



RP2.3-07 Development, delivery and evaluation of public safety workshops and a serious game for engineers

Interim Report #2

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Development, delivery and evaluation of public safety workshops and a serious game for engineers

Authors:

Professor Jan Hayes (RMIT)
Professor Sarah Holdsworth (RMIT)
Dr Orana Sandri (RMIT)
Professor Sarah Maslen (University of Canberra)

Project team:

Researchers:

Professor Jan Hayes (RMIT)
Professor Sarah Holdsworth (RMIT)
Dr Orana Sandri (RMIT)
Professor Sarah Maslen (University of Canberra)
Irina Rus (RMIT University)
Professor Fabio Zambetta (RMIT University)

Industry advisory team:

Ted Metcalfe
Garry Sharp
Jennifer Ward (APA)
Susan Jaques (Sage)
James Czornohalan (Advisian)
Hugh Evans (Jemena)
Josh Wickham (GPA)



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Department of Industry,
Science and Resources

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Centres Program

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Research Provider	RMIT University
Project Leader and Team	Jan Hayes, Sarah Holdsworth, Orana Sandri, Irina Rus, Fabio Zambetta (all RMIT), Sarah Maslen (University of Canberra)
Industry Proponent and Advisor Team	Ted Metcalfe, Susan Jaques (Sage), Garry Sharp, James Czornohalan (Advisian), Jennifer Ward (APA), Huw Evans (Jemena), Josh Wickham (GPA)
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Summary of Report

The project builds on the learning framework developed under project RP2.3-03 to develop, deliver and evaluate two different types of professional learning experiences regarding system safety in future fuels. The two modes are face to face workshops exploring lessons from accident cases and a workshop simulating project decision making incorporating a serious game.

This interim report #2 describes the evaluation of the impact on professional practice of eight serious games workshops conducted in the period December 2023 to May 2024. Interim report #1 describing evaluation of the impact on professional practice of ten face to face workshops was issued in November 2023 and is available on the FFCRC website.

The learning objective of the workshops was:

To develop in pipeline engineers, capabilities to make decisions that reflect the paramount importance of public safety through the transition to future fuels and into the future.

The workshops were designed to allow pipeline engineers to reflect on non-technical aspects of their professional practice by playing a serious game in small groups and reflecting on the outcomes. The specific capabilities that the workshops are designed to develop are:

- Use long term, foresighted reasoning, especially in the face of uncertainty
- Understand norms and values that inform actions
- Think systematically and understand interconnectedness
- Collaborate with and draw on the experience of others
- Ground decisions in reality
- Advocate for action and take responsibility

Cases are used as the vehicle for learning, specifically role play decision cases grounded in everyday engineering choices linked to three threats to pipeline integrity (third party damage, flood and welding in service). The treatment of the cases in the workshops is grounded in theory of experiential learning.

Eighty one participants of a target 150 have participated in serious games workshops. Adding this to the 105 people trained in accident case workshops means that the project objective of training 150 people has been exceeded.

The success of the workshops in meeting the above learning objective was evaluated using Kirkpatrick's Training Evaluation Model which addresses participants reactions, participants learning and changes in participants' behaviour. To make this evaluation, data was collected by four methods:

- Evaluation scenario
- Survey
- Focus groups on the day of workshop delivery
- Post workshop interviews

The results are:

Level 1: Favourability, engagement and relevance of workshop

In focus groups and via surveys, participants reported high levels of engagement, enjoyment and relevance of the workshops.

Level 2: Evidence of the development of intended learning outcomes

This manifested in two ways. Firstly, participants were given a small decision making scenario linked to day to day engineering work and were asked to respond both before and after the session. The data shows evidence of increased use of relevant capabilities post workshop.

Secondly, in focus groups participants reflected on what they had learned in the sessions. Overall, substantial evidence indicates that deep learning reinforcing the capabilities was achieved through the workshops based on the opportunity to reflect, interact, discuss, and apply relevant real-life lessons to professional practice.

Level 3: Application of learning post workshop in work practice

Follow up interviews approximately three months after the workshops showed that many participants consciously applied their learning (to various degrees) to their work practice in ways that indicate the use of the intended capabilities. This includes further discussion of the cases and changes to or reinforcement of decision making practice.

Overall, the learning objective has been achieved.

Throughout the preparation and conduct of these workshops, participants were encouraged to consider the relevance of the lessons being learned in a 'future fuels' context, and Section 8 discusses their feedback and responses on that matter.

In Section 10, we compare the results of evaluation of the accident case workshops (described in Interim Report #1) with the evaluation of the serious games workshops described in this report. In summary, both training methods have been shown to be effective. Accident cases (especially presented in the form of role plays) are effective and popular for learning, particularly with more experienced engineers and the cases themselves are readily shareable with colleagues outside workshops. Having said that, game playing is very popular with early career engineers, particularly when they have more experienced colleagues to mentor their game choices. There are significant benefits to be had for the industry in continuing to use both training methods into the future.

As with the accident case workshops detailed in report #1, the results of the evaluation exercise will also be used to inform preparation of the final deliverables from this part of the research project. This is critical in order to be able to give this kind of scenario-based learning life beyond the end of the research project. The materials used by the research team will be formalised into a package including:

- Facilitator notes (including overall learning objective, skills required of facilitator, session running sheet, likely key topic areas emerging from discussion, participant arrangements)
- Guidance to ensure focus on 'future fuels' aspects of engineering decisions going forward.
- PPT files with complete speaking notes
- Other handouts

APGA has agreed in principle to act as hosts for the final deliverables from this project and to become responsible for ongoing delivery of training on a commercially viable basis to maximise the benefits to members who have funded this research and the wider pipeline and energy industries. Details are yet to be developed.

1 Introduction

The gas industry relies on the skills, motivation and attitudes of its engineers to make the best decisions which will ensure that the industry thrives through the transition to future fuels. The industry recognises the importance of competent engineers with the major effort put into the pipeline engineering competency program in recent years. Existing professional development activities focus on technical competence, but decision making also requires the ability to make the best choices in complex and uncertain situations. This broader set of skills and abilities, including non-technical aspects, is known as capabilities and is particularly important when it comes to making decisions in the best interests of public safety. The overall aim of the project is:

To develop in pipeline engineers, capabilities to make decisions that reflect the paramount importance of public safety through the transition to future fuels and into the future.

This work builds on the completed project *RP2.3-03 Case Based Learning Framework for Public Safety for Pipeline Engineers*. This past project developed a framework of non-technical skills required for excellence in engineering decision making. This project aims to develop, deliver and evaluate workshop-based learning using past failure cases and a ‘serious game’¹. It has links to the APGA document *Public Safety in the Pipeline Industry: An Engineering Practice Guide* which aims to support excellence in engineering practice (i.e., how work is done) when it comes to decisions, actions and behaviours that impact public safety.

There is an enduring question among safety researchers about how best to support learning in hazardous industry to prevent disasters. Despite the industry and regulatory focus on learning lessons after major crises, investigations find the same causal factors again and again (Quinlan, 2014). A common learning strategy following a crisis is to embed lessons in procedures and standards (Hale et al., 2007). While rules are critical for safety management, they do not capture knowledge in its entirety (Maslen & Hayes, 2016). When it comes to learning how to do one’s job, there is a qualitative leap in learning processes when moving from the rule-driven analysis of a novice to the fluid, continuous action of the expert (Dreyfus & Dreyfus, 1986). Knowledge of particular cases is critical as experts ‘operate on the basis of intimate knowledge of several thousand concrete cases in their areas of expertise’ (Flyvbjerg, 2006). Cases offer, in effect, a form of experiential learning. For this reason, this project adopts a case based learning design.

Presentations and workshops on disaster cases for professional development purposes are popular among engineers. Despite common use of such case based learning, there has been only limited investigation into this practice in a hazardous industry context. While there is an established tradition of using hypothetical and historical scenarios in emergency management training (Smith et al., 1999; Wybo, 2004), there is only a small literature specifically on the use of disaster cases in education regarding disaster prevention. For engineering students, proponents have argued that stories of previous disasters offer a historical appreciation of what can go wrong and introduce an organisational model of accident causation (Saleh & Pendley, 2012). The only previous study of case based learning among practicing engineers was undertaken by researchers on this project (Maslen & Hayes, 2020). The pilot study showed that disaster cases as discussed in a small group facilitated workshop provided

¹ Serious games are games or game-like interactive systems developed with game technology and design principles for a primary purpose other than pure entertainment.

ample material for learning organisational, as well as technical, lessons thereby supporting the choice of case based learning for this project.

Building on our previous work, we aim to compare the effectiveness of two approaches to professional case based learning, including discussion-based workshops of failure cases, and a serious game based around management of threats to pipeline integrity through a pipeline life cycle. Our previous work left unanswered questions related to the most effective delivery model, and the long-term impact of case based learning on the practices of practitioners. By testing different methods and focusing on evaluating these approaches we will be able to provide a stronger evidence base for one approach or another for ongoing professional learning in the pipeline industry.

As such, the research aspect of the project focuses particularly on evaluation. Evaluation is best understood as a systematic process to determine the value of the learning module set against a developed criterion of comparison. Importantly, evaluation should determine whether participants have developed new knowledge and skills also whether they can implement these within their respective workplaces post-completion (Boulmetis & Dutwin, 2000). Evaluating professional learning is difficult, given the subjective nature of learning and change. It is often hard to set measurable objectives and even harder to collect the information on the results or decide on the level at which the evaluation should be made (Nagar, 2009). Drawing on Kirkpatrick's model of learning evaluation (Kirkpatrick & Kirkpatrick, 2016), this project attempts to compare the two learning approaches and to inform development of the final delivered packages that form part of the output of the project.

The importance of this research is further illustrated by the three output milestones in the Commonwealth Agreement that this proposal addresses:

Output milestone RP2.3.3: Approximately 100 end-users attend one day seminars on organisational accident prevention

Output milestone RP2.3.4: Approximately 50 industry operatives trained in organisational safety (using story-based learning).

Output milestone RP2.3.5: Prototypes of mobile/digital technologies to support better safety practices developed.

The project aims to train approximately 150 engineers to support better decision making regarding public safety. More than that, the project includes a pedagogical evaluation of the entire experience with the results used to inform final stand-alone professional learning modules delivered to industry to be used beyond the project.

The first interim report from the project details the evaluation of the impact on engineers' professional practice of their participation in a half day face-to-face workshop based on two accident cases adopting two different delivery methods. This report can be found on the FFCRC website.

This second interim report details similar research results for the serious game workshops.

2 Method

2.1 Workshop design

The workshops are designed to allow pipeline engineers to reflect on non-technical aspects of their professional practice using decision making case studies embedded in a serious game called *Planet Pipeline*.

Designing the game, bringing it to life and using it for professional education purposes was a multi-disciplinary undertaking involving expertise in pipeline engineering, game design and programming, accident prevention research and adult education. The scenarios in the game were developed with significant input from industry advisers to ensure that the logic and technical details underpinning choices is correct. While technical education is not the purpose of the game, all decisions are grounded in technical issues so the technical and non-technical are inextricably linked.

Three key domains that contributed to the workshop design are each explained briefly below.

2.1.1 Capabilities for decision making

The workshops are designed to improve engineers' practice in the areas of six capabilities that impact decision making in the interests of public safety.

The capability framework is shown in Table 1 below. This was developed as part of a previous research project RP2.3-03 *Case Based Learning Framework for Public Safety for Pipeline Engineers*. Further details regarding the development of the framework are contained in the project report available on the FFCRC website.

Table 1: Capabilities supporting excellent decision making for public safety

Capability	Interview themes
• Use long term, foresighted reasoning, especially in the face of uncertainty	• Imagining worst case outcomes • Choosing with the long term in mind • Dealing with uncertainty
• Understand norms and values that inform actions	• Using standards • Understanding risk processes and concepts • Making ethical choices
• Think systematically and understand interconnectedness	• Understanding context • Prioritising actions in complex situations • Applying risk concepts • Taking enough time
• Collaborate with and draw on the experience of others	• Build networks or seek others' opinions • Knowing your limitations • Building a good relationship with field people • Building external stakeholder relationships
• Ground decisions in reality	• Making practical choices • Learning from small failures

	• Be sceptical of models and calculations • Imagine being there
• Advocate for action and take responsibility	• Influencing senior management and clients • Standing up for public safety

2.1.2 Use of cases

Rather than teaching the capabilities in Table 1 directly in a lecture based style, the workshops use decision making cases based around particular threats to pipeline integrity presented to participants as a digital serious game. A detailed discussion about forms of case based learning and the justification for it are contained in the project report produced from RP2.3-03 *Case Based Learning Framework for Public Safety for Pipeline Engineers* and available on the FFCRC website.

The serious game called *Planet Pipeline* was designed to be played in a small group setting (3 or 4 players). The game includes three scenarios based around threats to pipeline integrity:

- Third party damage
- Flood
- Welding in service

Each scenario consists of a series of linked scenes where a small group of characters (such as a project engineer, engineering manager, commercial manager, operations manager etc) are in a situation that requires them to make a decision about the way forward with limited information. The game contains branching logic so that options that players are faced with vary according to choices made in previous decisions. A summary of each scenario is given in Table 2.

Each scenario is a complete learning experience in that each one includes scenes that draw on all six of the non-technical capabilities specified in Table 1. As players work through the scenes, planet pipeline time moves forward and the consequences of previous choices play out. Final outcomes vary from successfully navigating the decisions presented to catastrophe with several shades in between.

Table 2: Serious game scenario summary

Scenario	Description	Outcomes
Third party damage	The game starts with a new pipeline to be built at the outskirts of a large country town. The first scene in the design office turns on choices about the design basis for third party damage. These choices play out in two further scenes over the pipeline life as further pipeline threat management decisions are made and other facilities are built nearby.	There are 16 branches to the logic tree with 6 possible outcomes ranging from no damage to a lucky escape, to excess expenditure, to a repairable leak and, in the worst case, an explosion.
Flood	Similar to Scenario 1, the game starts in the design office where choices are made about the flood design basis of a new pipeline. The second scene is about landholder liaison regarding facilities	There are 11 branches to the logic tree with four possible endings ranging from no damage post-flood, to both pipeline and

	siting. The third scene revisits the design basis and the fourth focuses on construction verification. The consequences of choices made are revealed when a flood occurs.	main line valve severely damaged.
Welding in Service	In this more operationally focussed scenario, a new company has recently purchased a pipeline with a known defect. The game includes three scenes where people at the new company (who have limited experience) decide how to deal with the defect – get specialist advice or not, investigate or not, repair or not.	There are 7 branches to the logic tree with 5 possible endings ranging from successful repair to excess costs repair to fire and injury or pipeline rupture.

Each scene is completely scripted. Players are invited to take on the role of one of the characters in each scene as they work through the game and act out the dialogue as provided until they come to a decision point where the group must decide which choice to make.

More details of the choices and outcomes for each scenario are included in the appendix.

2.1.3 Experiential learning

Playing *Planet Pipeline* is the core of the workshop but not the entire experience. The workshop is set up by reference to the non-technical capabilities and the first play of the game (which takes around 45 minutes) is debriefed focussing on how the technical capabilities relate to the choices made and why various outcomes were achieved. Players are then invited to explore the game further in their small groups, replaying the scenario and making different choices. The entire session is then debriefed making links to professional practice and lessons to take away.

Thus, in addition to considering the capabilities to be explored and the kinds of cases to be used in the game itself, the delivery of the workshops was also informed by theory about how to structure effective experiential learning sessions. Again, further details are in the previous project report but, in summary, participants are encouraged to work through stages including:

- The concrete experience of being immersed in a particular case;
- Observations and reflections on the case (why was a particular outcome obtained? What professional capabilities were drawn on (or not drawn on) in achieving this outcome?), and;
- What can we learn from this about our own professional practice (what's important in our current practice? Do we have any similar gaps/areas for improvement?)

In this way, the cases become a vehicle for participants to reflect on what they need to do to improve their decision making capabilities.

In summary, the final delivered workshops were designed to immerse participants in realistic decision making scenarios, then invite them to reflect on how non-technical capabilities contributed to bad public safety outcomes and finally to consider how developing such capabilities themselves might contribute positively to their professional practice to prevent accidents.

2.2 Workshop delivery

Workshop participants were all from FFCRC participating organisations (with two exceptions who were approved by FFCRC). Participants were recruited through advertising in FFCRC publications,

snowballing via industry steering committee members and the professional networks of the research team involving targeted communication with contacts at FFCRC participating organisations.

Workshops were held in the period December 2023 to May 2024. The first workshop was an early pilot to test the game as it was being developed. No formal evaluation activities were conducted linked to this workshop so the evaluation focuses on seven workshops in the period March to May 2024 including 74 participants.

After consultation with industry, the ideal session length was kept at half a day (the same as the accident case workshops delivered in the first part of the project). One of the findings of the December 2023 workshop was that only a single game scenario was needed for a half day session. The March to May workshops were therefore each based around a single game scenario. Some participants attended more than one workshop.

Table 3: Summary of workshops held

Date	Location	Scenario	No of participants
13/12/2023	Melbourne	1 and 2	7
15/03/2024	Melbourne	3	6
4/04/2024	Melbourne	1	7
29/04/2024	Brisbane	1	16
30/04/2024	Brisbane	2	10
1/05/2024	Brisbane	3	11
20/05/2024	Adelaide	2	11
21/05/2024	Adelaide	3	13
	Total		81

All eight workshops were audio and video recorded with the permission of participants. Audio was professionally transcribed for analysis.

This research was approved by the RMIT Human Research Ethics Committee and the University of Canberra Human Research Ethics Committee.

2.3 Evaluation

A critical aspect of professional training is its evaluation, which identifies the impact of professional learning on an employee's performance and behaviour. This is vital to understand given it reflects an identified need and through education and the investment in the development of employees' skill development seeks to address that deficiency in an organisation (Topno, 2012). The most widely applied evaluation method is the Kirkpatrick Model (Reio et al., 2017). Kirkpatrick's four levels of evaluation introduced in a series of articles (Kirkpatrick, 1959a, 1959b, 1960a, 1960b) form the Kirkpatrick Model.

Details of the way in which the model was implemented are common with the face-to-face accident case workshops. Interested readers are referred to interim report 1 for further details.

As with the earlier workshops, four evaluation methods have been informed by the Kirkpatrick Training Evaluation Model and designed to determine the pedagogical value of the workshop and participant's entire learning experience. These are:

- Evaluation scenario
- Survey
- Focus groups on the day of workshop delivery
- Post workshop interviews

2.3.1 Evaluation scenario

In order to collect data on Kirkpatrick's Level 2 evaluation of learning outcomes, an evaluation scenario was used. Before the delivery of any workshop content, participants were given a short description of an everyday engineering dilemma and asked to write down what action should be taken. At the end of the workshop, participants were given time to reconsider their responses and make note of anything additional that they thought was important.

Given that some participants attended multiple workshops based on different game scenarios, three different evaluation scenarios were used. The scenarios are shown in Table 4 below with the follow up questions shown in Table 5 .

These written responses were collected for later analysis.

