Gaming, Simulation and Decision Making in Project Portfolio Management

by

Saeed Shalbafan

School of Built Environment
Faculty of Design, Architecture and Building
University of Technology Sydney

A dissertation submitted in fulfilment of the requirements for a degree of Doctor of Philosophy

2018

Professional Proofreading

I certify that this thesis has had the benefit of professional proofreading and formatting by Dr. Bronte Somerset and Richard Parker.

The thesis was proofread and formatted in accordance with the Australian Standards for Editing Practice, and the University of Technology Sydney's (UTS) specific requirements for thesis presentation and submission.

Signature of Student: Production Note: Signature removed prior to publication.

Date: 23/04/2018

Certificate of Original Authorship

I, Saeed Shalbafan declare that this thesis is submitted in fulfilment of the requirements for the award of Doctor of Philosophy (PhD) in Project Portfolio Management, in the school of Built Environment at the University of Technology Sydney.
This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.
This document has not been submitted for qualifications at any other academic institution.

This research has been supported by an Australian Government Research Training Program Scholarship.

Signature of Student: Production Note: Signature removed prior to publication.

Date: 23/04/2018

Certificate of completion: Research Integrity for Students

UTS

Graduate Research School

Research Integrity for Students

Certificate of Completion

This is to certify that

Saeed Shalbafan

has successfully completed

Module 2: Plagiarism and Misconduct
Module 3: Risk Assessment
Module 4: Risk Management and Health & Safety
Module 5: Project Management

Production Note:
Signature removed prior to publication.

Professor Lori Lockyer,
Dean, Graduate Research School

University of Technology Sydney

Date: 02/03/2017

Licence Agreement

Cognitive Edge Pte Ltd Pilot Licence Agreement

BETWEEN	Saeed Shalbafan (the Licensee)
OF	University of Technology, Sydney
AND	Cognitive Edge Pte Ltd. (the Licensor)
OF	Regus One Raffles Place, 1, Raffles Place, Tower 1, Level 24, One Raffles Place, Singapore 048616
RELATING TO	SenseMaker® Collector v3.x, Desginer v1.0a (alpha), Explorer v2.5b (the Software)
COMMENCEMENT DATE	15 12 2013 (DD MM YYYY)

The Licensor is willing to grant a licence to the Licensee to use the Software for a pilot project, and to sub-license the Software to the end user identified in Schedule A, subject to the terms of this Agreement.

NOW, in consideration of the Licensee abiding by licence terms,

IT IS AGREED as follows:

1. Definitions

(a) 'Designated Site' means the place(s) where the Software may be used, as described in Schedule A.

(b) 'Designated Users' means the directors and employees of the Licensee and the End User.

(c) 'End User' means the Licensee's customer identified in Schedule A.

(d) 'EULA' means the End User Licence Agreement made between the Licensee and the End User, strictly in the form set out in Schedule B, which is a sub-licence of the Software.

(e) 'Licence Fees' means the fees payable by the Licensee to the Licensor for use of the Software in accordance with this Agreement, as set out in Schedule A.

(f) 'Pilot Period' means the period for which the Software is licensed to the Licensee, as detailed in Schedule A.

(g) 'Software' means the software and associated documentation described and listed in Schedule A, excluding source code.

2. Licence

(a) The Licensor grants to the Licensee a non-exclusive and non-transferable licence to use the Software at the Designated Site by the Designated Users for the Pilot Period and to grant the EULA to the End User.

(b) In granting the EULA to the End User, the Licensee is not permitted to make any changes to it without the written agreement of the Licensor.

(c) The Licensor may grant further licences to the Licensee for the Software by the parties executing a new Schedule A and/or by issuing a licence key to permit the continued use of the Software by the Licensee. In either case, the Licensee's use of the Software shall be subject to the terms of this Agreement.

(d) Subject to the Licensor's right to withdraw the Software at any time upon the expiry of 10 (ten) days' written notice, the Software shall be licensed to the Licensee for the Pilot Period only. Once the Pilot Period expires, the Licensee shall return the Software to the Licensor or destroy it in accordance with Clause 3 (h), unless the parties have entered into a new licence agreement pursuant to Clause 2 (c).

3. Licensee's Obligations

(a) The Licensee shall pay the Licence Fees to the Licensor in accordance with Schedule A.

(b) The Licensee shall be responsible for collecting any licence fees from the End User, and shall pay the Licensor the percentage of those licence fees due from the End User which is set out in Schedule A (if applicable). The Licensee shall take the credit risk in relation to those licence fees, and shall be liable to pay the Licensor its percentage, regardless of whether it is paid the licence fees by the End User.

(c) The Software remains the property of the Licensor at all times and the Licensee shall have no rights to it other than those in this Agreement.

(d) The Licensee shall, at its own expense, take all steps which are necessary to enforce the obligations of the End User under the EULA, as may be directed by the Licensor.

(e) In using the Software, the Licensee may create signifiers in order to contextualise and add meaning to information collected using the Software ('signifiers' being labels attached to a geometric shape, such as a triangle). The Licensee shall own any intellectual property rights which may exist in relation to signifiers created by the Licensee. The Licensee hereby grants to the Licensor a non-exclusive, worldwide licence to use the signifiers created by the Licensee in any manner it sees fit, including the right to grant sub-licences of the signifiers to third parties.

(f) Subject to the right to grant a EULA to the End User, the Licensee shall not transfer, sell, assign or sub-license the Software.

(g) The Licensee may not reproduce, reverse engineer, decompile or modify the Software.

(h) If, by the expiry of the Pilot Period, the Licensee has not entered into a new licence agreement which entitles the Licensee to continue to use the Software, the Licensee will destroy the original Software and all copies of the Software in whatever form in its possession and the Licensee shall certify in writing that this has been done.

4. Confidentiality

The Licensee shall keep the Software confidential and shall not disclose it to any third party, except to an End User subject to a EULA.

The obligations of confidentiality in this Clause 4 do not apply to information that:

(a) is in the public domain, or becomes in the public domain, unless the Licensee caused the information to be in the public domain in breach of the confidentiality obligations under this Agreement;

(b) is known to the Licensee before it is disclosed by the Licensor under this Agreement; or

(c) must be disclosed under any law or in accordance with any court, tribunal or government decision or order.

Acknowledgement

This thesis undoubtedly transformed my view of research, work, and life. I would like to sincerely thank all the people who helped me throughout this transition. I gratefully appreciate the inestimable support from my supervisors Professor Shankar Sankaran, Dr. Julien Pollack, Dr. Elyssebeth Leigh and Dr. Leila Moslemi Naeni. Shankar has been a great supporter during hardship, and his patience over the slow process of research has been an invaluable help to me. Elyssebeth and Julien taught me how to think differently about life, work and writing in academic contexts. They even changed my paradigm of thinking from a quantitative engineer to a qualitative researcher. Leila was quick and passionate to provide constructive comments on a final revision of the thesis.

I am grateful to my family, specially my wife Dr. Naisana Seyedasli, and my father Khosrow Shalbafan, for their encouragement and compassion during difficult days, as they have provided me through moral and emotional support in my life. I am also grateful to my extended family members, children, great neighbours and friends who have supported me along the way. I have special thanks to all friends who attended the pilot sessions of Hooshmand-1 as I was designing the simulation and provided their honest feedback. I extend endless thanks to my research participants who contributed to the results of this research.

I am sincerely grateful for the continual support I received from the Faculty of Design, Architecture and Building (DAB) faculty, for UTS for helping with and funding the work and conference papers, and for their guidance during different stages of research. Special thanks to Dr. Heather Macdonald for her support during my stage 1 research acceptance and who provided facilities for data collection in DAB. Finally, I would like to offer my sincere thanks to Elyssebeth for her mentorship during the design of the experiment and writing, and great support with helping to facilitate the simulations. And last, but by no means least, also to everyone in my colleagues in the Aquenta-Jacobs company and Sydney Metro Delivery Office. It was great sharing my experience and feeling your support and attention during last seven years.

Although this research could not reach to maturity without these supports, I accept full responsibility of the research thesis.

Table of Contents

List of Figures and Tables

Glossary of Terms

Terms	Description
Project Portfolio Management	*Portfolio management* ensures that an organization can leverage its *project* selection and execution success. Project portfolio management refers to the centralized management of one or more *project* portfolios to achieve strategic objectives.
Action Learning	**Action Learning** is a process that involves a small group working on real problems, taking **action**, and **learning** as individuals, as a team, and as an organization. It helps organizations develop creative, flexible and successful strategies to pressing problems (wial.org/action-learning).
Simulation	Simulation is 'the abstraction of reality for a purpose' (Leigh 2013, p. 200).
Simulation Protocol	A document that explains the steps of a role-play simulation in order to standardise the process of facilitation.
Team Cognition	team cognition emerges from the interplay of the individual cognition of each team member and team process behaviors. (www.researchgate.net)
Cynefin	The Cynefin framework helps leaders determine the prevail- ing operative context so that they can make appropriate choices.
SenseMaker	Software to monitor a change of paradigms in a complex environment.
Widget	The widget is an embedded function in the software that helps a user to choose suitable combinations for using SenseMaker.
Signifier	Signifiers are signs or symbols that help research subjects to identify the pattern, the paradigm and the change in their perceptions during an experiment.
Dyad	A dyad is a two-dimension signifier that assesses the subjects' perception.
Triad	A triad is a three-dimension signifier and assesses the status of six questions at the same time.
MCQ	Multiple-Choice Queries are the usual method to assess subjects' opinions. SenseMaker uses MCQ to assist researchers with the categorisation of patterns in signifiers.
NVivo	A software which is used for qualitative analysis of research data.
Hooshmand-1	Hooshmand means intelligent in Persian. It is a role play simulation which I designed for data collection in this thesis.
Real-time events	Real-time events are intentional changes in the simulation Hooshmand-1 to observe the reaction of participants and their influence on participants' perceptions.
Turning points	Turning points are the key momentums of decision making experiment from a participants' perspective.

Abstract

The motivation for this research was due to my observation of project management practitioners in leading organisations and, in particular, noticing their poor judgement on key project portfolio decisions when faced with unexpected events. An initial review of the literature revealed that the impact of real time events on Project Portfolio Management has not been addressed adequately. The research problem was then formed as "What is the impact of real-time events on managers during decision-making processes for Project Portfolio Management (PPM)?" Two key themes were selected for investigation after an extensive analysis of relevant literature. These themes are: 1- PPM and its associated decision-making processes; and, 2 - the process of sensemaking while dealing with complex problems.

These two themes also aligned with my interest in investigating decision-making processes for project portfolio managers and the effect unexpected events had on them. Evolution of the research resulted in adaptation of a phenomenological focus on researching participants' perceptions during decision making on how decisions were made in the context being investigated. The final design of a tailored multiple-methods approach created for this investigation, resulted in a series of decision-making scenarios for use in a relatively controlled environment for data generation while, at the same time, testing the effect of unexpected events. Five simulation designs were then piloted using a series of action learning cycles, with the help of a simulation expert, to design the final research instrument.

The research instrument that emerged as a simulation, now called Hooshmand-1, developed because rapidly changing conditions made it impossible to conduct the research in the workplace where the initial observations had occurred. The research questions were further developed to address findings in the literature review, and a detailed questionnaire was developed to gather research participants' self-reflective observations on factors influencing their decision making, under both complicated and complex conditions. As the simulation

evolved into its final form, an opportunity emerged to use 'SenseMaker' © software to structure and analyse the data collected from participants in Hooshmand-1. This enabled a richer and more varied data collection method and enhanced the result of data analysis.

The observations which prompted this research included puzzlement about the role of emotions in decision making, especially during times of uncertainty. Creating a realistic environment within which to generate decision-making situations, made possible an exploration of research questions designed to elicit participants' thoughts and responses to abrupt changes and unanticipated events. It also enabled collection of a range of data to shed light on emotions influencing individuals' capacity for judgment when facing sudden change during decision-making events. The research provides evidence about similarities and differences among participants' perceptions regarding the impact of unexpected events on their group decision-making processes, and their individual judgment about decisions made during research conditions, which replicated a PPM context.

This research contributes to knowledge about decision making in PPM contexts. It applies new research methodologies to extend our understanding of the possible impact of unexpected and unanticipated events on individual responses. Helping project portfolio managers to improve their awareness of innovative tools and approaches to coping with uncertainty is an important outcome of the research. Additional contributions relate to emerging insight into practical applications of the theoretical concepts called 'Groupthink' and 'Abilene Paradox' as well as the use of simulation for learning more about management in complicated and complex conditions.

Thus, this research contributes to: theories of PPM and decision making in practice by guiding organizations and practitioners to improve their PPM practices; and, to methodology, by combining legitimate simulation with data collection and analysis software, SenseMaker, which was developed to investigate complex situations.

Publications and feedback

Refereed Conference Papers

1. SHALBAFAN, S., LEIGH, E., POLLACK, J. & SANKARAN, S. 2015. Using simulation to create a time-bound, space-constrained context for studying decision-making in project portfolio management using the Cynefin framework. Apros - Egos 2015. Sydney.

2. SHALBAFAN, S., LEIGH, E., POLLACK, J. & SANKARAN, S. 2016. Using simulation to study decisionmaking in project portfolio management. Second Danish Project Management Research Conference. Denmark.

3. SHALBAFAN, S., LEIGH, E., POLLACK, J. & SANKARAN, S. Application of Cyenfin framework to facilitate decision-making in complex conditions in project portfolio management IRNOP 2017 Boston. Boston University.

4. SHALBAFAN, S. & LEIGH, E. 2017. Design thinking: Project Portfolio Management and Simulation – a creative mix for research, ISAGA 2017. Netherlands: ISAGA.

Guest lecturer / Facilitator

1- Decision making and project finance – Postgraduate Course- UTS – DAB – 2016
2- Decision making and project finance – Postgraduate Course- UTS – DAB – 2017

Designers of Simulation for Educating postgraduate students

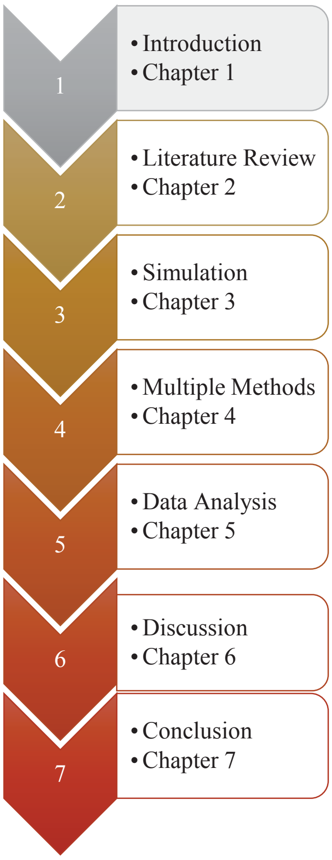
1- Hooshmand-2; Decision Making in PPM, MBA, UMEA, Sweden, 2016/ 2017
2- Hooshmand-3; Decision Making in project finance, Project Finance, DAB, UTS, Sydney, 2016 / 2017

Event Organiser / Manager

1- Sense Maker Community of practice workshop, 2014, NSW, UTS

"Wise people rain into thirsty minds that cause changes in the future", The Great Orod, Iranian Philosopher (Orod, 2017)

Chapter 1: Introduction



The experience which led to my beginning this PhD research.

