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Flipping the assessment model: Teaching and assessing 'things that matter'

Christopher Lilburne*, Paul Lant, Maureen Hassall
UQ R!SK Research Group
School of Chemical Engineering
Faculty of Engineering, Architecture and Information Technology
University of Queensland, Australia
*Presenter Email: christopher.lilburne@uqconnect.edu.au

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Abstract

At The University of Queensland's (UQ) School of Chemical Engineering we are developing and delivering courses about operational risk concepts and practices for undergraduate engineers with a view to preparing them for work in the 'real world.' The courses on offer begin with the foundations of risk management (based on ISO31000) and professional engineering practice (based on guidance from professional bodies such as the IChemE, Engineers Australia and relevant legislation). We then challenge the students to move from *knowing* the concepts towards *acting* as and *being* professional engineers by conducting a number of immersive learning experiences across a variety of risk areas: personal safety, process safety, environmental, social, supply chains, projects and contractors.

Effective assessment of student's *acting* and *being* has proven a challenge using traditional methods such as exams and assignments. Until recently, assessment has been a combination of group assignments, online quizzes, a final exam and an individual end-of-semester interview. Our observation has been that aside from the individual interview, students have little opportunity to demonstrate their individual understanding of the course concepts beyond simple recall of definitions and case studies.

This paper is a review of the 2018 iteration of the final year undergraduate course that is on offer at the University. Significant changes were made to how content was delivered and how students were assessed.

Introduction

Across all industries effective risk management programs are necessary, and in many cases legislated, to meet business objectives. Over the last 100 years much has changed in how risk management is carried out (e.g. Mannan, Chowdhury et al. 2012, Hassall 2015) and it is now well established that mature risk management capabilities can reduce undesirable consequences such as work place fatalities, provide a platform to capitalise on the upside of uncertainty (Hillson 2010) and deliver and overall competitive advantages (Ernst & Young 2013). However, major safety and other types of incidents continue to occur (Marsh Energy Practice 2016) and be repeated (e.g. Pyy and Ross 2003, Fishwick 2012, Gill 2013, Waite 2013, Fishwick 2014).

Humans are crucial to risk management and at an individual level, mastery is heavily reliant on professionals adopting risk-based thinking that leverages experience, individual and industry knowledge, as well as the appropriate theoretical concepts and approaches. Early-career professionals, such as engineering graduates, often lack the experience and skill needed to effectively identify, assess and manage the wide range of risks that impact their industry.

The courses on offer at UQ seek to address this gap and provide students with a base level of knowledge of risk concepts to help them perform more effectively as graduate engineers. This paper focuses on the undergraduate, fourth year course which is undertaken by students in the School of Chemical Engineering: "Impact and Risk in the Process Industries." The course scope is broad, aiming to teach both fundamentals and detailed content that extends beyond health, safety and environment and includes social licence to operate, emerging technology, regulatory compliance, data management, climate change impacts, supply chain disruptions, and reputational risk (Hassall and Lant 2017). The breadth of risk management on which the course is based is shown in Figure 1. Approximately 200 students currently take the course.

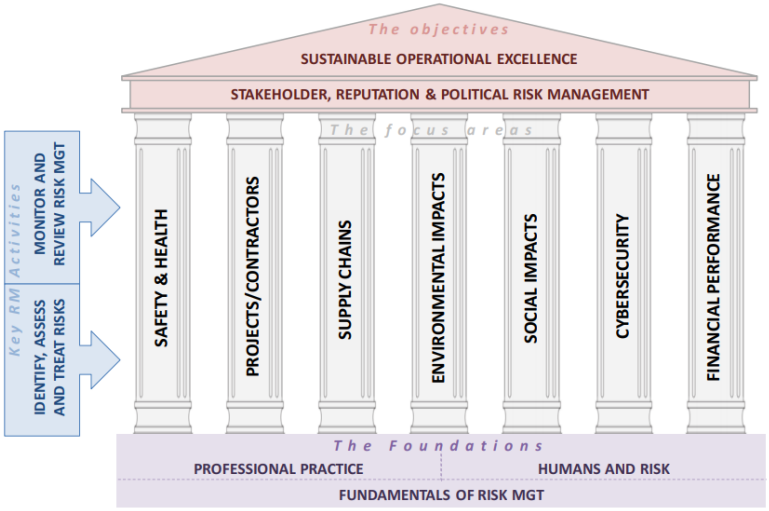

Figure 1 - The scope of risk management adapted from Hassall, Hannah et al. (2015)