Table 4: Evaluation scenario texts

Scenario 1:
Sam is a registered professional engineer working on a brownfield project for changes to a compressor station. The project manager insists that Sam should sign-off drawings as approved for construction (AFC) even though some key vendor details impacting pressure relief are not yet available. The client is also pressuring Sam to sign off on the drawings because there is a company project deadline to produce AFC drawings which will not be met if Sam waits for the final information that they believe is necessary.
Scenario 2:
Max is designing a large high-pressure mains extension for an old city distribution pipeline to supply a growing urban fringe development, in a T1 location class. The existing mains doesn't have any pig launching facilities, so he decides to design the new pipeline without the ability for in-line inspection with short radius elbows and no pigging facilities, as this will be cheaper to construct and there will be fewer long lead materials to purchase. The inspection group find out his intentions and ask for the new main section to be built to current standards including a pig launcher. Meanwhile, his project manager praises Max for saving money on their project. What should Max do?
Scenario 3:
Sam is reviewing a lifecycle cost estimate to be used for project economics calculations and notes that the annual allocation for inspections and maintenance drops off significantly in the later years approaching the end of the design life of the pipeline system. Sam knows that in fact ageing infrastructure is likely to require more attention to such activities in order to ensure continued integrity and public safety, not less.

Table 5: Evaluation scenario questions

Before the commencement of the workshop
Question 1: What should [Sam/Max] do? What does [Sam/Max] need to consider in the decision making process?
After the completion of the workshop
Question 2: Reflecting on your response at the beginning of the workshop: Is there anything else [Sam/Max] should consider in the decision making process?

2.3.2 Survey

The first method for evaluating the reaction of the participants to the learning module (aligning to Kirkpatrick's Level 1 evaluation) was the use of a survey. Following completion of the evaluation scenario, participants were asked to complete a short, written feedback survey about their workshop experience. The questions in the survey are shown in Table 6. Participants were asked to rate their answers on a 5 point Likert scale. Written responses were collected for later analysis.

Table 6: Day of delivery evaluation survey questions

Survey questions
Did you enjoy the delivery of the session content?
How do you rate your engagement in: a) the overall workshop; b) the serious game.
Having attended the session, do you think the identified capabilities are critical to public safety decision making in professional practice?
Was the training session content relevant to your professional practice?
How satisfied were you with the session in terms of understanding your development of the identified capabilities and their role in informing better decisions for public safety concerning practice?
Did situating the capabilities in a serious game help you to develop your understanding/knowledge/relevance to professional practice?
Do you believe you achieved the learning objectives for the workshop?
Which serious game did you play today:
Have you previously attended any of the following <u>Future Fuels CRC Learning from Accident Cases</u> workshops? Tick those you have attended.
☐ San Bruno pipeline failure discussion case/Challenger Role Play ☐ Massachusetts pipeline failure discussion case/Dreamworld Role Play ☐ Serious Game: Third Party Damage ☐ Serious Game: Flood ☐ Serious Game: Welding in Service

2.3.3 Focus groups on day of delivery

The second method for evaluating the reaction of the participants to the learning module (aligning to Kirkpatrick's Level 1 evaluation) was focus groups held directly after the completion of the workshop. Focus groups also collected data on participants reflection on insights and learning, which aligns to Kirkpatrick Level 2 evaluation. Questions used to guide the conversation are shown in Table 7.

Table 7: Focus group questions

1. Did you enjoy the delivery of the workshop? 2. What are your thoughts on the serious game approach for developing capabilities for decision making for public safety? 3. How relevant was the workshop to your professional practice? 4. Before attending this workshop, had you thought about the identified capabilities, and has this changed since attending today? If so, how? • Do you think the capabilities discussed are important for public safety? 5. Did this training session today assist you in changing your approach/thinking to your workplace practice? • What aspects of the workshop today had the most significant impact on your thinking? 6. Has this workshop facilitated your application of the capabilities to your work practice? If so, how? 7. How did you find: • Clarity of learning objectives/workshop purpose • The pace and length of the workshop • The workshop materials, such as slides and handouts? Were these clear, logical, useful, easy to follow, etc. • Room set up • Direction and support in playing the game • The time for discussion during the game and after • Links between game play and capabilities 8. Did you feel comfortable and motivated to participate in discussions? 9. How motivated and interested were you in the training session before it began? 10. How does this workshop compare with other training you may have participated in? 11. What makes a good learning experience for you, and what alterations would you suggest to improve the learning experience for future participants? 12. Is there anything that could be changed about the workshop to better: • support your learning/reflection of the capabilities • link to professional practice • engagement/enjoyment of the workshop?
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2.3.4 Post workshop interviews

To collect data on Level 3 of Kirkpatrick's model, workplace behaviour, workshop participants were contacted for follow-up interviews approximately three months after their participation. These interviews also provided data that relate to Kirkpatrick's Level 1 and 3 evaluation. The interview guide is shown in Table 8. Questions cover what interviewees remember from the workshops, what they learned, whether they have continued to reflect on the capabilities, the impact on their professional practice (including examples), the link between professional practice and public safety and any other feedback on the workshops.

Table 8: Interview guide: post workshop follow-up interviews.

Which scenarios did you play?
Since you attended the workshop, have you thought about the content at all?
Can you tell me what you remember about the scenario/s.
Have there been any instances where you have applied the lessons from the scenarios following the workshop?
Have you talked to anyone in the office about the training? (prompt: example)
In the training, we related the scenarios to a set of professional capabilities. Do you recall those? (prompt: examples, relevance to your practice)
Has the workshop changed the way you think about the relationship between your practice and public safety at all?
Last question, do you have any feedback on the design of the workshop, like the usefulness of the scenarios, or the game as a teaching method?

Interviews from each workshop are shown in Table 9. The number of participants interviewed is lower than the number of workshop attendees. There are several reasons for this including that some participants:

- Participated in multiple workshops and have only been interviewed once;
- Have changed employment since doing the workshop and are uncontactable;
- Are on extended leave,
- Were present in the workshop but are not part of the target group (i.e. not practicing pipeline engineers); or
- Did not respond to multiple approaches for interview.

Table 9: Post workshop interview participants

Date	Location	Scenario	No of Participants	No of interviewees
13/12/2023	Melbourne	1 and 2	7	0
15/03/2024	Melbourne	3	6	4
4/04/2024	Melbourne	1	7	7
29/04/2024	Brisbane	1	16	14
30/04/2024	Brisbane	2	10	8
1/05/2024	Brisbane	3	11	10
20/05/2024	Adelaide	2	11	8
21/05/2024	Adelaide	3	13	10
	Total		81	61

NB a small number of respondents chose to provide written responses to submitted questions, rather than participate in a spoken interview. We chose not to interview participants in the December 2023 workshop given the developmental nature of that event. The workshop format changed significantly based on feedback from that event.

The results are described by method in the following four sections.

3 Evaluation scenario

The first workshop evaluation method used was asking participants to share their thoughts on an everyday work scenario both before and after the workshop. This provides evidence of what participants have learned that relates to their everyday engineering practice.

3.1 Scenario 1

All 23 Scenario 1 workshop participants completed and returned evaluation scenario sheets. As described in Section 2.3.1, participants were presented with short scenario describing an engineer faced with a safety-related decision regarding whether or not to sign off on drawings as approved for construction when some safety-related information (about a pressure relief valve) is not yet available.

Prior to playing the game, 65 per cent of participants said that they would likely sign off the drawing but place a 'hold' on the relief valve details and add copious notes to the drawing. Most respondents (57 per cent) said they would first do a risk assessment to determine the safety impact of the uncertainty in design details. The results of the risk assessment could lead to a conclusion that the drawing could not be released even with a hold shown due to the risk of not providing adequate pressure relief using the information available. The risk assessment would also provide justification for the engineer's position to use in explaining the delay to the project manager. More than one third of participants (35 per cent - mostly people in Queensland) indicated that a Registered Professional Engineer (RPE) should not sign off a drawing with missing safety-critical information as this is unethical and they will be personally liable if things go wrong. Nine per cent of participants indicated the engineer should seek support from their discipline lead if the project manager applied more pressure to sign.

Others noted practical things they could do to get the situation resolved and the right facilities installed including:

- Expediting the missing information from the vendor (30 per cent)
- Highlighting the issue to the rest of the team and to procurement and construction personnel so the situation was resolved and not forgotten (9 per cent)
- Checking that the issue had been resolved before the start of commissioning (9 per cent)

One participant suggested that the engineer should emphasise the cost to the project of making a late change if construction goes ahead and the assumed data turns out to be wrong.

At the end of the workshop, participants were asked to revisit the scenario and note any additional thoughts. Almost all participants had more to say. Participants were even more convinced that refusing to approve a drawing for construction with important safety data missing was the right thing to do but the focus of their responses had shifted to be much more focused interaction with others and taking a broader responsibility to get the situation satisfactorily resolved.

The tone of comments has shifted to be much more persuasive and inclusive. Thirty five per cent of participants wanted to have further discussion with the project manager to convince them (rather than just telling them) that this information has serious consequences and public safety is paramount. A further 13 per cent wanted to remind everyone that public safety is more critical than corporate project concerns. Some participants thought it might also be useful to explain that the RPE sign off on the drawing is the last line of checking and it is an ethical issue for them to make sure this is correct (another 13 per cent). One participant suggested preparing a business case to help communicate concerns while another suggested that the regulator could be enrolled to be on their side. Nine per cent of participants suggested getting another opinion of the case to be sure the engineer's view was correct.

Several suggestions were made of actions the engineer should take to ensure the hold was closed out before commissioning:

- Only sign the drawing with a 'hold' if the hold system is robust and you know it won't be forgotten (9 per cent)
- Develop an action plan to get the information necessary for sign off (4 per cent)
- Raise the issue regularly with team members to be sure it is not forgotten (9 per cent)
- Make sure drawings are as built with available information as it comes to hand (4 per cent)

3.2 Scenario 2

Of the 21 Scenario 2 workshop participants, 20 completed and returned evaluation scenario sheets. As described in Section 2.3.1, participants were presented with short scenario describing an engineer faced with a safety-related decision regarding whether or not modifications to brownfield facilities should incorporate current standard requirements for safety that are not currently included i.e. whether or not pigging facilities should be incorporated in the design.

Prior to playing the game, 40 per cent of participants noted the need to consult the requirements of AS 2885 on this matter and 40 per cent also stated the need for a risk assessment of the inspection options. Thirty five per cent of participants suggested that the engineer should look into alternative means of inspection (other than installing pigging facilities) and 25 per cent also emphasised that the design process should be followed (implying that this would determine the way forward). One participant emphasised that it was important to take a long term view and 3 participants (15 per cent) suggested ways that the engineer might identify other benefits of installing pigging facilities that might make this approach more economic/attractive (such as extending the design life of the pipeline or allowing a higher operating pressure).

Twenty five per cent of participants noted that the engineer has a responsibility for public safety and so must ensure that effective inspection is possible. Thirty per cent said that the engineers should facilitate a conversation between all stakeholders, although the purpose of the conversation differed. For some this was to explain their decision and for others it was to seek consensus on the way forward. Some participants thought the engineer should seek further input from operations (1 participant), their manager (1 participant) and an independent review (1 participant).

At the end of the workshop, participants were asked to revisit the scenario and note any additional thoughts. Many participants had more to say. The most common suggestions in addition to those actions described above relate to seeking the opinions of others with 25 per cent suggesting further expert engineering advice should be sought and 20 per cent suggesting the engineer should talk to operations.

Another group of the additional comments focus on considering adverse outcomes with 20 per cent focusing on the need for robust risk assessment and 15 per cent specifically focused on considering the worst case scenario. One participant reiterated the need for the engineer to be aware of their legal obligations and another noted the need to take enough time with decision such as this and not be rushed.

3.3 Scenario 3

All 30 Scenario 3 workshop participants completed and returned evaluation scenario sheets. As described in Section 2.3.1, participants were presented with short scenario describing an engineer faced with a safety-related decision regarding how to respond when presented with a lifecycle cost estimate for a new pipeline that included apparently optimistic assumptions regarding expenditure on inspection in later years.

Prior to playing the game, 40 per cent of participants said they would raise their concerns with management. Forty per cent of participants also said that a risk assessment covering all aspects (short and long term financial effects, public safety, reputation and environment) should be done to determine the scope of the best inspection program and hence budget required. Thirty per cent of participants stated that drawing on examples of previous pipeline failures and/or benchmarking against the performance of other inspection programs would be an important input to the engineer's decision making. Some participants (17 per cent) emphasised the need for a program that takes into account local conditions (both in terms of the likelihood of failure but also the likely future use of the pipeline) although a further 10 per cent noted that companies often develop plans that require a design life extension so things that limit design life could be a lost opportunity. Ten per cent of participants suggested that the engineer should seek out those who did the modelling behind the original estimate and critically examine the assumptions made.

As well as these various engineering-based activities aiming at developing a more informed budget, two groups of participants took opposing orientations to the responsibility of the engineer involved in the scenario. Ten per cent of participants stated that the engineer would have to find a way to increase the budget, whereas another 13 per cent indicated that the engineer should live with the funding decision and find ways to optimise spending within that. A further 13 per cent of participants indicated the engineer should use a compliance-based approach (either with regulations/codes or company requirements).

At the end of the workshop, participants were asked to revisit the scenario and note any additional thoughts. Many participants had more to say. The most common comments relate to seeking the opinions of others with 30 per cent of participants saying that in addition to those actions described above, the engineer should seek expert advice and/or involve other stakeholders in decision making. Thirteen per cent linked this specifically to producing a risk assessment with input from all relevant stakeholders. Similarly, 17 per cent of participants indicated that the engineer should build a case based on history, costs, risks and benefits and present this in a plain language way to management with 23 per cent stating that the engineer should make it clear to decision makers what could go wrong and who will be responsible if there is a failure. Ten per cent of participants thought that the possible long term consequences to the business should be presented (in terms of lost opportunities for design life extension as well as potential public safety impacts).

3.4 Summary

In all cases participants responded quite well to the scenario they were presented with before attending the workshop². While the specifics vary between the scenarios, there are some overall trends that are apparent. Most of the initial responses are very process focussed (following procedures, consulting the standard, doing a risk assessment) with all respondents taking a path driven by safety considerations. Many responses detail actions that are individual and relatively isolated from most colleagues.

There are also common trends in the post-workshop responses. More respondents proposed actions that involved taking a more active responsibility for resolving the dilemma they were faced with. This includes seeking advice/support from more senior colleagues and/or operations, working actively to resolve the situation and convincing senior management of the importance of taking the safe path perhaps by reference to long term consequences.

Overall, these responses show application of many of the non-technical capabilities described in Section 2.1.1.

² Some attendees completing the scenario had already attended one or more workshops. It is not possible to identify these responses separately as responses were anonymous.

4 Survey results

For seven of the workshops, participants were invited to complete a short survey as described in Section 2.3.2. This is the second evaluation method and focuses on participants' reaction to and satisfaction with the workshop experience.

Of the 74 people who received the survey, 72 responded³. The results are shown in Table 10.

Table 10: Survey results

Question	Mean response (scale up to 5)
Did you enjoy the delivery of the session content?	4.75
How do you rate your engagement in:	
• The overall workshop	4.55
• The serious game	4.73
• Having attended the session, do you think the identified capabilities are critical to public safety decision making in professional practice?	4.67
• Was the training session content relevant to your professional practice?	4.75
• How satisfied were you with the session in terms of understanding your development of the identified capabilities and their role in informing better decisions for public safety concerning practice?	4.33
• Did situating the capabilities in a serious game help you to develop your understanding/knowledge/relevance to professional practice?	4.42
• Do you believe you achieved the learning objectives for the workshop?	4.50

Given the maximum score for each question of 5, immediately following the training participants were very enthusiastic about their engagement, the relevance of the sessions and the capabilities framework to their professional practice.

There was no significant difference in results for workshops which were delivered in different locations and using different scenarios.

³ Not all 72 participants gave valid responses to all questions.

5 Focus groups on day of delivery

As detailed in Section 2.3.3, a short focus group of all willing workshop participants was held after each of the seven face to face workshops. This is the third evaluation method and focuses primarily on their reaction to the workshop and their reflections on what they have learned. What follows is an analysis of key themes.

5.1 Overall impressions

As with the case based workshops, focus group participants reported overwhelmingly positive impressions of the workshops and the potential impact on their professional practice when it comes to decision making impacting public safety. Overall comments included:

It's engaging. It's 100 per cent engaging, that's for sure. (14/4/24)

I think it was very fun and interactive. That was really, really good. (29.4.24)

It was good ... very engaging (1/5/24)

Really loved it. Really good. (20/5/24)

Participants felt that the training was of value because it:

- was novel,
- was participatory, interactive and discussion-based, rather than based around a presenter delivering information to a largely passive audience,
- was engaging, fun and enlivening because of the interactive nature and so was likely to be more memorable,
- exposed participants to the way their colleagues would behave in particular situations that they do not normally see,
- was focussed on real world implementation, rather than technical content,
- provided an opportunity for less experienced engineers to hear from and learn from their more experienced colleagues,
- allows engineers to experiment with unsafe choices to see the potential consequences without experiencing the real world disaster that could result from poor decisions,
- was immediately transferrable back to their working environment, and
- provided an opportunity for reflection on professional practice that is hard to find amid daily priorities.

Many participants attended multiple sessions (covering different game scenarios) further indicating that they saw it to be of value. Similarly, many participants indicated that they would recommend the training to their colleagues.

Overall, the training was in the words of one participant 'something that's enjoyable and you'd want to do again. Something you take lessons from.' (29/4/24)

5.2 Comparison to other training experiences

Many participants commented that they had not experienced training based around a serious game previously and were more used to sessions based on a lecture style, perhaps followed by discussion and/or questions. Using the serious game as a basis for discussion about professional practice was seen to have several advantages.

Firstly, it's more engaging and participants are more likely to remember it as a result:

I think it was a lot more interactive than doing the presentation. I think some people have mentioned this already, but it was more – I think it will stay in my brain a lot better long-term, than just watching a presentation. I like this way of delivering the content. (13/3/24)

I think it is better to do it in a group rather than by yourself. I don't think it'd be as enjoyable or interesting even to do sitting alone by yourself reading through the text and the scripts. Doing it as part of a group's quite nice because it keeps you engaged and it's a part of the conversations, it's almost a conversation you're having with actual people. (1/5/24)

I think the blended media presentation – so having a speaker, and then you're having some time on the screen, and then you're having some discussions, and then you're writing some things down. It's not just one hour of somebody talking to you, followed by ten minutes of quiz – so it's nice and paced like that. (29/4/24)

Secondly, the sessions provide a setting for participants to interact with their professional colleagues and reflect on professional practice:

I think it's particularly useful, because often times when you're just listening to a presentation like that, if you don't necessarily resonate with that individual or what's exactly being said, then you probably don't have the potential to grasp things as well as you could do. Whereas if you're surrounded by people who are different in experiences, different skillsets, often times there might be clarity in what they have to offer as well. So, the opportunity to be able to sit together and work on something like that, I think gives much more potential to take in and be able to grasp a wider range of concepts, rather than you're just listening. (13/3/24)

And this way we were able to talk to each other too, hear each other's insights. Whereas the seminar is very just one person talking to you, but you don't get to interact with each other too much. So, in this way we could hear each other's opinions and experiences. (13/3/24)

Thirdly, the fact that playing the game gives groups an outcome provides a focus for playing that is not present in more traditional learning designs. It gives groups something to aim for, to strive for and with multiple groups introduces friendly competition/rivalry to achieve specific outcomes. As one participant noted you become 'personally invested' in the outcome. Most participants did not comment on this but this aspect was certainly clear to the facilitators.

