier road of trying to simplify the problems: this means that students leave university ill-equipped to face the challenges of the modern world.

The concept of the wicked problem comes from Horst Rittel and Melvin Webber (1973) and may have many of the following characteristics:

- No definitive formulation;
- No clear end, no ‘stopping rule’;
- An answer that is ‘good or bad’ rather than ‘right or wrong’;
- No immediate or ultimate test of their resolution;
- Consequences to every solution, there is no possibility of learning by ‘trial and error’;
- No well-described set of potential solutions;
- Essentially unique;
- Possibly symptomatic of another problem;
- Causes with no unique explanation;
- Expectations that their ‘owners’ will find the ‘right’ answer.

The challenges identified by Brundtland are the sort of issues that fall within Rittel and Webber's definition. These are radically different to the 'tame' problems with which students tend to be faced, particularly in science and engineering. In the field of global societal responsibility there is usually an additional complicating factor, in that different proposed solutions may appeal to different stakeholders and any such solution may disadvantage certain groups in society. Choosing a solution may then become a social and political issue rather than a technical one. Whilst individual issues of global societal responsibility can be seen as wicked problems, climate change, for example, or post-earthquake relief and reconstruction, the area itself can also be seen as complex and challenging. Moreover, Engel asserts that one of the keys to resolving these issues is that of managing change: a topic that seldom features in the curriculum. So, how does higher education take this message on board? The solution sought in Manchester was to use complex interdisciplinary scenarios within a PBL framework (an example is given at Appendix B).

Assessment

Key aspects of designing assessment are that the approaches used should be both valid and reliable; there is also an expectation that they should be economic and effective. Thought has to be given to formative, as well as summative, assessment partly in order that students are not faced with summative assessment of a type with which they are not familiar but also because the formative feedback is a key element of learning when using PBL.

Innovative forms of teaching mean that the requirements for assessment themselves have to be re-assessed to ensure their validity. The start for this process was to define a series of 'learning outcomes': Appendix A gives learning outcomes typical for the type of course unit being considered. John Biggs' (2003) idea that assessment should be aligned to the outcomes means that thought has to be given to the nature of those outcomes. In this case, the outcomes contain significant elements of skills development as well as the acquisition of knowledge. The Appendix includes suggestions as to the proposed assessment methods for one of the later units in the series, but that is neither the original starting point nor the complete story.

Assessment should be developed through encouraging and educationally valuable exercises - with their effect on lifelong learning, where the test of understanding is through application rather than through written examinations. In PBL, the process of 'maturation' means that progress is aided by well-structured formative assessment or feedback.

The initial proposals were for three forms of summative assessment – the 'modified essay question' (MEQ); a group project report and; a peer assessment exercise. Formative assessment took the form of a mid-semester peer assessment exercise and feedback on each of the first three group project reports.

Modified essay question

The MEQ is used widely in PBL for medical courses and tests the student's ability to apply skills, concepts or understanding learned during an exercise to a new problem or situation. It is not testing their ability to recall factual information. Due to the time constraint, the MEQ is also testing the ability to respond quickly to a question and understand what is being asked for. This can be

challenging for students for whom English is not their first language. Students are assessed on their ability to make suggestions or recommendations and then explain their reasoning or justification. The reason/justification will typically attract higher marks than the suggestion itself.

Using the MEQ, each question paper is based on a single scenario, in which the individual student is taking on the role of a professional early in their career, employed by a specific organisation. The question paper should not assume previous knowledge of the scenario. A pre-reading information page may be given to the students to be studied in advance under open-book conditions, a copy of which is then attached to the question paper. The paper is divided into three parts, each containing one question requiring several responses. Instead of writing an essay, students write short sentences comprising the three or four key points that they would have used if producing a full essay. Boxes are provided on the paper for the students to write in their responses. The paper is examined under strict time constraints. Just 20-30 minutes is allowed to complete three separate questions, with the time expected per question specified on the question paper. Each of the three parts of the paper is tackled as a stand-alone question. Students are not permitted to look forward or go back to previous parts of the question, each of which is shown on a separate page. The three parts of the paper complement each other to form a coherent whole. They address a problem from different perspectives, or follow a project through different stages of the timeline. There are often many possible answers to a particular question, and intelligent marking is needed to ensure students are given credit for sensible responses. Due to the wide range of correct answers, producing a definitive model answer is difficult, so in practice-papers an “example answer” has been produced instead. Although the questions should allow for a range of answers, they should not be so unrestricted as to leave the student unsure of what type of response is being sought. To avoid confusion, an example response is given for each question, to show the student the type of information that is being requested.

Two strong themes of these courses are those of managing change and of analysing social, environmental and economic aspects of a situation or problem. Many of the questions deal with change-management issues: identifying potential barriers to change, understanding mechanisms for change, developing arguments for and against a particular proposal, identifying who has the authority to drive change, influencing different stakeholders to implement changes, etc. Global societal responsibility is known to be an area where experts have conflicting views on everything from the approaches that should be taken to the viability of technical solutions: the MEQ should not simply be testing whether the student’s views are similar to that of the assessor.

In practice, the MEQ proved problematic in this context, not least because the time constraints weighed heavily against those for whom English is not the first language. Designing appropriate questions in MEQ form also posed some difficulties: trying to introduce sufficient complexity or ‘wickedness’ whilst keeping to a simple question format proved particularly difficult. For this series of units, the MEQ was subsequently replaced with an individual reflective report.

Individual reflective reports

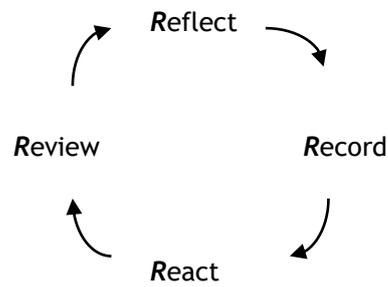
The idea of ‘reflective practice’ is that students should constantly think about what they are doing, analyse the results of their practice and learn from this in order to perform better in future. Building

this into a report enables the assessor to gain insights into the development of the individual, particularly in the area of skills.

