LESSONS FROM EXPERIENCED OPERATORS – A CASE STUDY IN CRITICAL DECISION-MAKING

Kathy Northcott, *Technical Specialist* - Water, Veolia ANZ
Marty Hancock, *Research Manager,* WaterRA
Sallyanne Bartlett, *Senior Water Quality Specialist,* Coliban Water

ABSTRACT

The ***Lessons from experienced operators project*** is an industry funded research project managed through Water Research Australia (WaterRA). This project aims to capture the lived experience of water industry operators, to gain an insight into their decision-making processes. These include everyday decisions made by operators, along with complex and time critical decisions, that are often made under pressure or with competing priorities.

This paper presents a modified Decision Ladder (DL) Template which has been applied to describe frontline worker decision-making across several industries, ranging from healthcare through to aviation, shipping and process industries. In the ***Lessons from experienced operators project***, the modified DL Template has been used for better understanding the decision-making processes used by water industry operators when faced with a range of operational situations.

A case study is presented, selected from a comprehensive background literature review report (Milestone 1 of the ***Lessons from experienced operators project***). The background literature review involved a detailed analysis of papers selected from across ten years of WIOA conferences. This was to demonstrate the power of the modified DL Template to better understand the critical decision-making process of experienced water industry operators, to facilitate training for new operators.

1.0 INTRODUCTION

Through previous technical competency projects and industry consultation, WaterRA identified a need for research into the workplace experiences and decision-making processes of water industry operators. This is an area of the Australian water industry that has received very little attention. This is despite a growing body of evidence indicating the influence of human factors on exacerbating water quality safety incidents.

The ***Lessons from Experienced Operators project*** focuses on the learning journey and the experience that contributes to some of the water industry's most valued operator skills. These include troubleshooting, problem-solving, and critical thinking. It is these skills that underpin decision-making by water industry operators in the provision of safe drinking water and wastewater treatment. Experienced water industry operators use these skills to provide a vital contribution towards a water utility's ability to meet its public health and environmental protection objectives.

The following briefly outlines the theory and models that underpin the research and training guidance development milestones for the ***Lessons from Experienced Operators project.***

1.1 Modified Decision Ladder Template

For this work a modified DL Template has been used (Lilburne et al. 2019), which shows the decision-making progression an individual can move through when encountering an operational problem. These activities are **situation analysis**, **knowledge-based reasoning**, and **planning and execution**.

Figure 1 and 1a shows the modified DL Template, with the ‘state of knowledge’ (i.e. the ‘known’ information) shown as ovals, and the processing of new information as rectangles. The modified DL Template decision-making progression starts from **situation analysis**, moves through **knowledge-based reasoning** at the top, and then down the righthand side (**planning and execution**), as shown by the arrows.

1.2 Situation analysis

This study applied the three-level model of situation analysis proposed by Endsley (1995) for field and control room operators (Figure 2):

- **Level 1 - Perception**. The perception of the condition, attributes, and dynamics of relevant elements in the environment.
- **Level 2 - Comprehension**. The understanding of the situation based on the combined elements of Level 1, which are used to form a complete picture of the environment.
- **Level 3 - Projection**. The projection of the near future onto the elements in the environment.

1.3 Knowledge-based reasoning

There are three levels of reasoning used in decision-making by frontline workers, these are:

- **Skill-based** – refers to the execution of highly practised actions with minimal requirement for conscious reasoning.
- **Rule-based** – refers to activities that involve the use of rules. These rules may have been learned from manuals and procedures, through formal training, or by working with other experienced workers.
- **Knowledge-based** – refers to an activity or task that is carried out almost in a completely conscious manner, where a beginner is performing the task for the first time, or where an experienced worker is faced with a completely novel or challenging situation.

How operators integrate the above reasoning modes can be described by the Recognised Primed Decision (RPD) model (Figure 3). Experienced personnel, in real-world settings, do not make decisions by laboriously comparing multiple options to select the best choice. Instead, they use situation analysis to understand the environment and context, and then perform mental simulations to select an option or goal state. They evaluate and modify the option or goal until the most appropriate course of action is decided (Klein, 1999).