5.3 Reflections on learning

Participants were primarily asked about the lessons they had learned from the workshops during the workshop sessions themselves, although many participants also spoke about the impact of the experience in the focus group.

Less experienced engineers reflected on the opportunity that playing the game presents to gain experience in decision making:

If you're a young designer, these are games you need to play before you rush into the decisions. Because if you play these kinds of games to tell you, you are prone to error and you should give it to all superior to look at, you might be very brilliant and still make error. You come by experience. (30/4/24)

Playing the game gave them insights of how their role as an engineer fits into broader decision making by the business.

I'm not at as senior level as my teammates, and yeah, my mind went essentially straight away this option, but I could see that running a business you're going to consider more aspects. (21/5/24)

us younger guys here, we aren't heavily involved in relaying those engineering decisions to upper management and I think that was one of the good things about this game, is it puts you in a hypothetical scenario where business meets engineering. Sometimes not the most conservative solution can be done based on business. I think that's a really good learning that I found out at doing this. (1/5/24)

It also provided a space to reflect and come up with ideas for where to focus their ongoing professional development efforts:

I guess the way they've designed the game it helps you to reflect your capability, teamworking in a group discussion also is very helpful. Also the game really helps to put that situation in a real situation that you're dealing in a daily basis. (1/5/24)

Just adding to that I think my personal feeling is looking at the capability list, made me realise that actually some actually have already applied you know real situations but we didn't realise. I just give me – "oh actually I've done this, I haven't done this". It will give me a good understanding, oh I should keep on doing this or I should start looking into this. (1/5/24)

that's what this workshop does, it gives you a chance to think about these bigger things that you otherwise wouldn't think about in the course of your day. (1/5/24)

Playing the game was also a reminder that poor decision making can lead to catastrophe thus linking their everyday engineering practice to the potential for very bad outcomes:

we have to do multiple risk assessments but ... it doesn't hit you as hard actually appreciating the outcomes and the adverse outcomes that can happen based on your design until it happens to yourself, until one of your design decisions actually could end in a fatality, heaven forbid. But I think that's a really good learning outcome from this too, actually, those I guess sequential decisions, how one wrong one in that line can really have a bad outcome. (1/5/24)

Discussions around capabilities also gave participants a language to talk about non-technical aspects of decision making.

I think I'll just be thinking about these individual things more specifically rather than just thinking that my decisions or everyone's decisions should just - from engineering decision making that everyone makes on a daily basis like I see what's behind that broad term now. So if something's lacking then I can point to it specifically like "hey, maybe that we're not considering this one aspect of engineering decision making. Maybe we should look at that more specifically". 'Cause before seeing all these on paper I would just attribute the decisions my seniors would make because of their experience or their general decision making process but now I see what actually goes behind that.

For more experienced engineers, playing the game provided reassurance about their professional decision making and an opportunity for recalibration of judgment if needed.

We explored the other options, but my perspective being in the industry for a number of years it's reassuring that I got the right answer so it's nice that I got something right. But no, it was good. I enjoyed that. And it is representing real life in the sense that there are all these different people competing - wearing different hats in the organisation - accountants want to focus on the dollars and very often find ourselves in the middle where we've got to try and be the mediator and convince the business that we're doing it for the right reasons. (21/5/24)

Participants also reflected on lessons learned which relate closely to many of the capabilities, for example the following quote draws on both thinking in the longer term and also advocating for safety:

I think I've definitely found it useful for that thinking more in the future, rather than just today. And I think probably just knowing to have the confidence when you've got those questions of queries, to actually go to the management and ask them. Not just have the thought and then just trust the seniors above you. (29/4/24)

Several participants were struck by the need to be more collaborative with other disciplines and functions within the organisation:

I think this course also let us realise that especially engineers, I think most of us are very busy most of the time and you're doing it technical but this course make us realise that your in a team and the other participants that are involved like operation team, commercial teams, accountants, management so they're different audience. So you have to think when you present some things, it has to be fit for purpose for all the audience. (1/5/24)

I think also, it sort of reminds me to be wary of tunnel vision, and thinking about others making a decision, or get other people or other teams as well in the discussion. (13/3/24)

Another participant told a story about the need to ground decisions in reality by going to site:

Whereas I reflect – looking at these capabilities, I can name situations in my experience where I'm like, "yep, come across that. Come across that. Note that one." So it is interesting – I've got a different perspective seeing it on a piece of paper, going, "actually, yeah, that's true." One example for me is ground decisions in reality. Like you said, applying it to decision making. I saw one situation – every acronym under the sun. They'd done every risk assessment. But I went on the plant and the guy was in the line of fire. So you go, "regardless of what you did outside of that technically, in reality it just wasn't working for them." And that was a big eye-opener for them, going, "gee, we actually never went to the plant to have a look." (29/4/24)

Another participant spoke of using an imagination test to ground their decision making in the reality of risks in the field.

What Jan said about imagine yourself there or imagine your 5-year-old being there with you, I think that was a good way of thinking. I think that will stick with me. (13/3/24)

Several participants spoke of ways to make the link between professional practice and the potential for disaster.

So you joke, so that's why there was a joke that was made like how many people have you killed today? It's a joke, but it's reality because our decisions as engineers, we kill people if we make the wrong decision. (30/4/24)

If you want to make a decision or work out which way you should make a decision, put the words, "Your Honor," after the end of it. And that will make you decide which way you should go. (30/4/24)

5.4 Links to capabilities

While the reflections on learning show that many participants were thinking about the non-technical capabilities that underpin the workshop design, participants were asked about the effectiveness and appropriateness of this approach.

Capabilities were described in the introduction before the first game play and then referred to again in each debrief conversation.

Many participants understood that the workshop was about these non-technical aspects of decision making and the technical content was a vehicle for example decisions.

I don't see this as being a training exercising a T1 or a flood, but they're trying to get across the capabilities. (30/4/24)

That's where I see it from you don't need that technical aspect. Otherwise that you go down this rabbit warren of technical design, which they haven't and that's where they've stayed away from it. (30/4/24)

The participants see the technical aspects of decision making in the forefront of their professional practice with non-technical capabilities as important but secondary or 'at the back'. The framework perhaps provides a language to talk about them.

[the framework] showed us that link between decisions taken and decisions you make to how the other aspects at the back that are actually influencing. (14/4/24)

I think if you hadn't had experience in this sort of stuff and you're probably new to pipeline design and stuff, it'd be a great way of really learning about the breadth of stuff you have to deal with. Even if you have some experience maybe, but maybe in a purely technical role. Often that technical role you've got very narrow band of responsibility, but in a way of opening up all the other things you have to think about. It's great. (14/4/24)

It gives you the opportunity to think about different approaches in a conversation. (29/4/24)

it's a good thing to reflect on and to think back of a previous conversation that you might have had where you might not have met that. (29/4/24)

5.5 Links to public safety

All participants could see the link between the workshop content and better engineering decision making and for most, the link between better engineering decision making and public safety was clear. As one participant said: ‘public safety was always on your mind.’

Two participants gave feedback that indicates they found it more difficult to conceptualise the link between the workshop content and public safety.

One participant was thinking about pipeline assets in remote areas where there is no public. For them, the issue of worker safety is more front of mind than public safety:

When I was looking at the scenario, I was thinking of the pipelines we work on, which are out in the middle of the desert, there ain't no public. So, when I was thinking public safety, I was thinking of the people actually doing the work.
(13/3/24)

Another participant found the link between engineering decision making and public safety hard to see.

[The training is] definitely worthwhile doing. My concern would be that I haven't got out of it necessarily what you wanted me to get out of it. ... I'm not sure my main takeaway is going to be around the public safety stuff. ... it'll be about the engagement with other people in the industry, the decision making process, some of the concepts that people use to make decisions, that kind of thing. But I'm not sure there's the direct, in my mind the takeaway will be directly correlated to the public safety. (13/3/24)

It must be noted this is a single participant but is nevertheless useful as a reminder for facilitators that not every engineer makes this link on their own.

5.6 Workshop design and delivery

Workshop participants were asked a series of questions regarding the design and delivery of the workshops.

5.6.1 Realistic

Many participants noted that the scenarios are ‘very real’ (14/4/24) with many comments such as:

This is really well designed because the scenario did feel real. That was very well done. (20/5/24)

It's really related to the work we are doing as well, so really informative. (14/4/24)

Apart from being technically realistic (see also section 6.4.3), participants found the situations that the fictional characters in the game found themselves in and their interactions reflected the participants real life working environments.

I think the scenario was really well done, particularly if you didn't select the safe option at the early time. Then the different bits that came up, I think that was more representative of some of the conversations that you'd have. I haven't really seen that much of being able to put forward ... very conservative designs, or what you think is right, and never have it challenged at any point. (20/5/24)

And it is representing real life in the sense that there are all these different people competing - wearing different hats in the organisation (21/5/24)

Like I said real life scenarios, and you quite often find yourself in that position where you've got to convince the business to spend money where they don't want to spend it. Quite often they can't see that money being spent. There's a comment that was made earlier on, 'You've wasted 25 million dollars.' No you haven't. It costs a lot more money when you have a failure, that's for sure. (21/5/24)

The characterisation of the different players in the scenario rings true to that because people are like, 'Oh yeah, this is the same as so and so our main character we really like' which engages people. It rings a bit true in some scenarios, right, the conversations we really have. (21/5/24)

It's that the scenario is so real, for me it is so real, and not only the technical part is real, the different level of management also is so real. So, you're sort of sucked into the thinking discussion, rather than just one direction, you can sit here to see all the sides and listen. (13/3/24)

5.6.2 Workshop structure

Participants were asked for their views on aspects of the workshop structure and other participants raised such issues without prompting.

5.6.2.1 Playing the game in groups

The first issue was the original playing of the game for the first time in groups of 3 or 4. Participants thought this was a good way to play with the game and encouraged a more thoughtful engagement than if they had been playing it alone.

I feel like if I was just given the game and said, "Have a go." I would just pick the best option each time, because it's kind of obvious to always be safe. You don't really actually talk about the repercussions of what you're doing and talking about the other side of it. It's quite easy to just click and go. Actually, being in a group and sitting down and talking amongst ourselves about, "Okay, I'm going to play devil's advocate for a second. What if I'm the landowner? What if I don't want it on my property or whatever?" I think if you distributed it just to people to play on their own, it would lose that value which was probably the strongest value I got out of it. (20/5/24)

As a standalone thing that you would just give to somebody to do when you click through it, not so much. It's fine, but I think there's quite limited outcomes along the way. I think the real benefit in it is the promotion of the discussion as to how you choose which one of your decisions. And that's the real barrier, I think. (29/4/24)

The discussion had in the small group is a key mechanism for learning:

I think the biggest thing that the game does is promotes the discussion. And the discussion I think is where we've learned the most from others experience through discussing it. (30/4/24)

So I think that's probably the best part about it, it's the discussion that forces. (30/4/24)

Using the characters in the game and their conversation as a script for the group to role play, rather than just read without vocalizing was seen as an important workshop feature. It makes the content more realistic, more engaging and so more memorable:

I think the format that the content's presented in is more engaging than if it was that we were just reading. (20/5/24)

The tip to read things out, and pick our person I felt really helped that, because then it becomes even more realistic, and it becomes clearer. So, I think that was a really important. Had people just sat there in silence and skim-read through it, you probably go back to the learning we've all just spoken about, where you're just in front of the monitor, you know I mean. So, that tip where each person takes on a character, I think is important. (13/3/24)

With the first couple of slides we were just quietly reading it, before Jan gave the tip. And I think if we did the whole thing like that, a lot of information would have just gone through my head. I wouldn't have registered it as well if I wasn't speaking it or hearing one of them say it. (13/3/24)

Some participants started to identify with the characters they or others in their group were acting or to form opinions about them as if they were real people in a real organisation:

Kind of identify with the characters, you can kind of put yourself in their shoes a little bit better, I feel like with that roleplay as well. (13/3/24)

[Roleplaying] made each one more personable, because we were not only getting it from their point of view, but going like, "Oh man, we really don't like that character. They're saying all the wrong things." (13/3/24)

Yeah, we were like, "Go, Tyler!" (13/3/24)

Forcing continual engagement in this way kept interest up due to peer pressure from the group.

It promoted engagement too, because if you forget to read your person, everyone's just sitting there waiting. (13/3/24)

Speaking in a scripted way also made it easier for less naturally forthcoming participants to voice their opinions in subsequent discussion.

I think making the role-play – having everyone's voice heard already starts that – you're comfortable to – your voice has already been heard. So then when you come to discussing, it's a bit more comfortable. (29/4/24)

5.6.2.2 *Playing multiple times*

After the initial play through and first debrief, participants were given additional time to replay the game and investigate one or more alternative decision making pathways. At this point, they were given a handout showing all the branching built into the game and the possible outcomes.

As one participant noted:

I guess since it's gamified, you can also run through that cycle, "oh, what if I did this choice instead?" more easily, and go from the, "I'll crack the pipe," to, "oh, we blew the pipe up," to, "it was fine," in relatively quick succession. (29/4/24)

This participant effectively articulated the benefits of replaying – learning about decision making by seeing what combination of choices gives both the best and worst outcomes.

I think that's when you get a real opportunity to learn too. Because I thought our initial run to get the B was pretty good, and then I wasn't quite sure where you would get to the A. So, to see that and then understand, "Oh yeah, okay. Now I can see how people could have potentially got there," and be open to that pathway. I thought that was a really important aspect of being able to go back and review like that, and have a bit of fun trying to blow the pipeline up at the same time. (13/3/24)

Other participants also valued seeing how the conversations between characters changed with the differing outcomes:

I liked playing around afterwards and saying what the best scenario, and what the worst case of fire and rupture. It was good to see how you get to that point, and what not to do. And the conversations that happened when you selected the better option or the worse option, and how it changed each of the characters' demeanour. (13/3/24)

Experimenting with the poor outcomes allows engineers to experiment with unsafe choices to see the potential consequences without seeing the real world disaster that could result:

I was going to say it's good to show the consequences of the choices you make today, and then how it impacts later down the track. I guess it all comes down to that uncertainty, and how do you make a judgement if you don't know what's going to happen? (29/4/24)

This participant was making a similar point, talking about a decision point where on a second playing their group chose an apparently less safe option and they found the resulting conversations interesting to learn from.

I think the most interesting thing for me was the SMS discussion. Obviously, on the first time it's very straightforward. Cool, you looked into it. Great job. Let's do the safe thing. For a second time, actually seeing those people come in after that was quite interesting for me. (20/5/24)

Overall, the participants valued being able to play through the scenario for a second or even a third time. As one said:

We liked it so much we started a third crack. It was good. (20/5/24)

Another wanted to play every option:

It'd be good to have enough time to go through all of the different scenarios. (20/5/24)

5.6.2.3 Debrief conversations

Many groups commented on the facilitated debrief held after the first game play and continued following the second game play session. This was held with all small groups coming together so between 7 and 16 people. As described in section 2.1.3, education theory suggests this is a critical part of the workshop design and our participants agree.

If I did this with just a team of four without the guidance I think you'd lose something because you do have the discussion as you're going through the game but then there's the analysis of what we should have – like why – you think about it during the game but you don't then have the hindsight to go "oh we did that because of these reasons and maybe this other group did because of these other reasons". So I think doing it as an individual group wouldn't be as beneficial. (1/5/24)

I'd say the discussion for me – the discussion has mostly been where I've taken my main learnings from, rather than the slides themselves. But yeah, prompting that discussion and hearing experiences and knowing the impact of your decision – yeah, it's quite – what's the word? Quite relevant or – yeah, emphasised by the discussion. (29/4/24)

To me, it's just got to be integrated with that discussion piece. (29/4/24)

It promotes conversation, and everyone's insights were – and through that you do learn more. (29/4/24)

during the debrief, the questions prompt you to think about that a little bit more, why you made that decision. And that definitely helps in understanding why those, in real life why those decisions are made. (13/3/24)

This all implies the need for a good facilitator:

You need to facilitate it. You need a facilitator (20/5/24).

Overall, participants could see that the structure of the workshops works well. As one summarised, the game playing and the debrief discussions work together:

They definitely go hand-in-hand. I know that one wouldn't have been as effective without the other. (13/3/24)

As others explained, the two workshop aspects work together and the game by itself would not be as effective:

I personally feel I've learned the most from the discussion that the game is generated. Within the room rather than the game itself, but if you're looking at just the game itself and in teaching you or reinforcing the capabilities, then it's not so important. (30/4/24)

I think it was less the game and more the discussions that came from the game. The game was a tool to facilitate those discussions. (20/5/24)

5.6.3 Group makeup

Game playing in small groups with several small groups coming together for wider discussion and debrief was universally seen as a good workshop design. It provides the optimum of a small group experience in making decisions and yet provides for variation in group outcomes and so a better overall debrief discussion.

Apart from the number of participants, the experience level of participants was an important factor with both more and less experienced participants enjoying the workshop and getting something from the experience.

As one of the junior engineers pointed out 'I think it's okay to fail, that's still learning' (30/4/24). Nevertheless, the learning is increased by insights gained from more experienced colleagues and hearing a diversity of views.

hearing other people's experiences and stuff that they've done, especially for a lot of us who are younger. It actually provides a lot of actual insight and extra information. (29/4/24)

Especially coming here face to face, normally you have like a webinar, and just talking to each other on the monitor. Because everyone here is more experienced than me, so I think having everyone's contributions in that game, doing it in a group setting, I think that's definitely helped, rather than just doing it on your own. You get everyone's opinions involved in that, and differing perspectives definitely helps. (13/3/24)

I think if you hadn't had experience in this sort of stuff and you're probably new to pipeline design and stuff, it'd be a great way of really learning about the breadth of stuff you have to deal with. Even if you have some experience maybe, but maybe in a purely technical role. Often that technical role you've got very narrow band of responsibility, but in a way of opening up all the other things you have to think about. It's great. (14/4/24)

I think as a junior as well it's quite easy to be like, "Oh, this would never happen." Whereas, a senior, you've seen it. You've actually seen it happen. Just having that person be like, "No, it would. Trust me." (20/5/24)

Because you're still nervous earlier on so you're like, I'll just do the conservative, I'll do the right thing. Whereas I was given a perspective from [a more experienced engineer] yesterday, but in reality if you do [pick a less conservative option] ... There's other things you can put in place. Then today one of [the more experienced engineers] had said, ... but there's other things that go on inside. So it's not like you both might not feel you've added that much, that it's huge from like a junior level. (30/4/24)

But more experienced engineers enjoyed this aspect too:

From one of the more experienced ones, the same again. To be able to actually impart some of that as well and reflect. You don't get a lot of time to do it when you're just in the thick of it a lot of the time. (29/4/24)

Having engineers with different perspective and backgrounds in the group is useful as this participant articulates:

It's less the game and more what the game facilitates from the group. If you got a bunch of people playing the game that were, let's say, 10 year olds and know nothing about it, they're just going to click buttons and be like, "It's fine." Whereas, if you get different engineers or project managers, like people were saying, ops guys, brings different perspectives to the table. (20/5/24)

As already stated, the training targets pipeline engineers but shows their decision making in a social context that includes other disciplines. Many groups thought that the training would be a good way to showcase the complexity and motivation for engineering decision making to other professionals. This is discussed in Section 5.7 below.