David Boud, Rosemary Keogh and David Walker (1985) see reflection and learning almost as two sides of the same coin and suggest that there is much reflection in any process of learning, but we do not always recognise it as such. They make three key points about this interaction:

- Only learners themselves can learn and only they can reflect on their own experiences. Teachers can assist with the process but they only receive what learners choose to reveal;
- Reflection is a purposive and purposeful activity. Reverie and meditation may help in the process but are not, themselves, goal-directed critical reflection;
- The reflective process is one in which cognition and feelings inter-relate and interact. Negative feelings can raise barriers and distort perception, whereas positive feelings can enhance the process and provide motivation.

Tomkinson and Warner (1997) propose a four-stage cycle for reflective reports:



'The whole process here is one of reflection but the *Reflecting* stage involves preliminary thinking about aims and objectives; the reflective practitioner approach comes in the *Recording* of events and feelings, of *Reactions* to them and in *Reviewing* the success of the reaction.'

In this context, the reflective report is intended both to assist the student learning and also to act as a source of data for the purposes of assessment. Appendix C gives typical guidance for the compilation of the report and Table C1 gives the structure of the assessment. In some cases students have been given additional 'scaffolding' to help them through the process – this takes the form of weekly diary sheets with prompts about what might be included. It should be noted that assessment here is much about "process" as about "content" and thus account is taken of the individuals' perceptions of how they have contributed to the group as a whole and how they have managed their own team-working skills.

Group project reports

Appendix B gives an example of a typical project brief. The nature of the report required would vary across the, typically, four scenarios and could involve an oral presentation as well as a written one. Group numbers have tended to vary between five and nine but have typically featured eight students, drawn from a variety of nationalities and academic backgrounds. The group project reports are intended to test the students' grasp of the subject matter as well as their communication skills and are designed to increase in complexity as the semester progresses. The design is intended to use feedback from each scenario as a means of learning and the scenarios are designed to cumulatively increase the students' knowledge. For this reason, only the final two project reports are awarded a mark, though students frequently ask for marks for the earlier reports as well as the

descriptive feedback. An example of the feedback is given at Appendix E; this relates to a report on an earlier version of the scenario given in Appendix B. This scenario was the first in the series. In some instances the students have been given indicative grades (not an individual mark but perhaps an indication of the mark range) when they have insisted upon it but, in general, it is not thought conducive to good education for the students to focus upon the marks awarded. Projects were intended to be structured so that they incorporated elements from a three-dimensional matrix but in practice it was found too unwieldy to try to cover all of the elements in a single course unit.

Each scenario has different learning points, but the generic criteria for assessing the group projects include:

- *Response to the brief:* Is this an appropriate answer to the question? Is it in the right form? Does it address the right audience? [10-15%]
- *Relevance:* Does this correctly identify the appropriate stakeholders? Does it correctly identify their needs? [15-20%]
- *Background review and references:* Is the literature search carried out rigorously? Is the selection of citations appropriate? Are they properly referenced? [20-25%]
- *Critical analysis and conclusions:* Is the analysis logical and accurate? Is the approach appropriate to the question? Does the proposed answer flow logically from the analysis? [30-40%]
- *Presentation:* Is the output appropriately structured and set out? Is appropriate use made of diagrams and illustrations? Is the presentation clear? [10-20%]

These do not have equal weighting and additional criteria may be applied that are specific to the task.

The overall mark for the piece of work is a mark the group as a whole. To obtain an individual mark the group mark is multiplied by a factor derived from the peer assessment exercise.

Peer assessment

During the first year of running this type of module the peer assessment score was calculated as an independent figure but this could be subject to abuse so thereafter the peer assessment score has been transformed into a multiplier to be applied to the group scores included in the summative assessment (a weighted average of the scores for the final two exercises). The peer assessment is undertaken twice: first in the middle of the semester, for formative purposes and then at the end of the semester for summative purposes. The attributes included are:

- Attended regularly and on time
- Contributed actively to the group discussions
- Gathered appropriate ideas and information
- Helped to shape ideas and analyse information to develop an appropriate solution
- Helped the group to reach decisions by summarising ideas and information
- Contributed to the structure and design of the report
- Contributed to the writing of the report
- Helped to keep the group focussed on the task
- Made sure the views of everyone were included
- Helped to identify and resolve potential conflicts in the group.

These attributes are linked to the learning outcomes set for the course unit and this is exemplified in Table 2. The learning outcomes referred to are undergraduate ones in the central column (Appendix A gives postgraduate ones) where category A outcomes are for knowledge and understanding;

category B outcomes are for intellectual skills; category C outcomes are for practical skills and category D outcomes transferable skills and personal qualities.

Initially the exercise was undertaken on paper – one sheet for each of the other members of the group – but latterly the exercise has been undertaken electronically. Again, initially the choice was to give a score of +1, 0 or -1 for each attribute but the electronic version allows for scores of +2, +1, 0, -1 or -2 for each attribute. The scores are then summed and averaged and adjusted so that the average score for each group is unity. This means that, if there were collusion between all of the members of the group to give one another maximum scores, then each member would still only receive a multiplier of 1. The scores are also adjusted to ensure that the range of multipliers is limited to a minimum of 0.7 to a maximum of 1.3.

Table 2 Links between peer assessment attributes and learning outcomes

Attribute	Outcome	
	<i>Undergraduate</i>	<i>P/g</i>
Attended regularly and on time	A5 Demonstrate understanding of the importance of professional ethics and stakeholder engagement.	G1.3
Contributed actively to the group discussions	D3 Work with others as a member of a multidisciplinary team.	G4.2
Gathered appropriate ideas and information	D3 Work with others as a member of a multidisciplinary team; D4 Develop, structure and communicate ideas and proposals.	G4.2 G4.1
Helped to shape ideas and analyse information to develop an appropriate solution	D3 Work with others as a member of a multidisciplinary team.	G4.2
Helped the group to reach decisions by summarising ideas and information	D3 Work with others as a member of a multidisciplinary team; D4 Develop, structure and communicate ideas and proposals.	G4.2 G4.1
Contributed to the structure and design of the report	D4 Develop, structure and communicate ideas and proposals.	G4.1
Contributed to the writing of the report	D4 Develop, structure and communicate ideas and proposals.	G4.1
Helped to keep the group focussed on the task	D3 Work with others as a member of a multidisciplinary team.	G4.2
Made sure the views of everyone were included	A5 Demonstrate understanding of the importance of professional ethics and stakeholder engagement; D3 Work with others as a member of a multidisciplinary team	G1.3 G4.2
Helped to identify and resolve potential conflicts in the group	A5 Demonstrate understanding of the importance of professional ethics and stakeholder engagement; D3 Work with others as a member of a multidisciplinary team	G1.3 G4.2

Student feedback was monitored through a variety of means (see below), including the use of nominal groups: the peer assessment process did not appear in the feedback in either a positive or negative regard.

