GENG5507 Risk Reliability and Safety unit – an overview for EA accreditation team and industry advisory panel members

The unit GENG5507 on Risk, Reliability and Safety is a core unit for engineers of all disciplines in UWA's Masters of Professional Engineering (MPE) program. It is a large enrolment unit of ~ 300 students and taught in both Semester 1 and 2. The unit is usually taken by students in their final (fifth) year of study.

The unit aims to provide a holistic an integrated overview of the theory and practice in the fields of risk, reliability and safety, to prepare our engineers for professional practice. The unit develops students' technical and statistical skills and covers the social and organisational contexts, extending the students' field of view beyond the technical to consider the customer and the organisation's needs. The unit is taught to all engineering disciplines in one class to reinforce the need for cross-discipline collaboration and accommodation of different stakeholders and perspectives in risk and safety management. The unit was developed by a team of academics from all the MPE disciplines (mechanical, civil, EE, process & chemical, mining and software) and a group of practicing engineers. It was launched in 2013.

Two parts to the unit – engineering and statistics

There are two parts to the unit. The engineering content focusses on the theory of risk, reliability and safety and its application to real engineering problems. The statistical section covers essential statistical and probability material to support the use of these quantitative tools in risk and reliability. These concepts include probability distributions, sampling distributions, inference techniques including confidence intervals and hypothesis testing, regression analysis, and tools for reliability and life testing. Risk subject matter, by its nature, is non-deterministic and as a result application of the concepts require interpretation, decisions are seldom clearly identified and often involve trade-offs. Given this context, a decision was made early in the development phase to teach this unit differently from traditional lectures and the engineering content is taught in a flipped learning mode. The aim being to give the students as much opportunity as possible to interact with experienced engineers, discuss issues, identify grey-areas, and practice decision making in an as near to real world environment using actual industry case studies. Risk and Safety decisions while grounded in engineering ideas have to be executed in a way that is acceptable to organisations and society.

Flipping the engineering part

In order to get to a point where students can hold an intelligent discussion about complex cases in risk, reliability and safety, they need to have an understanding of terms, concepts and tools in the area. There is a lot of theory in these three topic areas and if lecture time was dedicated to the delivery of material there would have been limited time in class for discussions. Traditionally these discussions have been done in tutorial classes but an absence of tutors with the necessary practical experience in risk, reliability and safety meant that this was not an option. The decision to use flipped learning was motivated by the desire to spend face to face time in class in peer-peer discussion and activities coordinated by academics with industry experience. It recognised that much of the theory could be delivered in pre-recorded lectures, videos and directed readings. Once they have engaged with the theory, the challenge is to develop an understanding of how they would apply the theory to real world situations. Some of the subject matter, for example safety tolerance and safety behaviour is very personal. Individuals will have different responses to the same situation. Getting students to both understand and reflect on their attitudes and values with respect to safety requires a more student-centred approach to learning. The flipped learning model accommodates this by providing opportunities for students to articulate their views to others within group discussions and then hear about others views in subsequent plenary sessions. The interactive weekly engineering workshops that have been such a feature of this unit have obviously been impacted by the current COVID situation. We have responded to this by providing face-to-face workshops when we have been allowed to do so, and for those who cannot attend, the workshops are recorded and we support any resulting discussions using the LMS on-line discussion boards.

Unit structure

There are five assessable learning outcomes for the unit. These are that the students are able to (1) use appropriate tools to quantify risk and uncertainty; (2) select appropriate risk identification approaches; (3) use specific risk evaluation tools and models; (4) identify risk and safety controls; and (5) calculate standard reliability metrics.

The unit is divided into twelve teaching weeks. Each week covers a different engineering topic area in risk reliability and safety. Statistical and probability concepts required for each engineering topic are covered in weeks prior to that topic. In weeks 9 and 10 of the term the engineering cohort is broken into disciplines for two weeks of discipline-specific topics for mechanical, electrical, chemical/process, mining, software and civil engineering, each let by an industry expert.

What does a week look like for the students?

Prior to the start of each week the students are provided with a list of instructions for the material they must cover ahead of the engineering face to face workshop held weekly on Friday afternoon. The pre-work involves watch ~ 5 recordings, each about 10 minutes long, which covered the core content for the week. These recordings were usually a mix of PowerPoint presentations and videos, particularly about major engineering failures. In addition, they are sometimes asked to look at specific internet sites to find information on engineering standards and regulations, or to read articles. To encourage students to engage in this pre-work the students take an on-line multiple choice quiz. The questions are based on the content of the pre-work. Weekly engineering quizzes (N=8) contain ten questions. Their overall score in the engineering quiz questions is worth 15% of the final grade. There are 2-3 questions on each section of the pre-work to encourage the students to read each section of the prework and hence be prepared for the workshop discussions. Each engineering workshop is based on an industry case study, these have been specially written for this course and are used in the workshops and the final exam, a list of cases is in the Appendix. The Engineering workshop is structured so that the students are introduced to a problem/ situation and presented with a set of questions. These questions are discussed in small groups of 3-4. The facilitator then identifies groups to share their responses with the class. This provides opportunity for the students to practice discussing in their groups how they would address the problem and by listening to the responses the workshop facilitator can correct misconceptions and explore ambiguities. Attendance at the workshops is voluntary.