The course

The course aims to help students understand, articulate and apply elements of risk management. The five course themes are shown below:

1. Understanding risks and their impacts – from technical, human, social, and environmental perspectives.
2. Professional engineering practice and risk – values, ethics, behaviour, accountabilities and obligations
3. Modern risk management approaches and tools
4. Humans and risk
5. Sustainability and risk

Importantly, the course seeks to push beyond the technical knowledge that the students already possess (shown in Figure 2) into a higher-level professional skill variously described as "phronesis & praxis", "acting and being" (Barnett and Coate 2005) or "hearts and hands" (Oliver and Dennison 2013). The higher-level, integrated thinking that is required from students is reflected in the 'pillar diagram,' which is referenced throughout the course (Figure 1) and the course learning activities (Table 1).

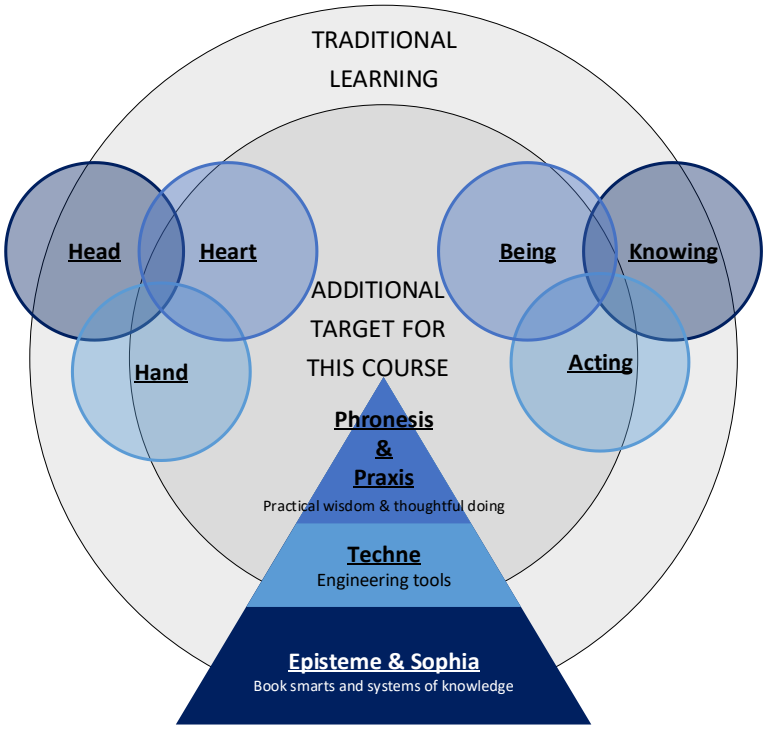

Figure 2 – Map of where course teaching and assessment methods are targeted

Table 1 - Course modules and learning activities adapted from Hassall and Lant (2017)

Modules	Key learning objectives
1. Fundamentals of risk management	What is risk and why is it so important? What types of risks are we considering? Risk, you and your decision making Understanding the risk management process (ISO31000) Understand risk identification and analysis theory and tools Understand and apply risk evaluation Selection and optimisation or risk controls and critical risk controls Management of controls – monitoring and review Communication and consultation
2. Professional practices	Understand what it means to be a professional engineer (ethics, competence and performance) Understand your own professional risk
3. Humans and risk	Understand the role that humans play in risk management in industry Understand that good engineering design is not just about preventing human error, it must also be about enabling successful human control Understand organisational safety cultures
4. Personal and process safety	Know the difference between personal and process safety Know the properties and classification of common workplace hazardous chemicals Know about some priority hazardous conditions that you are likely to encounter on manufacturing sites Discuss some of the major process incidents that have occurred and how they relate to personal and process safety
5. Risk review – event investigation	Use contemporary event investigation techniques which consider technical, human and organisational factors associated with incidents and unsuccessful events Consider how learnings can be integrated back into the business
6. Project risk	What is a project and what do we need to do to keep everyone safe? ALARP and HSE risk reduction in projects HAZID and HAZOP
7. Environmental risk	What does environmental risk look like? Legislation, regulation and the environmental impact assessment process Stakeholder analysis and management
8. Social risk	What does social risk look like? How are risks and opportunities identified and evaluated The social impact assessment process What is social licence to operate? Stakeholder analysis and management
9. Contractor and supply chain risk	What are supply chain risks and why do they matter? Understand contracting and the associated HSE risks Key activities in HSE contractor management