Evaluation

There are two different aspects of evaluation in this case study: the ongoing evaluation of course units and the initial evaluation undertaken of a new unit with a new approach. These two necessarily overlap.

Project evaluation

This series of course units started out as a project sponsored by the UK Royal Academy of Engineering (Tomkinson B, 2008). As part of that study a number of evaluations were conducted. The key questions to be answered, for this purpose, were:

- *Acceptability*: Was the educational initiative acceptable to all who have been involved?
- *Effectiveness*: To what extent have the aims and goals of the intervention been achieved?
- *Efficiency / Sustainability*: How costly has it been in terms of individual and corporate effort, time, facilities and resources (material and human)?

To test the first and, to a limited extent, the third of these, one of the key approaches taken was that of the Nominal Group technique (see Appendix F). The overall results suggest that there was unanimity, particularly at the end of the course, about the value of interdisciplinary working. Group collaboration featured in most of the group responses. Course content also featured in the top three positive aspects, occurring in half of the groups. The variety and nature of assessment featured positively at the end of semester but not at all in mid-semester, although the learning approach and feedback were both mentioned. On the less positive side, timetabling issues featured prominently. These varied from difficulties of trying to get together students from different programmes to lack of enthusiasm for 9 am starts! Timing of assessments (both formative and summative) featured, particularly where this conflicted with major pieces of work for other course units, and also the timing of the weekly two-hour sessions. A concern for a lack of contact with other groups in mid-semester disappeared by the end of the semester, and gave way to the noise of other groups, working in nearby areas! One of the minor negative aspects expressed by the students was the number of evaluation questionnaires.

To test the second question, a number of evaluation questionnaires were used. These were applied at the beginning and end of the unit. The intention was to look particularly at three areas: students' own perceptions of their competence in a number of relevant areas; changes in the way in which students approached their own learning and changes in the students' understanding of collaborative working. The self-perception questionnaire (Appendix G) was devised in the university's School of Education and the results showed a demonstrable improvement in perception of skills in relation to the learning, over the course of the course unit. The Approaches to Studying questionnaire was based on the ETL Project (2005), Shortened Experiences of Teaching and Learning Questionnaire. The SETL questionnaire showed significant increases in deep learning (from an average of 3.80 to an average of 4.18), and commensurate decreases in surface learning (from an average of 2.28 to an average of 2.02). The Approaches to Studying II questionnaire was based on the Readiness for Inter-Professional Learning questionnaire (Mattick and Bligh, 2006), modified for the wider inter-professional context. This failed to show any significant differences in pre- and post- scores but this may be due to the high levels of scores attained (an average of 4.40, rising to 4.53, on factor I and an average of 4.54, rising to 4.58, on factor II).

A subsequent project (Bessant et al, 2013) focussed on issues of whether this approach could be adapted to online working, at least in part, and re-examined some of the evaluation questions, including student self-perceptions. This suggested that students felt that their skills had been enhanced as a result of this type of unit, as well as their understanding of the issues, and that it had improved their chances of gaining employment. A later study (Hill et al, 2013) surveyed graduates of one of the units involved two years after leaving and taking up employment. This found significant perceived gains in eight employability skills as a result of the unit. The results were weighted according to their perceived importance to the roles now undertaken by the respondents.

Table 3 Perceived increase in skills as a result of taking this unit

Skill area	Percentage of respondents indicating an increase in skill
Communicating and working with others using online technology	79%
Communicating your point of view to a wider audience, e.g. oral presentations	90%
Effective discussion and negotiation within a team	94%
Listening to others opinions and respecting people's differences during group work	80%
Problem solving when presented with a task	97%
Reflecting on what you have learnt and applying new knowledge and skills to other situations	100%
Researching around a topic or issue	97%
Working in a team on a group task	100%

Project monitoring

The project team, including the facilitators, held weekly meetings after each class to monitor the progress of the course unit, noting what was more successful and what less so and remedying any identified deficiencies. Immediate changes made through this process were small but some fed through to the subsequent iterations of the course unit.

Routine evaluation

The Nominal Group Process is still in use as the main vehicle for student feedback. The unit is subject to the University's Student Satisfaction Questionnaire but this has proved problematic. Students complete the questionnaire online at the end of semester and the results are collated centrally. The results of this exercise have been positive but not particularly good and this is due largely to the design and analysis of the questionnaire. The core problem is that the questionnaire is designed for classes where most of the teaching is done didactically in a lecture theatre, possibly supplemented with small group tutorials or workshops connected to the lectures. This means that students are faced, for example, with questions about the use of visual aids and the lecturer's delivery that are irrelevant to this approach to learning and which pose problems for students trying to respond to a standard questionnaire. The responses to a few of the individual questions can produce some valuable feedback but the tendency has been to treat the Likert-type scales as having cardinal value and to inappropriately average these scores across all questions. Individual responses

that were found to be particularly positive were that 100% of students agreed, or mostly agreed, that the “skills developed in the unit would be valuable” and that the “exercises were helpful for learning the topics”; 96% of students agreed, or mostly agreed, that the “material studied was intellectually stimulating”, that “teaching and support staff were readily approachable” and that “teaching staff were helpful and willing to answer questions”. Some unsolicited student comments are also reproduced in Table 4.