5.6.4 Scenario design

The scenarios were intentionally designed with uncertainty. Participants noticed this and liked it.

I actually like that the choices were, not always difficult, but they were a bit challenging. You could see good sides to both choices. It's not like one was an angel and a devil, like one's definitely a throwaway option – they both would be relevant most of the time. So, it required a bit more thinking and a bit more of a discussion, so I like that. And that seems how it is in real life as well. (13/3/24)

This was part of what prompted discussion within the small group

I think the first one I remember going, "oh, I'd probably go conservative, the T1." And then he kind of explained more – "well, we don't exactly know that there's going to be that development happening within the next five years, so -" – (29/4/24)

... with the stakeholder engagement. I wanted to instinctively just do that. But the way [colleague] explained how he thought that would possibly have been captured through the process of, "we've already up-spec'd the pipe. We've taken the step to account for the possibility of it coming in the first place," often moves me away from the knee-jerk reaction to spend the money and talk to everybody under the sun. (29/4/24)

5.6.5 Software

Some groups commented on the software itself.

They saw useability as high.

It was a very user-friendly software. It was pretty easy to use, just keep clicking. And the language was simple, and the characters were easy to follow through, and they are fine. (13/3/24)

The level of complexity was appropriate:

It was the right level of complicated. There weren't too many characters involved, or too many options going on, and getting bogged down by a lot of details. (13/3/24)

The scripted conversations between characters were good:

And the script was written quite good, and it's not too long. We did read it out rather than someone talking to you, or you are in a meeting, or listening to audio. (13/3/24)

It was like a conversational tone, which was good. (13/3/24)

Some of the older participants commented on the retro style of the graphics:

Someone like me who grew up in the 80s, there used to be those games that we used to play at the school. Exactly like that. It kind of reminded – I mean, if you didn't grow up with that, you kind of wouldn't get the retro fun, but we used to play games like that. (20/5/24)

While younger participants know the black and white style is actually current:

There's still games like this. It's very reminiscent of a visual novel. (20/5/24)

5.6.6 Logistics and practicalities

The workshops were scheduled to run for 4 hours (including a 30 minute focus group at the end). Participants were asked to comment on their preferred length for such training. No participants expressed a view that the workshops should be shorter and generally the pace of the content was seen to be appropriate. Several participants suggested adding various things to the workshops, implying that the sessions could be longer.

It was noted that the space in which the workshops are conducted is important. Playing the game in small groups of 3 or 4 is preferred with the opportunity to come back together in a larger group (made up of 3-5 of the smaller groups) for broad discussion is ideal. This implies sufficient space (or breakout rooms) for the small groups to work without interfering with each other and a larger space for common discussion.

The workshops were relatively paper-free but some handouts were provided. Participants liked the game outcomes on one page and the capabilities list on one page. They were less interested in the game tutorial.

5.7 Suggestions for improvement

All focus group participants were asked for suggestions to improve the workshops.

Many participants saw an opportunity to use the game to showcase engineering decision making to other parts of their organisations. Many groups suggested running sessions with senior management, operations and maintenance personnel and/or procurement and commercial personnel. The overarching goal seemed to be

it might be good for teaching them ... when you do something bad in the real world, most of the time you get away with it. In this game if you choose the wrong things, you don't get away with it. (13/3/24)

or

[With an engineering background] we're always going to be relatively conscious of the public safety. It's nearly a given in your day-to-day stuff. Whereas if you get people in here from commercial and things like that, and you run them through the same scenario where they're a little bit out of their depth technically, if your intent is to try and get them to take-away the public safety in these type of thing, maybe they might get more out of that learning space. (13/3/24)

This could be interesting to try but these groups are not the current target audience for the workshop. A different audience implies different learning objectives and outcomes and therefore likely a different learning design.

Other common comments for further development were essentially to make the game more technical in content. One suggestion (20/5/24) was to give players a limited budget so it was not possible to choose the most conservative option at each decision point. This is not functionally feasible at this point and also not technically correct either⁴. Another participant (29/4/24) wanted

⁴ AS 2885.6 requires risk to be reduced to a level that is as low as reasonably practicable (ALARP). To make a definitive assessment would require more technical information for any given scenario. It is also important to note that capacity to pay (i.e. setting an overall budget independently of safety considerations) is not a valid reason for not implementing safety-related measures.

us the rewrite the entire game as a safety management study along with associated decisions. A third participant (14/4/24) suggested getting rid of all the graphics/animation and designing the game as a decision tree, perhaps with references to engineering controls and procedural controls from AS 2885. All of these suggestions appear to misunderstand the learning objective of the workshop.

Several people suggested that we could provide more technical information such as graphics showing effect distances of a ruptured pipeline. Several requests were also made for additional choices or additional decisions. None of these were because the existing material was incorrect but that it would be improved by additional details and additional complexity. None of this is feasible within the current project and is of dubious value from a learning perspective, although it might make engineers more comfortable.

When it comes to links to capabilities, one participant (20/5/24) suggested that on the second play through we could include popups flagging opportunities to draw on capabilities when they arise to make the links clearer. This is beyond the scope of the current project and is perhaps contradicted by a comment made by another participant (29/4/24) who objected to the way in which capabilities are treated in the game currently (which is to flag capabilities that were not successfully met for less-than-optimal outcomes). This group pointed out that this is overly simplistic, given the complex and social nature of engineering decision making i.e. an individual engineer might try to make a decision in line with a given capability but be overruled by others.

Several participants made comments about the final debrief and linking the workshop back to their daily professional practice. They suggested some more reflection time on capabilities and take away lessons learned. We attempted to do this but ran out of time in all workshops so we will build this more robustly into the facilitation notes and perhaps include a final short activity.

One participant (29/4/24) suggested concluding by linking to lessons learned from past accidents. This is effectively merging the two styles of case based learning that this project seeks to evaluate and could not be done very meaningfully without extending the workshop time.

Specific changes to the game/workshop design that were recommended and will be actioned include:

- Reviewing the script of Scenario 1 to check logic around T1S.
- Reviewing the script of Scenario 2 to clarify the landholder conversation re locating the MLV make more sense if option 1.2 is chosen in the first scene.
- Reviewing the script of Scenario 3 to make the preferred option at each decision point less obvious.
- Correcting typos and other small errors identified in the game itself.
- Making the back end of the game more robust to address the tendency to crash before the final scene (caused by clicking out of the white box).
- Building in a link to practice exercise to conclude the workshop.

6 Post workshop interviews

The final evaluation method was an online/phone interview in which participants describe what they remember from the workshops. This method focuses on the impact of the workshops on professional practice.

As detailed in Section 2.3.4, participants were contacted around three months after their workshop participation. The key themes from these interviews are summarised below.

6.1 Overall impressions

In post workshop interviews, most interviewees had some recollection of the workshop they had attended and some reflections on the session. A small number of interviewees had difficulty in recalling anything meaningful but these were a small minority.

Some interviewees reflected that the game illustrated the direct connection between decision making and real world disasters.

there's multiple different outcomes that you can produce from one project as such and it really does depend on the decisions which you do take throughout the process about the outcome which you'd get at the end. (I56)

it added a sense of realism and authenticity that makes the importance of these decisions even heavier than it already is. (I38)

In terms of learning, the interactive nature of the training design was memorable.

I think it being so interactive is such a – I walked away feeling like I got my hands a bit dirty. I actually saw things in real life, sort of. I felt like you gave us the power to make decisions instead of standing up and just talking to us about how things can go wrong. (I53)

It's like we had the power to make those decisions and see how – because sometimes it's like, you hear about these things that go wrong, well, how could that possibly happen? It's just like – but you can kind of see how that happened whereas if you had just lectured at us, like I wouldn't have absorbed it in the way I think I did. (I53)

As was the experience of playing the game in small groups.

I did gain something from the workshop definitely. This is the first time that I've seen such an interactive program carried on and it gave the opportunity for all of the attendees to brainstorm and work together to come out with the comments and the knowledge. (I28)

I thought the game was very really helpful and the game – playing the game and then having a discussion about each step was pretty top notch in my opinion. It beats just reading things and listening to someone for an hour or that session was three hours. So yeah, the game was more interactive, and it helps, I guess, team building, get everyone's ideas as well, not only within the three or four people I was in the group, but everyone else's discussion after. (I33)

The realism was valued but the gaming environment was valuable too as it allowed people to explore various possible outcomes in a zero risk environment.

the game environment was really good and took the pressure off. It wasn't like a test. (I13)

I think the most interesting thing was afterwards when we went back through and had a chance to see what the impacts of choosing different options were. So, not going with the obvious answer. Especially different combinations of quote, unquote wrong answers. (I39)

That's what I think it is the beauty of the workshop itself. Whether the outcome – we're not going to just come up with a pass or fail in the examination. It's this casting our mindset. Whether the team receive the best outcome, or the worst outcome, it doesn't matter. (I47)

Some reflected directly on the capabilities framework and its value to them and the rest of the industry.

this is the best list I've ever seen. This is so good. (I55)

So that's the takeaway points here, I've got [the capabilities handout]. And I've been doing this on a day-to-day basis, but it looks like this workshop can give me something like – it is kind of structured. (I47)

[The capabilities framework] was actually very good. ... A really good consolidator, of capability and how it applies, and I think that was really good. ... I recommended, this would ... be suggested to Engineers Australia as ... if not for the mechanical or general engineering, at least, because we had oil and gas pipeline engineering category in Engineers Australia. ... It would be quite useful. But I think in general it would be good for all engineers to understand that. (I32)

Many interviewees also asked whether more workshop sessions are planned and expressed interest in organising something in house or with Young Pipeliners Forum and similar further illustrating the perceived value of the learning experience.

Building on these opening reflections, interviewees were asked specifically about what they remembered about the scenarios themselves.

6.2 Recollections regarding game scenarios

As described in Section 2.1.2, there were three game scenarios developed. Each half day workshop focussed on a single scenario. Twenty-three people attended sessions where they played Scenario 1 about third party damage. Twenty-one participants played Scenario 2 regarding flooding and thirty participants played Scenario 3 which is about welding in service.

The number of evaluation interviews conducted for each workshop design is shown in Table 11, giving an overall response rate of 82%.

Table 11: Participants by workshop design

Case	Total Participants	Evaluation interviews	%
Scenario 1	23	21	91%
Scenario 2	21	16	76%
Scenario 3	30	24	80%
Total	74	61	82%

NB some individuals attended more than one workshop and so are counted twice or even three times.

Participant recollections about each of the three scenarios are included in the following sections.

6.2.1 Scenario 1: Third party damage

Scenario 1 starts in a design office where a design team is deciding what location class to use as the design basis for a new pipeline running near a regional centre. After a discussion between characters in the game, players must choose between R1, T1 or T1S as the location class which then sets engineering design requirements. Scene 2 takes place 20 years later in an SMS workshop where players need to decide whether or not to increase stakeholder liaison activities related to third party contractors who may be working in the area. Scene 3 takes place four years further into the future when the pipeline has been sold to a new owner. Details of the original design basis have been lost and the pipeline company finds that a school is to be built near the pipeline. Players need to decide upon the level of investigation to determine the depth of cover and pipeline wall thickness. In the final scene, construction goes ahead and, depending on choices made in scenes 1 to 3, outcomes vary from successful construction of the school and its associated playground (with or without excess costs) to rupture of the pipeline by third party construction activity leading to an explosion. The details of the scenario are such that the best decision making shows effective application of all six non-technical capabilities (see Table 1). A summary of decisions and outcomes is given in Appendix 1.

Uniquely, this interviewee remembered the scenario and four associated scenes accurately:

so it was a three-stage game, but the first discussion was whether the pipe gets installed in a – or should be sought for rural conditions or residence or industrial areas. And there was another one about discussing SMS with – whether that need to be revised and passed onto other key stakeholders. Can't remember exactly those details. Then there was a third one where a company took over the pipe, and then there was some details investigating more things, and there was a new school that's been put on top of the pipe. And that was at the final stage where the pipe was either ruptured or not. It depended on the choices you made. (I33)

Most interviewees remembered much less about the details of the scenario, describing it in different ways. Despite the scenario being labelled in the game and by the facilitator as being about third party damage, the scenario was most commonly remembered as a case of defining the best location class for the pipeline design and the subsequent urban encroachment:

It's putting something is close to the community, and they think to do some – to have encroachment of the pipeline (I02)

It was that pipeline scenario with those – you know, the location classes and in case of an incident happening in an area. So you've got the township at first, design for rural class, then up to 20 years, then another school and something came in next to it. (I09)

the dangers of urban development in terms of location classes (I31)

it was a pipeline in the rural area and then they built a city and then they built a playground or something like that on top of that. (I15)

cross-country pipeline running adjacent to residential, or expanding residential area. (I18)

constructing a pipeline near a school (I21)

we did the pipeline design one, where there was a potential future township expansion, I think it was (I08)

Most of these participants seem to remember the long timeframe over which the scenario played out.

The location classes mentioned by some interviewees are a tool used as part of the pipeline design process specified in AS 2885 and another participant notes this connection between the framing of the scenario and the requirements of the standard:

the session that I attended was exactly a revision of that standard, literally, with the, what would you do if there is a school coming up next to your pipeline or future construction going on in the easement (I03)

A final participant remembered most vividly that the scenario is very realistic.

it was definitely to the point. It was definitely an industrial experience, like working in the industry, I felt that, okay, this is exactly what we come across on projects. (I03)

A few characterised the scenario as being about third party damage:

Third party tried to erect a structure near to the pipeline, was it? They went and hit the pipe. (I01)

Third party damage from doing a project or something (I10)

Interviewees elaborated on these answers by describing what their activity of playing the scenario was about. Most remembered that the activity was about decision making that needed to balance a choice made now about design options with the operational requirements of the pipeline in the decades ahead.

we had to make decisions about whether we allow for that now, or how we go about in the future, and all that sort of stuff. (I08)

we were making decisions around, the consequences to the school or I actually don't completely remember the scenario. But whatever we made early on in that project phase was really going to have an impact in say, 10 or 20 years down the line. And yeah, I guess being able to understand that, even though there are plans

for the future in our designs that we're looking at, they could change over the years. (I13)

it was around about the SMS process and how that would work, and the considerations that would need to be made in the design phase, I expect. (I20)

that one kind of stuck with me as you're not necessarily assessing risk, or what's there, it's what could be there. (I21)

we had to make decisions about adding extra layers of protection, slabbing, and stuff like that. We had to make decisions about putting more people on the ground as inspectors and things. We had to make decisions about something to do with risk assessments, I think, and controls. (I01)

Several of these responses hint at the uncertainty involved in the sense of not knowing what future land uses near the pipeline might be.

Another factor of note was the need to balance sensible pre-investment versus gold plating. One interviewee commented that this highlights:

the different types of understanding you need, and the more you fully understand those different bits of knowledge you might make better decisions, at the beginning, if you know this is what you're going to have to deal with later. (I08)

This emphasises:

the interconnectedness of everything, ... and how that relates to the design decisions. It was a bit about how to deal with uncertainty and perhaps the economics of everything; you can't make everything 100% safe every time. ... don't gold plate stuff if it may never happen. There's lots of stuff we've put work into that's never ever happened, but we try not to do that, we try and do it as the demand requires. (I08)

Also balancing uncertainty, cost and conservatism, other interviewees noted:

We were looking to have the maximum safety and also having cost-efficient project based on the situations that may happen in the future like building a city. Are we going to consider that in the beginning or no, we'll think about it later on if something happens or not? (I15)

I think it was good in the sense of running down through a timeline of events to say something bad happen if you made the wrong choices, but if you made the right choices then you're all good. However, it also has a caveat of sometimes if you overdesign it too much that might not also be the best solution because it ends up costing more money in the long run in general and is not necessarily safer. (I25)

Aiming to communicate associated with how much pre-investment do you need to make in terms of an asset prior to it, depending on the risk profiles that you can foreseeably expect. So running past the township. I think from memory you were about five kilometres outside town. And over the 15 years they never expected it to migrate that far. Ended up being, "We're going to put a school in the vicinity of it," and then it became, "Let's put a playground right over the top of it", with big poles that then need to go into the ground, (I18)

Overall, participants mostly describe the scenario in very concrete terms, rather than the abstract concepts it illustrates. Also, they are overwhelmingly focused on the first decision in the game – what location class to choose. Later decisions regarding stakeholder liaison or dealing with gaps in design data decades on seem not to have remained in focus. Some interviewees immediately link the scenario to their professional practice in a technical way noting the common factors between the game and their work in compliance with AS 2885.

6.2.2 Scenario 2: Flooding

Similar to Scenario 1, Scenario 2 starts in a design office where two junior engineers are discussing the appropriate design basis for flooding for a new pipeline to be built in a remote part of northern Australia. In the first decision choice, the junior engineers have to decide whether to seek assistance with the task they have been given. Scene 2 turns on negotiations with a landowner and the decision regarding location of a mainline valve station. Scene 3 occurs in a SMS workshop and revisits the question of the flood design basis. Scene 4 occurs during construction when a pipeline section has been buried without complete verification that buoyancy control measures have correctly been put in place. Players need to decide how to respond. In the final scene, a severe rain event occurs and, depending on choices made in scenes 1 to 4, outcomes vary from minor damage to facilities to complete loss of the pipeline section and valve station as a result of flood damage. The details of the scenario are such that the best decision making shows effective application of all six non-technical capabilities (see Table 1). A summary of decisions and outcomes is given in Appendix 1.

Almost everyone who played this scenario characterised it as being about flood, particularly in relation to Scene 2, the discussion with the landholder about pipeline routing.

looking at flood risks for pipelines, I believe (I31)

I did number two, which was the pipeline construction on the floodplain. (I39)

We looked at a pipeline which was being built throughout a farmer's property which needed a bit of consultation. (I56)

It was to do with floodproofing, essentially; (I44)

it was a flooding of the pipeline (I45)

the flood one where we were looking at going across farmers' land (I46)

There was one that was about you had to talk to the farmer because he wanted to move the pipeline. Or he didn't want to move the pipeline and we told him he had to. There was a creek. You had to move it away from the creek, I think. It was something like that. (I55)

going through a landholder's property, and do we go into the creek, do we not go into the creek, we run it up on his ridgeline, which he didn't want us to do, or do we not, and put the facility up there or not. (I18)

going through the particular land and whether it needs to be within the valley or a little bit of a trench, I suppose, on this land or located elsewhere. So yeah, I guess that communication with the land owners (I13)

Noticeable in these descriptions is that interviewees are identifying with the pipeline company employees e.g. 'we run it up on his ridgeline, which he didn't want us to do'.