Focussed teaching methods

In the 2018 iteration of the course, contact time through formal lectures was significantly reduced although the modules and overall course content was retained (as per Table 1). Previously students attended a two-hour lecture (which included formal lectures, guest speakers and workshop-type activities) and a two-hour tutorial per week. In preparation for the 2018 course, transcribed lecture recordings were used to develop online, pre-recorded keynote lectures presented by the course coordinators, academic experts and guest lecturers. This process was resource intensive (100+ hours of work) however the outcome was a doubling of tutorial time i.e. time spent working in smaller groups collaborating and working with the teaching team. For example, in 2017, one tutorial session was used to cover all the incident investigation tools included in module 5 whereas in 2018 this was tripled to three sessions (which also allowed for time to work on assignments and ask questions). Figure 3 shows the differences between the 2017 and 2018 teaching activities.

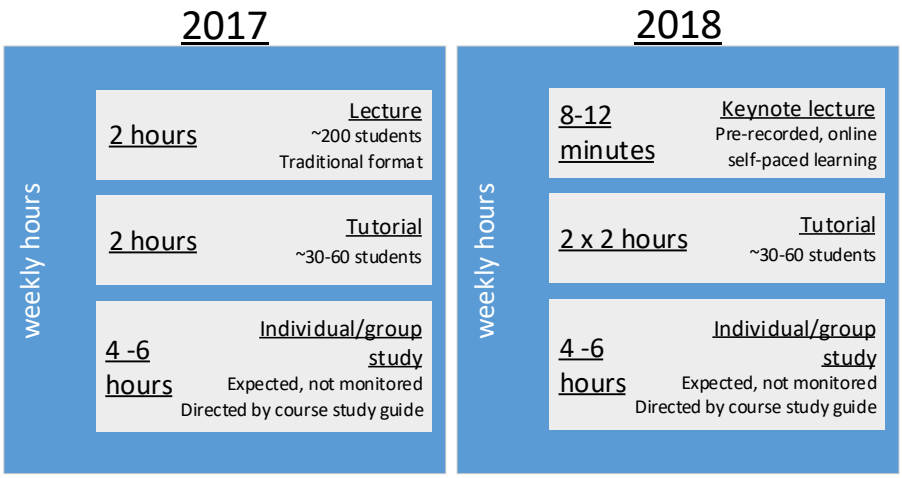

Figure 3 - Typically weekly learning activities (2017 compared to 2018)

Focussed assessment methods

As this course has evolved, the focus of the assessment has evolved from written assignments and an exam to the current model which comprises shorter technical submissions, two quizzes, and three oral exams. Figure 4 shows the differences in how the course is assessed - the oral exams now comprise 40% of the overall assessment. Since 2015, the course has used an end-of-semester oral exam to gauge student's understanding of the core course concepts. This one-on-one interview-based exam was originally introduced as a way to test critical thinking skills and how effectively students are able to apply concepts from the course. In 2018 the oral exam component of the course was nearly trebled and a group presentation was introduced. All the oral assessment, excluding the final interview is related to one of the three assignments and an average of 50% or more is needed in both of the individual oral assessments to pass the course. There are three key features built into the oral examination program designed to add transparency, robustness and integrity:

- All examiners (total of 12 in 2018) are qualified engineers with significant and current industry experience
- All interviews conducted by a single examiner are recorded