1.4 Planning and execution

This study adapted the work of Schakel and Wolbers (2019), who described a planning and execution model for rapid response scenarios. Responders will adapt their mode of organizing through three simultaneous activities:

1. **leadership**
2. **accountability (and responsibility)**
3. **communication**

Figure 4 shows a planning and execution process model with modes of organising (**incident control**, **frontline** and **small teams**), adapted from Schakel and Wolbers research and contextualised to the water industry based on the Australasian Inter-Service Incident Management System (AIIMS) approach. The model demonstrates how during an incident, team members are routinely transitioning between modes of organising, assessing, and evaluating the frontline situation and working within their functional groups to plan and execute what is required to bring an incident or situation back under control.

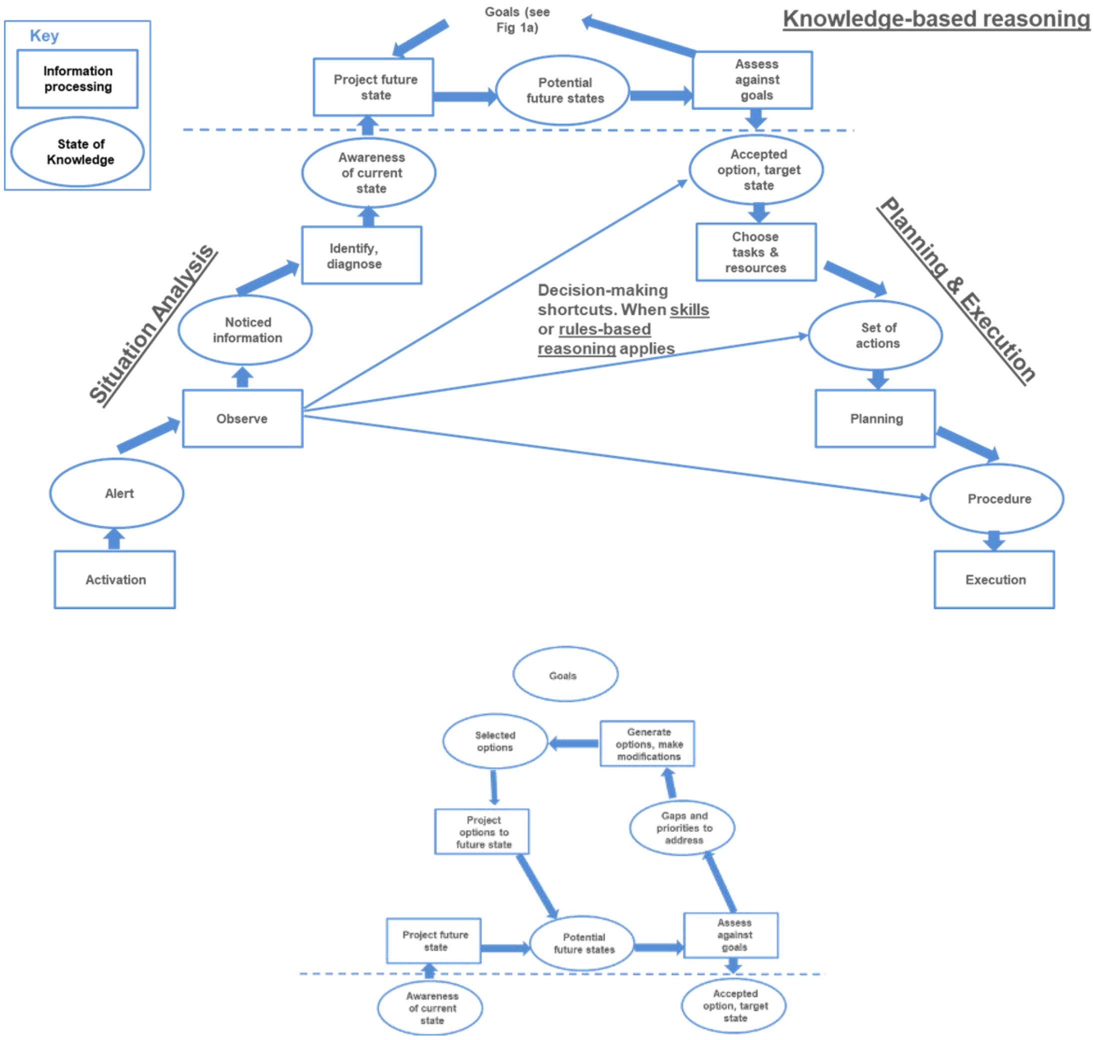

Figure 1 and 1a: *Modified Decision Ladder Template (Lilburne et al. 2019) and detail of the 'Goals' decision-making loop from modified DL Template.*