In terms of the decisions that players needed to make, many interviewees also recalled Scene 2 involving the landowner:

do we put the facility down in the paddock, in the gully of the paddock along the creek line, which is where the landholder preferred to put it. Or based on the flood risk scenarios I think it was a one in 100 flood risk that you gave us, rather than a one in 50. Had the potential for it to flood and significantly damage the asset. Do we pre-invest in putting it on the - down the bottom with barricading and other mitigations in place or do we move it up onto the hill. Can we manage that without interfering with his cattle and stock migration routes that he was working on, that he had. How would we access that facility as well, came up into it in terms of the impact on gates and other access around his property. (I18)

talking to the farmer because it was going to need to go across the farmer's land potentially, either across the farmer's land or in a lower position, so if there was a flood it'd be more likely to be damaged. I'm going to assume we went that way. We talked to the farmer. The farmer obviously doesn't want anything built on their land, which, understandable, I wouldn't want anything built over my property either, but we decided to push to build the pipeline on the farmer's land in a respectful way, hopefully. We had that built there. (I46)

Obviously, I've not had much experience with that, I haven't done anything around that, but seeing how the more senior people talk about how the options in the game versus what just happens now; whereas, they just do a compensation and then they just - Say one farmer's particularly unhappy about it, they might just try and increase the compensation or still be accommodating. Like the options in the game, where it was either put it down by the creek or actually, no, it needs to go up on the ridgeline to avoid the MLV station being waterlogged, which is the outcome if you don't do that. And then I think the inference there is maybe they cover the cost for the farmer to move his sheep or his cattle from one paddock to another so they can construct it or something. Something around that. (I12)

Other players remembered the first scene involving two junior engineers quite vividly, in some cases linking this to Scene 3 where the issue of investigation into the flood design basis comes up again:

The initial part of the scenario was junior engineers were working on it without necessarily – some of the designs checked which I think we spoke about. And really just, dare I say, not the standard, but some of the normal things that happen in a particular project such as that, but I can't remember the exact – what made it unsafe in that particular circumstance. (I44)

the design was the site was prone to floods. And based on the calculations, it was initially with the engineering and design. So we had a discussion that was a kind of game between – a play between project engineers and the design – design. First of all, they contacted the design lead. And then they recommended a junior engineer ... run through some calculations, and we know that he was kind of inexperienced. But there was ways how the calculations were done. We did have a trouble-shoot of how we reached to the accurate solutions. And we did had a session where the only calculations done by junior engineer led to a flood, and then the re-checks of those with several stakeholders, including the seniors – that led to very accurate, good designs, and even the cost-friendly. So I think that was – the scenario is still fresh in my mind. Yeah, so I could recall – because, you

know, these things we deal in our everyday working. So that's the reason. But yeah, this is what I can recall from the session. (I45)

I think there was some like – it was like standing up, like the girl right at the beginning didn't quite stand up for herself and I think that – that's something I've remembered a lot, I think. Also being a young woman in the industry, that is something that has stuck with me, about how she – had we just listened to what she said, then it wouldn't have happened. She kind of second guessed herself and then went down a different road and it kind of ended in disaster. Obviously, it's a very far-fetched kind of domino effect, but I think that is something that stuck with me, that it's like, stick to your guns, I guess. Which I know like it wasn't necessarily the whole point of it, but that was just something I did think about. (I53)

there is intern or making some investigations – decision on whether to make further investigations and can choose yes and no and then we have client meeting and then after that there is site investigation, I think. Then there's a severe rainfall event and then it cause flooding. (I16)

I remember it started with some - I'm going to say junior engineers but they were more inexperienced - working on a project. They were looking at the flood zones around this area and they were a little unsure and the first point to the side was do we go ask a senior engineer for help or do we say, 'No, what we've done is good'? ... We went and talked to the senior engineer and they said, 'I've done something similar before, you need to look at a bit of a wider area'. And I believe there was a dam nearby or something that went looking into it. (I46)

While many interviewees found this scene sufficiently compelling that they remembered it, they mostly do not talk about themselves as being the junior engineers, rather the interactions in the scene are mostly something they observed. The exceptions are the last two quotes where part way through their descriptions these two interviewees move into the scene and talk as if they are taking part rather than just observing.

A few people recalled Scene 4 which was about construction verification:

I remember the decisions that got made. I remember with the different scenarios – for example, one of them was digging it back up to check to see whether it had been laid at the correct depth with the correct – I can't remember if it was the correct structure behind it. (I44)

Then there was also a section around - it was double checking whether it had been buried to the right depth and we had the choice to either trust what the guys onsite said or to doublecheck. We doublechecked and it was too shallow so we redid that and obviously that cost money but saved us in the long run at the end. (I46)

there was the part where the pipeline wasn't dug low enough, so then you had to choose to re-dig it (I53)

The other one was the flooding case of should – I remember there was a should we do the flood study? Should we do buoyancy control? And then obviously there was do nothing or implement it or dig it up. I can't remember, something like that. Again, it was that risk approach of should you do it, or shouldn't you? (I30)

Similar to Scenario 1, participants mostly describe Scenario 2 in very concrete terms, rather than the abstract concepts it illustrates. Scene 2 involving landholder liaison seems to be most memorable but some interviewees were also very engaged by the office-based decision making regarding the selection of the flood design basis. The scene regarding construction verification was least memorable, although some interviewees did recall it. Despite this focus on concrete details, some interviewees had connections to their own experience close to the top of mind when recalling the workshop.

6.2.3 Scenario 3: Welding in Service

Scenario 3 is more operationally focussed and turns on decisions regarding an in service pipeline repair. A company with little previous pipeline experience has purchased a transmission line with a known defect and in Scene 1, key players in the new company meet to decide what to do about it. Scene 2 involves negotiations with specialist contractors and the regulator about how best to move forward to plan the repair work. Scene 3 involves deciding who to trust to do the physical repair based on earlier responses received. In the final scene, repair work goes ahead and, depending on choices made in scenes 1 to 3, outcomes vary from successful repair of the pipeline (at optimal cost or with excess costs) to rupture of the pipeline by botched repair work leading to an explosion. The details of the scenario are such that the best decision making shows effective application of all six non-technical capabilities (see Table 1). A summary of decisions and outcomes is given in Appendix 1.

Almost everyone who played this scenario remembered that it was about doing a welded repair on a pipeline.

something to do with the pipeline defect repair. (I28)

it is welding in service decision points and endings (I47)

it was about a defect on a pipeline which we had to repair via hot tapping (I50)

It was more to do with operations, but I think it might have been a damaged pipeline and then whether the repair or not (I14)

in the welding scenario and making sure that welds are up to standard. (I13)

Some also remembered that the pipeline had recently changed hands and the new company was lacking in information about the pipeline condition and the experience to deal with the situation.

I think that was about the company's recently purchased the pipeline. (I26)

that one is to do some hot tapping with not much knowledge of the pipeline information. (I02)

they didn't have the ... pipeline information, or the data was missing, or they didn't have that information in hand. (I19)

I guess the scenario was, yeah, that there was a new operator that basically purchased, took over an existing asset from another operator and then was running through the engineering assessment basically validating that was fit for service, I guess, and then running into challenges as business challenges. (I22)

The company in the scenario had bought or inherited a pipeline with a known defect. (I27)

Others initial recollections focused on problems which arose depending on whether the new company chose to get specialist contractors involved and how they chose who was best placed to help them.

the welding one, there was, one company was more expensive, one company was available and cheaper and then we went with that one and they blew up the pipeline.

it was the new company taking over the pipeline, the sort of historical anomaly data, and they were deciding their best approach going forward as to repairs, or going out to tender, and comparing quotes that they'd got, or whether they look for another cheaper offer, or stick with the more experienced contractor. (I42)

I think it was repairing a pipeline, or like, we should repair a pipeline, but then if you made all the wrong decisions, you don't repair the pipeline and you go down all the wrong routes, and don't get the correct subbies in, and then the pipeline blows up. (I04)

The welding one. That just, to me, reinforces the idea that if you don't know you probably shouldn't be doing it. (I12)

Similar to the other scenarios, interviewees recalled that they were called upon to make a series of decisions working as a small group.

It was in relation to us being part of this new pipeline company and we got this information about the pipeline that we either had the option to reduce the MAOP or to rectify this defect. So, yeah, we got information about a defect on the pipeline, it had been a year since we initially had that information, and yeah, there was those initial options and they branched out into further options down the track. So, we worked together as a team to go through the scenario and hopefully not blow up the pipeline. (I40)

so since all of us were engineers in the team, we were looking at the game from a real technical standpoint. So what would happen, basically, if things in the game were to fail on a technical standpoint, and that would be catastrophic. Since we don't really have commercial backgrounds, we don't really have that. (I06)

Scenario 3 includes three scenes that all turn on balancing short term cost with the need to repair the pipeline to ensure ongoing reliability. When recalling and recounting the decisions that needed to be made most people merged the scenes together and remembered one or more broader characteristics of the choices that needed to be made. Some people focused on the lack of experience of the company in the pipeline business.

I think a lot of the choices were in relation to the company and the game being a very new company so they didn't have a reputation of, you know, maintaining that standard of safety. (I06)

Others emphasised the uncertainty regarding the pipeline condition.

the first decision on either reducing the pressure or going through a contractor was we need to know what we're dealing with, whether we can just run with a reduced operating pressure for a long time, or yeah, you need to know what you're dealing with, so that drove that decision. (I40)

Others emphasised the need to balance commercial and practical engineering aspects.

The second decision about going with the first contractor or going to tender, that one was a bit more debated amongst the group. So, they said the typical company policy is you're meant to go to tender, get three quotes from three different companies to ensure you get the best price. But on the other hand, based on the information we got, we were saying well, the sleeve is a long lead time item, if we go to tender then that's going to delay that whole process and then we might be behind by the due date of when we need to rectify this. (I40)

that was all about it was a company the bought the asset with a known defect and then they sat on it for a bit and then, eventually when they had to fix the problem, they had three options: fix it the right way, don't fix it, or try and fix it without the shutdown effect, with the wrong way or the highest-risk way. And the game ended up showing that the only one that worked out was you do a shutdown of the pipeline, lose a whole bunch of money, but you still have a pipeline at the end of the day, you don't have an inferno or an explosion like the other two scenarios' output. (I12)

They were presented with options to repair the defect, first by a reputable company who had relevant experience, and second by a company who could execute the work immediately and at a lower cost. Choosing to go with the reputable company to execute the repair was more expensive upfront, but resulted in the best result with the work being completed safely and with positive effects on the reputation of the pipeline owner. (I27)

Some players identified with the characters in the game and spoke in first person as if they themselves had to make the decisions.

we need to make a call whether it's good to do a hot tapping, or we isolate the pipeline. (I02)

It was like a pipeline with corrosion, I believe, and we had to get in specialised – or well there was an option of like delaying it, or going out to get pricing of specialised subbies to come in and do it. (I04)

Then there was one where price came back and it was do we use the people who have been doing this forever, even though they're a little bit more expensive, or do we go to someone who's mega cheap? (I04)

The first major decision point I guess was either reducing the MAOP or getting in a contract to further assess the defect as we were playing a young pipeline company and we didn't have the internal expertise to provide the answer on how to proceed. Then from there, there was a contractor that we could proceed with the works, all be it that might have been a bit more pricey, but they could order all the required parts straight away because there was a lead time, or there was the other option to go to tender and look at the other companies. (I40)

Compared to the other scenarios, more players took general lessons about decision making directly from this scenario:

It stuck with me about how to influence the management to buy into some safety, or decision making from the engineering point of view. So that is the things I can remember. And then the other thing is how we look at the overall project decision; whether we should engage a consultant to do it up-front, or whether we just go by the book and based on the historical information. (I02)

I think that's very, very crucial to know before you take ownership of an asset without knowing the full history behind it as well, so I think that was a key learning as well, there. (I19)

I think it was more of a comment from someone in the classroom, maybe not in the actual game, but yeah, saying, making people accountable. And if you are to take a photo of the person who's done the weld with their work beside them, then they're probably going to make sure that that weld is perfect. So yeah, making people accountable for, and having pride in, their work is important. (I13)

As for the other scenarios, initial recollections of interviewees mostly turn on the technical problem that the scenario presents. The most memorable aspects relate to the choices regarding minimising short term expenditure and some interviewees have generalised this to their own practice. Other factors in the scenario such as the relationship with the regulator or various contractors have faded from memory.

6.3 Recollections of capabilities

Most interviewees remembered that they had been given a one-page description of engineering non-technical capabilities. Many remembered that they thought the list made good sense at the time and several interviewees still had the course handout, telling the interviewer where it is or showing them (in the cases where it was on the interviewee's desk).

Despite this very few interviewees could recall any specific capabilities. Rather, what we see in the data is that when participants describe how the workshop experience has impacted their professional practice, they mention issues or important actions they now undertake that reflect the capabilities framework.

6.3.1 Foresighted reasoning

The first capability is Use long term, foresighted reasoning, especially in the face of uncertainty.

By far the most common link to practice made as a result of the workshops was the need for long term thinking. Many engineers made this general point.

Basically, what I would say is that, don't try to make short-term gains. Whether it's dollar amount, or time and resources. If you put in a little bit more extra hours and money into what needs to be done, then in the long-term gain, you have very long-term gains in terms of safety and risk. In terms of even the long-term, even it brings up the bottom line, up as well, because you've invested that short-term thing. (I01)

I think the decision making-wise I think it gave us a bit of a long-term planning – I mean, just to make sure that we keep the – we do plan it for a long term rather

than for a short term. Like just to be long sighted. That's what I feel the main outcome which came out of that training which I attended. (I09)

sometimes people in industry think about cost effective solutions, but sometimes they are cost effective for a short time but in the long term maybe they are not the good decisions for the future. So that's why I learnt and if we spent a bit of extra money this year, or this duration or whatever we had, you know, taking decision, it may help in the future. (I11)

it does make you think about some of the decisions you do make. It kind of reinforces the work that I do in the pipeline industry. There is a lot of risk there to people, the environment, even the economic risk of failure, things like that. (I22)

I think it kind of opened up a bit of a bit more awareness of the future impact when you're involved in the early design phases, or even in review phases when you're doing those five yearly SMSs and things like that. (I25)

And sometimes we look at the calcs and say "Well, this is your required thickness and then this is roughly how much it would be extra in tonnage of steel. Whereas if you chose to come back later this is what you might have to do, which would be a far greater cost than doing it now". (I30)

I think that was just my key takeaway was: take a step back, have a think, sometimes. (I46)

Saving money in that instance, especially in the long run, it was never going to be helpful. (I50)

Another link to practice made as a result of the workshops is the need to consider uncertainty in decision making inputs.

I guess being able to understand that, even though there are plans for the future in our designs that we're looking at, they could change over the years. And so yeah, I guess I can take that back to my everyday work because I can try and imagine, well, this is the plan right now but what if they do want to change the type of infrastructure in the future? What are going to be the consequences there? (I13)

So I have seen it in reality. We already made that conscious decision to actually over spec elements similar to what came up in the scenario modelling to allow for future potential. (I18)

Several interviewees noted the need to consider the ultimate consequences of one's actions.

Thinking more about safety, being more cautious and think about different scenarios that may happen in the future. (I15)

just looking at those consequences, and obviously where we sit with that. Seeing that barrier between industry and the public, so it needs to look in, but it's not something you really think about as a whole in your day-to-day work. You think about the pipeline itself and the integrity of that pipeline rather than what the then outcome is, and the effect on the public, or to the company itself. (I42)

it is good for me to remember the worst outcome. (I47)

Your decisions have real-world consequences. It's easy to feel removed. ... I think that was an important reinforcing point. (I55)

I guess after the workshop, it came more to the forefront about how it really does impact - those key decisions really do impact your end outcome, cost, client satisfaction, stakeholder satisfaction and that. (I56)

These all demonstrate use of the first capability that has been developed or reinforced as a result of attendance of a workshop.

6.3.2 Understanding norms

The second capability is Understand norms and values that inform actions.

The most relevant norms for professional practice are use of the standard (AS 2885) and consideration of risk. These are mentioned on numerous occasions by all interviewees as can be seen in the quotes included in other sections. Here are a few other specific examples of dozens that could be included here:

Yeah, the risk assessments are a major part of what we do. If it's a transmission pipeline, we assess it as per AS2885 and the guidance where it's very clear on what we can and what we can't do. (I50)

And what's the trade-off between the risk of putting it down on the ground, down in the gully versus the risk of moving it on the hill. (I18)

I think being an engineer - even at home as well some of the decisions that I'm making are very calculated. I'm thinking ahead of the risks and whatnot. Whereas, say for instance my wife, she wouldn't think that far ahead. So I guess working in this industry or as an engineer helps you manage some of those risks even in a day-to-day role as well, not just at work. (I19)

That said, though, the risk discussion is part of, not everyday occurrence for me, but it's a regular discussion. Just yesterday I was approached by another department within the organisation to have a conversation about a justification for a project and part of the justification is 'well, what is the risk? Is it tolerable risk or is it a risk that we have to address?' and until we're in a position and we understand that, then it's hard to justify a project either way. It plays a big part in what we do in this industry. (I48)

The other important norm for safety in engineering practice is professional ethics. Several interviewees took lessons about ethics from the serious game workshops.

being able to make sure that you're being true to yourself in a situation if it feels a bit - not dodgy, but for a better word, you don't feel 100 per cent about what's going on, then questioning it and having the confidence to actually do something about that. (I13)

It's probably more with regards to the ethical issues that you face in your career. ... It's basically coming out of that scenario with an outcome. Pretty much the takeaway is never to jeopardise on safety. (I22)

I guess there's a level of ethics there. Providing proper solutions. ... cost benefit, all those kind of things come into it. Obviously, you don't go and design rocket ships for something that you don't need to, but it has to work as well. Sometimes

you have to defend those with a client. The client might be cost focussed, whereas some people aren't. ... And then obviously there's a level of safety there too. (I30)

because professional ethics, it is critical. And also, we look at professional ethics, we're not just doing our own, we need to take care others and the public safety. (I47)

This demonstrates that workshop participants developed skills linked to the second capability.

6.3.3 Think systematically

The third capability is Think systematically and understand interconnectedness.

A key aspect of this capability is taking context into account. Several interviewees noted that a key takeaway for them was the need to understand the context of their decision making. This can mean the physical surroundings but also means the overall business context.

Public safety, yes, is always my number one concern. But I also need to look outside the safety regime, because sometimes you have to think about budgeting, timing and all this, and see how we fit into make a decision. (I02)

More about basically putting more emphasis on consideration of the surrounds. I remember that being a big thing, and then another big one that I do remember that the stakeholder impact. (I21)

The one thing, it's changed my vision to what issue is coming up on the assets so – and how should I think? How should I look at it? So I shouldn't actually just focus on what's engineering look, I should look at that, even the finance, commercial and the safety perspective as well. (I26)

we need to understand the risk, whether it is the risk is high or things like that. And then on this business, when I present this even to my manager, or to my counterparts, and then I have a kind of systematic thinking about the risks. And also, understanding the context is important; if I understand this wrongly, it becomes a garbage in/garbage out, and then it will make the wrong decision. So if understanding the context, that means I need to have a good cooperation and interaction with other part of the business before I can understand or have the holistic picture. (I47)

Understanding context can also be about communicating with others.

checking with the risk engineer or checking with the project engineer on – or the GIS team on what's the future plan or what government has planned in that area. Or maybe – you know, get an idea before you actually start building the pipeline, what they had on, what's the future industrial development plan in those areas and maybe taking measures or protect your pipeline accordingly. (I03)

Yeah, I think it's good. I think, a lot of times in work you can get siloed a bit, and you just get down to making decisions, and you don't always try to initiate that communication beforehand and see where other people are coming from and what their thoughts are on it. (I42)

The workshop experience was also a useful reminder of context for those who do not see the full implications of their decisions across the entire project cycle because of the nature of their work.