Table 4 Student comments on their experience

- This unit gave me the opportunity not only to learn new things, but to apply this knowledge in a dynamic way." "I have learned a new an effective way of tackling problems."
- "My preconceptions regarding sustainable development included assumptions that it was relatively easy to implement wherever it is needed. This course has shown me that this is not the case."
- "I have learnt how big an impact sustainable development can have on the world and how far reaching it is".
- "Some group members were pretty quiet to begin with but as the discussion progressed, so did everyone’s contributions."
- "The biggest change is making sure we understand the task completely and what the objective is before undertaking it".
- "It is obvious to me that the more I contributed effectively to the team, the higher the level of confidence the team had in me".
- "My advice: Praise your team members. Do not presume to know the strengths and weaknesses of someone from a different discipline or culture".
- "In this module, I have learned how to learn".

UK universities appoint External Examiners, usually professors from other universities, to monitor every degree programme that they offer. In this case the course units have been in a number of different programmes and in every case the external examiners have either commended the unit or offered no comment. In some cases the unit has formed part of a programme that is externally validated by a professional body. Again, the validating authorities have either commended the unit or offered no comment. For the project, the Royal Academy of Engineering appointed an external adviser who was initially very sceptical of the course unit. However, after attending some of the sessions and reviewing some of the evaluation, this individual expressed satisfaction with the unit and suggested that the students had developed a degree of maturity in understanding that he would normally expect from graduates with two or three years’ work experience.

Conclusions

Meaningful assessment and evaluation, relevant to innovative learning, are of necessity both problematic and also likely to be viewed with some suspicion. All stakeholders have to view the processes and results with at least some measure of confidence. In order to develop ‘buy-in’ the initial project set up a number of teams including senior staff from within and beyond the university. Details of this are given in the Appendices to the Royal Academy of Engineering report (Tomkinson

B, 2008). Throughout the various iterations of this series of units, careful attention has been paid to feedback from all of those involved – staff, students and facilitators. This has enabled units run in different contexts each to develop their own character, but building on the successes of other units.

Assessment and evaluation are important elements of any curriculum but, where the intention is to develop innovative approaches in order to meet global challenges, then there is a need to consider and develop creative, transparent, perhaps complex, methods of assessment and evaluation.

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Learning Outcome	Students should be able to:	Assessed by	Delivered through
Knowledge and Understanding			
G1.1: Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics.	Demonstrate understanding of key aspects of humanitarian aid, including stakeholder engagement and analysing social, environmental, economic and ethical considerations.	Group project report	Group project
G1.2: Appreciate the wider multidisciplinary engineering context and its underlying principles.	Demonstrate knowledge of major aspects of change management and means of overcoming barriers to change.	Group project report. Individual reflective report	Group project
G1.3: Appreciate the social, environmental, ethical, economic and commercial considerations affecting the exercise of their engineering judgement.	Demonstrate understanding of how professional activities interact with society and the environment, locally and globally, in order to identify challenges, potential risks, impacts and possible solutions to problems.	Group project report. Individual reflective report	Group project
Intellectual Abilities			
G2.1: Apply appropriate quantitative science and engineering tools to the analysis of problems.	Apply a holistic and systemic approach to investigating complex, "messy" problems.	Group project report	Group project
G2.2: Demonstrate creative and innovative ability in the synthesis of solutions and in formulating designs.	Use problem solving skills in examining complex, multi-criteria, issues that incorporate uncertainty and conflicts of interest.	Group project report. Individual reflective report	Group project
G2.3: Comprehend the broad picture and thus work with an appropriate level of detail.	Work across discipline boundaries in order to pursue goals.	Group project report. Individual reflective report	Group project

Practical Skills			
G3.1: Use basic fabrication, machining and measuring equipment	n/a	Group project report	Group project
G3.2: Design and conduct practical investigations in an effective and safe manner	Carry out and utilise Primary Research	Group project report	Group project. Individual research
G3.3: Use and develop engineering software for design, analysis and problem solving	n/a	Group project report	Group project
General Transferable Skills			
G4.1: Communicate information accurately and effectively	Develop, debate, structure and communicate ideas and proposals in writing, verbally in meetings and in presentation format. Develop strategies to work more effectively with those from different disciplinary, national or cultural backgrounds.	Individual reflective report	Group project
G4.2: Work as an effective member of an engineering team	Work collaboratively as a member of a multidisciplinary team, contributing to the development of effective team processes and effective team dynamics.	Individual reflective report	Group project
G4.3: Make effective use of general IT facilities for information management and retrieval	Demonstrate the ability to practise self-directed learning including: defining a problem, formulating questions to be explored, identifying relevant sources of information, critically appraising information, applying new knowledge and understanding, referencing accurately, justifying approaches and decisions, reflecting on their application and analysing what has been learned through the experience.	Group project report. Individual reflective report	Group project. Individual research
G4.4: Undertake independent learning as	Apply reflective practice to enable continuing self-improvement in a professional context.	Individual reflective report	Group project

the foundation for lifelong learning/CPD.			
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Appendix B

Example exercise

You are a team of 'facilitators', working with international aid agency *Building for Humanity*, which encourages collaboration between architects, builders and designers and the humanitarian world.

Background

The agency has been involved in a number of rebuilding projects in recent years – for example, in Kashmir, Indonesia and Haiti. Initial logistics was provided by the military and much was done to save lives by the simple provision of tents and tarpaulins, but longer-term assistance was required to help the population rebuild their communities and infrastructure, whilst providing medium-term solid shelter (transitional accommodation). The agency has been concerned with this latter step.

Task

As a multi-disciplinary team, your aim is to provide guidance for teams who may be called upon to work on transitional shelter in future disasters in any country. This is not essentially a design exercise, but the guidance needs to relate to

- Local community groups
- Local police and security forces
- Army and other military personnel
- Aid agencies and charities – both at organisational level and in the field
- Non-governmental organisations (UN, UNHCR, ICRC, etc.)
- Designers
- Manufacturers
- Other organisations (including health organisations and food charities)

...to enable the agency to develop a strategy to provide suitable transitional accommodation (housing, schools, clinics, etc). It is vitally important that all issues of sustainability are taken into account, and a realistic balance is achieved between emerging technologies and the constructional methodologies traditional in the area. Take account of potential transport difficulties, severe shortages of skilled labour and building expertise, as well as the availability of potentially suitable building materials. It is worthy of note, at this point, that many of the surviving buildings were of locally traditional construction. A pack of additional material about indigenous housing is given in support of this task.