"In Feb 2010, one of the biggest infrastructure projects in Australia was cancelled because of political and financial crises. The sudden decision of the NSW State Government just weeks before awarding the first major contract, created an unexpected event which was devastating for many project team members and private partners. One of the leading consultancies had to return a big team of senior fellows to its headquarters at short notice. I was among those consultants sent back to their headquarters. The challenge now became how to make the right decisions in a chaotic situation because there was no established plan for managing multiple projects and their resources. The firm lost the majority of its expertise as people found they did not have any immediate assignment in an economy hammered with the recession of 2008-2009. This event created a turning point that was the start of a massive shift in the firm's business methods and its decision-makers' views of the future of its operations. The firm continued losing ground until the business brand was completely extinguished in 2015.

That period of uncertainty encouraged me to seek understanding of how leaders and senior managers could lose their capacity for decision making and thereby create an atmosphere of organisational anxiety.

A 'portfolio' is a component collection of programs, projects or operations managed by a group to achieve strategic objectives (PMI, 2013b, p. 3) which was seen as relevant to manage the turning point as mentioned in the situation described. The proposed initiative—to use a project portfolio road map as an output of portfolio planning (PMI, 2013b) as a case study for the PhD research—was agreed to with senior managers. The confidence and willingness of the firm to continue the research project was subsequently declined and access to strategy meeting discussions was withdrawn due to sensitivity of the information. This second turning point prompted me to turn to the innovative research method of 'simulation' to generate data through creation of similar scenarios for understanding the nature/qualities of decision making in times of uncertainty."

The direct experience of this troubled time was an example indicating that corporations which manage multiple projects need to be prepared to cope with a volatile business environment. The fast changing pace of businesses has increased the complexity of courses of action for senior managers and key decision makers in organisations. The use of projects and project management techniques are part of the solutions for management practitioners and researchers to cater for changing business situations and the temporal nature of businesses. To decide on which projects to pursue, organisations use project portfolio management (PPM). Portfolio management is the coordinated management of one or more portfolios to achieve organisational strategies and objectives (PMI, 2013b, p. 5). PPM is defined as the function of managing multiple projects and programs to achieve strategic goals as set up in a corporate strategic planning document. PPM is a management function in organisations which are governed by a project-based structure.

However, there are debates about methodology and tools organisations can use to manage increasing uncertainty across multiple projects. The literature review indicates growing concerns with regards to the maturity of the current practices of senior decision makers when it comes to having the ability to foresee and make decisions on project portfolios; particularly in uncertain conditions.

Thus, the first concern of this research was to understand how to open up new debates for theory and to introduce new tools with which to study decision making in changing conditions. The second concern of this research focused on how project portfolio managers could utilise new tools to cope with uncertainty in decision making.

This research provides researchers and practitioners with innovative approaches, such as a role-play simulation, to studying decision makers when unexpected events cause uncertainty or even anxiety for them. Causes and factors that create uncertainty around PPM decisions are discussed in the literature reviewed. However, the roles of the decision makers, and their skills and available tools for making good decisions in a timely manner within the context of changing conditions, has been given little attention in the literature. The current study aims to address this gap by finding out how PPM decision makers cope with uncertainty and what factors might influence their judgement when they deal with such PPM decisions.

A role-play-based simulation which is called 'Hooshmand-1', ('Hooshmand' means 'intelligence' in Persian), was designed to create conditions similar to those of limited access to real-time and confidential information as experienced within organisations' PPM steering committees. The simulation was presented as a workshop applying decision making on PPM scenarios, within which participants could reflect on their experience in the simulation and I could observe the flow of actions during the simulation itself.

This chapter introduces key concepts of PPM, the nature of unexpected events and decision making in PPM, and mechanisms that could be used to make sense of complex problems for effective decision making. It also describes the research questions and processes used for collecting data to answer the research questions and concerns.

Finally, the introductory chapter provides an outline of subsequent chapters in this thesis.

1.1 Project Portfolio Management

Portfolios represent the totality of an organisation's investment in the changes required to achieve its strategic objectives (OGC, 2011, p. 11). Portfolio management is a discipline that enables executive management to meet organisational strategy and objectives through efficient decision making concerning projects, programs and operations (PMI, 2013a, P. 21). Although evidence for successful implementation of portfolio management was limited to IT projects and new product development projects, the outcomes are influencing organisations' practice in other industries (OGC, 2011). Portfolio management cycles comprise two cycles: portfolio definition and portfolio delivery. Portfolio managers are encouraged to collaborate with strategy development teams and make decisions regarding portfolio definitions such as understanding change initiatives, categorising, prioritising, balancing and planning (OGC, 2011). Decisions and processes that influence delivery of planned portfolios of projects and programs are summarised as portfolio delivery practices such as management control, benefits management, financial management, risk management, stakeholder engagement, organisation governance and resource management (OGC, 2011). This research takes into consideration three factors—uncertainty, decision making and sensemaking—with a focus on portfolio definition decisions and processes as outlined in the next section.

1.2 Uncertainty, and decision making in PPM

The quality of decision making about items included in a portfolio of projects is highly dependent on the particular mix of three factors: a) maturity of the organisation in regard to its project management knowledge; b) the competence of individual decision makers in regard to tackling complex problems; and, c) the organisation's readiness to support decision making on a portfolio of projects whilst facing uncertainty.

Growing pressure in business environments, including macro-economic factors, is urging corporations to think differently. There has been an increased focus on researching decision making in conditions of uncertainty in PPM contexts (Petit & Hobbs, 2010) and more recently, use of control mechanisms for the management of uncertainty (Korhonen et al., 2014). Recent research is presenting some frameworks with which to categorise sources of uncertainty to improve management and control of decision-making processes (Martinsuo et al., 2014, Petit, 2012). However, most of this research indicates that there is a need for further research on decision making in uncertain conditions in PPM.

The context for effective PPM is less certain and more complex than ever before. The overall significance of these factors lies in the extent to which individual responses to conditions of complexity influence decision makers' intuitive Judgement as well as their cognitive ability to integrate information required for decision making in uncertain conditions.

The concept called the 'Black Swan Theory' (BST) developed by Nicholas Taleb (2007) postulates that not all uncertain events can be anticipated as manageable risks. Black Swan occurrences are defined as events that are highly improbable and unpredictable, yet have a massive impact. Often people attempt to explain these events as more predictable than perceived before their occurrence (Taleb, 2007). The concept of such events has been applied to such global surprises as the Oil crisis (Krupa & Jones, 2013). This study applies the concept of the Black Swan Theory through use of 'real-time events', occurring during decision making in the simulated context of PPM, for assessing the influence of such events on decision makers' Judgement. Introduction of these events became a vital element in analysing the data created in the simulation and collected for this research. The next section of this chapter introduces aspects of the impact of such complexity and uncertainty on decision-making processes in a PPM office.

1.3 Making sense of complexity

'Sensemaking' is a term applied to the process through which people develop their understanding of an event. Individuals arrive at an understanding of organisational events by selecting and shaping elements from among all the available information to help them improve their feeling of control over complex situations (Sardon & Wong, 2010). Senior managers with good situational awareness and effective decision-making skills can deal with problems occurring in complex conditions. Four factors having an impact on a manager's capacity for making sense of complex problems are: a) the quality of expertise in top management teams; b) how strategic decisions are made; c) changes to the external environment; and, d) changes to the business and company (Shepherd & Rudd, 2014).

'Abduction' is about investigating the relationship between 'everyday language and concepts', which is obviously similar to 'induction' (Dubois & Gadde, 2002). This study uses abduction to combine observations of the efforts of groups and individuals to make sense of (artificially constructed) complex conditions. It combines a specific form of narrative with participation in, and reflection on, a unique simulation, followed by analysis of data collected during and after the simulation.

1.4 Simulation as a research instrument

As discussed in the last section, simulation games or simulations are useful tools for the study of decision making in complex conditions. Defined as 'abstractions of reality' (Leigh & Kinder, 2001) simulation games engage participants in interactions with an imitation of a system parallel to real-world settings within defined rules (Sa. Silva et al., 2011). Contexts, individual components settings, and learning objectives are three key elements of design for simulations.

The simulation game creates bounded contexts within which actions become available for analysis, because they are occurring in artificially constructed environments which sufficiently replicate recognisable contexts, enabling participants to behave as if the requirements for action and interactions are factual and real.

In this research, PPM was used as the model to create a context of decision making for the simulation game. Hence, gaps were identified from a literature review of PPM decision making and decision making under uncertainty with Black Swan events (in this simulation known as real-time events). These gaps together addressed research problems that supported evidence collected from practice, such as that which I witnessed in my workplace. In this thesis, the short term 'simulation' is used interchangeably with 'simulation games'. Also, turning points are usually used to describe a key shift or start of a transition in a decision maker's judgement or decision-making processes that can occur during simulation.

‘Real-time events’ are designed as intentional changes in the simulation to observe the reaction of participants, and their influence on participants’ perceptions, while ‘turning points’ are the key moments that participants perceive, based on their observations in Hooshmand-1.

1.5 Research questions

The literature review explored three key themes to arrive at the research problem and its component factors, these were: 1–PPM; 2–decision making under uncertainty; and, 3–making sense of complex problems. Conclusions which emerged from the literature review supported my work experience—namely that existing PPM processes are not sufficiently advanced to support senior managers in decision making when Black Swan events occur.

The key research problem is thus framed as follows:

“What is the impact of real-time events on managers during decision-making processes for PPM?”

This research problem triggered a literature review with a further breakdown of research problems to form research questions. The research questions that connect the findings of literature review to the research problem is as follows:

Research question 1—How do decision makers change their decision criteria for selection and prioritisation in a project portfolio when conditions are uncertain?

Research question 2—How do real-time events influence decision-making processes for project portfolio management?

Research question 3—How do decision makers adapt to changes brought about by real-time events and why?

1.6 Multiple Methodology Research

The literature investigations showed that there was little said about the gaps identified by the research question. A phenomenological research method was selected to identify phenomena through exploring how research participants perceive the situations in the simulation which require decisions.

> Phenomenology is concerned with the study of experience from the perspective of the individual, 'bracketing' taken-for-granted assumptions and usual ways of perceiving. Epistemologically, phenomenological approaches are based in a paradigm of personal knowledge and subjectivity, and emphasise the importance of personal perspective and interpretation (Lester, 1999, p. 1).

This research dedicated great attention to tailoring a multiple research methodology that promotes research by experimentation and exploration of research participants' perceptions from the simulation. The design of the research methodology was validated through a vigorous process of Action Learning to provide a repeatable and reliable instrument for data collection for researchers which could also help improve participants' awareness.

After a comprehensive investigation on existing simulation designs which were available at the time through published and unpublished methods, no single design was found which could address the aims of the research and answer the research questions as evolving in this exploration. Hence, Action Learning cycles were used to conduct an exploratory study on simulation methodology where I arranged for the conduct of a suitable design, and participated in the design process. Reflection on each experiment and application of sensemaking principles after each cycle led to an intuitive understanding of the desired method for creating a simulator with an appropriate and clear set of rules for use in the research.

A questionnaire was developed for data collection after simulation scenarios. SenseMaker software was used to provide simulation participants with an opportunity to express their opinions about decision-making experiments via the questionnaire and to support the data analysis tools embedded in the software.

1.7 Study aims

The current study aims to deepen understating of academics, and practitioners, about how decision makers position themselves when they face unexpected events during decision making in PPM. The research questions explore specific aspects of real time events and their impact on decision makers' judgement for selecting decision criteria, shifts in decision-making processes and the decision makers' adaptability to changes due to real time events.

1.8 My Background

My background may influence interpretation of data in the second stage of data analysis which concerns themes of narratives. I had worked as an industrial engineer in different engineering, consultancy and management roles. This provided a solid experience in analysing complex problems within and outside Australia. Familiarity with a different culture, history and rituals played a key role in bringing forward the research questions for practitioners and academic staff members. To mitigate risks of researcher's bias, several prototyping exercises supported validation of design assumptions in multiple methods. I have also used an independent facilitator to carry out data collection workshops and presented conference papers to receive feedback from other researchers and practitioners on results of data analysis.

1.9 Research contribution

This research contributes to the body of knowledge mainly with regard to decision making and techniques for coping with uncertainty during the process of decision making. Key areas that can benefit from the outcomes of this research include; project portfolio decision making and management of complexity during decision making. An unintended contribution has also emerged from the research which is an understanding of the measures used to develop team cognition and their importance for organisational resilience in a fast changing situation.

Furthermore, the research can contribute to the awareness of executive managers in regard to the dynamic nature of decision making for PPM. An additional outcome is recognition of the value of using Cynefin heuristics (Snowden & Boone, 2007) as a tool to understand the differences among domains of knowledge and the types of leadership style that suits decision making in these various domains of knowledge. Recommendations included in Chapter 7 provide guidelines for practitioners to use simulation for decision making in education classes and organisations dealing with uncertain business environments.

1.10 Thesis outline

An outline of this thesis's seven chapters is presented here.

Chapter 2, the literature review, explores the theories relevant to decision making in PPM in uncertain conditions. The literature reviewed is categorised into two sections: 1– PPM concept; and, 2–making sense of complexity and decision making. These sections influenced the research questions in relation to the impact of Black Swan events or real-time events on decision makers' judgement, their team cognition for decision making in uncertain situations and decision-making patterns and processes for project portfolios.

Chapter 3, the simulation chapter, has two sections. Firstly, the theory of simulation, its design and application to research, is introduced and principles of designing a simulation and its validation are described. This section also discusses trends in literature for the application of simulation to research and practice. The results of this literature review on simulation supports the choice of simulation as an instrument for undertaking this research. The second section describes the development of a simulation and sensemaking framework (questionnaire) for reflection, and reports on the use of Action Learning cycles to evolve the design of simulation Hooshmand-1 through trials and reflection on the lessons learnt from each cycle.

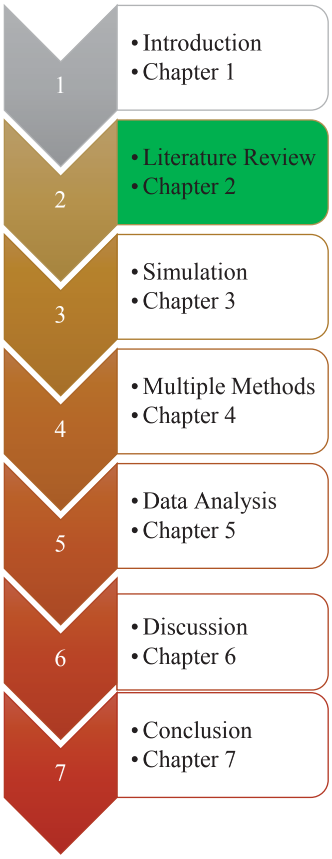
Chapter 4, the methodology chapter, describes how multiple methods such as development of Hooshmand-1, use of the SenseMaker software and a sensemaking framework are used in a phenomenological paradigm to collect and analyse data relating to the research questions. The research used a sensemaking framework, and its relationship with the research questions and outcomes of the literature review, are discussed. The chapter includes discussion of a triangulation process used to valídate the findings of the data analysis.