This can apply to more junior engineers or design contractors who do not necessarily see operational outcomes.

I think because I'm not making a lot of the big decisions on projects like the people in those scenarios were making. So more just for me understanding what's going on behind the scenes, and having the confidence to ask, 'What are those decisions that are being made in projects,' rather than just doing my work and being oblivious to those. (I13)

You definitely don't think about it on a daily basis, so it's definitely good to always be reminded that these things do have implications, even if you're just designing something. You don't always get to see the final product. We don't have a lot of construction experience, for example. We don't get to see the end product. (I24)

These all demonstrate use of the third capability that has been developed or reinforced as a result of attendance of a workshop.

6.3.4 Collaborate

The fourth capability is Collaborate with and draw on the experience of others.

A key aspect of this capability is working only within one's field of competency. These interviewees have learned that lesson.

I think the main thing would probably be not stepping outside the boundaries of your competence. I think that was one of the main things they were trying to get across with that scenario. (I39)

making sure if it's not your area of expertise, that you get the expert involved and you pay the additional money. (I52)

Others spoke about the benefits of collaboration. As this interviewee emphasised, the benefits of collaboration emerged from both the scenarios themselves but also the experience of the workshop and working in small groups on the game.

just that ability to communicate with these people in the industry who do have that knowledge, and that they're happy to share. I think that even came across in the scenario, it was like there was that experienced contractor there and these people are out there, they're a good resource to try and tap into and get the information from. You don't have to have all that knowledge yourself because people are happy to help you out. (I42)

Less experienced participants often learned a lesson in professional collaboration from their experience in the workshop discussions.

we had the more experienced person in our team with the technical knowledge, so it was eye opening, and not to be scared of these more experienced people, and that they're always happy to share what knowledge they have and get a chat going about some things they've learnt over the years. ... Yeah, just that fear of asking questions that you think are a bit silly, and basic knowledge, but they're happy to explain it to you. (I42)

It highlights the need for group work and collaboration in design and learning, because, I don't know, we all have different levels of knowledge and experience.

Yeah. By attacking a problem together, we can solve different parts of it and leverage off everyone's own individual strengths. (I31)

I think that fundamental philosophy around when you're working in a group is the ability to be able to stay open-minded, listen to other people's ideas and use that collaboratively to come up with a better solution than what would have been the case if it was just your opinion or just someone else's. And, yeah, I think that probably is the biggest takeaway for me. (I07)

I think just knowing that it's okay but also they've usually got a different perspective because of their experience, rather than spending lots of time trying to research the answers or read through standards. Yeah, a call is usually a lot quicker and more informative. ... I think it's definitely, yeah, brought me out of my shell a little bit in terms of that. (I13)

The workshops made some interviewees reflect on collaboration with organisational colleagues outside engineering, too. One interviewee (I26) told a story of how he tried to schedule some safety-related engineering work, only to be told by his company's commercial team that he could not undertake this activity during winter due to high gas demand from customers. The workshop was a further reminder that different parts of the organisation may have differing and equally valid perspectives that need to be taken into account when organising engineering work.

Similarly for these interviewees perspectives beyond engineering are important.

But it does give you that sense to maybe be a little bit more sensitive to the commercial side and what they are thinking about how that could affect your projects because that ultimately is a large part of a business. So, yeah, definitely thinking about that more. (I06)

get influenced by other parties as well involved. Like for example, the council or the designers, the consultants. Everyone has got their different view. (I09)

These all demonstrate use of the fourth capability that has been developed or reinforced as a result of attendance of a workshop.

6.3.5 Ground decisions in reality

The fifth capability is Ground decisions in reality.

Fewer interviewees made comments on lessons learned in the workshops that link to this capability.

The game itself provided a useful experience in linking pipeline engineering to the reality of possible outcomes.

Because being office-based obviously you don't necessarily see things down in the ground. Maybe it's easier not to worry, or just to do something quickly or do something the way we've always done it. But then playing the games, looking at the different – even playing the games after, where we got to the right answer, but then we wanted to see what would happen. Trying to make the park explode or something. It was quite good in that sense of getting an appreciation for what the impacts our decisions make. (I21)

definitely just being aware of public safety and how important that is, and I do remember one point in the training of being able to stand beside whatever it is that

you've designed..., you want it to be safe enough that you'd be willing to stand beside it, not just the workers out in the field and remove yourself from that. (I13)

One participant noted that consideration of site realities in design is important:

I think we've already always had that kind of thought process because sometimes it looks good on a piece of paper, but when you go out to site, it's actually not constructible. Even though it looks like it should be, it's not actually able to be put into the ground. (I04)

Another interviewee noted that the best decisions are about 'the practicability as compared to purely engineering' (I28)

A third participant told a story about a conversation where someone had challenged the status quo, bringing a new perspective to what constitutes reality.

I did run a risk assessment workshop about a month ago now and I do think some of those learnings came into it, just because we had some things where things came up where the general consensus in the room was 'this is fine, we deal with it every day, don't worry about it' and someone else in the room who was still pretty new to the company said, 'This is fine, are you sure?' I wasn't really thinking of the workshop, this is more in a hindsight/reflection thing, but that whole idea from the workshop of stepping back came into my mind and approaching it as a 'hang on a sec, yeah, I've seen this around a bunch, but is this okay?' and reanalysing it from that step back rather than - it's quite easy to get enmeshed in the 'yeah, this is what always happens, this is what we normally do' compared to 'okay, maybe if this is what we normally do, but is it what we should be doing?' (I46)

These demonstrate some use of the fifth capability that has been developed or reinforced as a result of attendance of a workshop.

6.3.6 Advocate for action

The sixth capability is Advocate for action and take responsibility.

Playing the game made some participants reflect on their responsibility for safety.

I need to alert the management that, "if you do this, just be aware this is a new technology, and you weld onto the pipeline with ethane, it's a new knowledge." And we have to assess it. And it's not just rush it through, "okay, we do it in the past many, many times for natural gas, but this time for ethane we can do the same." So I sort of related the risk – relating the project, and the project risk, and also the regulatory requirement. Because if something goes wrong, the regulator may shut down the whole project and then we have a problem. (I02)

the key learning was how you need to personally think about when you want to make a decision, of how to focus on safety, and how is it going to be practically working, not being really affected or impacted by management. That they may have less information about the actual technical aspects of the project. Because it often happens in the real world projects that project managers and some of the management, they're more focusing on schedule, budget, meeting targets, and then they might – they will not be aware of the pathway that they're choosing, might actually compromise safety and integrity of the work. So, as an engineer, you need to understand issues from the management, and you also need to be

very careful about decisions being made to make sure safety comes first and you make the right choices, and it's not always the budget. You need to understand if there are consequences that might be too severe that result in even more significant costs and loss and reputational damage and all of that. So, I think that was what the game was trying to emphasise on, for the younger engineers. (I32)

we have to speak up if we think it is not right, we have to speak up. Even though you speak up to your manager, whether your manager agree or disagree, we have to discuss this and with a kind of full flow discussion, debate, and to drive the best interests to the company. (I47)

I think that it's kind of something that's always in the back of my mind, is wanting to – it's not even necessarily like make a stand, but it's just like believing in myself. I think that sometimes I've thought about the conversations that we had around that and there was another girl in my group and we kind of talked about that a little bit. (I53)

With that responsibility comes a need to know how to effectively speak up and some interviewees reflected on that aspect.

I remember it being very much being able to put across your reasoning for making the correct decision I guess, for making the correct safe decision versus the correct corporate finance decision. And how really safety should be the number one thing. (I04)

So that was one of the biggest takeaway for me, is if you're going to have a meeting with the finance team of lifecycle specialist, how should I present my request to them, to convince them and try to approach what my role is for that purpose? Again, for the different person, it could be the asset manager or the regional manager of that asset, which they don't usually have the engineering perspective of that issue. So how I'm presenting that issue and that request, that's very important and effective. That's one of my biggest takeaway that games which was pretty good. (I26)

So, it's important to be able to mount an argument thinking about not just now but also in the future, and that it's not just about finances, it's also about pipeline integrity and I guess the overarching finances in the long-term, but as well as safety. The convincing others, that's around also I guess knowing your conviction around what's important as an engineer and maintaining or pursuing decisions that you think ethically are important, not just from a business perspective, but just as an engineer. (I40)

you have to effectively communicate the real consequences and risks through to the people who make those decisions. Even if you have the answer, and you know what's going on, and what needs to be done, but if you can't effectively communicate that and bring people onside, then despite your best efforts you can end up with a catastrophic situation. (I41)

A few interviewees noted that sometimes it might be necessary to take a stand.

I think the engineering decisions take precedence of the financial decisions. I mean, obviously, financial decision has an important impact, but regardless, we, I think as an engineering – as an engineer, the team has to make that point clear to

management, that these are the risks there. If they don't agree with it, we don't have to back down. We put our foot down, and if it has to go to the CEO, it goes to the CEO. It doesn't matter. We're not signing off on things that we're not comfortable with. (I50)

These all demonstrate use of the sixth capability that has been developed or reinforced as a result of attendance of a workshop.

6.4 Benefits of this type of learning

Most workshop participants had not attended a professional development or training activity that was based around a serious game as a learning tool. Given the novelty of this type of learning, many participants spoke about what they saw as benefits of this type of learning compared to their expectations based on typical training delivery methods.

6.4.1 Learning from others in the workshops

Most people claimed that they remembered more and learnt more from, the discussion parts of the workshop than from the game per se but the game provided the structure to prompt the conversations.

This structure gave less experienced people an opportunity to learn from more experienced colleagues.

I think more the discussions. It wasn't as much the game. It was more the discussions the game prompted. I remember after the game – we had gone through all the decision processes of the game, I think there was, yeah, four or five of those different decision trees – we had um 20, 25 minutes questions. That was just asking us questions, and we could ask questions back. I remember that I felt like that helped me more than the game. (I06)

I think the game's a good tool to promote the discussion, which I see as the more important aspect. I still think it relies on having at least two to three senior engineers, maybe one in each team or just a couple in the room. Definitely a good spread of experience levels, I think is better. (I12)

Talking to other people like with different mindsets and how they think about different situations. Also being new to the pipeline engineering in Australia in general that's really – helps to talk about more experienced people in the field and learn from them. (I15)

Not only the game, but also these people really helped me. And also at the end of the game there was a group discussion session. So we learnt what they did and what was the conclusion, the results. So which steps they did and whether it was the correct or wrong decisions. So it was also a good experience. Maybe instead of the game I liked the experience with the people. I liked the experience with hearing their thoughts, their experience. The environment was really good. (I17)

I think it'd be good to have more experienced people attending as well. Get that balance and conversations happening. Yeah. It's good to see there was a lot of younger graduates there. That's good for them to learn, but at the same time to get into these in depth discussions, it'd be good to have more experienced people there as well. (I50)

For more experienced colleagues, the game provided a mechanism for networking, testing their own decision making and calibrating it against other companies or other experienced engineers.

My biggest takeaway was the ability to network, see how other people made decisions, understand their thought process around it, which I guess indirectly related to the public safety side of thing. (I07)

Even the bit where we didn't get the best answer at the end, they were kind of arguing about that, and I think the fact that we didn't agree was still fine. We thought we'd made a better decision than ... the optimal, but that's fine. (I08)

Just working with the other colleagues, and obviously their considering the risks to their existing assets and things. Everyone else – or the people from various companies were doing that, they had safety at the forefront of their mind, I guess, or they were considering it as a high consideration, and safety and supply risks. (I10)

being able to collaborate with other people in the industry from different companies I think was super valuable, rather than just being an internal within our one company that we work in because we're all solving the same problem. And if we take away the whole company logos, then it's nice to work together. Yeah, rather than you're not competitors. (I13)

I think I've picked up some valuable insight from other colleagues where they share some practical experiences they had in the past (I16)

think it was good to see that the decisions that I was making was impact - stood out to be what the scenarios were aiming for, what it was leading to. I thought my answers were, pretty much as I said, spot on. So good to see that. But of course, also, to hear the other side of people who've made different choices, what that was, what the thinking was behind that. It was interesting. Definitely interesting, yes. (I19)

By having the right people in the room, and the tool – creating that environment where everyone felt comfortable to speak up but also it ... prompted conversation and discussion which was very useful. ... people in the room applied their own experiences and discussed things that they'd come across in their professional experience related to the scenarios (I31)

it definitely promotes mind challenging topics to talk about and decision making processes and how we, I guess, collectively decided what we thought was the best option or approach. (I33)

The perceived value of the group learning could be for several reasons. Pedagogically, the small group discussions provided a chance to learn detailed content-related information from experienced colleagues and extend the perception of less experienced participants about the reality of their industry and their place in that as professional engineers. Referring back to the Kolb learning cycle (Section 2.1.3), the large group debrief is an important part of participants being able to generalise what they have learned back to their individual professional practice.

6.4.2 Different perspectives on decisions

Many interviewees commented on the value of seeing different perspectives on decisions through the workshop. This relates partly to the different views of their colleagues in the room as described

in the previous section but extends beyond that to the different decision orientations shown by characters in the game.

All three scenarios involved engineering decisions being challenged by characters that wanted to cut back on expenditure. Participants noted this and found seeing how such conversations can play out as a useful aspect of the game experience and a useful reminder for their professional practice.

But just as in just being sensitive to that commercial side as well. How that plays into my projects and how it could affect my projects as well. So, I guess it's just given me a little bit more, yeah, sensitivity into that other side of the business. (106)

For engineering, usually we are more on textbooks, but there's a lot of aspect which is reflected in the workshops. There is a business aspect you got to take into consideration when you're making decisions. (128)

Knowing that there's definitely cost implications. There's schedule implications, and different people need to be involved. (124)

I think it's clear that the different characters in the scenarios had different agendas, which is how it works. I think we just agreed, and made certain decisions, that I think, quite obviously with the benefit of hindsight, resulted in the worst possible outcome. It was a valuable exercise to see that eventuate. (141)

There's the technical response versus the budget constraints and then there's the compliance element of it as well. And it was illustrating that different departments in an organisation have different drivers. It also illustrated management coming in and asking the questions that sometimes are perceived as being ridiculous and you having to work with management, guide them and things like that, so it was quite clever, a play like that. It was realistic in some terms, in some respects. Just the different points of view on that, as well, working with - well, there was only a team of three of us. And I've been in leadership positions so I've seen it from both sides and I really interested to see the conversation around that and seeing it from other people's perspectives. (148)

Importantly, this is not to say that safety is no longer paramount. The value comes from being able to anticipate questions that may be raised and so make a more effective case for safety expenditure (see also Section 6.3.6) as this participant explained:

Safety is still very important; it's the most important. But it's helped me to consider what other people – I guess it's not helped me to think about projects, it's more helped me to think about the social aspect of a business. What other people are going through, what's going into their decision making, everything like that it's helped me to consider that more. But, I guess, it hasn't really changed my thinking about safety; I still think that's the most important. (106)

One participant reflected that in days gone by more junior engineers working for operating companies used to change assignment regularly in the first few years of their employment and so get a general view of a corporation or industry. In contrast now 'they don't necessarily sit in on commercial decision making or how a project decides to rationalise a cost in favour of a certain outcome' as career paths tend to be more narrowly focused. This makes the workshop experience very valuable.

These early career participants confirmed that they are not typically in the room when difficult conversations take place and saw value in learning what goes on.

I'm usually in the background more supporting my lead, in that regard. That's why I think it was good in that regard because it gives you a bit of insight into some of the decision making processes that are done for engineering assessments, I guess, where you can't really – I mean, you're bound by some sort of financial aspect and it's kind of trying to assess the risk and lower it enough within the constraints that you do have from the business side of things. (I22)

I'm not you know that high up in the company, so I don't make a lot of the decisions. So, seeing how my managers and their managers make those decisions, and how that outcome comes out is good to understand. And, you know, getting the background on that definitely helps. (I06)

In any case, not everyone in industry works for an operating company. One regulatory participant found it useful to see how internal company discussions play out and the types of views that might be put from different disciplines.

it was useful because I could understand the perspective, two different perspectives of the industry. As a regulator, it gives us a good understanding of how the industry thinks when a scenario like this comes. (I01)

A participant from a construction company made a similar point:

it was very interesting. Because I've only ever come from a, I guess, construction background. I've never done technical and design, so it was quite interesting to see how their perspective was very different to mine. (I04)

6.4.3 Realistic scenarios

For the game to be beneficial in the ways already described, it needed to realistically portray technologies, people and situations realistically. We were successful in doing at as these comments attest.

I agree with the format of this game-playing, because it gives us some real scenario you can think of. It's not just come up with someone never getting work in the industry, or any researcher they don't know what exactly we're doing. The scenario is really real. Like I say, I was so surprised at the level of detail, the engagement of the management. And your scenario is so real. (I02)

I just think the whole thing, how you showed – the people who were there at the start weren't there making decisions later on, they're different people, that's just how it works, people move on and people retire, pass on, pass away. You're just down the track and not having any idea what that past decision was about. I liked that. (I08)

The content was really – I mean it was very much aligned with what we operate and what we work on a day to day basis. (I09)

I'm seeing some of the scenarios that you played out coming out in real play as well, at this point in time. (I18)

these things are quite common in the industry. (I28)

Several interviewees specifically mentioned our financially driven characters. One thought our financially driven characters were not tough enough.

sometimes in reality people are a lot more firm on their way of what the decision should be, and managing that in reality is probably something that isn't I guess covered in that course or that seminar. (I25)

Another thought they were realistic:

other people in the room, were able to say, "Oh yeah, I've had conversations when we were doing this job, on this line, and they wanted to do it this way," and those interactions were sort of reinforced perhaps by examples. (I41)

Another did not believe such behaviours would occur in the pipeline industry:

A lot of pressure from the finance guys where – I guess I've been fortunate enough not to work in companies like that, but look, I can see that happening in – maybe not in the pipeline industry (I50)

6.4.4 For early career engineers?

Some interviewees were of the view that the workshop and the game were best suited for early career engineers.

I would say the course would be more – or the game would be more suited for beginners. Probably people who've been a year or two or even less than who are just wanting to get an exposure on what are the different stakeholders, how do people think, what sort of risks we need to take into consideration. A lot of short-term, medium, long-term, what are the effects on it. ... maybe even for beginners, it would be a really good understanding that will actually give them a good understanding of how these things happen. (I01)

I found it helpful for probably junior engineers. Though, as a more experienced pipeline engineer where I've done a lot of these types of things a lot of it was fairly logical to me, and naturally driven. Where I think the value would come is in those people that have not been through significant risk review processes associated with pipeline designs to give them the scenario models of what could occur in terms of what's happening, and the types of choices you make, and the influence of those choices on the end outcomes. (I18)

it's a really good workshop for a graduate engineer. But of course having some who's more experienced as well to gain some of that experience or knowledge from the actual work incidents. Or anything that they can share with the group. (I19)

I think it's a great introduction for a certain level of engineer. Probably at the graduate entry-level space, and familiarising people. ... I would hesitate to recommend it to a journeyman engineer or senior level and above because it is I suppose quite basic in terms of what it does. It's something they should have done throughout their career already. So, I think it really does target the less experienced, or people that are less experienced in how design works. That's not supposed to be a criticism, I think that's where the product sits, if you like. That's its niche, where generally it's best value. (I20)

I'm more on the project side anyway, like more project with technical backgrounds. So for me those conversations are pretty day to day for me, so it wasn't anything necessarily new for me. I think potentially for more younger guys it is. It gets them exposed to that environment with zero risk. So I think they're helpful and I think how the conversations were had was essentially in alignment with how the conversations usually go in the office. (I25)

As the earlier sections illustrate there are several benefits in having participants of mixed levels of experience attend. Early career engineers learn from their more experienced colleagues and more experienced colleagues get to calibrate their experience with their peers.