Each week there is a statistics lecture and small group tutorial. The statistics material is also assessed weekly (N=9) using an online multiple choice quiz of 10 questions that is worth 15% of the total mark. The material covered in the statistics is aimed at both ensuring the engineering cohort has retained a grasp of basic statistical concepts from earlier in their courses and build of these to introduce concepts specific to the reliability and risk disciplines. Every effort is made to make it clear to the students how the application of these statistical methods inform engineering decisions and to apply these methods to real industry, rather than textbook, data.

Management of the unit

The unit has a core teaching team made of the two unit coordinators: Professor Melinda Hodkiewicz and A/P Gopalan Nair, and an all-important academic support professional (Gemma Wade). There has been a strong emphasis on developing processes to document and manage all parts of this unit. Gemma carries the load of managing the contracts to and payment for the externals and the student tutors, drafting the budget, updating the LMS system each semester, and dealing with all the students' questions about administration of the unit. The academics concentrate on developing and delivering the materials, engaging with the students both in class and in the discussion boards and keeping assessment novel and relevant. There is a large extended team of external experts who also contribute and have responsibility for specific workshops, please see table in the Appendix. We also have a small team of facilitators who run the statistics tutorials, these are selected based on their expertise with teaching and reliability-focussed statistics.

Assessment

In addition to the weekly quizzes (both engineering and statistical) there are two summative tests, a mid-term (1hr) and a final exam (2 hrs). Both exams are multiple-choice and prepared by the same two staff, an engineer and a statistician who prepare the weekly quizzes. The final exam is reviewed by a team of four external practicing engineers in the fields of risk, reliability and safety. It is based on a case study that changes every semester and requires the student to demonstrate application of the concepts and practices learned in the unit to the specific case study.

Appendix

Table 1 Case studies developed for and used in the unit

Case studies used in teaching	**Case studies written for exams**
Piper Alpha accident (W1)	Westralia fire
Google driverless car (W2)	BP Texas refinery
Tailings dam failure (W3)	Refinery PD pump failure
Design of an electronic telemetry system (W4)	GM Ignition switch
Ground engaging tool reliability (W5)	Varanus Island fire
Pump station maintenance (W7)	JAL 829J Lithium battery fire
Construction site HAZID (W8)	Hatfield rail disaster
Rio Tinto Incident Investigation (W11)	Takata air bag
Fukishima and BP Macondo (W12)	Dreamworld accident
Many different ones used by the 6 discipline specific lecturers in W9 and W10	Nimrod aircraft accident

Table 2 Information on the team members involved in delivering GENG5507

Workshop presenter and company	**Subject area in ENG5507, and starting date with us**	**About our team**
Gerry Burke CPEng, MIE Aust, CEng MICE, FIE, BSc (Hons) Civil Eng, MSc Fire Safety Engineering	W6 HAZID, 2013-	https://www.linkedin.com/in/gerry-burke-77131630/ Safety Engineer Risk Impact Pty Ltd
Professor Alastair Walker FR Eng, FI Mech E.	W9 and W10 Civil Engineering 2013-	https://www.linkedin.com/in/alastair-walker-5872a932/?originalSubdomain=au Engineering Consultant

Mark Mackenzie FIE Aust, CP Eng, Eng Exec, CMRP, CFAM	W9 and W10 Mechanical Engineering 2013-	https://www.linkedin.com/in/mark-mackenzie-96120820/ Executive Advisor GHD
Alex Atkins GAICD FIEAust, CPEng, EngExec, NER, FAusIMM(CP)	W9 and W10 Mining Engineering 2016-	https://www.linkedin.com/in/alexatkins/ Non-executive director (mining)
Dr. Chirag Sathe, PhD, MBA	W9 and W10 Electrical Engineering 2019-	https://www.linkedin.com/in/dr-chirag-sathe-59a69484/ Principal autonomy BHP
Gareth Topham	W9 and W10 Electrical Engineering 2019-	https://www.linkedin.com/in/gareth-topham-a576864/ Principal Advisor Functional Safety Rio Tinto
Professor Terry Woodings Bsc DipComp PhD FACS	W7 Software Engineering	https://research-repository.uwa.edu.au/en/persons/terry-woodings Retired Software developer
Dr Lisette Kanse MSc Industrial Safety Mgmt, MSc Industrial Engineering and MGMT Science, PhD in Human Performance MGMT.	Incident Investigation W10 2013-	https://www.linkedin.com/in/lisette-kanse/ UWA lecturer in Organisational Behaviour
Dr Brendan Graham	W9 and W10 Chemical Engineering 2013 -	https://research-repository.uwa.edu.au/en/persons/brendan-graham UWA Senior Lecturer in Chemical Engineering
Gemma Wade	Unit Administrator	https://www.linkedin.com/in/gemma-wade-75b569159/ Academic Services Officer and core team member
Dr. Gopalan Nair BSc, MSc, PhD	Unit coordinator All weeks 2013 -	https://research-repository.uwa.edu.au/en/persons/gopalan-nair UWA Senior Lecturer in Statistics
Scott Yates, BEng, MEng, MSc Reliability Engineering, CPE, CAMA	Alternate Unit coordinator for Engineering material. Teaches in S2 2015-	https://www.linkedin.com/in/swyates/ Adjunct Assoc. Professor UWA Manager Western Power
Professor Melinda Hodkiewicz FTSE, CEng, BA Hons (Oxon), PhD	Unit coordinator All weeks 2013 -	https://research-repository.uwa.edu.au/en/persons/melinda-hodkiewicz UWA Professor in Engineering and BHP Fellow for Engineering for Remote Operations