Chapter 5, the data analysis chapter, describes the results of data collected from four simulation-based case studies using multiple methodologies. It presents the results from the analysis in three sections as follows: 1–patterns, 2–fragments, 3–findings and triangulation. At the end of the chapter, graphics illustrate the summary of findings for each research question.

Chapter 6, the discussion chapter, organises the findings in four sections: 1–real-time events and their influence on decision-making process; 2–Group decision making and its challenges considered through the lens of two theories of group dynamics—Groupthink and Abilene Paradox; 3–Team versus individual cognition and methods of measurements are discussed; and, 4–Reflection on the use of multiple methodologies with some suggestions for improvements for future researchers.

Chapter 7, the conclusion chapter, presents the key contributions of this research to the PPM body of knowledge and practice. The chapter summarises responses to the research questions, data analysis and discussions, and it closes the thesis with some recommendations for research and practice in uncertain decision making in PPM.

Chapter 2: Literature Review



The literature review focussed on two themes to develop 1) an understanding of the current knowledge and trends in project portfolio management (PPM) relevant to this study and, 2) decision making in complex and complicated situations.

The first section discusses the decision processes and theories of decision making in project portfolios with a focus on portfolio planning or definition, the second section reviews the relevance of complexity in project management, extends it to PPM and examines how decision makers perceive and react to complex problems.

Further literature is reviewed to understand the nature of the inherent complexity in PPM decisions covering: the current view on the role of PPM as a function in organisational management; quantitative approaches to decision making in PPM; and, mechanisms to manage uncertainties during decision making in PPM. This theme aims to identify gaps in theory related to factors which impact PPM decision making under uncertainty.

The second section of the literature reviews focuses on: individual decision makers and their ability to make sense of complex situations; the role of individual awareness in their judgement in complex problem solving; the application of Cynefin framework to categorise domains of knowledge; and, the usefulness of simulation as a tool to make sense of complex situations. The main aim of the second section is to enhance understanding of theories related to individual Judgement during decision making in complex and uncertain situations.

2.1 Project Portfolio Management (PPM)

PPM is a multidisciplinary function for aligning corporate strategies with the process of choosing and executing the right projects. Engwall & Jerbrant (2003) state that a multiprojects corporation carries out the majority of business operations through execution of projects. They outline the importance of having effective processes for making decisions on portfolios of projects and programs for successful implementation of their strategy. Decision making can be improved if there is a clear understanding of key decisions and objectives that senior managers must deal with in project portfolio processes.

A project portfolio life cycle involves the following steps: identification; categorisation; prioritisation; and, checking the balance of the selected projects and programs. This cycle can be used in corporations for a collection of projects, programs, major change initiatives or a combination of either of these.

Identification

Portfolio identification is the first key decision made by senior managers working closely with a strategic management team to identify gaps and initiatives, new projects and programs in order to achieve business strategic objectives (OGC, 2011). Corporate strategy is the pattern of major objectives, purposes and goals and essential policies or plans for achieving those goals, stated in such a way as to define what business the company is in and the kind of company it is or is to be (Andrews, 1971).

Strategic managers are expected to identify all internal or external projects in each business unit that contributes to the organization's strategic plan targets and requirements. Traditional views of strategic management develop corporate strategic goals and apply it to the lowest organisational level and develop action plans. However, Henderson and Blackman (2015) argue that the traditional view of strategic planning often ignores engagement of people who are supposed to implement them. Therefore, an emerging view of strategic planning emphasises the planning of business strategy, by involving people at the level where action is taken, as being a dynamic approach (Helfat, 2007). The dynamic approach is also effective to respond to the changing nature of business competition as different levels of the organisation can act as sensors of changes in the environment. Actions taken to deliver strategies often involve projects. Thus, the execution of a business strategy requires a close relationship between organisational strategy and projects for successful implementation.

In PPM literature, the term 'strategic fit' refers to the alignment between project portfolios and organisational strategic goals. Strategic fit was introduced as a means to assist senior managers take key decisions in PPM decision making. Senior managers' involvement is very important for project termination decisions, as it requires careful consideration, when it is determined that a project is not aligned with an organisation's strategic objectives (Unger et al., 2012b). Paying attention to strategic fit can also support transparency in the PPM processes and help to improve alignment of projects and business strategies.

Categorisation

Categorisation decisions assist senior managers to understand the focus of the identified initiatives in the portfolio of projects and programs, such as, revenue generation or cost-saving initiatives (OGC, 2011). According to (OGC, 2011), when making decisions on categories senior managers have to make decisions on resources, funds and expertise availability, that help to determine strategic fit of initiatives.

One of the key factors guiding PPM decision making is having a clear view of the resources available to the organization. Resource-based views, is one of the applications of the theory of strategic management in PPM (Killen et al., 2012). Resource fitness (resources fit) of project portfolios concerns availability of an organisation's expertise and knowledge to achieve the objectives for the projects that contribute to the firm's strategy.

Resource allocation is identified as a prime challenge for multiproject management (Engwall & Jerbrant, 2003). Resource allocation includes sharing available budget, facilities and human expertise to realise the selected portfolios of projects. Opportunistic project management could result in benefitting some projects at the expense of others and having a negative impact on resources availability, and it often results in political games being played out in organisations (Engwall & Jerbrant, 2003). Blomquist & Muller (2006) add that a lack of resources is a key problem for implementation of PPM.

Prioritisation

Corporations usually aim to achieve three key goals while implementing PPM. These are: 1–maximizing the value of the portfolio; 2–achieving the right balance and mix of projects; and, 3–linking the portfolio to the strategy of the business, through implementation of PPM (Cooper et al., 1997a, Cooper et al., 1997b). The three goals are interdependent and sometimes can be contradictory. For example, the goal of value maximisation may clash with the second goal of achieving balance, if senior managers pay too much attention to the profitability of their organisations and not enough attention to the constraints, e.g. availability of resources and expertise. Furthermore, strategic alignment for the third goal may result in termination decisions, which can negate the first goal. Thus, PPM becomes a complicated multiple objectives problem during prioritisation, balance and selection decisions.

During prioritisation decisions, senior managers must make Judgement based on financial criteria. However, sometimes senior managers use multiple criteria analyses to prioritise the list of existing and newly identified initiatives in the portfolios beyond financial considerations (OGC, 2011). Maximising values of a portfolio during prioritisation, balance and selection is often focused on financial indicators such as the cost-benefit ratio (Shalbafan et al., 2015), rate of return (ROR) (Pendharkar, 2014), or return on investment (ROI) (Belaid, 2011). All these indicators are commonly used for financial analyses of projects. Winter & Szczepanek (2008) argue that senior managers should pay great attention to the value of project portfolios. The value of project portfolios concerns maximising utilisation of resources and expertise against the cost of implementing project portfolios (Ghapanchi et al., 2012).

Despite an emphasis on cost-benefit analysis, there is an increasing focus on achieving value through effectiveness of decision-making processes at both early planning and project delivery stage. The optimisation process during prioritisation assists senior managers to use scores and criteria that later can be used for selection, in order to conduct a comprehensive analysis of the corporations' capacity and capability against its profitability (PMI, 2013a).

This challenge for portfolio selection balancing is to find an optimised selection of projects mix within an organisation's constraints. Taking into account organisational limits and constraints such as resources availability, and interdependencies between projects and programs, Ghasemzadeh et al. (1999) proposed a zero-one integer model that generates the right mix of projects and initiatives based on mathematical models while supporting portfolio managers' ability to select an initial solution. According to Ghasemzadeh et al. (1999), the nature of selecting project portfolios is discrete; hence a zero-one mathematical program which considers constraints such as finance, manpower and equipment, can achieve an approximate solution. This model is designed to maximise the sum scores of all projects in the project portfolio in which the project scores can be based on net present value (NPV) of each project. The mathematical results provide solutions but allow portfolio managers to adjust the selected solutions based on management preferences. The integrated model proposed by (Archer & Ghasemzadeh, 1999) acts as a simplified version to select projects and programs. Archer and Ghasemzadeh (1999) argue that strategic decisions should be made in the first instance, before proceeding to the second phase of the framework. The two phase framework provides decision makers and stakeholders with a flexible framework for decision making using group decision support systems (Archer & Ghasemzadeh, 1999).

Achieving balance

Achieving a good balance of mixed initiatives for a portfolio of projects is the next important decision in the definition cycle of PPM. When a ranked list of initiatives is available at the end of the prioritisation process, the balance of initiatives regarding their use of resources, timing and returns and fitness to corporations' strategic goals, are the next important decisions to be made by senior managers (OGC, 2011). Senior managers must decide and confirm the balanced mix of programs and projects in the portfolio during a final stage of selection and authorisation (Oh et al., 2012). Because of the use of a common pool of resources and expertise, projects interdependencies have proven to be a challenge to the process of balancing project portfolios (Rungi, 2010). Killen (2013) adds that information overload and time pressure can further intensify the challenge of making decisions in relation to project interdependencies. To make it easier to evaluate project interdependencies, they could be presented using different tools such as relationship diagrams, tabular forms and so forth. This has proven to be an important way to improve a decision maker's performance (Killen, 2013).

The topic of selection of initiatives and committing to them in planning, has attracted many researchers over the last decade. Corporations that supply innovative products use Innovative PPM (IPPM) to select Research and Development (R&D) projects to maintain a company's strategic position in competitive situations. Cooper (1994) argues that the new generation of decision-making processes for selection of projects does not demonstrate a fine line between the generation of stage-gates. These gates exist throughout the project's life cycles such as preliminary investigation, business case, development, test and validation which have a fuzzy nature with significant overlaps among gates and stages of product or service development. As a result, new decision processes have been developed for more effective decision making. Achieving balanced values that meet overall business goals, and the goals of different business units' interests, has been a challenge for portfolio decision makers. Senior managers face a challenge to choose the right selection criteria in IPPM. Hassanzadeha et al. (2014) argue that cost-benefit techniques are not sufficient to achieve the goal of value maximisation. In addition, because R&D projects face uncertainty, the selected portfolio of projects is unable to guarantee a predictable cash flow over a long life time (Hassanzadeha et al., 2014).

Performance for project execution contributes to overall achievements for balanced project portfolios. Martinsuo & Lehtonen (2007) argue that every single project has a key role in the measurement of the efficiency of project portfolios; therefore, project managers require competencies to understand PPM and the involvement in the PPM processes should not be limited to senior managers. While the majority of research papers on PPM have described studies about carrying out R&D projects in a manufacturing context, recent research papers reveal that the process of PPM is proving to be a competitive advantage for companies in services and manufacturing industries as well (Killen & Hunt, 2010, Killen et al., 2008b). The trend of recent papers in PPM indicates the importance of having PPM for both manufacturing and services industries where the companies are competing to propose innovative products to their customers.

Organisations often find that implementation of PPM is difficult due to multiple constraints. Unger et al. (2012a) state that managing multiple projects simultaneously is a challenge for organisations as managing them leads to competition for scarce resources. The challenging function of managing PPM, coupled with growing pressure from the business environments such as macro-economic factors, has urged corporations to rethink the management of multiple projects. While PPM has been discussed in project management literature over past 20 years, it has not paid sufficient attention to addressing constraints at the organisation level; problems faced by individual decision makers and teams involved in decision-making processes. These hurdles for implementation of PPM can be categorised into 'soft' and 'hard' attributes (Williams et al., 2012).

Yahaya & Abu-Bakar (2007) state that soft attributes include leadership styles, top management commitment and team and individual skills and competencies. On the other hand, hard attributes refer to the need for additional infrastructure and the space to manage strategies for the selection, execution and operations of projects. Project portfolio management information systems (PPMIS) support identifying hard attributes (Williams et al., 2012) for successful implementation of PPM. Dedicated information systems can support learning, structuring and steering of project portfolios at different gates of a project portfolio funnel (Killen et al., 2012, Kodukula S., 2014, Teller et al., 2014). However, Gemünden et al. (2015) argue that PPMIS are still in the early stage of development for complex processes of decision making for project portfolios. The complexity of PPM processes is discussed in section 2.2. The use of PPMIS and its importance from an organisation perspective is discussed in section 2.3.

2.2 Complexity of project portfolio processes

Inherent and contingent factors contribute to complexity of decision making in PPM (Blomquist & Muller, 2006, Petit & Hobbs, 2012). The inherent factors (Petit & Hobbs, 2012) link the complicated process of analytical and rational decision making for project selection. The process of decision making for selection, prioritisation and authorisation can also become complex (Gemünden et al., 2015). The complexity of the processes for PPM is related to key determinants including the number of projects and initiatives as elements of a portfolio, the degree of interdependencies between elements and the predictability and magnitude of changes to these elements and their interdependencies (Daft, 1992, Dietrich, 2007, Dooley & van de Ven, 1999, Levinthal & Warglien, 1999, Ribbers & Schoo, 2002, Teller et al., 2012). Projects are comprised of interdependent elements which can be affected by each elements' results in a portfolio of projects. This type of interdependency is called 'outcome dependency' (Teller et al., 2012). The number of elements depends on several criteria including: the number of business units involved; distribution of budget and resources; single projects and business as usual among the business units; and lastly, overall number of projects in the project portfolio. Changes in these elements, and interdependencies can happen due to internal and external factors (Martinsuo et al., 2014). For example, the manufacturing industry deals with changing pricing regimes, increased pressure to reduce the cost structures, shrinking experienced workforce and a cautious capital market which influence decision making on selecting and balancing project portfolios (Walls, 2004). However, the PPM complexity can also arise from contingent factors because of the lack of information in advance and decision makers' bounded rationality (Blomquist & Muller, 2006).

The concept of complexity is a well-developed area for project management at the single project level. Remington and Pollack (2008a) identified four dimensions of complexity for single projects as follows: 1–structurally complex projects relating to the physical scale of the projects; 2–technical complexity, which emphasise the relationships among components of the projects; 3–directionally complex projects when the output of the project cannot be predefined; and, 4–temporality complex projects when the time scale is moving too fast (or slow) and can interrupt confidence in predicting project activities. At the portfolio level complexity is defined as the number of projects in a project portfolio and the degree of interdependency among projects in the portfolio (Daft, 1992, Dickinson et al., 2001).