You are to analyse possible alternative approaches and propose an environmentally sound and sustainable **strategy** for the construction of buildings, listed above. Achieve a realistic and workable balance between international aid and local skills and manpower. Make a reasoned proposal for a technological strategy which, if employed, would facilitate the creation of sustainable and safe buildings, and act as the building blocks of a longer-term rebuilding of communities. Present your analysis and proposals both as an A4 report of up to 1000 words together with a list of reference sources.

Reflective report structure (5000 words maximum)

Your Reflective Report must include the following components. (The word limit is 5000 words.)

- A short introductory paragraph, setting the scene, explaining why you chose the course-unit and what you hoped to achieve from it (100-300 words).
- Your reflections about your experiences undertaking each task. Guidance is given below on the topics that should form the basis of the reflective report. These, in general, will promote reflection on what has been learned from the experience and how your abilities have developed, both in terms of dealing with problems in the context of humanitarian aid and also in terms of professional skills. You should also refer to the assessment criteria in Appendix 'A'. Each individual, for each exercise, is expected to write 500 to 1000 words.
- A final conclusion (500 to 1000 words), developed from but not merely repeating your reflections on each task and each discussion. This should explore questions as described in the reflective writing prompts.

Prompt questions

The following list provides examples of questions you might ask yourself as a basis for reflection. Do not restrict yourself to considering only these questions - include others. Reflections should ideally flow from events you experience rather than from a pre-determined model.

Generic Questions

- What went well? Why was this? What didn't go well? Why was this?
- What have I learned about humanitarian aid from working on this task that would be relevant in a wider context or to other specific situations?
- What have I learned about enabling change and about overcoming barriers to change from working on this task?
- What have I learned about myself and my skills from working on this task?
- What have I learned about working as part of a team with other people?
- What have I learned about methods for efficient and effective group-working, communication and problem solving?
- What specific things have I learned about literature research and critical analysis of information sources?
- **ACTION POINTS:** What, with hindsight, could I have done differently? What specific actions will I aim to undertake in future as a result of reflecting on my experiences during this task? What was the outcome of implementing my previous action points?

Introduction: 100-300 words

- How would you describe yourself in 1 or 2 sentences?
- Why did you choose this course unit? What did you hope to achieve?
- What were your preconceptions about teamwork and humanitarian aid?

Task 1: 500-1000 words

This is your first experience of working in this team, so you will be getting to know each other as well as learning to apply this learning approach, supported by a facilitator.

- What did I learn about forming a new team?
- How much did I contribute to the discussions in general?
- How useful was my contribution to the progress of the task?

Task 2: 500-1000 words

By now the group should be getting into its stride and building upon the previous exercise. You are now ready to tackle a more complex problem, making use of your experience and lessons learned in the first task to improve your performance in this task. Pick up any more ideas about how the group works and also to reflect on how these will affect the way that you tackle issues in the future, and in your future professional career.

What did I learn about how to support successful team-working?

- How might I act differently in future to be more effective?
- What did I learn from discussing co-operative problem solving?
- What was my reaction to the feedback to Task 2 and what did I learn from it?

Did I: Provide factual information? Ask questions? Offer advice? Try to keep the group in harmony?

- What did I learn about finding appropriate information?

Task 3: 500-1000 words

By now the group should be comfortable with working together and have begun to understand individual strengths and use these to the best advantage. You will now have received feedback for the first two tasks, so it would be of benefit now to consider how the feedback has promoted the development of your abilities.

- What has changed in the way that I now approach the tasks that is different from the way I approached the task at the beginning of this unit? How do I use the feedback from the previous task to inform my future work?
- How do I now plan my work and the team's work to promote collaboration within the team and enhance individual contributions?
- What was my reaction to the feedback to Task 3 and what did I learn from it?
- How prepared do I feel to undertake the final task without the support of a Facilitator?

Task 4: 500-1000 words

In this final scenario you will have had the pressure of knowing that your group report counts more significantly towards your results and that you are relying on the contributions of your colleagues. You will also have faced the challenge of tackling an ill-defined problem.

- How has working in a multi-disciplinary team affected my view of problem-solving? What have I learned about working with individuals from other disciplines?
- How do I feel about the contributions that I have made to the group process and team dynamics?
- Looking back over the whole course-unit, how do I think that my knowledge and skills have developed? Where are my weak points? What am I going to do about them?
- What have I learned in terms of knowledge, skills, techniques or perceptions that may be of use in my future professional career?
- How has my understanding of processes of change and project management, towards humanitarian aid, developed over the course of this unit?

Conclusion: 500-1000 words

A final conclusion, developed from but not merely repeating your reflections on each task and each discussion. This should explore questions such as the following:

- How have your own abilities and professional skills developed and how do you intend to further build on these skills in the future?
- What have you learned about enabling change and humanitarian aid that could be applied to other situations or projects?
- How has your perception of project management changed as a result of considering this in a humanitarian context?
- What have you learned about how to research and critically analyse literature sources and practical problem solving?

- What have you learned about working in a team with people with different personalities, from different backgrounds and different academic disciplines?
- What are the key lessons you have learned during your experience in this course-unit; from your team, your tasks, your own contributions and feedback given? How do you intend to apply these lessons in your future endeavours?

FINAL CHECKLIST

You may wish to use this checklist to review your report before submission.

Structure:

- Have you checked that your spelling and grammar are correct?
- Have you included an introduction at the start and a final conclusion?
- Is your report divided up into paragraphs with subheadings where needed?
- Is everything that you have included relevant?
- Is the length close to what was asked for? (Don't exceed the 5000 word limit.)

Participation:

- Does it demonstrate that you have attended throughout the unit and reflected on activities each week, showing briefly how you personally contributed to your team's efforts?
- NOTE: missing one or two sessions due to illness/interviews is acceptable. Unexplained absences and missing multiple classes are not acceptable, and this will be picked up on in the assessment of your reflective report.