One more experienced participant (I30) told us 'I think it would be more suited to a younger person than say myself.' When pressed as to whether there was value for him in having attended, he said, 'It's kind of just all brought it back of okay yes, you do do this for a reason, and you probably should argue for it rather than just going – pushing it aside going someone will sort it out later.'

This seems like a reasonable learning outcome to us and demonstrates there is value to be had at all levels.

6.5 Links between professional practice and safety

The previous sections set out what interviewees told us they remembered of the game scenarios and capabilities. In recounting that, some participants spoke of what they had learned as already noted above. Building on that, this section describes some specific examples and what interviewees told us was the overall impact of workshop participation on their professional practice.

Some participants had experienced real life situations in the approximately three months since the training that resemble a game scenario in terms of technical content/objectives.

One participant (I02) described how they had recently been involved in a hot tap on a pipeline that was broadly similar to Scenario 3. It was a fast-track project and I02 remembered the problems that arose in scenario 3 as a result of decisions to cut corners in a technical sense. They were sure to take a measured approach to considering technical risk in their real-life project partly as a result of what he recalled of Scenario 3.

Participant I18 has been working on developing the engineering design basis for a new pipeline and similar to the engineering characters in Scenario 1 they have to decide what assumptions to make regarding further land use in adjacent areas. Speaking of the value of the workshop, they said,

I've already had to try to pre-plan for what if scenarios 10 years down the track, 15 years down the track. But it's a good refresher when you - it would be a good refresher as well for those experienced people to do prior to going into a scenario like this that you haven't done in a while. (I18)

Another participant (I08) was able to relate the uncertainties in pipeline data they had seen in Scenario 1 to uncertainties in a current future fuels project. Despite the very different nature of the uncertainties involved (lack of access to old data for an existing pipeline in Scenario 1 and lack of knowledge about new technologies in his project), their workshop experience made them step back and think about uncertainty and public safety in their current project.

Participant (I17), a junior engineer, recounted a recent conversation in their office about the best options for some specialist pigging activities. They were happy to have been able to contribute to

the conversation by framing it as a question of risk where safety is critical but it is also possible to be overcautious.

Participant I45 has been considering the two junior engineering characters left to develop the flooding design basis for the pipeline in Scene 1 of Scenario 2 and discussing with his colleagues whether there is a need to formalise in their workplace the level of experience required to undertake various kinds of tasks. His goal is to make sure the right experience is brought to bear on any given task depending on its safety criticality. In a similar vein he had queried a decision made by a colleague to send a single junior engineer to an important HAZOP study.

Participant I52 has recently declined to sign off on a procedure that was outside their field of competence. As they explained:

The thing that reinforced from that session, if there was one thing I took out of it, it was if it's not your area, you need to say, "It's not my area" and if the company doesn't have someone, that's bad luck. You have to go out to a third party. That was the one thing that I think really resonated, was if it's not your area, ... it's not your area. I've been good at that. I feel like that's reinforced – because when you know what could happen. (I52)

Others spoke more generally of the value to their professional practice:

A lot of what we do as engineers is critical infrastructure, critical. Has big consequences if things aren't properly – yeah, I suppose it gave me a bit of an appreciation for the gravity of that. It's good to know your limits, know your competencies and leverage off others to achieve the outcomes that are required. (I31)

Several mentioned having thought about the workshop they attended while at a safety management study validation workshop in the last few months.

Several early career engineers were able to give examples where they had checked their knowledge with more senior colleagues a result of playing and discussing Scenario 2 and/or having the experience of working with more senior colleagues in playing the game (see section 6.4.1).

No one gave any feedback that attending the workshop was not useful or in any way a waste of their time. Rather interviewees saw it as a very useful exercise in strengthening professional practice.

6.6 Discussion of cases with others

In addition to directly influencing those who attend workshops, the goal of the project is to indirectly influence more pipeline engineers as the workshop ideas and lessons are carried into the organisations by workshop attendees.

As with any kind of social network, this is very difficult to track, but follow up interviewees were asked whether and with whom they had discussed the workshop materials. The key mechanisms that interviewees described for discussing the workshop material with others are described in the following sections.

Participants who had attended sessions with colleagues or had colleagues attend different sessions in the same week typically debriefed their common experience. While this perhaps acts to reinforce participant learning, it does little to spread lessons to new learners.

Several participants reported that they had given a positive summary of the training to colleagues at a regular team meeting and encouraged others to attend.

We are aware of two early career researchers who are intending to speak about their learning experience at conferences in the context of mentoring.

6.7 Workshop design

Interviewees were asked for any additional feedback on the workshop design. Many of the points made in the post workshop focus groups (described in Section 5.6) were repeated.

No new insights were gained from this data.

6.8 Suggestions for the future

Interviewees were also asked for any feedback about future training.

There is broad enthusiasm for this type of training to be made readily available across the sector.

7 Future fuels

The non-technical capabilities which are the subject of this professional development exercise are technology agnostic. They are as applicable to engineering in a future fuels environment as they are in the base business.

Scenario 3 includes a reference to an existing pipeline being moved to a blended hydrogen service as part of the decision making. Also, during the workshops, participants were asked about any differences in professional engineering practice in relation to public safety decision making that would be required to safely manage a transition to future fuels.

The overwhelming view was that differences are marginal and that the principles of good engineering practice do not change with technology.

The scenarios used in this training emphasise the need for good decision making in conditions of uncertainty and that is certainly what is required for successful development of future fuels.

8 Discussion

This project aimed to pilot a series of professional development workshops for pipeline engineers to develop capabilities to make decisions that reflect the paramount importance of public safety through the transition to future fuels and into the future. The workshops were based on a learning design framework informed by educational and professional development theory. Based on the framework, appropriate learning methods were selected for the workshops to develop capabilities for professional practice (See report for RP2.3-03 Case Based Learning Framework for Public Safety for Pipeline Engineers and available on the FFCRC website). In the part of the project described in this report, cases based on real life pipeline engineering decisions presented as a serious game were used as the focus point of the workshops. An active learner-centred approach allowing participant interaction, reflection, exploration and analysis was used and underpinned by Kolb's (1976) Experiential Learning Cycle. Situating the discussion in real-life engineering case studies, aimed to make the workshops directly relevant to professional practice.

As detailed in the previous sections, four methods were used to collect data evaluating the effectiveness of the workshops. The methods used align with Kirkpatrick's (1998) professional development evaluation framework as described in Section 2.3 and provide insight into workshop outcomes regarding participant's initial reactions to the workshop experience (favourability, engagement, and relevance), participant learning (acquisition of intended learning outcomes), and participant behaviour post-workshop (application of learning in work practice). The following discusses the workshop outcomes across these three levels.

8.1 Level 1: Favourability, engagement and relevance of workshop

Level 1 evaluation assesses the reaction of the participants to the learning experience drawing on the survey and focus group responses. This level provides an assessment of the degree to which participants were satisfied with the education they experienced determined through perceptions of the favourability, engagement and relevance of workshop. This level of evaluation looks at the experience of participants during the workshop based on the survey results and their reflections directly after.

Participants found the game playing nature of the workshops interactive and interesting, unlike any prior professional development activities they had participated in. The game scenarios were seen as realistic and playing the game allowed engineers to experiment with unsafe choices to see the potential consequences without experiencing the real world disaster that could result from poor decisions. The structure of the workshop, with game playing occurring in small groups and then debrief discussions held in a larger group, was seen as a great way of promoting discussion and learning from other people's experience. Less experienced engineers in particular found the mentoring from more experienced colleagues in making choices in the game to be very useful and interesting. According to participants, the three-hour workshop length was appropriate for the workshop to cover materials and discussion.

According to Warburton (2003), engagement is essential for deep learning where knowledge and concepts are integrated into existing conceptual frameworks. Participants' high levels of engagement in the workshop aligns with the pedagogy underpinning the delivery and content, which aimed to create a learning environment that facilitates learning through reflection and analysis. The action-reflection cycle underpinning the workshop design informed by Kolb's (1976) learning cycle theory also worked to support participant engagement and critical reflection leading to the achievement of intended learning outcomes as evidenced in the following two sections.

8.2 Level 2: Evidence of the development of intended learning outcomes

Level 2 evaluation assesses the learning outcomes of the workshops. Learning is defined by Kirkpatrick and Kirkpatrick (2016, p. 23) as ‘the degree to which participants acquire the intended knowledge, skills, attitude, confidence and commitment based on their participation in the learning event.’ Assessing and evaluating knowledge and skill at this level requires the incorporation of activities into a professional learning module. In this section we discuss the findings from the participant scenario responses, focus groups and interviews.

8.2.1 Scenario

Most of the initial responses to the evaluation scenario are very process focussed (following procedures, consulting the standard, doing a risk assessment) with all respondents taking a path driven by safety considerations. Many responses detail actions that are individual and relatively isolated from most colleagues. The following discussion presents the discussion capabilities participants brought to the scenario response prior to completing the workshop and the developed capabilities because of participating in the workshop:

Scenario 1: Initial responses to the scenario heavily drew on the *Understanding norms and values that inform action* capability and *Think systemically and understand interconnectedness* capability. Collaborate with and draw on the experience of others capability was also identified. Post-workshop responses identified the importance of these capabilities, but *Advocating for action and taking responsibility* was now identified in relation to safety decisions in practice.

Scenario 2: Before attending the workshop, participants, when responding to the scenario, predominantly drew on the *Understanding norms and values that inform action* capability, citing the need to follow standards and design specifications and the need to make ethical choices, *Think systemically and understand interconnectedness* through the application of risk concepts, and *Collaborate with and draw on the experience of others* when making decisions were also identified. A small number of participants also applied the *Use of the long-term, foresighted reasoning*, especially in the face of uncertainty through the consideration of long-term implications associated with decision making. As a result of the workshop, participants placed greater emphasis on *Collaborate with and draw on the experience of others* capability, the *Think systemically and understand interconnectedness* capability applying risk concepts before making a decision, and thinking about the long term and considering the worst-case scenario.

Scenario 3: Participants before the scenario drew on *Advocating for action and taking responsibility* drawing on the experience of others recognising the need to stand up for safety and influencing senior management and *Think systemically and understand interconnectedness* capability by undertaking a risk assessment. Participants also drew on *Collaborate with and draw on the experience of others* capability in that they sought additional information, and *Advocating for action and taking responsibility* drawing on the experience of others. Post-workshop responses drew on the same capabilities but identified their importance in the decision making process.

Overall, post workshop more respondents proposed actions that involved taking a more active responsibility for resolving the dilemma they were faced with. This includes seeking advice/support from more senior colleagues and/or operations, working actively to resolve the situation and convincing senior management of the importance of taking the safe path perhaps by reference to long term consequences. The change in decision making considerations post-workshop demonstrates evidence of thinking that draws on all six capabilities (see Table 1). It can be concluded at this stage the workshop objective had been met.

8.2.2 Focus groups

Participants reflected on what they felt they had learned through the workshops in the focus groups (see Section 5). Many participants noted that workshop themes, including the decision making capabilities, were familiar concepts to them, however, the workshop reinforced their importance and increased the rationale for drawing on the capabilities in day-to-day practice. Less experienced engineers noted that playing the game and discussing the choice to be made with more senior colleagues gave them a better idea of how their work fits into the broader decision making of the business and what it means to be an engineer. Others found that playing the game gave them new insights into how poor decision making can lead to catastrophe with the capabilities also giving them language to talk more easily about what makes for good decision making. More experienced engineers found that the workshop gave them an opportunity to focus on decision making which is often difficult to find in the busyness of everyday activities and also to calibrate their own decision making with others.

Participants identified in the focus group the relevance of the decision making for public safety capabilities to their professional practice. However, while the game provided a valuable and realistic scenario to situate and contextualise these capabilities, it was the time for small group discussion and facilitator-led discussion that enabled the recognition of capability as informing decisions and links to professional practice.

The nature of the game structure and key decision points requiring small group discussion forced choice consensus, which enabled participants to learn from each other and better understand different perspectives concerning practice. These experiences reflect the work of Biggs (2011), who suggests that group work enables hearing different interpretations of situations and consideration of practice not previously considered. In this instance, participants relate their own experience and each other's to the capabilities embedded in the game. Biggs (2011) argues that participants must have the necessary experience to develop this shared knowledge. Our participants noted the importance of having a mix of experienced and early career engineers in teams to be able to maximise the learning experience. The serious game scenario acted as a case to enable participants to undertake narrative-based reasoning in order to come to a decision and move forward in the game thus displaying an experiential learning pedagogy (Edgell et al., 2016; Maslen, 2020). In this situation with multiple possible responses, 'the learning comes from actually participating in the search for solutions' (Tripathy, 2008). To ensure democratic participation in the scenario role-play was encouraged; not only does this ensure active participation, but active participation is essential for deep learning outcomes (Warburton 2003)

The deliberate space for guided reflection at the end of the gameplay through structured questions led by the facilitator enabled the connection between capabilities and decisions made by each group and the consequences concerning public safety outcomes. Further, playing the game multiple times actively engaged participants in decision making with conscious knowledge of the capability being applied or omitted, enabling a recognition of consequences for decision making for public safety outcomes. This approach draws successfully on the principles of learning from reflection on 'doing' and aligns with the theory of inquiry/experiential learning. In order to develop these capabilities participants need to first engage with the serious game, apply knowledge and skills in response to the scenario, and reflect on the outcomes of their response as well as their own actions and learning through the inquiry process (Pedaste et al., 2015).

The data show that at this level, participants were successful in meeting the learning outcomes due to the inquiry-based constructivist educational approach, which requires the learning to be developed from and situated in current concepts and issues related to the specific disciplines and professional practice. The value of this learning approach is that participants recognise the purpose associated with their learning, due to the 'real world' task/s and issue/s, increasing their motivation and learning. Learners were challenged to participate actively, think critically, and reflect. This approach leads to participatory teaching methodologies that enable learning based on a problem-solving approach.

8.2.3 Interviews

Based on the findings of the follow up interviews, all the capabilities were addressed through participant discussions of their practice since the workshop. While this is a level three outcome it confirms deep learning about the capabilities from the workshop experience as participants are describing their practice rather than reflecting on what they remembered about the capabilities (this is further explored in the following section).

Overall, substantial evidence indicates that deep learning reinforcing the capabilities was achieved through the workshops based on the opportunity to reflect, interact, discuss, and apply relevant real-life lessons to professional practice. The links made by participants connecting learning with professional practice indicate that the workshops provided the opportunity for participants to make connections between existing knowledge and practice and insights from the workshop, which are critical for deep learning (Cullen et al., 2012). These outcomes are also echoed in the following discussion of Level 3 evaluation through the post workshop follow up interviews.

8.3 Level 3: Application of learning post workshop in work practice

Level 3 evaluation assesses the degree to which participants apply the knowledge and skills gained in the module to their workplace activities. Follow up interviews were used to collect data on the behaviour and thinking of participants post-workshop and found that participants described applying their learning in their work practice in several ways that indicate the workshops had an ongoing impact on participants' work practices and achieved the desired learning outcomes.

The findings show that many participants consciously applied their learning (to various degrees) to their work practice in ways that indicate the use of the intended capabilities. The findings highlighted a range of work practice situations in which the participants reflected on their workshop learning and applied this to their decisions and subsequent actions. The spectrum of responses that participants reflected on as a consequence of attending the workshop ranged from reflective validation of current workplace behaviours as aligned with good decisions for public safety to proactively identifying and resolving safety issues brought to light in the workshops. Most participants felt that the workshops either broadened their consideration of safety in decisions or reinforced their existing approaches.

Participants could not articulate the list of capabilities or the details of the game; however, the results indicate deeper learning regarding decision making capabilities for public safety. Participants' reflections on what they had gained from participating in the workshops and how they had used this learning demonstrate that all six capabilities had been developed or reinforced through the workshops and used by most participants in the months following the workshops. The post-workshop experiences of the participants reflected the intent of the workshop objective and pedagogy, which sought to ensure the learning outcomes evolved beyond surface learning and the retention of high-level information to deep learning, involving interpretation and contextualisation.

This would indicate a degree of effective learning change, as argued by Biggs and Tang (2011, p. 23), where participants experience resulted in a level of '*conceptual change*, not just the acquisition of information'.

The findings highlighted some pedagogical and delivery factors that supported such learning outcomes. Using cases themselves helps learning to resonate with participants after the workshop to support the application of learning to their professional practice. Reinforcing comments made straight after the workshops, in follow up interviews, many participants spoke of the value of the group interactions facilitated by the workshop design and what they had learned from colleagues as a result. The feedback summarised in Section 8.2.2 was essentially repeated at the three month mark.

A second important pedagogical factor was the role play aspect of the game. Players were invited to treat the words of each game character as a script and act out each game scene within their small group. This seems to have generated a better understanding of the logic of choices and opinions of non-engineers (commercial staff, senior management) and so emphasized the need for professional engineers to be able to take responsibility for making a good case and so convincing non-engineers of the merits of their preferred course of action.

Another factor which supported ongoing reflection of the workshop was the relatability of the case studies to professional decisions, for example, the dilemma regarding the best design basis on Scenarios 1 and 2. The cases highlighted the potential negative consequences of professional decisions, if not made in the context of the capabilities such as thinking in the longer term.

Overall, the workshop experience affected most participants' actual decision making practice to some degree, articulated through the ongoing reflection on key learning outcomes, including the capabilities, in professional practice. The findings indicate that the emphasis placed on the experience of working through the role plays and situations (aligning with Kolb's experiential learning theory), supported the exploration of safety and decision making capabilities. As Kolb and Goldman (1973) describe, this allowed for the translation of experiences into 'concepts which in turn are used as guides in the choice of new experience' (Kolb & Goldman, 1973, p. 2). Turning the workshop experiences into concepts that have been applied in professional decision making practice highlights how the experiential learning approach has supported the attainment of learning outcomes and ongoing impact on work practices. Aligning with experiential learning theory, the learning experience clearly extended beyond the training session, extending the boundaries of this 'stand-alone' learning experience to integrate it successfully with ongoing practice.

8.4 Summary

The evaluation of the workshop drew on the first three levels of Kirkpatrick's professional development evaluation framework and evaluated outcomes against the intended workshop learning outcomes and objectives developed through the Professional Learning Design framework.

The participants' enjoyment, engagement and relevance of the workshop experience as reflected in Kirkpatrick's Level 1 evaluation was achieved. The active, creative and emotional aspects of the serious game scenarios and associated discussion engaged participants in the content such that they enjoyed the learning experience and perceived relevance to professional practice. The focus groups provided evidence of learner satisfaction with the learning experience and outcomes. The structure, content, facilitators, length and pace, and delivery mode were well received and created a meaningful, engaging and supportive learning environment, where participants learnt not just from

the game but from each other. Whilst some small improvements were suggested, on the whole, all participants were appreciative and satisfied and suggested others from their industry and organisations would benefit from participating in the training session.