- A standard set of questions is used and interviews are marked using a standard marking rubric (which is given to students beforehand)
  The first and second oral exam are based on the written assignments which students produce in project teams of four students each. In the first written assignment (presented as a technical memorandum) students are required to conduct a risk assessment of a maintenance task and provide recommendations to site management. A short-technical report (with attachments) was chosen as the written deliverable to challenge students to prepare a synthesised summary of their findings and to mirror a more professional type of document. The technical memorandum also has the benefit that assessors can quickly read it in preparation for the interviews.
  In the first oral assessment, students are interviewed on their first assignment groups by two examiners. A half-hour group interview was chosen to ease the students into what might be an otherwise novel and intimidating process. The interview is framed around the students, having completed a risk assessment exercise, reporting their findings and being challenged by the client. The presentation and challenge process is useful in this instance as it allows the examiners to gauge how deeply the students have engaged with the task and to understand their thinking around ranking risks or designing recommendations. For this task, all members of groups were assigned the same grade although the written submission was subject to peer-review within groups.

  The second assignment requires students, in their groups to perform an incident investigation around an event related the scenario explored in assignment one – again the written component was presented as a technical memorandum. In the second, 15 minute, one-on-one interview students present their investigation findings and recommendations. They are challenged by the examiner on: how they came to their conclusions, the appropriateness of tools used and how investigation recommendations were prioritised. As with the first interview, this is a useful process to understand how well students understand the content and tools as well as how engaged they were with the task. Questions around strengths and limitations of different investigation techniques, priorities of recommendations, what are the ‘must-dos’ are useful to identify higher-level, critical thinking skills in students.
  The group presentations are framed around the third and final written assignment. The students, in their assignment groups prepare social impact management plans related to a proposed or actual project (e.g. carbon capture and storage or nuclear fuels transport). In the presentation they have 15 minutes to present their findings to an audience of stakeholders and respond to questions based on their presentation and written submission.

  Students take two quizzes through the semester to test their foundational knowledge of the course material however their overall knowledge of and engagement with the course is assessed in the final one-on-one interview. Students are asked to recall case studies covered during the course, describe one case study in detail and summarise the main learnings arising from it. They are also asked to synthesise other course topics with their chosen case study (such as describing the social risk aspects of the 2010 Macondo oil spill). To test their critical-thinking students are finally asked to describe how their overall learnings from the course might impact them when they work as graduates in industry or continue with further studies.