Describing your learning:

- Have you described what you have learned about change processes, humanitarian aid and professional skills from each exercise? It is useful to check your report against the assessment criteria to identify any gaps.
- Some points may seem very obvious (e.g. improving verbal and written communication, finding information or timekeeping) but that shouldn't stop you including them - you can't be given any credit if you don't about write these in to your report.

Team Processes and Dynamics

- Have you focused on the positives as well as the problems you encountered? You need to have identified actions to counter the difficulties you and your team have encountered, but you also need to have picked out what you all did that you feel went well and would therefore aim to repeat in future. Remember, you are not expected to be perfect at teamwork, especially at the start, but you need to show awareness of where you could, with hindsight, have handled situations differently. Remember to talk about the team, not just about yourself.
- If you want to refer to specific people in your team without revealing their identity, it is fine to refer to "Person 1" and "Person 2". This can help avoid confusion caused by just referring to "someone" in each case.
- The discussion week aims to help you in your reflections on group process – as well as reflecting on the discussions themselves, think about how decision making, managing differing views, enabling creativity, handling interdisciplinarity, etc, has been managed in each of the tasks you have tackled.

Reflective Practice and Action Points

- Did you apply: DESCRIPTION – ANALYSIS/JUDGEMENT – ACTION – FOLLOWUP? For every situation or aspect you analyse, you need to translate this into an action point: either it went well and you aim to repeat it, it went ok but you can improve on it, or it went badly and you need to take positive action to change it. This applies both to what you did, and to what your team did. What, with hindsight, could you have done differently in each case? It is fine to highlight where things went badly, showing that you recognise this and plan how you would tackle it differently in future.
- If you could go back and give yourself or your team three tips about what to do and what not to do, what would they be? You need to show how you and your team have consciously improved throughout the unit by applying the actions you've specified.

Table C 1 : Assessment of Reflective Report (40% Total Unit Mark)

	CRITERIA	(1) UNSATISFACTORY 0-5%	(2) SATISFACTORY 6-10%	(3) GOOD 11-15%	(4) EXCELLENT 16-20%
A	<p>Completeness and presentation of report</p> <p>Quality of reflective practice</p>	<p>Sections missing</p> <p>Incomprehensible</p> <p>No attempt to present in a logical order</p> <p>Poor reflective practice - no attempt at change in practice throughout unit</p>	<p>All sections present</p> <p>Understandable</p> <p>Some reflection - actions have been identified, resulting from appraisal of own behaviour, though these are not always followed through</p>	<p>Complete report</p> <p>Well written</p> <p>Good reflection throughout module, identifying actions resulting from appraisal of own behaviour and skills, and seeking to implement these. The results of making these changes are sometimes described.</p>	<p>Complete report</p> <p>Presented in clearly laid out sections with appropriate subheadings</p> <p>Has adopted a structured, reflective approach to own skills and learning needs, identifying areas for improvement, taking positive measures to enhance performance in these areas and then analysing the results of ongoing changes</p>
B	<p>Demonstrating comprehension of underlying learning points</p> <p>- Humanitarian aid</p> <p>- Enabling Change</p>	<p>Superficial view of exercises, with no understanding of wider implications</p> <p>(e.g. mechanisms for change, long term impacts or the need to balance social, engineering and economic concerns)</p>	<p>Has analysed the projects to grasp some of the wider implications.</p> <p>Describes some key learning points.</p>	<p>Has analysed the projects in depth and described the wider implications.</p> <p>Describes the key issues learned from each of the projects.</p>	<p>Has analysed the wider implications of all the exercises, fully grasped key learning points, considered how these could apply in other situations and related this to their own perspective and to project management.</p>
C	<p>Demonstrating development of self-directed learning skills</p> <p>- analysing problems</p> <p>- researching literature</p> <p>- evaluating sources, critical appraisal of information</p> <p>- accurate referencing</p>	<p>Oblivious to personal practice in self-directed learning.</p> <p>Has ignored the processes and professional skills involved in literature research, critical analysis and summarising and communicating information.</p>	<p>Has made some attempt to develop own skills in identifying questions, researching, analysing and citing sources of information and communicating findings to colleagues.</p>	<p>Has discussed how own skills in formulating questions for enquiry, researching, analysing, citing sources of information and communication have been proactively developed throughout the module.</p>	<p>Throughout the module, has appraised own skills in self-directed learning, identified areas for improvement and taken positive measures to enhance performance in all the areas listed.</p> <p>Has also been involved in developing the skills of colleagues in some of these areas.</p>

		(1)	(2)	(3)	(4)
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	CRITERIA	UNSATISFACTORY 0-5%	SATISFACTORY 6-10%	GOOD 11-15%	EXCELLENT 16-20%
D	<p>Awareness of and contribution to the team dynamics</p> <p>- team development throughout the course-unit</p> <p>- fostering good working relationships with team members, managing different personalities</p> <p>- working with colleagues of different culture, nationality or discipline</p>	<p>No comment on changes in team culture or morale.</p> <p>Oblivious to own impact of own behaviour on others in the team – passive team member.</p> <p>No comment on cultural or disciplinary differences or similarities.</p>	<p>Shows some sensitivity to changing group dynamics.</p> <p>Some awareness of impact of own behaviour on others in the team, though no attempt made to modify this in response to different situations or to promote harmony.</p> <p>Has recognised that individuals from different disciplines or cultures may have different points of view.</p>	<p>Shows understanding of group dynamics and of his or her contribution to changes</p> <p>Demonstrates awareness of different team roles, the need for group cohesion and of behaviours of self or others that promotes harmony and effective team-working.</p> <p>Some sensitivity to issues of working effectively with those from different cultural, national or disciplinary backgrounds.</p>	<p>Has reflected throughout unit on team dynamics and how and why they have changed.</p> <p>Clear awareness of different team roles. Has made effort specifically to promote harmony and effective team-working. Has identified and tackled any problems that arise in a positive way.</p> <p>Has analysed and commented on issues of working across disciplines, or with students from different nationality or culture, and how these have impacted on team-working.</p>
E	<p>Awareness and development of effective team processes</p> <p>- analysis of team processes (decision making, time management, communication, leadership, etc)</p> <p>- responsiveness to feedback and team review discussions</p>	<p>Oblivious to the mechanics of team processes</p> <p>Passive team member, not contributing to developing effective practices</p> <p>No comment on response to reviews or feedback</p>	<p>Has analysed some team processes and commented on their effectiveness.</p> <p>Superficial response to team reviews or external feedback</p>	<p>Has analysed team processes and how they have changed throughout the module.</p> <p>Active in attempting to develop effective team-working practices.</p> <p>Has understood and acted upon feedback from own team and external feedback.</p>	<p>Demonstrates awareness of the need for a structured approach to responding to process team issues.</p> <p>Active in attempting to develop effective team-working practices throughout the module.</p> <p>Has understood and acted upon feedback from team reviews, individual colleagues and from external sources.</p>