Kodukula (2014) describes the funnel model as a good guide for common PPM practice. The funnel model uses three gates: 1–Initiation (pre-project); 2–Development (project); and, 3–Production (post-project) (Kodukula S., 2014). Initiation assesses the feasibility of projects from inception until commitment. The development gate monitors the quality of delivering projects against defined key performance indicators (KPIs). The production gate is when the delivery of project values commences. The funnel model is a classic example of a theoretical view of PPM.

Figure 1 illustrates the framework in which project portfolio managers can take the lead on key activities. Decision making for project portfolios has direct links to organisational objectives for finance, strategy alignment and human resources as shown in the right side of the Figure 1. Projects are in different life cycles such as evaluation, prioritisation or termination/completion (retirement) while progress in stages include initial planning, development and implementation or production. This occurs in parallel, which may lead to further complications requiring the use of a holistic decision-making process for effectively managing project portfolios (Kester et al., 2009, Teller et al., 2012, Walls, 2004).

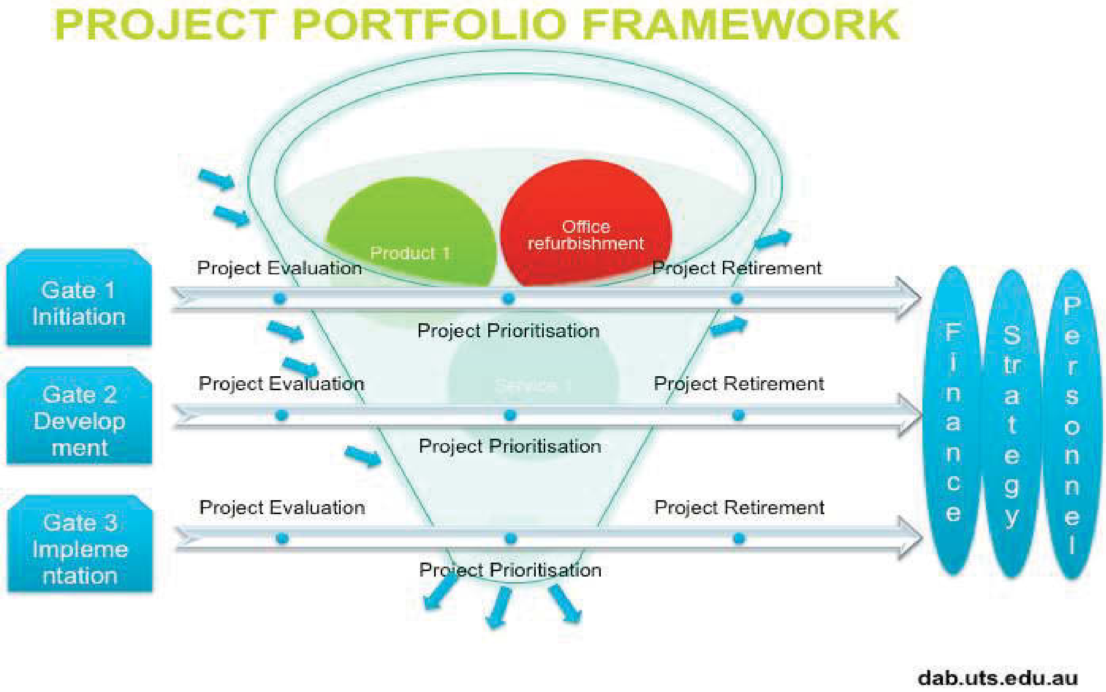


Figure 1- project portfolio overall framework, (Shalbafan et al., 2015)

Increased complexity for PPM decision-making processes and tasks has demanded better risk management to improve corporate business objectives' chances of success. A well-established risk management framework for PPM can support management of complexity during PPM decision making by helping senior managers develop strategies to manage those risks. Archer and Ghasemzadeh (1999) define 'risk' as the probability of an event with undesirable outcomes and the consequences associated with the events. Kodukula (2014) identifies key risks for a project portfolio as: 1–lack of formal process; 2–lack of governance; and, 3–practice and biases of judgement in decision making in gateways shown in Figure 1.

Furthermore, Belaid (2009) identifies two types of risks for portfolios: individual risks and relationship risks. Individual risks refer to single project risks and relationship risks considers interdependencies among projects. Lack of necessary and relevant information for making decisions in PPM can affect the quality of decision making. The lack of complete information is often caused by the high cost of getting complete information in the initial stages. Williams et al. (2009) state this high cost may result in inadequate provision of information to senior managers and result in poor preparation for them before final decisions can be made, thus increasing the risk exposure (Archer & Ghasemzadeh, 1999) for implementation of PPM.

2.3 Organisations and project portfolio management

The management of project portfolio as a key function in organisational management is useful to explain the role of project portfolio managers and their impact on PPM decision making. Organisation studies could help to illuminate key areas such as organisational capabilities to execute PPM, defining roles for project portfolio managers, steering committees, and defining success factors for decision-making processes, and information systems to support decision making (Arlt, 2010, Christiansen & Varnes, 2008, Cooper et al., 2000, Gemünden et al., 2015, Killen et al., 2008b).

Organisational capability for effective PPM includes the processes and capacity to execute PPM and align project selection processes with organisational strategy (Killen et al., 2008a). Organisational capacity refers to resources, expertise and structures that are recognised as providing essential support for decision making in PPM (Ghasemzadeh et al., 1999). The limitation of available expertise is one of the decision criteria that decision makers should consider when they are making decisions such as portfolio expansions, or alignment with business strategy (Kester et al., 2009).

Organisations can also sustain their competitive advantages by developing dynamic capabilities (DC) to respond to the changing environments. Dynamic capability is defined as "the capacity of an organisation to purposefully create, extend or modify its resource base" (Helfat, 2007, P. 4). Killen & Hunt (2010) suggest that dynamic capability leading to the implementation of PPM could result in competitive advantages for businesses in service and production industries. The two key dynamic capabilities, absorptive and adaptive, have a fundamental impact on a company's competitive advantage (Killen & Hunt, 2010). Adaptive capabilities are an organisation's competencies for incremental innovation in response to market, customer and product changes (Biedenbach & Müller, 2012). As a key strategic DC, Absorptive Capacity (AC) is an organisation's ability to acquire knowledge from external resources. AC connects external knowledge and learning from previous experience to result in an organisation finding innovative solutions (Easterby-Smith & Prieto, 2007b).

On the other hand, Martinsuo & Lehtonen (2007) state that skills and competencies for managing project portfolios should be extended to the project portfolio management teams. In addition, enhancement of PPM knowledge for project managers can result in a more integrative approach (Jugend & da Silva, 2013) to decision making in uncertain conditions. Therefore, Jonas (2010) suggests project portfolio managers should involve project managers in PPM decisions. This could help in making decisions if the managers do not possess sufficient project management knowledge.

The role of portfolio managers is an emerging concept in organisational management and needs further attention apart from that given to analysis of tasks and processes.

According to Jonas (2010, p. 818),

> Without analysing who is responsible for the newly arising issues and how the key actors should cooperate and cope with their tensions, project portfolio management can neither be understood nor be implemented successfully.

Portfolio managers are focal points for other stakeholders such as project managers, program managers, portfolio review committees and project sponsors (Belaid, 2009). A PPM role has two key components; 1–clarity of formal tasks, responsibilities and PPM processes; and, 2–the significance of the role from the top managers' perspective (Jonas, 2010). The responsibility of alignment between projects, programs and portfolios and corporate strategies is an emerging role for portfolio managers (Koh & Crawford, 2012).

The role of project portfolio manager has to be pivotal between the planning and the implementation of complex projects (Koh & Crawford, 2012). Roles and responsibilities of project portfolio managers are listed as follows:

- business planning and strategic alignment;
- portfolio prioritization and selection;
- stakeholder management;
- risk management;
- resource planning; and value assessment and benefits realization (Blomquist & Muller, 2006, Jonas, 2010).

In addition, the typical activities for project portfolio managers include collecting information for possible projects, their prioritization and evaluation according to available resources, and the assessment of projects in progress concerning their continuing fit with the portfolio (Kaiser et al., 2015).

Several models and frameworks, proposed in the literature, discuss various perspectives of PPM implementation. However, these models and frameworks are based on certain assumptions which result in shortcomings. Khurana & Rosenthal (1997) state that front end strategic planning is not carried out properly in organisations. Poor strategic planning can be manifested as misaligned selected projects which can result in unwanted consequences for the corporation. Proposed models and frameworks for PPM are not universally applicable to all situations when selecting portfolios (Coldrick et al., 2005). Yuming et al. (2007) suggest that an E-Diamond framework can be utilised in conducting enterprise strategic analysis for PPM. Figure 2 shows how an E-Diamond model proposes assessment criteria for five key elements of: organisation, management preferences, strategy, resources and environment (Yuming et al., 2007).

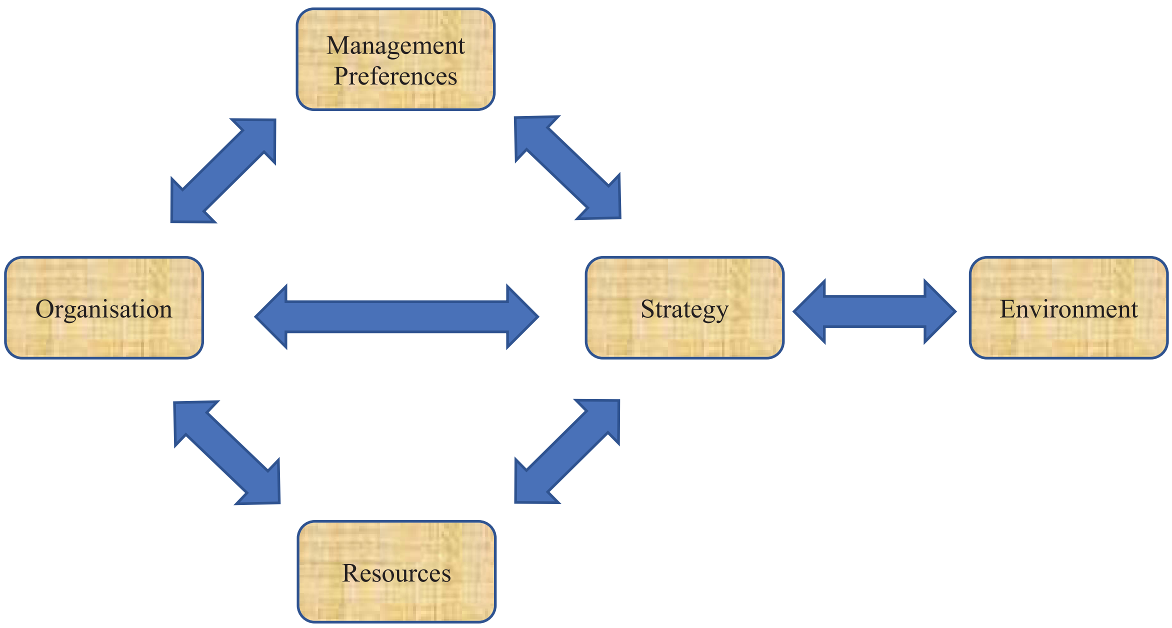


Figure 2 - The E - Diamond model (Yuming et al., 2007)

In summary, the uncertainty and its impact on decision makers' perceptions for decision-making criteria have not been addressed clearly due to this singular focus.

Good practice in project portfolio management is becoming a key competency for organisational management (Martinsuo & Lehtonen, 2007). A successful practice for PPM can be identified via measurement of key success factors such as average project success, strategic fit, portfolio balance for resources allocation (Engwall & Jerbrant, 2003, Jonas, 2010, Maged, 2008, Rogério Tadeu de Oliveira et al., 2011, Unger et al., 2012b).

Steering committees or portfolio review teams are very important components of a successful implementation of PPM in organisations (Unger et al., 2012b). In order to sustain a successful steering committee for PPM, it is necessary to understand the key factors at play in the performance of steering committees. However, the common use of steering committees across organisations remains limited (Lechler & Thomas, 2015).

Steering committees make the decisions for PPM with available information and in a business context. Lack of information and a proper system to share knowledge is another key challenge influencing the quality of decision making (Unger et al., 2012a). A dedicated information system can support successful decision making by the steering committee (Teller et al., 2014) and enable the Project Portfolio Manager to stay in control of the complexity of tasks involved. The business context concerns the level of formalisation of processes. The use of information systems, is an indicator of an organisations' maturity in regard to implementing PPM successfully (Petit & Hobbs, 2012). Formalisation is defined as policies, procedures or processes, which are clearly defined and followed in the organisations (Jang & Lee, 1998). Simultaneous formalisation of processes at the single project level and the project portfolio level influences positively the success of PPM (Teller et al., 2012). Process formalisation and project portfolio management information systems (PPMIS) are considered co-existing and correlated to the PPM's success (Gemünden et al., 2015). According to Gemünden et al. (2015), prioritisation has attracted the first score for use of PPMIS and supporting software and tools and steering committees are at the bottom of the list as they are dependent on senior managers' communication and negotiation skills.

While information-based models for project portfolio prioritisation drives organisations to invest in supporting the use of information systems for decision making, there is a danger that the steering committees may also be driven by other subjective factors such as politics, consensus and negotiation to deal with uncertainties in decision making (Christiansen & Varnes, 2008). This supports the claim that formalisation of processes can impact decision makers negatively where uncertainty exists (Teller et al., 2012). This points to the need for elaboration on understanding the role of negotiation skills, senior managers' competencies and team building skills for members of steering committees to manage decision making in PPM under uncertainties.

2.4 Decision making approaches and PPM

Quantitative decision-making models are perhaps one of the most discussed research models in academic literature on PPM. A summary of previous research is presented in the following section to compare benefits and weaknesses of proposed models. This literature review opens up debate on the need for further research in decision making with a different lens. In the next section, sources of uncertainty and their potential implications for decision making in PPM are presented. Understanding causes of uncertainty can help managers to monitor those sources and be prepared for unexpected events.

2.4.1 Quantitative decision making

Quantitative decision making on project portfolio processes has been discussed extensively in the literature. A variety of tools are used to aid decision making in PPM. Processes such as project selection and prioritisation are advanced in formalisation and application of computer-aided decision making (Archer & Ghasemzadeh, 1999, Gemünden et al., 2015). Several quantitative models and frameworks have been developed to overcome the complexity of multidimensional problems for PPM. For example, quantitative decision making for project selection encompasses several criteria such as resources availability, strategic fit, and targets for profit maximisation or cost reduction (Ghasemzadeh et al., 1999).

As noted earlier, Ghasemzadeh FIX. (1999) proposed a zero-one integer linear programming model for selecting and scheduling an optimal array of projects for a portfolio. Four key factors were identified as difficult issues to make decisions on project selection: 1–Uncertainty associated with project risks and costs; 2–project interdependencies; 3–constraints such as resources, equipment and finance; 4–requirements to balance projects in the portfolio in terms of time to completion and riskiness of projects. The Ghasemsadeh /Archer model (1999) requires detailed deliberation for quick decision making and decision makers' preference and intervention on the optimised solutions.