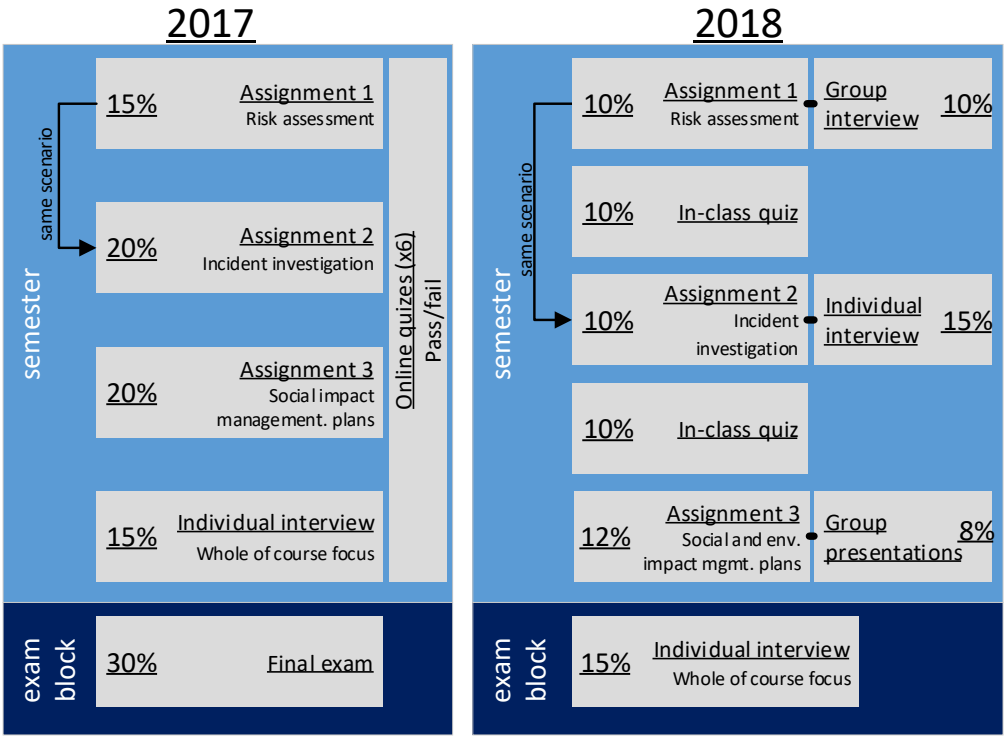

Figure 4 - Course assessment models (2017 compared to 2018)

Outcomes and discussion

In general, the new model of the course means a more costly product is delivered in terms of hours payed, number of people involved, complex logistics and the University facilities required. However, it is believed that more contact time in a tutorial setting and more effective assessment has led to a better overall outcome. From the authors' point of view the strengths, weaknesses, opportunities and threats around the changed teaching and assessment model are shown in Table 2.

A significant challenge has been gathering appropriate information to understand if the changes in the course have been effective from a student point of view. Informal feedback has been mixed but in general it seems students understand and accept the new assessment model without too much angst. At this stage, with the standard questions asked in the University's course evaluations, a detailed analysis has not yet been possible. More detail feedback and questioning will be put in place in the 2019 course to properly understand the impact of the changes.

Table 2 – Teaching and learning SWOT analysis of 2018 course delivery

Strengths	**Weaknesses**
Clearer focus on teaching and assessment activities in line with the targeted levels of knowledge (Figure 2) Increased 'time-on-task' i.e. small group tutorials led by experienced industry professionals Higher portion of teaching activities focused on helping students achieve a base level of expertise required of new professionals and masters level study (e.g. collaboration, workshopping, use of industry best practices) Higher portion of assessment activities aligned with the professional world (e.g. technical memoranda and interviews) allows identification of high and lower performers against course goals Greater focus on students' meaningful engagement with seminal case studies Online content provides a self-paced learning structure for students which easily be used for multiple iterations of the course	Learning objectives (particularly around professional practice and ethics) remain hard to clearly articulate and communicate to students i.e. hard to sign-post the course Resource intensive to develop, deliver and modify i.e. significant cost in terms of remuneration, coordination and room allocation Quality control in assessment may be an issue (real or perceived) due to high number of examiners with different backgrounds some of whom are not involved in delivering the course content Some students struggle in an interview scenario and outcomes may not reflect their knowledge e.g. English as a second language students Online lecture format makes incorporating guest speakers into the course a challenge Students can still be get a free ride in group work (though peer assessment helps identify 'passengers')
Opportunities	**Threats**
Expansion of risk, professional practice and ethics into other areas of curriculum and assessment is a significant opportunity Successful piloting of teaching and assessment format opens opportunities to expanded into different areas of the degree Opportunity to develop more online resources (e.g. videos of tools being used) – possibly shared across subjects, faculties and institutions Improved understanding of how students view the different methods of teaching and assessment via course more targeted surveys and feedback Sharing and feedback with other institutions offering similar subjects Continued integration of leading approaches (e.g. augmented reality) as well as further	Significant rework (and possibly cost) required if content becomes out-of-date or if course structure changed The non-conventional course content and structure means that the quality of the course is heavily reliant on existing staff and succession planning may be a challenge. Course content being taught and students being assessed by people without recognised competencies not experience in applying integrated risk-based optimisation approaches in process industry operations

exposure to real world environments and scenarios through field trips and practical learning	

Summary

This paper has provided an overview of the Risk and Impact in the Process Industries course taught to fourth year chemical engineering students at UQ. It has also described in some detail the assessment used to gauge the level to which students have learned about, and are adopting, risk-based thinking. Insights in the paper are based on some of the teaching team's (author's) observations and opinions. Further research is planned during the next iteration of the course to collect and assess students' perspectives on the course structure, teaching methods and how assessment is carried out.

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