Appendix D

Scenario Design Matrices

The briefs for the project reports were initially intended to conform to a multi-dimensional matrix to ensure that the underpinning skills and engineering practice tasks were covered as well as a range of topics in sustainable development. The following matrices amplify these three dimensions.

Table D 1 Matrix of underpinning generic and technical skills

	Underpinning interpersonal and technical skills	(A) Business Sustainability Assessment Tools	(B) Increasing Water Supply vs Leak Reduction	(C) Electrical Waste (PCs)	(F) The Energy Debate (Nuclear vs Renewables)	(J) Ecohomes	(K) Information Sources - Controversial Topics	(N) SD in Graduate Careers	(Q) Transitional Shelters	(U) Climate Change Negotiation Exercise	(V) Sustainability Risk Assessment Investment
1	Understanding and working with risk, uncertainty, detriment and applying judgement		x		x	x	x		x	x	x
2	Divergent, rather than convergent, thinking			x		?			x		
3	Written communication, including information gathering and dissemination and minute-taking	x	x	x	x	x	x		x		
4	Oral communication and rapport-building, including debating, chairing meetings and consulting others	x	x	x	x	x	x		x	x	x
5	Understanding group processes and collaborating in diverse teams	x	x	x	x	x	x		x	x	x
6	Self and group awareness, knowing own limits, practising concern for others in team	x	x	x	x	x	x		x	x	
7	Self-reflection and critical evaluation				x		x	x		x	
8	Broader knowledge and awareness – global and societal			x		x	x	x	x	x	x

Table D 2 Matrix of tasks in Engineering Practice

	Tasks in Engineering Practice	(A) Business Sustainability Assessment Tools	(B) Increasing Water Supply vs Leak Reduction	(C) Electrical Waste (PCs)	(F) The Energy Debate (Nuclear vs Renewables)	(J) Ecohomes	(K) Information Sources for Controversial Topics	(N) SD in Graduate Careers	(Q) Transitional Shelters	(U) Climate Change Negotiation Exercise	(V) Sustainability Risk Assessment Investment
9	Problem definition			x	x	x	x		x		x
10	Identifying information needed	x	x	x	x	x	x	x	x		
11	Background research	x	x	x	x	x	x	x			
12	Criteria for determining optimal solution	x				x					x
13	Generation of options			x		?			x		x
14	Evaluation of options	x	x	x	x	x			x		x
15	Decision making	x	x		x				x	x	x
16	Action, implementation and facilitation									x	x
17	Review of outcomes	x	x	x	x	x	x	x	x	x	x

Table D 3 Matrix of chosen aspects of sustainable development

Aspects of Sustainable Development	(A) Business Sustainability Assessment Tools	(B) Increasing Water Supply vs Leak Reduction	(C) Electrical Waste (PCs)	(F) The Energy Debate (Nuclear vs Renewables)	(J) Ecohomes	(K) Information Sources for Controversial Topics	(N) SD in Graduate Careers	(Q) Transitional Shelters	(U) Climate Change Negotiation Exercise	(V) Sustainability Risk Assessment Investment
INTERCONNECTEDNESS										
i) Individual – Local - Global		x	x			x	x	x	x	x
ii) Social – Economic - Environmental	x	x	x	x	x	x		x	x	x
iii) Timescales: Past – Present – Future and Short-term – Long-term		x	x	x	x	x			x	x
iv) Company – Supply Chain - World	x		?		x	x	x			x
UNDERSTANDING MECHANISMS FOR CHANGE										
v) Regulation, Policy & Standards	x		x	?	x				x	x
vi) Economic Instruments & Cost-Benefit Analysis	x	x	x	x	x				x	x
vii) Culture & Attitude	x	x	?	x	x	x	x	x	x	x
viii) Innovation & Technology			x	x	x			x	x	
UNDERSTANDING SOCIETAL RESPONSIBILITY										
ix) Quality of Life & Human Needs		x	?				x	x	x	x
x) Individual and Cultural Values and Philosophies		x			x	x	x	x	x	
xi) Ethics, Morality and Respect	?					x	x	x		
xii) Citizenship: Diversity, Harmony, Empathy, Community & Congruence				x		?	x	x		
TRIGGERS FOR CHANGE										
xiii) Social Inequity, Poverty, Conflict & Human Suffering								x		x
xiv) Environmental Detriment & Harm to Ecosystems			x	x		x		x		x

The first of the full-length scenarios is aimed primarily at stakeholder analysis. Key points expected to be tackled in this assignment are: identifying all of the stakeholder groups— many of the stakeholders are listed but you are expected to think through this list and see if any group has been overlooked or any given too much prominence; understanding the roles of the different stakeholders and any potential conflicts between them and; identifying local cultural susceptibilities. In addition, there are issues of identifying appropriate local resources; identifying short, medium and long term outcomes and potential conflicts between these. Issues of location may also be important – do you rebuild *in situ* or move the settlement to a safer location? This may be asking rather a lot in a short report and another key learning point is that of critical understanding of what is important and what is less so, as well as the ability to write concisely. The key thing to bear in mind is that the report is expected to deal with strategy, not specifically with design, engineering or resource issues. Questions also arise as to whether to replace with traditional building methods or with more resilient designs. This is not a straightforward issue and may vary with type of disaster (eg earthquake, hurricane, flood) and from location to location. Another possible item for consideration is the re-use of construction debris (see Karunasena: 2011)¹. It is also important that the factors are well researched and that this is suitably documented through appropriate referencing.