The fuzzy integer linear programming model is used to take the uncertainty into account for project selection (Juite & Hwang, 2007). Uncertainty is a prominent issue in R&D project selection and it is an important factor in decision making for new products development (Cooper et al., 2004, Cooper & Kleinschmidt, 1995, Rogério Tadeu de Oliveira et al., 2011). In order to tackle uncertainty, use of fuzzy models for decision making on R&D projects has been proposed (Durbach & Stewart, 2012, Juite & Hwang, 2007).

A new approach that also takes into account the probability of failure in investments has been proposed for PPM (Walls, 2004). Zarghami, Szidarovszky and Ardakanian (2008) suggest that most models proposed to date are either focused on stochastic approaches or consider fuzzy logic as their focus, thus ignoring the probabilistic nature of risks concealed in the decision criteria.

While the finance-based approach is common for stock markets (Markowitz, 1952), it is difficult to foresee all uncertainties in industry projects such as R&D or in construction projects because the projects are neither similar nor replicable. Belaid (2011) argues that the model is applicable to petroleum upstream project portfolios where trends and uncertainties are identifiable through the oil market.

Multicriteria Decision Making (MCDM) techniques and tools are at the centre of various quantitative decision-making processes in PPM. Maged (2008) describes an MCDM model to find the optimized selection of R&D projects where resource dependencies pose constraints to decision-making processes. The combination of a Simple Multi-Attribute Rating Technique (SMART) and visualisation techniques with the efficient frontier are used to provide information required for decision-making support system software (Maged, 2008). The software was developed to support decisions for prioritization, resource allocation and budgeting of R&D projects (Maged, 2008). MCDM is also used to measure the performance of project portfolios to make decisions on strategic changes or turning points using a variety of criteria, which are required for decision makers to reprioritize projects based on their performance (Rogério Tadeu de Oliveira et al., 2011).

Both financial and non-financial indicators at the project level are used in MCDM models that assist decision-making processes in PPM. Analytical Network Process (ANP) and Artificial Neutral Network (ANN) are two common models that are used for decision making with multiple types of decision criteria. According to Costantino et al. (2015),

ANN is a nonlinear and non-parametric model which is inspired by the functioning principles of the biological nervous system in the human brain that searches for relations between data to aim for solving two key problems: 1–functions approximations (regression); and, 2–classification of phenomena. As a simpler approach for top manager engagement in decision making, ANN facilitates communications between project managers and project portfolio managers to assess riskiness of a project's success based on the project managers' past experience (Costantino et al., 2015).

ANP is used to achieve organisational sustainability through implementation of robust PPM (Turan et al., 2009). According to Turan et al. (2009), ANP has two advantages for PPM decision making. Firstly, it considers the attributes and criteria and their interdependencies and, secondly, it uses a network of sub models with feedback loops, which makes it more comprehensive than other MCDM models to support decision-making processes in PPM.

Table 1 – A Summary of the portfolio selection models in literature adapted from (Ghapanchi et al., 2012, p 793)

Author and research aim	Strength	Weakness
Bardhan et al. (2004) introduced a nested real options and traditional discounted cash flow for IT investments	They claim that "Our nested options model provides a better understanding of project interdependencies on valuation and prioritization decisions" [p. 33]	They assume that "the overall portfolio volatility can be estimated accurately" [p. 53]
Lin & Hsieh (2004) introduced a fuzzy weighted average; Fuzzy integer linear programming for projects in food industry	Their method copes with incomplete information and uncertain circumstances	They assume that "all strategic plans are independent of one another" [p. 389]
Huang et al. (2008) introduced a fuzzy AHP for R&D projects	They extend "fuzzy AHP application for R&D project selection in the public sector" [p.1050]	They assume the evaluation criteria are independent
Tiryaki & Ahlatcioglu (2009) introduced a fuzzy AHP for stock selection	They rank "a set of stocks in a fuzzy environment" [p. 67]	They do not consider the interdependencies among the DMUs
Tiryaki & Ahlatcioglu (2005) introduced a fuzzy MCDM for stock selection	Their model "demonstrates the usefulness of fuzzy methodology in financial problems" [p. 144]	They do not consider the interdependencies among the DMUs
Chen & Cheng (2009) introduced a fuzzy MCDM for IS projects	Their model "provides more flexible and objective information in dealing with multicriteria decision-making problems in a fuzzy environment" [p. 398]	They do not consider the interdependencies among the IS projects
Ghasemzadeh et al. (1999) introduced a zero-one integer model for portfolio selection	This model provides support for optimised solutions for selected project portfolios based on project scores and known constraints	The model is linear and does not fit for nonlinear sudden changes to parameters and unknown constraints
Costantino et al. (2015) introduced an application of ANN to select projects based on project CSFs	The model supports iterative nature of decision making	The ANN approach is focused on two key problems only; regression and classification
Turan et al. (2009) introduced an application	The proposed model overcomes some	It does not discuss uncertainty and sudden

of ANP to evaluation and prioritisation of project portfolios based on projects' contribution to organisation sustainability	restrictions with AHP for prioritisation decision making. E.g. no alternative or sole option is allowed in ANP.	changes to strategic directions

Despite the use of quantitative techniques used in PPM, Müller, Martinsuo FIX. (2008) challenged the notion that quantitative methods for project portfolio optimization resulted in better performance of portfolios.

Table 1 shows a summary of models which were discussed in previous research and the current literature reviewed and provides insight into the strengths and weaknesses of these models for project portfolio selection decision making (Ghapanchi et al., 2012). The failure of a traditional optimization model may be attributed to ignoring the judgment capacity of decision makers (Archer & Ghasemzadeh, 1999). Arguably, companies are struggling with sub-optimization and irrational decision-making processes (Martinsuo, 2013). Kaiser et al. (2015) emphasised that, despite development in project selection models for decision making, the key to successful implementation of PPM is the organization's structure and its alignment with decision-making criteria. This has resulted in shifting the focus of studies from quantitative decision making to the study style of decision makers, and their capabilities to carry out PPM in uncertain conditions.

2.4.2 Uncertainty, impacts on decision makers

Uncertainty is one of the key factors that influences decision making for project portfolios. Uncertainties are factors that are beyond an analyst's ability to predict events and cannot be reduced to a risk level (Quade, 1989). Growing uncertainty has put pressure on decision makers, requiring them to be specially aware of their resource fit and strategic fit.

Quickly changing scenarios are a reality of business environments. The changes influence decision-makers' perceptions for choosing processes, and decision criteria. Christiansen & Varnes (2008) suggest that decision makers have to deal with multiple criteria and sometimes conflicting interests. This nature of PPM decision making directs decision makers to abandon traditional rational thinking tools and look for suboptimal problem solving approaches. This is because traditional tools for project selection have failed to consider dynamics of uncertainties and project interdependencies in a project portfolio (Ghapanchi et al., 2012). Changes in the business environment are identified as one of the sources for uncertainties in decision making for PPM (Petit & Hobbs, 2010).

In order to understand the influence of the decision makers' perception for identifying sources of uncertainty on their judgement for decision-making processes and decision criteria, the nature of the uncertainty in PPM decision making must be understood first. Sources of real-time events can be internal or external for a PPM team. Petit & Hobbs (2010) categorised these key events as changes to technology, budget, organisation, scope and project performance, with high frequency and high impact for scope and project performance. In addition to this list, Martinsuo et al. (2014) assert that external uncertainty can be related to factors such as competitors' actions, customers' needs or changes to macro-economic conditions. Furthermore, organisational complexity, managers' competences and portfolio autonomy trigger organisational uncertainty while changing customer requirements can bring uncertainty to the single project level (Martinsuo et al., 2014). Therefore, managers should develop tools and skills to deal with challenges due to these uncertainties. Christiansen & Varnes (2008) suggest that negotiation skills would be useful at a portfolio committee meeting to address such challenges. Moreover, Duncan (1972, p. 325) states that:

> …uncertainty and degree of the complexity and dynamics of the environment should not be considered as constant features in an organisation. Rather, they are dependent on the perceptions of organisations members and thus can vary in their incidence to the extent that individuals differ in their perceptions.

Individual perceptions of uncertainty can be influenced by several factors such as work experience, personal background, organisational routines and rules. The perception of uncertainty and its impact on projects has been discussed but relatively fewer studies addressed their impact at the project portfolio level (Petit & Hobbs, 2010). Perception of decision makers can influence their decision-making style. Korhonen et al. (2013) assert that managers cannot stick to their rational decision-making approach while exposed to uncertain or unknown conditions. Furthermore, there is a need for further investigation on how to manage uncertainty for PPM in future research (Korhonen et al., 2013, Petit, 2012).

The influence of uncertainty on decision-makers' intuition, their organizational roles and their perception on decision criteria are arguably key areas for further discussion as the key drivers for decision-making processes. Zheng (2009) claims that a visual exploration approach can support decision makers with intuitive decision making as a way to improve the process. Martinsuo (2013) suggests that uncertainties change the practice of PPM. The extended framework for managing uncertainty offers categorization of uncertainty based on the sources of uncertainty—external context, organizational context and single project changes—for which managers can identify and prepare contingency plans to overcome those events (Martinsuo et al., 2014).

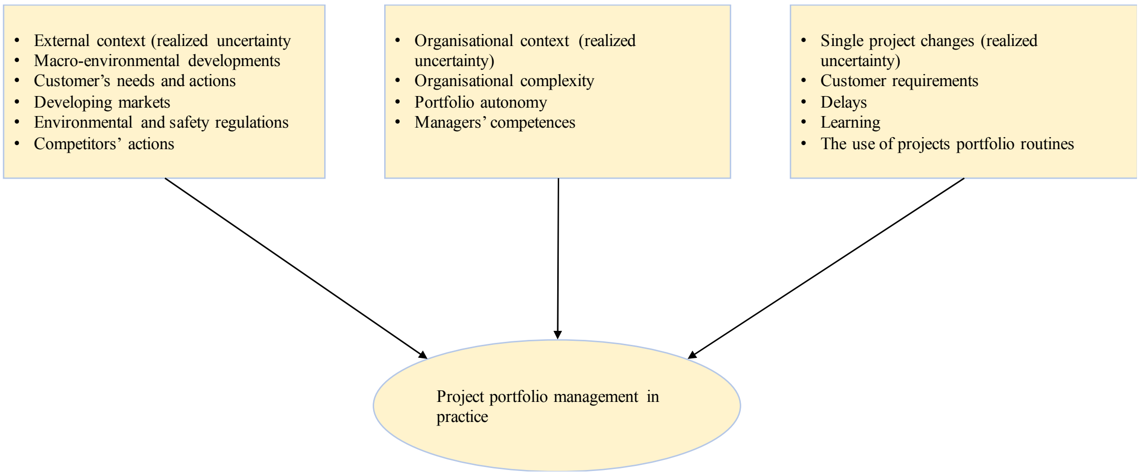


Figure 3 – Extended framework for PPM and uncertainty (Martinsuo et al., 2014, p. 13)

The perception of decision makers could be affected in different ways by various sources of uncertainty. For example, Martinsuo et al. (2014) state that, in their research, customers' needs received more attention for interviewed managers as they perceived that increased competition for product industries and elevated consumer needs meant that they should work on a comprehensive solution in new product development to satisfy their customers.

The perception of top managers plays a key role in selecting tools to overcome challenges due to uncertain conditions (Martinsuo et al., 2014). This will be further assessed in the data collection and analysis section of the thesis. According to Martinsuo et al. (2014), the sources of uncertainty, as illustrated in Figure 3, have been identified and classified based on the senior managers' perceptions who were interviewed in their research. In their comprehensive research paper, Martinsuo et al. (2014) argue that there are three key challenges to manage uncertainties at the project portfolio level consisting of insufficient rules and routines, lack of accountable people to identify emerging uncertainty, and an immature stage of PPM in organisations.

According to Kester et al. (2009), PPM decision-making processes can be categorised into formalist, intuitive and integrative firms. Formalist firms stick to a top down approach for project selection and project terminations based on quantitative decision making. Intuitive firms use their decision-makers' experience to deal with uncertainty in decision making (Kester et al., 2009). Integrative firms use a hybrid approach by applying supplementary qualitative and quantitative decision methods. Through their research, Kester et al. (2013) found that intuitive firms understood uncertainty better. The process of decision making at the organisation level follows a sensemaking process which has plausibility rather than accuracy at the centre of attention (Weick, 1995). However, further research is needed to understand how individual decision makers with different professional backgrounds make decisions in each of these decision-making approaches (Kester et al., 2009).

2.5 Mechanism to manage uncertainty at project portfolio level

From the discussions in the previous section it appears that less attention has been paid to managing uncertainty in PPM decision making. As the concept of growing uncertainty is becoming an integral part of decision making because of a rapidly changing business environment, the literature on PPM has suggested group decision making as one of the approaches to mitigate and manage uncertainty in decision making. Furthermore, the role of individual and team cognition in the final decisions in PPM becomes crucial in changing conditions and this research tries to extend the previous studies in general decision making to a particular PPM context. These are now discussed.

2.5.1 Group Decision Making (GDM)

Yahaya and Abu-Bakar (2007) argue that group decision making works across several processes and can be used as a powerful mechanism to overcome factors related to uncertainties during decision making for project portfolios. The decision-making processes in these cases cannot follow statistical or quantitative approaches but use creative thinking, intuition and negotiation in the portfolio steering committees (Christiansen & Varnes, 2008, Yahaya & Abu-Bakar, 2007). Some organisations embark on capability enhancement to handle PPM deliberations in teams by using skills similar to a crisis management team. A proposed model of creativity for organisational crisis management proposes that three factors namely, creative intentions, familiarity with solutions and trust within team members, play key roles to determine the value and novelty of decisions (Sommer & Pearson, 2007). This model suggests that using simulation-based activities with members of an organisation can help team members improve their readiness to face uncertain conditions during decision making (Quarantelli, 1988).

Managers at different levels of the organisation must make decisions for their allocated domain. The process of decision making depends on the context and temporality. The context is highly dependent on industry and the nature of specific problems as well as on the skills and competencies of decision makers during decision making. For example, when facing a hostage crisis police officers needs to make several decisions by considering the potential for significant impacts in a very short period of time (van den Heuvel et al., 2012). Temporality concerns the factor of time for the interval and time pressure on decision makers.

Uncertainties can result in crises if the top managers neglect, or fail, to oversee the sources and develop potential alternatives to work around them. Management controls (Collyer & Warren, 2009) and its disciplines such as strategic planning, group decision making and group decision support systems should help organisations to reduce the likelihood of crises due to unintended consequences. However, managers' perceptions of uncertainty influence their choice of means to manage uncertainty on a case-by-case basis. There appears to be no clear evidence of using management controls to overcome consequences of uncertainties in decision making in PPM (Korhonen et al., 2013).

Careful planning is a common process to identify risks and share information in the group to reduce any surprises because of poor information sharing. PPM decision makers have suggested that planning is a means to manage uncertainties inside and outside their organisations (Korhonen et al., 2014). Despite the importance of group decision making, the literature lacks studies regarding a structured approach to decision making by applying GDM to PPM processes.

