Integrated natural hazard risk management: A two-week intensive course

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Abstract: Natural hazard risk is the result of complex interactions between hazard, exposure and vulnerability. These components of risk change over time due to a number of drivers, such as climate, population, demographics and economic development. Each of these components can also be targeted by a range of risk reduction strategies that generally have an impact over different timescales and are funded by different "actors". In addition, there is a range of social, environmental and political factors that determine which, if any, risk reduction strategies are actually implemented (Figure 1).

In this paper, we provide details of a two-week intensive summer course on Integrated Natural Hazard Risk Management, which gives students first-hand experience of the complex interactions outlined above via an immersive learning experience. This is achieved by adopting a project-centred approach utilising spatial modelling and visualisation of risk. In the first week of the course, students develop an integrated regional risk map for a specific geographical region, which they discuss in a report. Development of the map is supported by online lectures and structured GIS exercises that form components of the project, covering hazard intensity and likelihood (day 1), exposure, vulnerability and direct impact (day 2) and risk (day 3), leaving students to complete the report on days 4 and 5. In the second week, students develop an adaptive risk management plan for the same region, which they also discuss in a report. Development of the plan is supported by online lectures and structured GIS exercises that form components of the project covering plausible future changes in hazard, exposure, vulnerability and impact (day 6), and different risk reduction strategies on days 7 and 8, including land management, land use planning and asset hardening (day 7) and structural measures and resilience (day 8), leaving students to complete the report on days 9 and 10. At the completion of the 2-week intensive teaching period, students have 6 weeks to complete an additional major project on a natural hazard risk management problem of their choice.

The course was run for the first time in 2022 and student feedback was very positive, with average scores of 6.6 and 6.9 out of 7 for the question "this course helps me build my understanding of key concepts" for cohorts of undergraduate and postgraduate students, respectively.

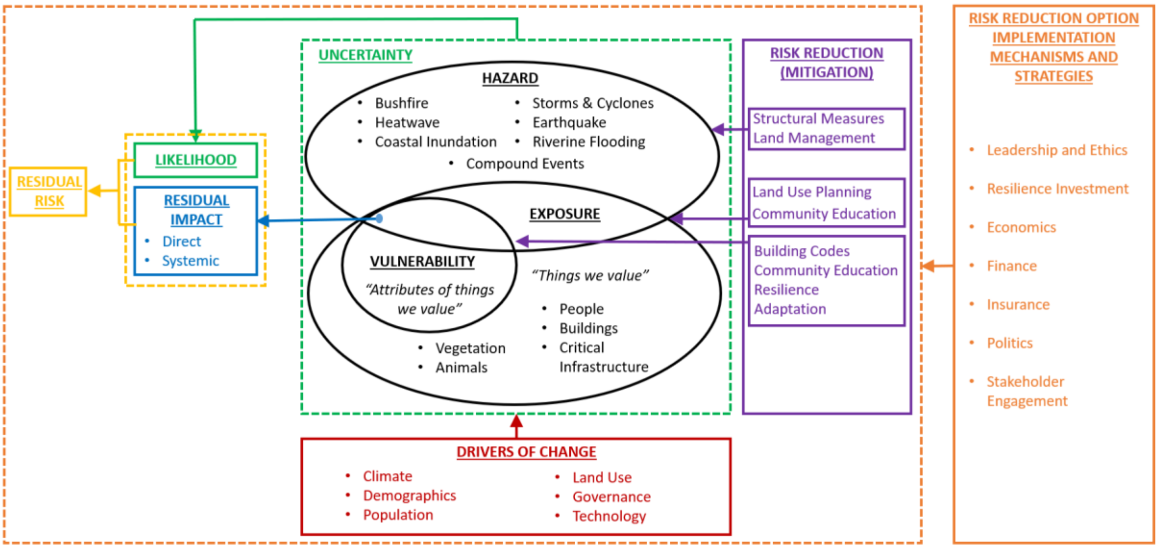


Figure 1. Overview of topics covered in the integrated natural hazard risk management course

Keywords: *Natural hazards, risk, mitigation, adaptation, resilience, teaching*

1. INTRODUCTION

As the impacts of natural hazards are becoming increasingly acute, there is a need to build capacity to better understand these risks and how to best mitigate them. In order to meet this growing need, a 2-week intensive summer course was developed as part of the Environmental Engineering degree at the University of Adelaide (https://www.adelaide.edu.au/course-outlines/109943/1/summer/). The course is offered to both undergraduate and postgraduate students and draws on the first author's experience as leader of the Economics and Strategic Decisions research cluster of the Bushfire and Natural Hazards Cooperative Research Centre from 2014 – 2021, as well as leader of a research project on Improved Decision Support for Natural Hazard Risk Reduction during the same period. The course was co-developed with a range of stakeholders from research, government and industry, both in terms of input on course design via an online survey and informal discussions, and in terms of their contributions to the course via pre-recorded online lectures (see Section 2.1).