Aligned with the learning objective of the workshop, Kirkpatrick's Level 2 evaluation indicates that, to varying degrees, participants further developed or reconfirmed their existing decision making processes as informed by the capabilities associated with the workshop. Responses to the scenario questions indicated using all capabilities explored in the workshops. However, while some participants drew on these in their responses prior to workshop participation, their understanding and application in practice were more expansive and detailed in response to the scenario post-workshop. This highlights that participants drew more heavily on the capabilities when making decisions with public safety consequences and that the level two outcomes were achieved.

Central to all successful learning experiences is a change in practice, whether this be in thinking or in doing. Since attending the workshops discussions with participants about subsequent workplace actions as reflected in Kirkpatrick's Level 3 evaluation revealed a mix of outcomes:

- Some participants were now conscious of the capabilities that they brought to their decision making.
- Some participants had changed their practices and or set up new processes that aligned to key capabilities.
- For some participants their understanding of public safety was broadened, for others, ongoing reflection of their definition informing professional practice was a recognised outcome.

While we have not evaluated the workshop in relation to level 4 outcomes knowledge sharing and its influence on organisational change may be inferred/evidence with additional data collection.

Based on the evidence collected through this three level evaluation process, it is possible to claim that the professional learning workshops utilising a serious game model enabled participants to achieve the intended workshop learning outcomes.

9 Comparison with accident case evaluation

In this section, we compare the results of evaluation of the accident case workshops (described in Interim Report #1) with the evaluation of the serious games workshops described in this report.

Overall, both methods were well received and evaluation shows that learning objectives were achieved for all pedagogical styles. The differences between the two types of workshops are subtle, but there are interesting things to be drawn from the data on the way in which learning happens.

Learning is linked to both the form of the cases and the structure of the workshop. When playing Planet Pipeline and reflecting on their choices, players are stepping into a world very similar to their day to day working life for those who work in operating companies and have the level of seniority to make significant professional decisions. For some others, despite working as engineers in the pipeline sector, the world of operating company decision making depicted in the game is less familiar. Playing the serious game opened the door on how operating companies make decisions for those who do not see these decisions directly including more junior staff and people who don't sit in operating companies such as design consultants, construction contractors and regulators. These participants told us that the experience gave them insights into how their activities fit into the bigger picture.

Another key aspect of learning from Planet Pipeline is that playing the game allows people to see the direct link between real life difficult decision making under uncertainty, and adverse outcomes. This is emphasised by the logic of the game where the best choices lead to favourable outcomes and a range of less than optimal choices result in adverse outcomes including pipeline rupture. Players can see the banal nature of routine conversations where choices going one way or another can have huge consequences. In real life, poor decisions do not always lead to a poor outcome due to the strong random factor at play but in the world of Planet Pipeline bad choices always lead to bad outcomes. Players are sophisticated enough to understand this but showing what can happen is impactful, especially for less experienced engineers.

The workshop structure that sits around the game itself is also key for learning as described in other sections of this report. Working directly with small groups of colleagues to reach consensus on the best decision is a useful learning experience, especially for more junior engineers, as is the broader conversation with the entire group about decisions made, game outcomes and links to professional engineering practice. Further, the role play aspect involved in playing the game (where character scripts are read aloud) seems to develop an improved understanding of the logic of choices made by non-engineers and so emphasizes the need to be able to take responsibility for convincing such individuals.

Given the nature of the cases, lessons learned are specifically about practice and aligned to capabilities, but mostly not related to recollections of the game scenarios. The evaluation indicated that the discussions instigated by the situations and decision making points in the game were key for learning and engagement, rather than the game format and visuals themselves. The opportunities to learn from others through discussion and reflection were also valued in the accident cases as well, indicating it is the social interactions and situations to be discussed that are a critical part of both the serious game and accident case delivery methods.

Learning from the accident cases is also linked to both the form of the cases and the structure of the workshops. In contrast to the game scenarios, accident case workshops involve participants

reflecting on poor decisions made by others. Accident cases give people the insight that poor decision making can lead to a poor outcome in a different way to playing the serious game in that participants need to have sufficient imagination to see the relevance to their own professional practice and day to day decision making. This allowed the participants the freedom to be more critical of the decisions made as they related to other sectors. As described above, while some senior engineers enjoyed sharing their knowledge with less experienced colleagues in playing the game, broadly speaking many experienced engineers found the accident cases a more useful learning experience.

Some accident cases were gas sector cases presented as discussion cases and some were accidents from other sectors presented as role plays. While both were memorable, the lessons learned were somewhat different. In cases from the gas sector, participants tend to remember some technical aspects of the case whereas cases from other sectors seem to be particularly effective in teaching non-technical lessons. Scripted role plays that involve participants standing in the shoes of professional peers gave insights into how poor decisions come about and so the professional practices needed to avoid them. Based on the Level 2 evaluation methods, for the accident cases, capabilities were learned and remembered through the case itself, while in the serious game workshop, participants' reflections on capabilities were linked to the discussions they had in their groups about the decision making points, rather than recollection of the details in the game itself.

The emotional connection to the accident cases is different too. Some participants connect to the disaster cases at an emotional level identifying either with the engineers who made catastrophic choices or the people who suffered as a result. This is not usually present for the real-life decision cases like in the serious game despite the fact that the worst choices in each game lead to a pipeline rupture and notional deaths. Some players were reluctant to play through these worst cases and a few others claimed they were unrealistic. It seems that some participants may find the connection between a real-life decision making scenario and the potential for catastrophe too confronting to engage with directly.

In the serious game, the role of the facilitator during the game play differed to that in the accident cases. The structure of the serious games allowed groups to play through the game twice independently, while in the accident cases all discussions were facilitated. During the serious games, the facilitator took a step back and allowed groups to explore the decision making points independently. This had two key implications. Firstly, the facilitator needed to observe and listen to groups so as to link individual group discussions to the capabilities during the following whole workshop debrief. And secondly, the nature of the discussion in the groups themselves depended on the dynamics and expertise of the group members to facilitate meaningful exploration of the decision making points and links to capabilities. The group dynamics and levels of expertise were highlighted as important for a good learning experience when playing serious games, more so than in accident cases.

For all experience levels, knowledge of the accident cases themselves, as well as the lessons regarding capabilities, are a take away from the accident case workshops. These cases are recalled when decisions need to be made that have similar characteristics and directly inform choices. They are also easier to share with others and so extend the influence on professional practice more easily than the serious game experience.

In summary, both training methods have been shown to be effective. Accident cases (especially presented in the form of role plays) are effective and popular for learning, particularly with more

experienced engineers and the cases themselves are readily shareable with colleagues outside workshops. Having said that, game playing is very popular with early career engineers, particularly when they have more experienced colleagues to mentor their game choices. There are significant benefits to be had for the industry in continuing to use both training methods into the future.

10 Conclusions

Using the second of two professional development methods planned for the project, 81 participants of a target 150 have participated in serious games workshops. Adding this to the 105 people trained in accident case workshops means that the project objective of training at least 150 people has been met.

The learning objective of the workshop was: to develop capabilities to make decisions that reflect the paramount importance of public safety through the transition to future fuels and into the future.

The success of the workshops in meeting this objective was addressed at three levels:

Level 1: Favourability, engagement and relevance of workshop - In focus groups and via surveys, participants reported high levels of engagement, enjoyment and relevance of the workshops.

Level 2: Evidence of the development of intended learning outcomes - This manifested in two ways. Firstly, participants were given a small decision making scenario linked to day to day engineering work and asked to respond both before and after the session. The data shows evidence of increased use of relevant capabilities post workshop. Secondly, in focus groups participants reflected on what they had learned in the sessions. Overall, substantial evidence indicates that deep learning reinforcing the capabilities was achieved through the workshops based on the opportunity to reflect, interact, discuss, and apply relevant real-life lessons to professional practice.

Level 3: Application of learning post workshop in work practice - Follow up interviews approximately three months after the workshops showed that many participants consciously applied their learning (to various degrees) to their work practice in ways that indicate the use of the intended capabilities. This includes further discussion of the cases and changes to or reinforcement of decision making practice.

Overall, the learning objective has been achieved.

These results are broadly similar to those obtained for the accident case workshops delivered in 2021/22 and the subject of interim report #1 for this project. Comparing the two sets of evaluation results, we find that accident cases (especially presented in the form of role plays) are effective and popular for learning, particularly with more experienced engineers and the cases themselves are readily shareable with colleagues outside workshops. Having said that, game playing is very popular with early career engineers, particularly when they have more experienced colleagues to mentor their game choices. There are significant benefits to be had for the industry in continuing to use both training methods into the future.

The results of the evaluation exercise will also be used to inform preparation of the final deliverables from this part of the research project. This is critical in order to be able to give this kind of scenario-based learning life beyond the end of the research project. The materials used by the research team will be formalised into a package including:

- Facilitator notes (including overall learning objective, skills required of facilitator, session running sheet, likely key topic areas emerging from discussion, participant arrangements)
- PPT files with complete speaking notes
- Other handouts

11 Implications and recommendations for industry

The value that participating engineers have seen in this kind of case based professional development provides a strong incentive for the industry to continue with a program of this kind beyond the work of the Future Fuels CRC.

While interim conclusions are strongly in favour of the learning methodologies trialled, the benefits to industry can only be realised if the deliverables of this research project are actively implemented by industry following the completion of this project.

The responsibility for ensuring that this happens rests with industry leaders, not with the researchers. The researchers are however keenly interested in working with industry to ensure that such implementation occurs in an effective manner.

12 Next steps and future works

This is the second report from project RP2.3-07.

As noted above, the results provide strong incentive for the industry to continue with this type of professional development activity. From the perspective of the research, final session packages for workshops based around each of the three game scenarios will be prepared and delivered. Insights gained from the above evaluations will be included in the final deliverables.

The final project deliverables (due 7/2/25) are:

- Two targeted workshop-based training packages on public safety capabilities for transmission pipeline engineers and networks engineers including detailed facilitator notes and recommendations for future delivery based on the results of the evaluation of the pilot programs.
- A training package structured around a serious game that supports capability development across the sector in a future fuels environment including facilitator instructions.

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Appendix 1 Game decisions and endings

Scenario 1 – Third-Party Damage Decision Points & Endings:

SCENE LIST	
Scene 1 Decisions	
1.1	Design this pipeline section for a rural area
1.2	Design this pipeline section with controls for a residential area
1.3	Design this pipeline section with controls for a residential area with sensitive uses
Scene 2 Decisions	
2.1	Continue with controls based on existing SMS documentation
2.2	Increase stakeholder liaison
Scene 3 Decisions	
3.1	Assume the pipeline design controls are appropriate for a school near the pipeline
3.2	Undertake Investigation / Upgrade the pipeline to comply with engineering requirements for a residential area
3.3	Undertake Investigation / Upgrade the pipeline to comply with engineering requirements for a residential area and sensitive uses.
3.4	Undertake Investigation / Accept the pipeline controls that are designed for a residential area
3.5	Undertake an investigation and find out what the Location class is (T1S) (Since the T1S Pipeline cannot be upgraded further, other choices are removed.)

DECISION POINTS			ENDINGS	TOTAL	DAMAGE COST	GRADE	CAPABILITIES NOT MET
1.1	2.1	3.1	Explosion	0	\$\$\$\$\$	F	All
1.1	2.1	3.2	Repairable Leak	\$\$\$\$	\$\$\$\$	D	All
1.1	2.1	3.3	Unaware (No Damage)	\$\$\$\$\$	0	C	2,4,5,6
1.1	2.2	3.1	Lucky (No Damage)	\$\$	0	C	2,4,5,6
1.1	2.2	3.2	Excess Costs (No Damage)	\$\$\$\$	0	B	2,4,5,6
1.1	2.2	3.3	Excess Costs (No Damage)	\$\$\$\$\$	0	B	2,4,5,6
1.2	2.1	3.1	Repairable Leak	\$\$	\$\$\$\$	D	All
1.2	2.1	3.4	Repairable Leak	\$\$	\$\$\$\$	D	All
1.2	2.1	3.3	Unaware (No Damage)	\$\$	0	C	2,4,5,6
1.2	2.2	3.1	No Damage Aware	\$\$	0	A	None
1.2	2.2	3.4	No Damage Aware	\$\$	0	A	None
1.2	2.2	3.3	Excess Costs (No Damage)	\$\$\$	0	B	2,4,5,6
1.3	2.1	3.1	Unaware (No Damage)	\$\$\$	0	C	2,4,5,6
1.3	2.1	3.5	Unaware (No Damage)	\$\$\$	0	C	2,4,5,6
1.3	2.2	3.1	Excess Costs (No Damage)	\$\$\$	0	B	2,4,5,6
1.3	2.2	3.5	Excess Costs (No Damage)	\$\$\$	0	B	2,4,5,6

EXTRA COST KEY		
VL = Very Low	\$	< \$100K
L = Low	\$\$	\$100K - \$500K

M = Medium	\$\$\$	\$500K - \$1M
H = High	\$\$\$\$	\$1M - \$5M
VH =Very High	\$\$\$\$\$	>\$5M

CAPABILITIES	
<i>Use long term, foresighted reasoning especially in the face of uncertainty</i>	1
<i>Understand norms and values that inform decision making</i>	2
<i>Think systematically and understand interconnectedness</i>	3
<i>Collaborate with and draw on the experience of others</i>	4
<i>Ground decisions in reality</i>	5
<i>Advocate for action and take responsibility</i>	6

Scenario 2 – Emergency Flood Decision Points & Endings:

SCENE LIST				
Scene 1 Decisions				
1.1 Stick with Junior Engineer Ajay's conclusion.				
1.2 Seek further input from a more experienced colleague				
Scene 2 Decisions				
2.1 Situate the MLV along the creek				
2.2 Convince Anthony the MLV remains on higher-ground in the paddock				
Scene 3 Decisions				
3.1 Agree that the project needs to move forward.				
3.2 Insist on conducting another study				
Scene 4 Decisions				
4.1 Don't Verify Weights				
4.2 Verify Weights				

DECISION POINTS				ENDINGS	TOTAL	DAMAGE COST	GRADE	CAPABILITIES NOT MET
1.1	2.1	3.1	4.1	Very Bad	0	\$\$\$\$\$	F	All
1.1	2.1	3.1	4.2	Not possible since verifying weights is skipped.				
1.1	2.1	3.2	4.1	Very Bad	\$\$\$	\$\$\$\$\$	F	2,3,4,6
1.1	2.1	3.2	4.2	Good	\$\$\$	\$\$\$	C	2,3,4,5,6
1.1	2.2	3.1	4.1	Bad - Weights is skipped.	\$	\$\$\$\$\$	D	2,3,4,5,6
1.1	2.2	3.1	4.2	Bad - Weights is skipped.	\$	\$\$\$\$\$	D	2,3,4,5,6
1.1	2.2	3.2	4.1	Bad	\$\$\$	\$\$\$\$\$	D	2,3,4,5,6
1.1	2.2	3.2	4.2	Very Good	\$\$\$	\$	A	None
1.2	2.1	-	4.1	Very Bad	\$\$\$	\$\$\$\$\$	F	2,3,4,6
1.2	2.1	-	4.2	Good	\$\$\$	\$\$\$	C	2,3,4,5,6
1.2	2.2	-	4.1	Bad	\$\$\$	\$\$\$\$\$	D	2,3,4,5,6
1.2	2.2	-	4.2	Very Good	\$\$\$	\$	A	None

VERY BAD ENDING	Pipeline and MLV Site is damaged with great collateral damage.
BAD ENDING	Pipeline and MLV Site is damaged with minor collateral damage.
GOOD ENDING	Pipeline remains underground and the MLV Site sustains some damage.
VERY GOOD ENDING	The pipeline and MLV Site remain in good condition after the flood.

EXTRA COST KEY		
VL = Very Low	\$	< \$100K
L = Low	\$	\$100K - \$500K

M = Medium	\$\$\$	\$500K - \$1M
H = High	\$\$\$\$	\$1M - \$5M
VH =Very High	\$\$\$\$\$	>\$5M

CAPABILITIES	
<i>Use long term, foresighted reasoning especially in the face of uncertainty</i>	1
<i>Understand norms and values that inform decision making</i>	2
<i>Think systematically and understand interconnectedness</i>	3
<i>Collaborate with and draw on the experience of others</i>	4
<i>Ground decisions in reality</i>	5
<i>Advocate for action and take responsibility</i>	6

Scenario 3 – Welding in Service Decision Points & Endings:

SCENE LIST	
Scene 1 Decisions	
1.1	Get an experienced contractor to provide advice and a proposal
1.2	Reduce maximum operating pressure and defer repair until another budget year
Scene 2 Decisions	
2.1	Award full scope of works to the experienced contractor
2.2	Prepare tender documents and call tenders
2.3	Request an extension of time
2.4	Call tenders from contractors
Scene 3 Decisions	
3.1	Choose another contractor and pay the extra for expensive sleeves
3.2	Give Q&D Welding Co. the job
3.3	Shut down and blow down to do a cut-out repair
3.4	Accept the unsolicited offer of Q&D Welding Co to repair defect
3.5	Get Q&D Welding Co. to complete job with homemade sleeves
3.6	Agree with the Regulator to suspend operations

ENDINGS				TOTAL	DAMAGE COST	GRADE	CAPABILITIES NOT MET
1.1	2.1	-	Best – Third Scene skipped.	\$\$	0	A	None
1.1	2.2	3.1	Excess Costs	\$\$\$	0	B	1,2,4,6
1.1	2.2	3.2	Rupture	\$\$	\$\$\$\$\$	F	All
1.2	2.3	3.3	Excess Costs	\$\$\$	0	B	1,2,4,6
1.2	2.3	3.4	Fire & Injury	\$\$\$	\$\$\$\$	D	All
1.2	2.4	3.5	Fire & Injury	\$\$\$	\$\$\$\$	D	All
1.2	2.4	3.6	Poor	\$\$\$\$	0	C	1,2,4,6

FIRE & INJURY ENDING	Burn-through ignites local jet fire, some workers are seriously burned. All operations are formally shut down
RUPTURE ENDING	Catastrophic explosion, share price rockets downward.
EXCESS COSTS ENDING	Job Completed Safely but very expensive.
POOR ENDING	Licence to Operate that pipeline is formally suspended. No damage or injury, but much loss of reputation for the new company in the industry.
BEST ENDING	Job Completed Safely, as Planned and as Priced.

EXTRA COST KEY		
VL = Very Low	\$	< \$100K
L = Low	\$\$	\$100K - \$500K
M = Medium	\$\$\$	\$500K - \$1M

H = High	\$\$\$\$	\$1M - \$5M
VH =Very High	\$\$\$\$\$	>\$5M

CAPABILITIES	
<i>Use long term, foresighted reasoning especially in the face of uncertainty</i>	1
<i>Understand norms and values that inform decision making</i>	2
<i>Think systematically and understand interconnectedness</i>	3
<i>Collaborate with and draw on the experience of others</i>	4
<i>Ground decisions in reality</i>	5
<i>Advocate for action and take responsibility</i>	6

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Enabling the Decarbonisation of
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www.futurefuelscrc.com



info@futurefuelscrc.com