This assignment is well organised and laid out, though at times the language is a little difficult to follow. The suggestion of using military forces in the early stages is an interesting one, particularly in post-conflict situations, but not always appropriate. You, rightly, point to the importance of involving the local community and sometimes it can be useful to involve them in clearance operations, not only because of their local knowledge but also to give them a sense of worth – a feeling that they can do things for themselves. The use of indigenous materials is key to rapid transition, even if subsequent rebuild proves to require greater imports of material. As you point out, technical assistance is probably a higher priority need from international aid agencies rather than buildings that may be out of character and which the local populace will disown. Sustainability is also an important issue and your idea of training the local community to be part of the rebuild will aid this: bringing in manpower and materials from other countries will not. There are issues of building in resilience (to storm, earthquake etc) but in many cases the local construction methods will have already taken account of this – the strategy may have been to cheaper building materials and methods, so that the buildings can readily be replaced, rather than very expensive modern techniques. Who is to say which is ‘right’? Overall this a good start to your studies, but you need a keener appreciation of the stakeholders involved and the potential conflicts between them. You see the local community as the heart of reconstruction, but how is this to be achieved in the face of government bureaucracies and aid agencies with different agenda? The references are generally appropriate but you need to consider a wider range of academic sources.

¹ Karunasena G (2011) ‘Sustainable Post-Disaster Waste Management: Construction and Demolition Debris’. In Amaratunga D and Haigh R *Post-Disaster Reconstruction of the Built Environment*. Chichester, Wiley-Blackwell.

This is described in more detail in Delbecq et al (1975) but the summary given here is that which was presented to facilitators and students in the early versions of the course unit.

The Aim:

Apart from gathering data for monitoring and evaluation, the educational aim is to foster abilities and skills for change management.

The Purpose:

1. To enable each participant to state her/his personal opinion.
2. To obtain a group judgement of priority rating of the opinions expressed by the individuals.

Process:

1. The cohort elects a Chair and a Scribe
2. Induction of Chair and Scribe who, in the absence of members of staff, will be responsible for the conduct of the NGP and the resulting report:
 - 2.1 The Chair explains the aims and rules of the NGP.
 - 2.2 Each participant will be given repeated opportunities to nominate a positive and a negative aspect of their experience (i.e. the pilot course unit)
 - 2.3 Each participant will be asked to write down up to three aspects which were so positive that they should be retained with minimal change; and up to three aspects which were so negative that they should be removed/replaced/ seriously amended.
 - 2.4 Only three minutes are to be used, in order to concentrate on what is uppermost in the participants' minds.
 - 2.5 Each participant will then be invited in turn to nominate **one** of her/his positive and **one** of her/his negative aspects;
 - (i) Each aspect should be stated in not more than **four** words – without any explanation and no justification; the aim is to gather as many views as possible in minimum time.
 - (ii) As the aspects are read out they are crossed out on the participants list and on the lists of other participants who have noted the some aspect(s).
 - (iii) As the aspects are nominated, the Scribe will enter them in the respective positive or negative column on the flip chart.
 - 2.6 The Chair invites the next participant to nominate her/his one positive and one negative aspect.
 - 2.7 When all participants have exhausted their three responses, the chair will ensure that each, very brief, positive and negative observation has been fully understood. Where there is doubt, the proposer of the observation is asked to illustrate the meaning, not to argue or defend the statement.
 - 2.8 Each observation is then judged by a show of hands, if judged very important. This will be recorded as the group's view of what is judged to be of major importance.

The programme aims to introduce you to the concept of Sustainable Development (SD) and its implications for business, the environment and corporate social responsibility. It will enable you to develop abilities and skills for assuming professional responsibilities in relation to SD.

This questionnaire explores your own perception of the confidence you have in carrying out various activities relevant to the programme. Try to be as honest as possible. This self-evaluation will not form any part of your formal assessment, but is there to help you to see how you have improved and to help us to evaluate how well we have helped you with your learning.

For each of the activities listed below, please indicate the level of confidence you have in your ability to carry out the activity by circling the appropriate rating from 1-5; this should take no longer than 5 minutes. Please circle the appropriate number on each line.

1=Completely sure I could NOT carry out this task effectively

2=Fairly sure I could NOT carry out this task effectively

3=Unsure whether I could carry out this task effectively

4=Fairly sure I could carry out this task effectively

5=Completely sure I could carry out this task effectively

1.	Explain the key challenges of SD as they relate to engineering and science practice	1	2	3	4	5
2.	Explain strategies for minimising adverse environmental and social impacts of projects	1	2	3	4	5
3.	Identify potential challenges, risks and consequences of how scientific and engineering work impacts upon society and the environment, locally	1	2	3	4	5
4.	Identify potential challenges, risks and consequences of how scientific and engineering work impacts upon society and the environment, globally	1	2	3	4	5
5.	Make use of major aspects of change management	1	2	3	4	5
6.	Show understanding of the importance of professional ethics and involving all interested parties	1	2	3	4	5
7.	Draw on knowledge from outside my discipline in pursuing SD goals in science/engineering practice.	1	2	3	4	5
8.	Use a holistic and systematic approach in exploring solutions to complex problems	1	2	3	4	5
9.	Identify relevant sources of information	1	2	3	4	5
10.	Critically appraise information	1	2	3	4	5
11.	Apply new SD knowledge and understanding	1	2	3	4	5
12.	Use problem solving skills to examine complex problems incorporating uncertainty and conflicts of interest	1	2	3	4	5
13.	Work with others as a member of an multi-disciplinary team	1	2	3	4	5
14.	Develop and structure ideas and proposals	1	2	3	4	5
15.	Communicate ideas and proposals effectively orally	1	2	3	4	5
16.	Communicate ideas and proposals effectively in writing	1	2	3	4	5

If you would like to add any comments, please do so below.