2. COURSE OVERVIEW

The Integrated Natural Hazard Risk Management Course provides students with first-hand experience of the complex interactions between hazard, exposure and vulnerability, how they change over time, how they are affected by various risk reduction strategies and how likely they are adopted in practice (Figure 1) via an immersive, project-centred approach (e.g. Maier, 2008a). As shown in Figure 2, the project-based activities are nested, with daily, guided GIS modelling exercises feeding into weekly projects, culminating in a major project on a topic of choice. The daily GIS exercises are supplemented by daily online lectures providing relevant theory and context (e.g. Maier 2008b). Online lectures are also provided to guide students through the daily GIS exercises, enabling the course to be done either face-to-face, providing an intensive, community-based learning experience, or completely online, as students can work through the material at their own pace, therefore catering to remote students or people working in industry.

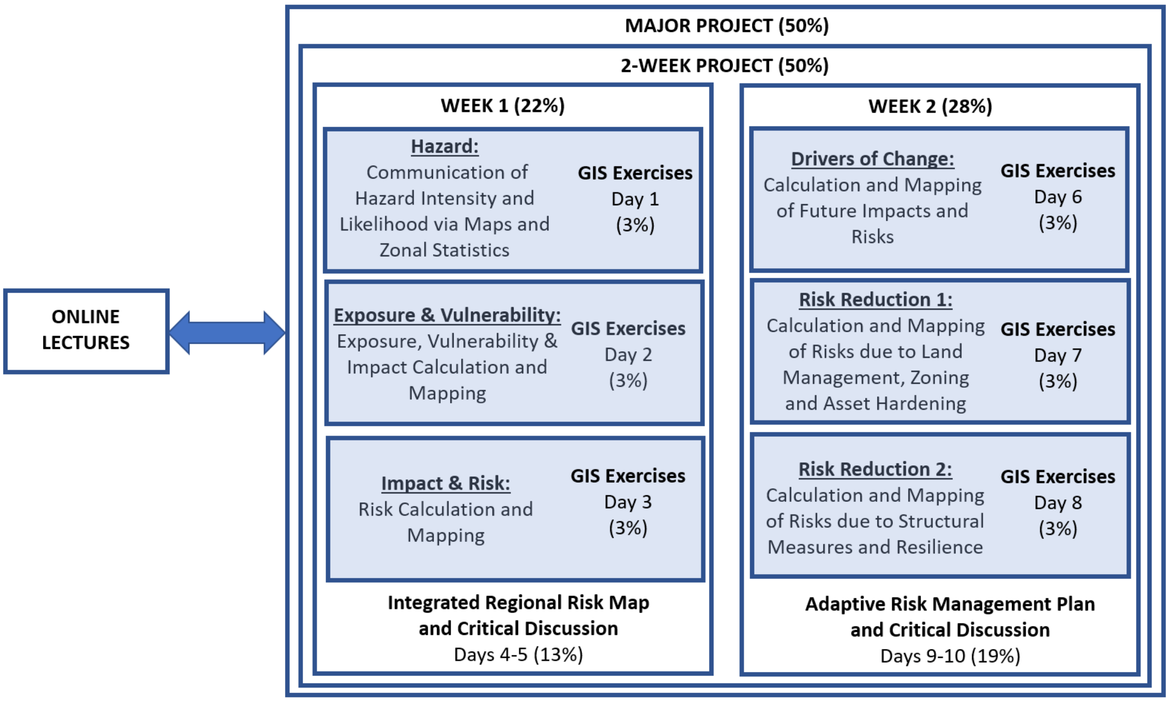


Figure 2. Overview of course activities, including online lectures and project-based activities, as well as the corresponding assessment weightings