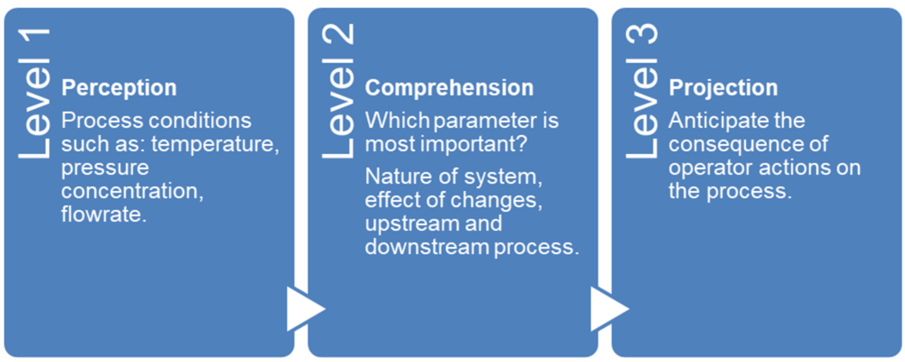

Figure 2: *Three levels of situation analysis (Endsley 1995).*

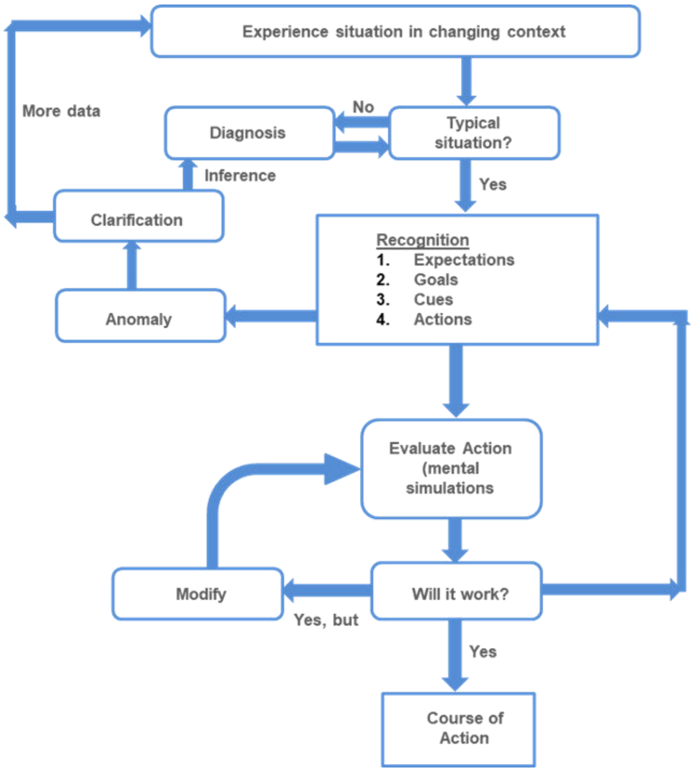

Figure 3: ***Recognised Primed Decision (RPD) Model (Klein, 1999).***

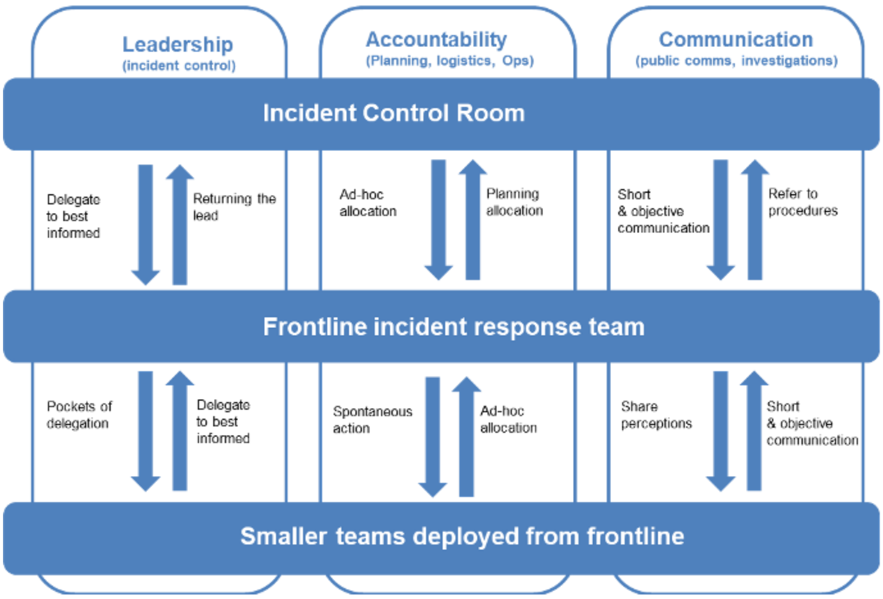

Figure 4: ***Process model and modes of organising (Schakel & Wolbers, 2019) contextualised to the water industry & AIIMS.***