Group decision making (GDM) is used as a tool for strategic planning where decision makers have to overcome uncertainties. Sources of uncertainties due to incomplete information about the future can be addressed through GDM. GDM encompasses a process of decision making where individual decision makers contribute to the final outcomes. Strategic decision making and project selection and termination processes can benefit from GDM as a mechanism to mitigate or even manage uncertainties for their decisions (Khalili-Damghani & Sadi-Nezhad, 2013, Shepherd & Rudd, 2014).

Decision Support Systems (DSS) are used for collecting and distributing information across organisations in a timely manner. DSS has supported decision makers in the field of PPM decisions. Ghasemzadeh and Archer (2000) state that the organisations in their studies on project analysis and selection system (PASS) have benefited with improvements on the quality of decisions from application of DSS to the project selection process. Some of these improvements on the final decisions are summarised as balanced portfolio of projects, considered project interdependencies, and satisfactory management of constrained resources (Ghasemzadeh & Archer, 2000). Group Decision Support Systems (GDSS) have been proposed to top managers to support the decision-making process through information sharing. Furthermore, the positive impact of combining GDSS and simulation has proven to help interactive decision making in groups by senior managers (Mayer & Martin, 2004).

GDM can address the need for planning in a crisis when the information about the future and consequences of the decision alternatives are not clear to decision makers. According to Silver (2014), the institute of crisis management (Crisisconsultant, 2017) has categorised causes of crisis in organizations into four groups: 1–human errors; 2–technological or mechanical problems; 3–acts of god; and, 4–board decisions where senior executives do not take a problem seriously till it becomes a crisis. Group decision making has some traps known as ‘Groupthink’ and ‘Abilene Paradox’ (AP) which can result in destructive outcomes (Kim, 2001).

> Groupthink as Janis (1972) originally defined is a mode of thinking that people engage in when they are deeply involved in a cohesive in-group, when the members' strivings for unanimity override their motivation to realistically appraise (Hart, 1991, p. 1).

As an example of poor handling of a crisis due to the operation of Groupthink (Janis, 1972), the executives of the car manufacturing giant, Toyota, ignored technical faults in their cars made between 1999 and 2009 which caused four deaths and led to customers’ anger forcing the CEO to step down (Silver, 2014). While it is evident that group decision making can assist decision makers by providing a diversity of opinions to find solutions based on consensus, the GDM can have traps for decision makers such as Groupthink, where the majority prevent the minority from expressing their opinion. Another issue with GDM is poor information sharing among decision makers when they focus on their common information neglecting the diversity of opinions. Three key symptoms can indicate existence of Groupthink in GDM. Symptom Type I concerns overestimation of group power , while Type II deals with closed mindedness and Type III is related to pressure toward uniformity (Yetive, 2003).

Finally, Abilene Paradox is another trap for GDM. AP is described as situations in which "organisations frequently take actions in contradiction to what they really want to do and therefore defeat the very purposes they are trying to achieve" (Kim, 2001, p. 170).

Five interrelated components of AP that contribute to its occurrence are: 1–Public agreement that a current situation is not acceptable but in private they may not be dissatisfied, in which the case is called 'pluralistic ignorance'; 2–ineffective communication when the majority of group agree because of others; 3–vocalisation of group sentiments because of their misinterpretation; 4–decision makers' reprise and their questions on the rationality of their decisions; and, 5–failure of managers to understand the process that resulted in poor decisions in order to avoid such situations in future (Harvey et al., 2004).

2.5.2 Team cognition and decision-makers' judgment

Individual judgement and team cognition can often play key roles in influencing data integration processes and sensemaking of a situation and its expected outcomes. Naturalistic decision-making studies show that decision makers mostly rely on their heuristics and make decisions leading too far from an optimal solution in a real decision-making scenario (Klein, 2008). According to Shepherd and Rudd (2014), while previous studies have addressed individual decision makers through the lens of cognitive abilities, a critical study on team cognition and adaptation to complexity at the team level (Klein, 2008) can improve understanding of strategic decision-making process through groups.

> Team cognition is the process of understanding how the knowledge that is important to team effectiveness is mentally held and distributed within the team (Huey-Wen et al., 2012, p. 383).

The context of team cognition is seen as a key variable for team performance (Huey-Wen et al., 2012) and a research on team cognition can benefit performance of PPM steering committees, particularly for strategic decision making.

Cognitive limits of decision makers can affect decision making on project portfolios when facing sudden changes due to bounded rationality. According to the bounded rationality concept, three elements affect decision-making capability: the lack of complete and accurate information, the human cognitive limitations in interpreting the information, and the finite amount of time available to make decisions (Killen, 2013).

For example, use of teams for decision making can bring different results. Measurement of team cognition helps when engaging individuals in decision-making processes. There are many examples of human errors in team cognition, ranging from the relatively mundane failures of business teams to the catastrophic failures seen in the USS Vincennes incident (Collyer & Mallecki, 1998). Measurement of team cognition can help senior managers predict the performance of the PPM steering committee during future crises. It also helps organisations with a systematic gap analysis to advance their maturity for implementation of PPM systems through human resource enhancements (Perry, 2011).

Individual Judgement are influenced by individual cognitive limits such as previous experience, knowledge and bounded rationality. Furthermore, previous research illustrates that portfolio decisions can be influenced by managers' viewpoints, their cognition limits and leadership styles (Blichfeldt & Eskerod, 2008). Individual decision makers demonstrate their approach to decisions and recognise key turning points in a decision-making process according to their cognitive abilities and their decision biases. Project termination or 'go-kill' decisions are critical decision-making processes for successful project portfolio implementation.

Kester et al. (2009) claimed that emotions and biases influence decision makers' rationality when they face project termination decisions. In their recent research, it was shown that even managers who had not been involved in the planning stage for projects listed for deletion, exhibited interest in keeping those projects alive (Kester et al., 2009). Although there is little evidence on individual decision biases and cognitive limits for decision making in PPM, there are gaps in the literature for PPM relating to how team cognition and group adaptation can help decision makers deal with uncertain events.

Making Sense of Complexity and Decision Making

The previous section discussed project portfolio contexts, sources of uncertainties and mechanisms to manage uncertainty in PPM decision processes. These mechanisms can be explored through understanding of three key factors: a) human cognition; b) tools and processes; and, c) contexts within which decisions are made. Decision making on complex problems may result in unintended consequences when the decision-making scene is exposed to uncertainties and environmental complexity. Managers learning how factors relevant to PPM decision making influence final decisions can find this to be beneficial for measuring and controlling uncertainties and their impacts, as well as for reducing unintended consequences. Therefore, this section reviews the Black Swan Theory (BST) as a theoretical framework for sources of uncertainty and real-time events, making sense of complex contexts and perceptions of decision makers on complex problems. The Cynefin framework is also reviewed as a suitable framework for identifying domains of knowledge wherein decision making happens and reactions that decision makers might have to sudden changes.

2.6 Sensemaking of Complex Situations

Complexity and uncertainty are recognised as factors creating fundamental difficulties for decision makers, especially when they are being expected to make decisions with insufficient information (Gorzen-Mitka & Okreglicka, 2014). For such problems, managers must make decisions while possessing a less than mature understanding of all the relevant factors; while often thinking that they need to obtain a deeper understanding of the domain (Hansen et al., 2009). While the term ‘complexity’ has various meanings in different industries and perspectives, in project environments, complexity is linked to interactions among the various dimensions of projects. For example a complex system is described by Sardon and Wong (2010) as having six characteristics:

1- Large numbers of interdependent elements
2- Very sensitive to small changes
3- Emerging solutions depend on circumstances
4- Systems adaptability based on feedback and history
5- Cause and effect relationships is vague and changing
6- Well-intentioned actions may result in undesired consequences

Similarly, Remington and Pollack (2008b)—as mentioned in section 1.2 Uncertainty, and decision making in PPM—categorise the causes for project complexity into four elements: 1–structure; 2–technical issues; 3–direction; and, 4–temporality. For example, the physical size of a project or a large number of technical interdependencies can cause complexity in decision making (Remington & Pollack, 2008b). In particular, unexpected destabilisation may result in chaotic situations, where traditional techniques for decision making may be ineffective.

The phrase 'Black Swan' has been adopted to refer to phenomena which are entirely unexpected and yet, once uncovered, are quite explainable.

> "A black swan is a highly improbable event with three principal characteristics: It is unpredictable; it carries a massive impact; and, after the fact, we concoct an explanation that makes it appear less random, and more predictable, than it was" (Taleb, 2010, p. 1).

In nature, such a phenomenon occurred when a prior belief that 'all swans are white' was disproved by the discovery of Black Swans on the Australian continent. Taleb (2007) proposed the term as a new way of thinking for risk practitioners, and specifically quantitative risk assessors, who are dependent on statistical analysis.

Black Swan events could be considered to include events emerging from: 1–the chaotic nature of nonlinear systems; 2–the complexity of systems; 3–under appreciation of extreme events; and, 4–multiple stable states for systems that may result in a failure to predict environmental consequences (Suter, 2009). Although there is much evidence of Black Swan events in nature (such as earthquakes or tsunamis), there is, as yet, less focus on the application of such a concept to corporate decision making.

However, application of the concept of Black Swan events can be usefully extended to real-time events in management decision making. The term 'real-time events' (RTE) refers to the actual time during which an event occurs. If an RTE occurs so quickly that decision-making processes cannot capture the changes in decision-relevant factors, the results may have serious consequences. In this context there can be an increasing nonlinearity of relationships between causes and effects, making the world more unexpected and hence the occurrence of Black Swan events more obvious (Taleb, 2007). In the process of developing Hooshmand-1 (used in this study) it became evident that the Black Swan concept could help in making sense of the dynamic environments created by the nonlinear nature of the action being designed, and would thus shed light on factors influencing participants' responses to rapidly changing RTEs.

Sensemaking of a complex problem or environment, as exposed to Black Swan events, boosts awareness among senior managers and researchers about tactics to tackle those conditions in decision making. Sensemaking is defined

> …as the way that humans choose between multiple possible explanations of sensory and other input as they seek to conform phenomenological (sic) with the real and in order to act in such a way as to determine or respond to world around them.
> (Snowden, 2005, p. 46)

Weick (1995), argued that all people apply sensemaking as a way to overcome ambiguity and associated interpretations of a set of conditions. Shrivastava (1987) states that individuals engage in sensemaking to find out what to do next, as well as dealing with the anxiety and fear that may accompany disastrous experiences. People use sensemaking to identify unknown areas of a complex problem and to predict possible approaches to those areas. Mills et al. (2010) identified the seven characteristics of sensemaking process as:

1. identity;
2. retrospection;
3. enactment;
4. social;
5. ongoing;
6. cues; and
7. plausibility.

In various ways, these will inevitably affect the manner in which decision makers go about the process of arriving at decisions that have both intended, and unintended, outcomes.

Identity is central to the sensemaking process, as people act based on their perception of who they are in a context. In effect, our work and life experiences influence our construction of identity and how we perceive events especially during crises (Weick, 1995). In contrast, retrospection provides opportunities for people to pay attention to certain disruptions in their past experiences. According to (Brown & Jones, 1998, p. 74):

> Individuals construct their understandings of organizational events by shaping and omitting information to bolster their self-esteem and feelings of control. Explanations of failure may therefore, be largely imposed after the event as participants seek to make sense of, and synthesize the many possible meanings available to them.

People enact their beliefs and lessons learnt from previous work experience when they write a narrative or speak about experiences. Enactment refers to how people make sense of an event, and is significantly influenced by the perception of the sense that can be made from the context in which the event occurs. Sensemaking is a social activity that shares plausible stories based on interactions between participants. Furthermore, the existing rules, roles and routines can influence the way people make sense of an event. As Gorzen-Mitka & Okreglicka (2014) state, people can convert a vague feeling into meaningful perceptions for complex situations while 'sensemaking' through use of efficient communication. People react to the environment as sequential events and the conclusion of each event contributing to the approach that people choose for making sense of future events. Hence, sensemaking is a continuous forming of anticipations and assumptions, and subsequent re-interpretation of experiences that differ from these anticipations and assumptions (Hansen et al., 2009). Furthermore, people extract cues from the context to understand what information they should use in their decision making, especially when they are facing a fast-changing environment, and we tend to be selective about the information available to them; in such contexts, for example, as scanning a Map. Lastly, people tend to use plausibility (Clemens, 2009). Plausible explanation of sudden changes for business plans involves new skills for management teams and individuals (Snowden, 2010a). People tend to use sensemaking to generate plausibility for unknown situations (Mills et al., 2010). Together, and separately, these seven characteristics of sensemaking can be used as a guideline for complex decision making in PPM.

Decision making in complex situations becomes a challenge because of limitations in available management tools. Traditional management tools and models are dependent on available information, although their accuracy and reliability of decisions—being made in fast changing situations—may be variable (Sinclair, 2005). Miller & Ireland

(2005) argue that complex market forces create a demand for quick decision making. Gorzen-Mitka & Okreglicka (2014) state that common management tools such as Gantt Chart or timeline are designed based on assumptions including high levels of certainty and ready availability of skills and expertise to finalise a solution. Managers make decisions with a less developed understanding of problems; hence, they need to obtain a deep understanding of the domain to explore smart solutions with new approaches (Hansen et al., 2009).

Managers must create processes for making effective decisions while they deal with many unknown factors. Nevertheless, the decision makers must tackle problems for which they have little advanced information and experience. Until the moment that the taboo of rational thinking was broken, rational decision models had existed independently from decision makers and decision processes (Tsoukiàs, 2008). In recent years, intuition has been defined as "a non-sequential information-processing mode, which comprises both cognitive and affective elements, and results in direct knowing without any use of conscious reasoning" (Sinclair, 2005, P. 357). Decision makers must use intuition to work with the little available information at the moment of decision making. Although use of intuition has increased in strategic decision making recently, further research claims that, if used alone, intuition can be a problematic decision-making tool (Miller & Ireland, 2005).

The processes of decision making and the sensemaking of situations are dependent on the context in which decisions are made. According to Shepherd & Rudd (2014), "1 - context refers to top management team (TMT), 2 - strategic decision-specific characteristics, 3 - external environment and 4 - firm characteristics". Each of these four characteristics can be an important factor guiding people to approaching complex problems as well as making sense.

Sensemaking has been used to reduce researchers' bias by considering research subjects as central within a study. The use of this research principle has proved reliable in several research studies (Browning & Boudès, 2005). Different tools are used to facilitate sensemaking such as storytelling, serious game and simulations. Listening to others' stories is one way to collect richer research data than conventional questionnaires and interviews, since storytelling brings the subjects' opinions directly into the research field (Berry, 2001, Boudes & Laroche, 2009, Brown, 2004, Brown & Jones, 2000). Specifically, the use of storytelling to make sense of the actions of people dealing with complexity in issues of workplace management helped me better understand their situations.