2.1. Online lectures

The online lectures were recorded by national and international experts on different aspects of natural hazard risk management from a range of industry, government, research and university organisations (Figure 3). This provides variety from a student perspective and ensures that all information is relevant and presented with authority. The lectures are divided into six topics in accordance with the different elements of integrated risk management for natural hazards, as shown in Figure 1, including:

Figure 3. Organisations who contributed online lectures

- **Hazards:** Bushfire, heatwave, riverine flooding, coastal inundation and flooding, storms and cyclones, earthquake, compound disasters.
- **Exposure, Vulnerability and Impact:** Values, direct impacts on different things we value (people, buildings, electricity infrastructure, vegetation, animals), quantification of direct impacts and system-wide impacts (background and motivation, vulnerability, economic, household income, insurance affordability, case study (bushfire impact on water supply on Kangaroo Island)).
- **Uncertainty and Risk**: Risk paradigms and perspectives (overview, national emergency risk assessment guidelines, perspectives on bushfire risk), case study (regional flood risk assessment in South Australia).
- **Drivers of Change / Future Impact and Risk**: Climate change impacts (greenhouse effect, climate change, impact of climate change on building stock, impact of climate change on local government), quantification of future impacts and risks (integrated scenario modelling and decision support), case studies (future bushfire hotspots in Western Australia, future social vulnerability and bushfire risk in Adelaide, future coastal inundation and flooding in Port Adelaide).
- **Risk Reduction:** Risk ownership, risk reduction strategies that increase resistance (capacity) (system resilience, community resilience), risk reduction strategies that reduce load (stress) (structural measures, building codes, land use planning, land management), adaptation (adaptive pathways – theory and practical implementation), case studies (reduction of bushfire risk for electricity infrastructure, reduction of coastal flooding risk at Port Adelaide, reduction of asphalt road rutting risk due to heatwave, reduction in heatwave risk in London).
- **Risk Reduction Option Implementation Mechanisms and Strategies:** Transition theory, leadership and ethics, resilience investment, economics, finance, insurance, politics and advocacy, stakeholder engagement, case study (coastal inundation in Port Adelaide).

As mentioned previously, the above topics were determined in consultation with a range of stakeholders. It should be noted that the last topic (risk reduction option implementation mechanisms and strategies) was added to the initial course conceptualisation based on feedback from the online stakeholder survey. An example of a typical layout and format of the online lectures is given in Figure 4.

2.2. Projects

The course includes a project that students complete during the 2-week intensive phase of the course (2-week project, worth 50% of the course mark) and a project they complete in the 6-week period after completion of the 2-week intensive phase of the course (major project, worth 50% of the course mark) in their own time (Figure 2). The 2-week project is divided into two weekly submissions. The focus of the week-1 submission