2.0 DISCUSSION

The first milestone of the ***Lessons from experienced operators project*** involved a comprehensive review of ten years of WIOA conference papers, and selection of useful case studies, to demonstrate the power of the modified DL Template to convey the critical decision-making process of water industry operators. The following describes a specific case study presented at a WIOA conference and contextualises it using the modified DL Template and the associated decision-making models described above.

2.1 Case study – Challenging treatment plant analysers

This case study is taken from a presentation given at the 2017 WIOA Queensland Conference and Exhibition - '*THE ROLE OF THE OPERATOR IN CHALLENGING SEWAGE TREATMENT PLANT ANALYSERS AND INSTRUMENTATION* (Tosh, 2017), contextualised to **situation analysis** from the modified DL Template.

2.1.1 Overview

There was an issue with rising nutrient levels in final settling tanks (FSTs) at a Sewage Treatment Plant (STP). Routine operator sampling and analysis detected rising ammonia (NH-3) and phosphorous (P) concentrations in the FST. The operator knew this was an indication of under-aeration in the bioreactor.

To help with early detection of similar events the operations team previously developed a Dissolved Oxygen (DO) checklist; to compare results against a handheld DO probe and the online field DO probe.

2.1.2 Timeline and decision points

Table 1 is a summary of the key timeline events as presented in the paper, contextualised according to the modified DL Template – situation analysis (SA)

Table 1: ***Mapping operator knowledge and actions to situation analysis in Modified DL template.***

Timeline and decision points	Situation Analysis (Modified DL template, Fig 1)	Level of situational awareness
Daily testing result indicates high nutrients in FST.	**Activation** - information processing	Perception
Operator alerted to problem in treatment process, from high nutrient results in FST.	**Alert** - knowledge	Perception
Operator observes that nutrient levels in FST have been on the rise.	**Observe** - information processing	Perception
Operator knows that high nutrient in FST is an indication of under-aeration in bioreactor	**Noticed information** – knowledge	Comprehension
Operator checks field DO probe with handheld DO probe, according to checklist (procedure)	**Identify/diagnose** – information processing	Comprehension
Operator knows that field DO probe is likely out of calibration if a different reading is returned compared to handheld probe.	**Awareness of current state** - knowledge	Projection
Field DO probe reading higher than handheld probe. Operator determines field probe needs maintenance or replacement.	**Projected future state** - information processing	Projection

2.1.3 Discussion of the incident

The operator in this case study demonstrated effective problem-solving, troubleshooting and critical thinking skills. This started with the way information was obtained through situation analysis. With their skills- (training and experience) and rules-based (DO probe checklist procedure) reasoning, the operator was able to determine that the online DO probe in the field was reading too high.

Then using knowledge from their training and experience (knowledge-based reasoning), the operator established that the bioreactor had been under-aerating due to the false high online DO reading. The operator then planned and executed a fix to the issue by requesting maintenance services investigate the DO probe in question. As a result, the probe was replaced. The probe was then able to signal for correct levels of aeration for the bioreactor.

2.1.4 Lessons learned

The author of the conference paper emphasised the importance of regular testing for plant performance and checking of the reliability of field instrumentation. Despite new and more sophisticated technologies on offer to operators, the basics of regular testing and monitoring of a plant's performance should not be lost.

Operators must understand the functionality of a plant, the establishment of critical set points and key process parameters. An appropriate testing regime can then be tailored to ensure results outside of the 'normal' range can be swiftly brought to an operator's attention, before STP performance is adversely affected.

3.0 CONCLUSION

Critical decision-making is a process involving situation analysis, knowledge-based reasoning, and planning and execution, to achieve an end goal or outcome. The modified DL Template provides a tool to better understand and communicate the decision-making process of water industry operators. The case study presented demonstrates the application of troubleshooting, problem solving and critical thinking skills during the key stages of decision-making, specifically in the context of **situation analysis** during a process incident.

4.0 ACKNOWLEDGEMENTS

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