Narratives are commonly used to help people make sense of uncertain conditions or complex problems. People 'make sense' based on their rituals of belief and experience. Hence, individuals make sense of organisational shocks such as mergers, layoffs and expansions from different perspectives (Mills et al., 2010). According to Browning & Boudès (2005), narratives act as lenses to monitor individual behaviour, where narratives provide insight on "who said what to whom with what effect". There have been debates and schools of thoughts about how to use sensemaking processes to overcome the ambiguity of decision making in complex conditions. The common sense between different streams of thoughts emphasises that managers try to utilise participation of organisation members and exception of rules to pass through complex occasions (2005). Narratives can help understand complexity, as it is very difficult to establish assumptions or hypotheses for complex problems. A simulation creates the opportunity to collect narratives from its participants and to analyse complex problems over time; however, it may result in unexpected consequences (Kurtz & Snowden, 2003, Weick, 1995).

2.7 Simulation and Complexity

Simulation is used as an instrument to generate outcomes that can be analysed for learning and research purposes. Participants come to a simulation to understand organisational events, in an effort to improve their feeling of ability to be able to take control in complex situations they increase the simulation's level of difficulty by shaping the situation and even by omitting essential information (Sardon & Wong, 2010). Explanation of organizational failure, as a result of maniplating a simulation, may lead to several possible meanings emerging from different people's perspectives (Mills et al., 2010).

Simulation has been used as a tool to improve situation awareness in ambiguous conditions. Its use in facilitating the sensemaking process of complex problems has at least three benefits (Brown & Eisenhardt, 1998) which are :

1. Cognitive Benefits

Simulation helps researchers with two cognitive benefits, a) an increase in involvement and b) the opportunity to draw new insight from different sources of evidence. People become involved through deep concentration on complex problems where they work in a flexible time frame in a simulated scenario (Csíkszentmihályi, 1990, Hansen et al., 2009).

2. Social benefits

Simulation provides participants with a place to interact in comparative safety away from day-to-day organisational politics. Participants are encouraged to communicate their viewpoints on complex problems, which can result in social benefits (Papert, 1996).

3. Emotional benefits

Simulation helps participants to take risks in a new role, or new practices, in a safe and reasonably harmless exercise (Vygotsky, 1978). This is an advantage for industries where mistakes in decision making may result in significant consequences. According to Allal-Chérif & Makhlouf (2016) and Bateson (1972), these activities allow error because participants play in virtual workplace with low risks and can learn at their own pace. Considering the three characteristics above, simulation such as experienced in Hooshmand-1 can provide opportunities for learning more about how senior managers make decisions in uncertain or complex conditions.

2.8 Situation awareness and complexity

Situation awareness and creation of knowledge from an individuals' intuition are becoming essential elements to assist decision makers with limited knowledge and information during decision making in complex and changing situations. Senior managers' skills and organisational capacity to create knowledge of the current flow in businesses is crucial for supporting increased situational awareness and contributing to informed decision making in uncertain conditions.

Decision makers are expected to enhance their skills to make sense of complex situations as quickly as possible. The temporality of complex situations emphasises the essential nature of sensemaking in a short time in order to be responsive to changes. Knowledge is a justified true belief (Allal-Chérif & Makhlouf, 2016, Hosseini, 2010, Lis, 2014, Nonaka et al., 2000). Knowledge creation and information sharing about complex problems, as well as employment of competent managers, seem to be essential components for organizational success. Snowden (2002) argue that knowledge management prior to 1995 was focused on re-engineering processes through computerisation of major business applications to help with availability of information to decision makers. “The need for anticipatory awareness and anticipatory thinking – that is of preparing in time for problems and opportunities in order to have a resilient capacity to deal with surprising events” (Snowden, 2010b, p. xii) – is the key driver for introducing the narrative research tool to facilitate novel solutions (Snowden, 2010b).

There are two types of knowledge, 1–Explicit and 2–Tacit.

> Explicit knowledge can be expressed in formal and systematic language and shared in the form of data, scientific formulae, specifications, manuals and such like. It can be processed, transmitted and stored relatively easily (Nonaka et al., 2000, p.7).

However, tacit knowledge is deeply rooted in organisational procedures, routines, actions, emotions, ideals and values and not necessarily based on explicit ‘beliefs’ about facts (Nonaka et al., 2000). Tacit knowledge is associated with intuition, the senses, and values (Schon, 1983). On this matter (Nonaka & von Krogh, 2009) introduced the process of knowledge creation and self-awareness within the context of time and space.

Nonanka and his associates used the word Ba—a Japanese word meaning place and context—to refer to a place where people create knowledge through reflection on their own experience or sharing of others’ experiences (Nonaka et al., 2000, P. 7). They argue that the source of knowledge can be in individuals, project teams, emails or temporary meetings.

The integrated view of knowledge creation considers the place, plus people, as the conveyor of knowledge and regards interactions as key components to transfer knowledge through spiral processes between explicit and tacit knowledge beyond organizational boundaries (Nonaka & Konno, 1998) . Ba is a place where tacit / intuitive knowledge and explicit knowledge can be shared.

They describe how the process of knowledge creation goes through the phases of Socialising, Externalising, Combining and Internalising—which is known as the SECI model shown in Figure 4, while the knowledge assets are referred to in terms of inputs, outputs or moderators in the knowledge creation process (Nonaka et al., 2000).

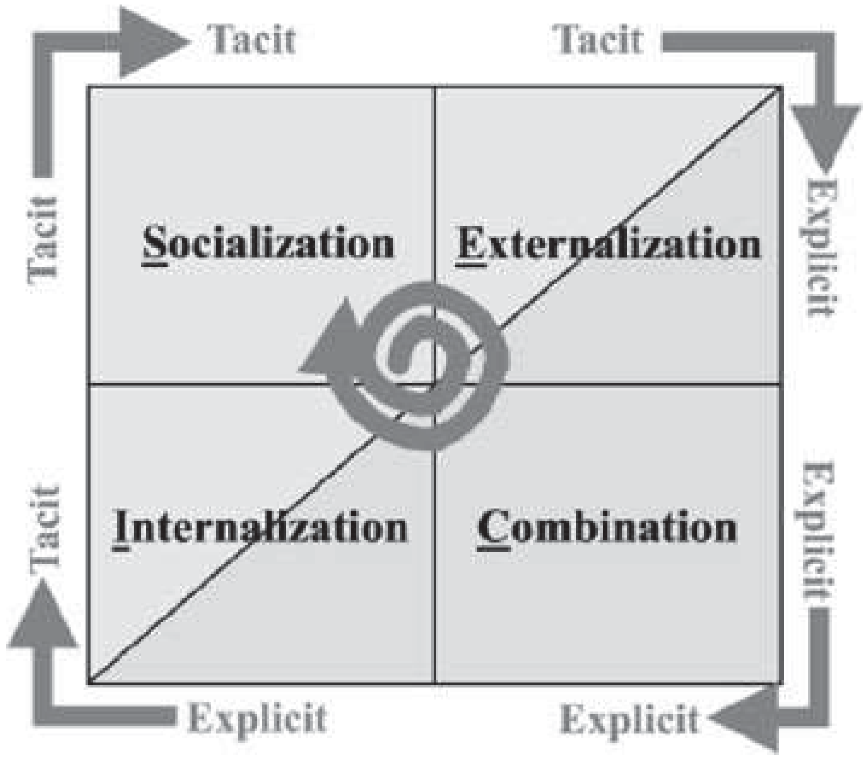


Figure 4 - The SECI model as outlined by (Hosseini, 2010, p. 264)

Socialization means sharing tacit knowledge among individual subjects, while, during the 'externalization' process, individuals commit to the group and create knowledge within the group resulting in conversion of tacit to explicit knowledge (Nonaka et al., 2000). Tacit and explicit knowledge are mutually complimentary (Nonaka & Konno, 1998).

According to Nonaka & von Krogh (2009), the process of 'combination' converts explicit knowledge to a complex form of a new explicit knowledge. For example, managers might gather external and internal data to generate planning and operational strategies (Nonaka & Konno, 1998).

However, internalisation involves converting newly emerged knowledge into organisational tacit knowledge (Nonaka et al., 2000). For example, participants in simulations play facilitated challenges and share the results of their experiments with an entire department (Nonaka & Konno, 1998).

Knowledge creation is a continuous process of conversion between tacit and explicit knowledge and thus the nature of the place (or Ba) can change throughout this process. Nonaka and Konno (1998) identified four specific aspects of Ba in regard to knowledge creation, which they called: Originating, Interacting, Cyber, and Exercising. Originating Ba provides a space for socializing and expressing individual experiences and feelings; Interacting Ba is a space for knowledge creation occupied by groups collaborating via constructed dialogue; Cyber Ba is a virtual technology-supported space for sharing and combining knowledge; Exercising Ba supports internalization of new knowledge through focused training with the help of experienced mentors.

Furthermore, knowledge creation is recognised as a flow that is continuous within individuals, teams and beyond organizational units. To manage knowledge generation as flow, narratives and attention to the context rather than content are key criteria for organisations (Nonaka et al., 2000). Snowden (2002), commenting upon the SECI model, states that context, narrative and content management provide a radical change to ways of synthesising complex situations. A proper approach to information processing can help individuals to enhance their situational awareness through sensemaking. Information processing through abduction results in making sense of revealed information such as stories, narratives and feelings into a single situation that is the best representation of the reality at the point of time (Snowden, 2002). The situation awareness, sensemaking and the concept of Ba are used in design of simulation Hooshmand-1 (Shalbafan et al., 2015).

2.9 Cynefin framework a new approach to sensemaking

The Cynefin framework proposes a new perspective in management science to study decision making in complex situations. ‘Cynefin’ is a Welsh word meaning habitat (Kurtz & Snowden, 2003), includes aspects of knowledge exchange, and is a framework to help people make sense of complexity through relaxing boundaries and checking assumptions deriving from existing theory, belief or practices (Krems, 1995, Sardon & Wong, 2010). The Cynefin framework has encouraged researchers to embark on an innovative approach to explore opportunities to resolve research questions. Kurtz &

Snowden (2003) describe an idealized model of knowledge flow through three key transitions; 1–the disruption of entrained thinking; 2–the creation and simulation of informal communities; and, 3–the just-in-time transfer of knowledge from informal to formal.

The Cynefin framework has attracted practitioners and researchers from different fields who have a common interest in studying decision making in complex situations. Growing complexity in workplaces and a lack of support from existing theories for providing resolution to problems emerging in a fast-changing world have been two key factors in this trend towards using Cynefin concepts. The Cynefin framework is designed particularly for sensemaking of decisions in complex problems (2002, p. 108). According to Kurtz and Snowden (2003) five domains constitute the Cynefin framework: obvious or simple, complicated, complex, chaos, and un-ordered.

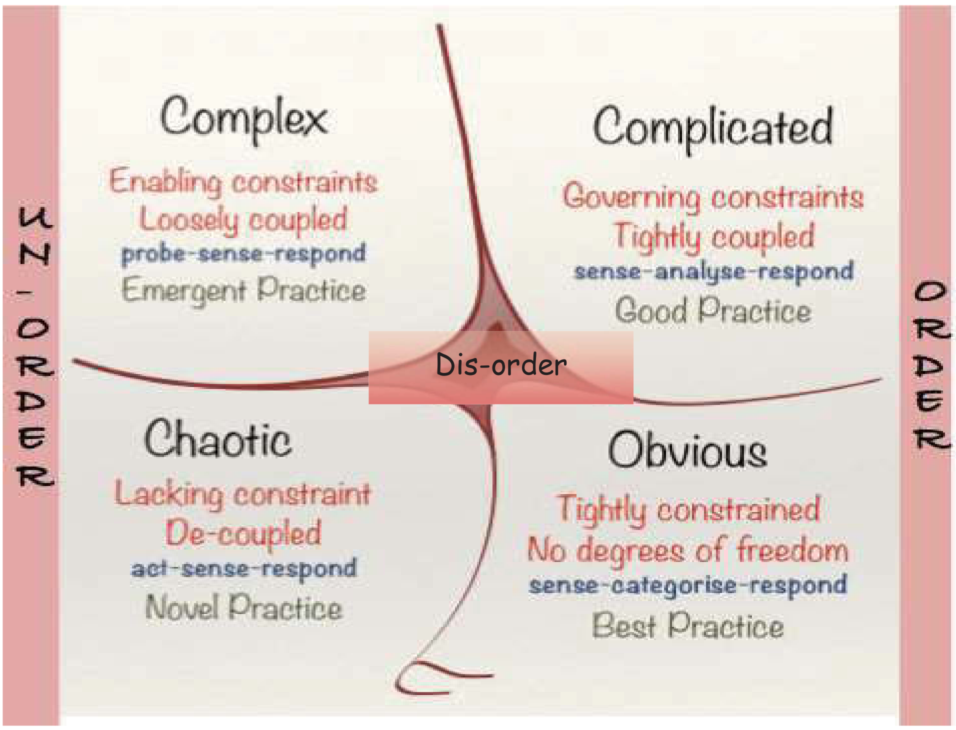


Figure 5 - Cynefin Framework - Kurtz & Snowden (2003, amended with recent publications)

Figure 5 illustrates the Cynefin framework with the boundaries and cliffs (signified by the curved line and 'foot' on the vertical axis) between domains. The cliffs remind the user of the impact of sudden movements between ordered and un-ordered conditions (Kurtz & Snowden, 2003, PMI, 2013a).

Certain features characterise each of the five domains, which are categorised into ordered and planned approaches, and un-ordered which apply emergent approaches (Snowden, 2005). The ordered systems are constrained where cause and effect relationship is identifiable while the un-ordered systems concern a loose or random constraint with vague or changing cause and effect relationships (Snowden, 2010b). Firstly, Simple or Obvious, which are used interchangeably in this thesis, is the name used to refer to the domain where people use known information for decision making through structured processes. It means that available data provides inputs into defined procedures and results in certain well known (familiar) decisions or options for decision making. In such contexts cause-and-effect relationships are known and they usually demonstrate linear relationships. In the world of project management PMI has assumed the prevailing reliance on rational decision making based on the assumption that all information that was necessary was already known and available. For example, the PMI–PMBOK (PMI, 2013a) approach to project managers' decision making is based on a simplified world where inputs generate outputs through defined processes (Kurtz & Snowden, 2003).

Perception of decision makers and sensemaking approaches to problems draw on different assumptions when the situation shifts from one domain to another illustrated in Figure 5 as a 'cliff' between some domains' boundaries that can drastically shift the way people think and act. In the complicated domain, the cause-and-effect relationship is not obvious but can be understood by following an event over time. Expert judgment is a crucial element in this domain for overcoming 'Complicated' problems and identifying relevant best practices (Kurtz & Snowden, 2003). According to Kurtz & Snowden (2003), the appropriate sequence is sense-analyse-respond (i.e. make sense of the context/analyse the data/plan the response) for tackling complicated issues.