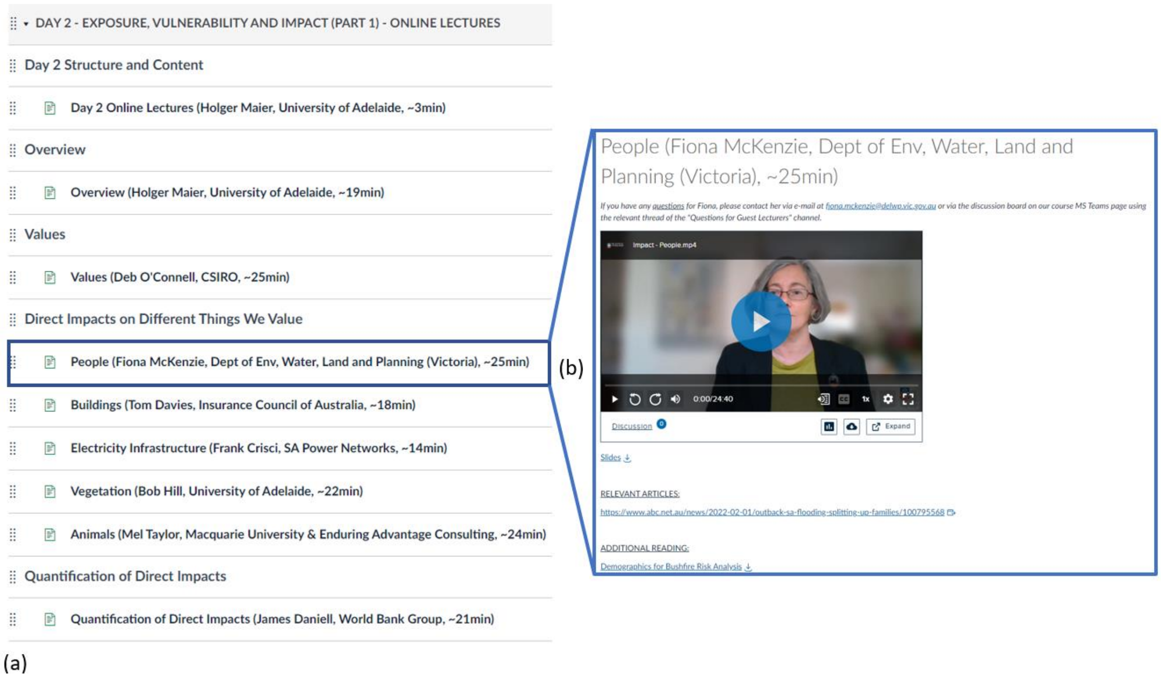


Figure 4. Typical details of layout and format of online lectures in the online learning management system including (a) structure of lectures on a particular topic and (b) structure of individual lecture

is on the development and critical discussion of an integrated regional risk map for Adelaide, South Australia. This integrates the first three of the six topics covered, including hazards, exposure & vulnerability and impact & risk. The focus of the week-2 submission is on the development and critical discussion of an adaptive risk management plan for Adelaide. This integrates the last three of the six topics covered, including drivers of change, risk reduction and risk reduction option implementation mechanisms and strategies (Figure 2). Despite the similar workload for both weekly submissions, the assessment of the week-2 submission is weighted slightly higher (19% compared with 13% for the week-1 submission). This is done to minimise the impact of any misinterpretation of the marking rubric, as students are able to incorporate any feedback on their week-1 submission into their week-2 submission.

To assist with the development of the knowledge and skills required to complete the 2-week project, students undertake structured GIS exercises on the first three days of each of the two weeks (i.e. Days 1-3, and Days 6-8), as depicted in Figure 2. These exercises generally align with the different topics covered in the course, as well as the corresponding online lectures (e.g. hazards on day 1 etc.), in addition to exposing students to different GIS functionalities and data sources in an applied context. Details of the GIS exercises are as follows:

- **Day 1 - Hazards:** Students import intensity and likelihood data for riverine flooding and bushfire hazards, add appropriate symbology, create map layouts and summarise hazard intensity and likelihood statistics for different statistical areas.
- **Day 2 - Exposure, Vulnerability and Impact:** Students import hazard data for coastal flooding, as well as corresponding land use, building stock and value-at-stake data and vulnerability curves, calculate direct damage to different types of building stock and produce a map layout to communicate the relationship between hazards, exposure, vulnerability and direct impact.
- **Day 3 - Risk:** Students calculate bushfire risk in $ using the Hazard-Exposure-Vulnerability paradigm and classify bushfire risk in accordance with the National Emergency Risk Assessment Guidelines (NERAG) into low, moderate, high, and extreme categories. In addition, students produce a map layout to communicate regional bushfire risk.
- **Day 6 - Future Impact:** Students apply the approach used on Day 2 to calculate direct damage to building stock for riverine flooding under current conditions, as well as future conditions, including changes to the flood hazard due to climate change, changes to building stock due to socio-economic development and a combination of both drivers. In addition, students produce a map layout to communicate how flood risk could change into the future.
- **Day 7 - Risk Reduction (Land Management, Land Use Planning and Asset Hardening):** Students quantify and compare the reduction in average annual damage to building stock due to bushfire as a

result of land use planning (zoning), which affects exposure, land management (planned burning – using the Prescribed Burning Atlas (http://prescribedburnatlas.science/)), which affects the hazard, and asset hardening (changing building codes), which affects vulnerability. In addition, students produce a map layout communicating the relative effectiveness of zoning in reducing bushfire risk.

- **Day 8 - Risk Reduction (Structural Measures and Resilience):** Students quantify and compare the reduction in average annual damage to building stock due to riverine flooding due to different structural measures affecting the hazard, including a dam and a floodway. In addition, they produce a map layout comparing flood damage with disaster resilience with the aid of the Australian Disaster Resilience Index (https://adri.bnhcrc.com.au).

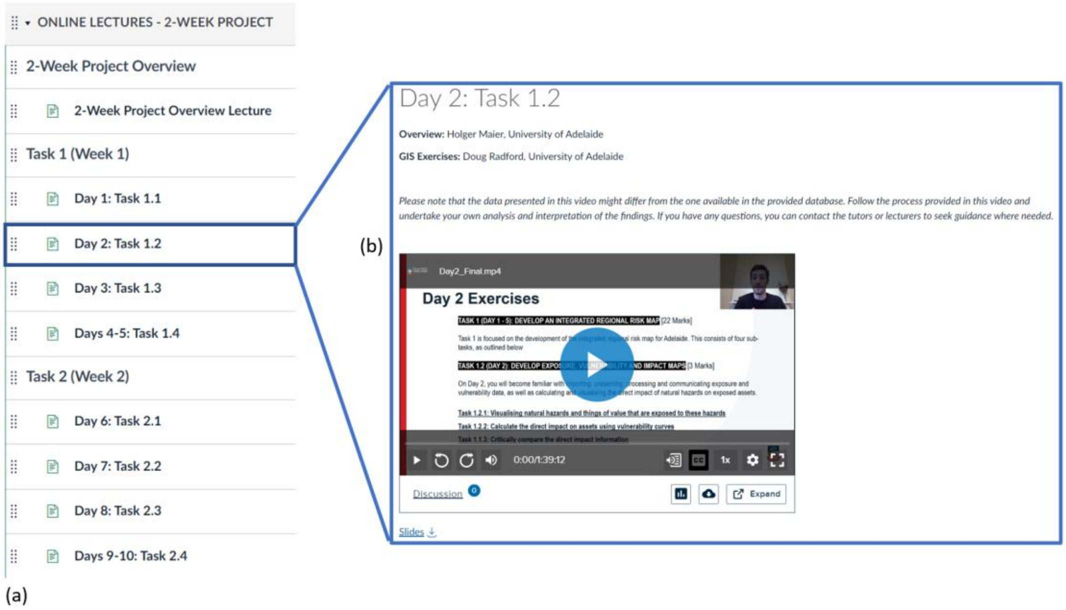
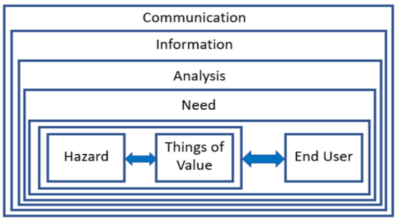


Figure 5. Typical details of layout and format of online lectures for the tasks associated with the 2-week project (a) structure of lectures and (b) structure of individual lecture.

Detailed assistance is provided to enable students to complete these exercises successfully, including detailed project briefs, online lectures (see Figure 5), online assistance via MS Teams and 5 hours of daily face-to-face interaction. One of these hours consists of a feedback / overview / Q&A session in which the previous day's task is reviewed, examples of good practice and innovation in the map layouts students submitted are highlighted, student queries are answered and a high-level overview of the current day's GIS exercises is provided to complement the recorded lectures on the topic. The remaining four hours provide an opportunity for students to work on the GIS modelling tasks in a computing suite, where they can interact as a group and seek assistance from the lecturers and tutors. Given the intensive nature of the course, the majority of students attend the computing sessions, enabling a community-of-practice to be established and significant social learning to occur. However, as mentioned previously, as all material is provided online, the course can also be taken remotely, which has been done successfully by a number of students.

On the last two days of each week during the 2-week intensive teaching period (i.e. Days 4 & 5 and 9 & 10), students combine and extend the analyses from the previous three days to enable them to develop and discuss their regional risk map (Days 4&5) and their adaptive risk management plan (Days 9&10). During these tasks, emphasis is placed on framing and answering a question for an end-user who has a specific need, as well as performing the requisite analysis and communicating the findings (Figure 6a). The marking rubric for these tasks is shown in Figure 6b, which is based on the SOLO (Structure of Observed Learning Outcomes) taxonomy (Biggs and Collis, 1982). As can be seen, a credit corresponds to a detailed critical discussion of the results, a distinction requires these results to be linked to information provided in the online lectures (Section 2.1) and a high distinction requires linking to relevant outside references to enable the wider relevance and generality of the results to be discussed.

At the completion of the 2-week intensive teaching period, students complete their major project in their own time over a 6-week period, which is worth 50% of the course mark (Figure 2). Students can select the topic for



(a)

	FAIL < 50%	PASS 50-64%	CREDIT 65-74%	DISTINCTION 75-84%	HIGH DISTINCTION 85-100%
Critical Analysis and Discussion	Brief or incomplete answers to some or all questions.	Detailed answers to all questions.	As Pass PLUS: Arguments and critical discussion supported by results from analysis.	As Credit PLUS: Use of information from online lectures to support arguments and critical discussion.	As Distinction PLUS: Use of external sources to support arguments and critical discussion.

(b)

Figure 6. Details of 2-week project, including (a) a conceptual representation of the structure and purpose of the project and (b) the rubric used to assess the critical analysis and discussion component of the submission, which are both the same for the week-1 and week-2 submissions

this project based on their interests. Successful completion of the project requires students to not only draw on and integrate the knowledge they have gained and the skills they have developed during the intensive teaching period, but to also formulate the problem and design the computational experiments needed to answer the question they have posed. Consequently, in addition to being assessed on their level of critical discussion (Figure 6), students are also assessed on their degree of initiative and originality, quality of problem formulation and quality of data, methodology and modelling.

3. STUDENT EXPERIENCE

The summary results of the Student Experience of Learning and Teaching surveys for the course the first year it was taught (2022) in terms of average student responses were captured on a 7-point Likert scale. As can be seen in Table 1, overall, students felt very positively about the course, with average scores ranging from 6.4-6.6 out of 7 for the undergraduate students and from 6.7 to 6.9 for the postgraduate students across a range of questions, covering the development of understanding, degree of intellectual stimulation, assessment, course organisation and overall satisfaction.

Table 1. Average student evaluation scores on a 7-point Likert scale

	Undergraduate Students	Postgraduate Students
This course helps me to build my understanding of key concepts	6.6	6.9
Overall, this course is intellectually stimulating	6.5	6.7
The assessment tasks in this course help me to learn	6.6	6.8
This course is well organised	6.4	6.7
Overall, I am satisfied with the quality of this course	6.6	6.9

The following student comments also highlight different elements of student satisfaction with the course:

"*The theoretical and practical components of this course were very well integrated and thought out. The lectures gave a good background on the concepts in the morning, and then this was solidified and made tangible by the afternoon GIS exercises. The extremely wide range of guest lecturers made this aspect of the course very engaging. Focusing on different hazards within the Adelaide area was also a great way to give context as well as making it more obvious what the different impacts of each hazards was. All the lecturers/tutors were extremely helpful and very willing to discuss concepts and processes one–on–one with students. This is definitely one of the best courses I have taken at the uni*!"

"*Overall, the course was inspiring and made me want to work hard on every project and improve upon the last one.*"

"*This course was really well constructed and on a topic that I was interested in and found extremely practical*."

"*This course has been one of the most enjoyable ones I have had at the university*."

"*Intensive summer school course offers lots of interaction and focus on relevant material to the course each day. Enjoyable experience using software and engineering skills*."

It was particularly pleasing to see that students felt that the theoretical and practical components were well integrated and that they valued the wide range of expert guest lecturers. It was also good to see that students could see the practical relevance of the course and that they were motivated to work on the projects. The fact that they found the course inspiring and enjoyable, and that the 2-week intensive format facilitated greater interaction, was also satisfying.

4. CONCLUSIONS

Understanding the risk natural hazards pose, how this could change into the future, and how this could be mitigated, is becoming increasingly important. However, this is not an easy task due to the complex interactions of a range of factors, the time lags between decisions and corresponding system responses, and uncertainty about risk ownership, to mention a few. In order to build capacity in this space, the 2-week intensive summer course Integrated Natural Hazard Risk Management was developed as part of the Environmental Engineering degree at the University of Adelaide.

The course provides students with an immersive, project-based learning experience that enables them to explore the different facets of natural hazard risk management, as well as the interactions between them, in an authentic learning context. The project-based work is scaffolded so that understanding of basic concepts is developed as part of structured GIS modelling exercises, which form the components of larger, more complex, problems, culminating in a major project on a topic of student choice.

The practical modelling work is accompanied by series of online lectures developed by a range of experts around Australia and the rest of the world, which enable students to make connections between their project experience and broader problem contexts, including a range of complexities and interactions that are difficult to quantify. We believe such a learning approach provides an example of how to build capacity in our ability to manage natural hazard risk in a way that engages students in their learning, which is likely to result in higher-order learning outcomes.

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