Situations can shift from the Familiar or Complicated Domain into the Complex when the relationship between cause-and-effect becomes loose or unclear. The Complex domain is the domain of 'unknowns' where a structured approach to problem solving may not work. Kurtz & Snowden (2003) argue that good practice is not effective in a complex domain. In fact, the solutions in this domain are in the form of emerging patterns because of individual or team interpretation and perception for the complex event. Contextual complexity shows that people are capable of working across all four domains while at the same time moving between the domains because of accidental or deliberate actions (2003). Working in this domain involves changing the sensemaking approach to one of 'Probe-Sense-Respond' (find out as much as possible, knowing it is not possible to get it all/make sense of what is found/respond to the analysis) to manage the unexpected nature of emerging patterns. There is a fundamental difference between problem solving approaches as the domains shift between ordered and un-ordered (Kurtz & Snowden, 2003, Snowden, 2005). Table 2 shows a summarised comparison between the two types of situations known as 'Ordered' and 'Un-ordered' from a decision-making perspective.

Table 2 – Comparison of Order and Un-order (adapted from (Snowden, 2005, p 52))

Order	Un-order
Focus on rational individuals making choices based on personal self-interest	Focus on identities making decisions based on patterns arising from personal experience and collective knowledge expressed in narrative form
Manage - to achieve goals based on ideal models and central planning	Manage - starting conditions and monitor for the emergence of pattern to sustain or disrupt
Simplistic – Complicated	Chaos – Complex
Efficiency	Effectiveness (Allow inefficiency for adaptability)
Exploitation	Exploration
Stable	Resilient
Reductionist measures: ROI	Invisible, emergent measures
Measure outcomes based on explicit goal based criteria	Measure the stability of barriers, the attractiveness of attractors and the stability of identities
Dichotomy and the resolution of dilemmas as an either / or choice	Dialectic and the resolution of paradox to see the world in a different way
Analysis and expert interpretation	Stimulated emergence so that the patterns of possibility become more visible
Economic example, Credit scoring	Economic example, Micro lending

The Chaotic domain encourages people to think of innovating and developing novel solutions. These solutions are based on an Act-Sense-Respond approach (don't wait – act! / make sense of what happens next/ respond as emergent understanding suggests) to examine the results of actions and learn from that for the next cycle of advancement. The fifth domain, located in the middle of the matrix format, is known as Dis-order. According to Snowden (2005, p. 52), "multiple perspectives jostle for prominence, factional leaders argue with one another, and cacophony rules". No useful array of 'cause-and-effect' relationships can be used here.

Cynefin has been used to study knowledge transfer, shifts of decision makers and their perceptions in different domains by Snowden & Boone (2007, p. 72). Cynefin is known as a tool for generating ideas and exploring possibilities, rather than for recommending a specific course of action (Snowden & Boone, 2007). It is used to generate ideas in a social setting, where people interact, and can be particularly helpful in the effective transfer of knowledge (Nonaka & von Krogh, 2009).

The Cynefin framework helps challenge the 'too quick' selection of 'first best fit' options whereby people opt to choose the first reasonable option from a list of known alternatives in complex settings (Lipshitz et al., 2001, Snowden, 2005). The Cynefin framework is also a tool to generate simulations and examine the thinking process of decision makers in an abstracted world setting. In one research project, for example, Lego blocks were used as a common tool/language to examine project managers' decision-making capacity in the four domains of Cynefin (Tomasini, 2013). This simulation is being used for PM's professional development.

2.10 Application of Cynefin framework to decision making

The Cynefin framework is applied to diverse research fields spanning from meta data collection and analysis including ethnography to the use of special simulations to study management decision making. Application of Cynefin is especially useful in collective sensemaking as it is designed to share emerging understanding through several discourses in group decision making (Tomasini, 2013). According to (Kurtz & Snowden, 2003), leaders can use the tools to manage complexity and stabilise vibrant conditions in three different ways:

1- Open up discussion

Discussion and interaction among large groups of people might produce unexpected results and even breakthroughs when complex issues occur. According to Snowden & Boone (2007), Large Group Methods (LGMs) have developed new approaches to work with much larger groups in order to get representatives of the whole system in the same room. Several LGMs have created new problem-solving methods which include a) Future research conference, b) Open Space Technology, and c) real-time strategic change (Nixon, 1998, White, 2002). Success stories of LGMs in different industries have encouraged researchers in the Soft Organisational Research domain to utilize these approaches when they deal with uncertainties. Interactive communication through large group methods (LGMs) generates innovative ideas to help leaders with decision making in complex situations. Although there is good evidence of successful interventions with these methods for developing corporate strategies, and development through community and stakeholders (Snowden & Boone, 2007), some LGMs such as Operation Space Technology (OST) do not suit all research cases. As White (2002) notes in regard to use of OTS, in such entities as Dutch Railways, Prudential Assurance and Shell, there are examples of successful OTS in Europe. He described the key success factor as being acceptance of unexpected consequences because of the format of the OTS workshops and loose control over the process. Minimum intervention by time/task facilitators is essential to support maximum involvement and potential breakthroughs Nixon (1998).

2- Encourage dissent and diversity

Dissent and diversity are proven approaches to encourage people with formal communications to share their knowledge and interpretations of a complex event. For instance, the same problem is allocated to different groups of people, and spokespersons from the group rotate among the groups to share the different emergent views. This approach was adapted during design simulation Hooshmand-1 to define the rotation of team leaders as a real-time event.

3- Manage starting conditions and monitor for emergence

As leaders may not predict consequences of actions in complex situation, they aim to create environments where good things can emerge. For example, 3M encourages its researchers to spend 15% of their time on any project of their own personal interest. One outcome of this policy was the successful product now called 'Post-it' notes.

People usually carry on decision making on multiple domains at the same time. This depends on individual cognitive capacity to deal with one problem while it has different aspects in familiar, complicated, complex and chaotic domains. For instance, during the Palatine murders of 1993, Deputy Chief Gasior—as reported in (Snowden & Boone, 2007) —faced four contexts at once. He had to: 1) take immediate actions via media to restore calm to the community, in a chaos domain; 2) keep all procedures working during emergency conditions, in a simple domain; 3) take follow on actions to communicate with the community for days and weeks after the event, in a complex domain; and, 4) ask experts for their opinions about the event, associated with a complicated domain (Snowden & Boone, 2007, p.75). This approach was used to support the design of Real-Time Events and the facilitation process during those steps.

Thus, the Cynefin framework is proving to be a useful tool to support decision making and meta data analysis when used with large numbers of participants. One outcome of its successful application is the creation of a powerful toolkit that includes the software package, called SenseMaker, which is popular for making sense of complex problems (Gorzen-Mitka & Okreglicka, 2014, Snowden & Boone, 2007). This software was made available for the purposes of this research.

2.11 SenseMaker (SM)

SenseMaker (SM) is a software package developed to help participants make sense of complexity based on the Cynefin framework. The software employs certain tools that help generate mixed data in a real-time approach from narratives. For example, 'Triads' are a triangular shaped tool which allow for three alternatives on a question. The Triads help people make Judgement by asking them to compare three criteria at the same time, providing a less biased outcome than that arrived at through use of traditional two dimensional tools. Furthermore, a qualitative answer is able to be converted into a quantitative measure for a point in order of real-time generation of mixed data which were used in trend analysis (see data analysis). Sardon & Wong (2010, p 5&6) describe the key benefits of using SM as it:

a) Allows the researcher to distribute the analysis load across participants and makes it possible to analyse stories in a relatively short time.

b) Reduces the authors' bias that might otherwise be introduced in the interpretation of the stories. In doing so, each story contributor makes sense of their own story so the researcher does not need to impose external analyses.

c) Engages participants and positively prepares them for next steps. Involvement is a key success factor for long-term success of any intervention.

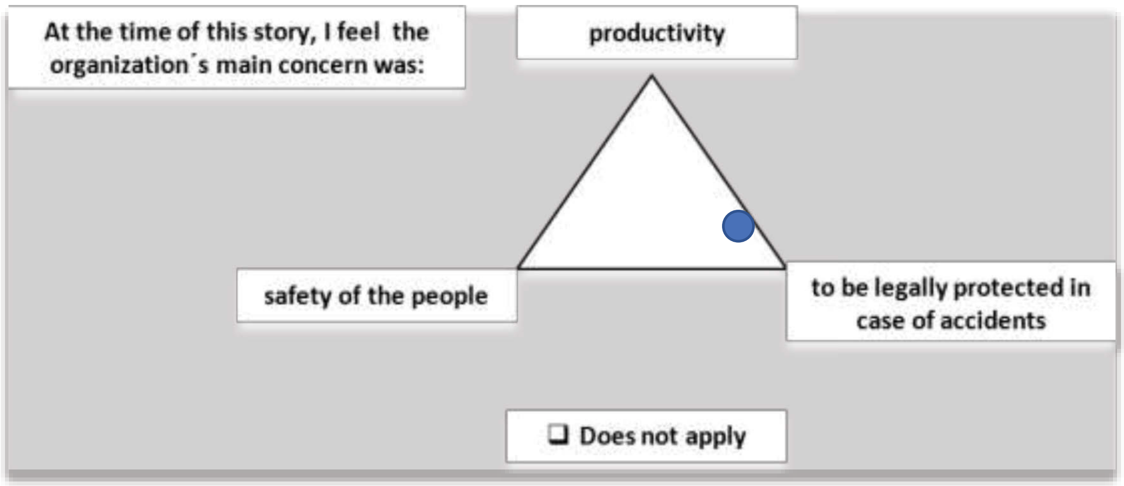


Figure 6 - A sample Triad for study of safety and complexity (Sardon & Wong, 2010, P. 5)

The use of a triangular shape allows tension to be created amongst three equivalent alternatives. Participants must pay attention to how they choose their preferred options thus reducing conformity bias. Figure 6 shows a Triad where the maximum score for each variable is 100, then productivity is assessed at 20, Legal Protection at 70 and Safety at 10. All these tools in SM help participants to make sense through analysing their experience or reflection on actions (Greenwood, 1983, King, 2002, Scho¨n, 1983).

The use of reflections for learning and data interpretation is aligned with use of other tools. Some examples of this use of such techniques includes reports about Critical

Incident Analysis techniques that have been used for training and education of groups who deal with uncertainty such as nurses, fire fighters or police officers (Tripp, 1993, Flanagan, 1954). Critical incident analysis helps researchers using a qualitative approach to research to carry out open-ended method of enquiry to understand the experiences of the research subjects (Sharoff, 2007). Vachon & LeBlank (2011) describes the Pause Model Exercise as a particular CIA technique that helps participants to pause in their work place and reflect on an event that is perceived as unpredicted. Vachon & LeBlank (2011, p 897) summarises the key steps for this exercise as follows:

1. The trigger: identifying a surprising or unanticipated situation
2. Goal articulation: stating the desired outcome for the situation
3. Gap analysis: identifying the gap between the actual and the desired situation
4. Action: experimenting in action or hypothesis testing to move closer to the desired outcome
5. Evaluation: evaluating the success of the interventions or actions

Having reviewed five steps in the example, the Pause Model Exercise seems to occur in the simple or complicated domain. Subjects may identify best practice or desired results to carry out gap analysis and evaluations. A meaningful gap analysis can occur through having access to relevant information. However, this approach may not work in a chaotic environment with fast changes and poor availability of information (Kurtz & Snowden, 2003). SenseMaker has the advantage of supporting knowledge development and acquisition in all four domains of the Cynefin framework and supports a real-time mixed-method approach. It allows researchers to generate qualitative and quantitative data simultaneously.

The Cynefin framework has created a range of tools to support research and education, and is reputed to be a helpful tool for researchers when interpreting data about complex problems.

Table 3 provides a comparison of the characteristics of six such tools (Gorzen-Mitka & Okreglicka, 2014).

Table 3 – The summary of relevant tools for Cynefin to understand complexity

Description	Process	Proposed Usage	Similar Methods

Ritual dissent	Uses Cynefin domains to test ideas in meetings	Refine a final or intermediate story as a result of a workshop	Red-Blue teaming in military
Future backwards	Embed lessons learnt into decision making	Conflict resolution	Scenario planning
Safe-fail probes	Create small experiments to assess innovative ideas	Making decisions in uncertain situations	Strategic planning
Four tables	Current status interpretation or constructive conflict management	Conflict resolution, contextualisation	Strategic planning
Archetype extraction	Organizing training leaflets (Abe et al.) for tacit knowledge and skills	Understand customer needs	Product design, user requirements
Anecdote Circle	Capture or intervention mechanism	Decision making in uncertainty, knowledge mapping, culture audit	Product design, user requirements

Further details about these methods are available in the Appendix 2.1 SenseMaker tools. The PPM, strategic decision making and their balancing tools against the volatile environment were discussed in Chapter 2. The literature review seeks a better understanding on publications that have mentioned the gap identified in the research questions outlined in Chapter 1. The origin of the research hypothesis was from my observation in industry on the lack of responsiveness by my workplace which resulted in dissolution of the corporation in a changing market. Also, Group Decision Making was discussed as a mechanism to managing decision making in uncertain situations and making sense of the complex issues.

Chapter 3 discusses the theory of simulation and its application as a research tool for data collection and analysis.

The key research problem identified in Chapter 1 was:

“What is the impact of real-time events on managers during decision-making processes for PPM?”

This question focuses on special kinds of ‘real-time events’—including those involved with aligning the projects in the business’s portfolio with overall business strategy, issues arising from the existence of conflicting interests among business units and the impact of a rapidly changing environment. Together, or separately, these can quickly convert decision making from a complicated problem-solving activity into a chaotic and uncertain state of affairs.

Additional factors are likely to have an impact on the complexity of the decision-making processes for those involved in PPM. These include the decision makers’ experience and skills, their particular roles and the extent of their knowledge of PPM; other factors include overwhelming time pressures and limitations of available information. Consideration of all these factors helps the main research question to be sub-divided into the following three specific research questions.

To further investigate the research problem three research questions were formualted to investigate the dynamics of decision-making processes in PPM, as well as the roles of individuals and teams as actors in decision making. These aspects have not received sufficient attention in the literature reviewed.

Research question 1—How do decision makers change their decision criteria for selection and prioritisation in a project portfolio when conditions are uncertain?

Making changes to the decision criteria for a multi-objective process such as project portfolio selection can be of critical importance, especially when projects are facing uncertain conditions. This first research question addresses three sources of uncertainty. These are: a) the impact of time factors; b) individual skills; and, c) information likely to be available to participants when facing crucial decisions about prioritising their portfolio of projects.

Research question 2—How do real-time events influence decision-making processes for project portfolios management?

Unexpected real-time events requiring spontaneous decision making with limited information are becoming the reality of senior managers' tasks in a volatile world. The implication for decision makers have been discussed in recent research. Korhonen, Laine et al. (2013) who, argued that sources of uncertainty, managerial perceptions and means to manage the uncertainty on project portfolios, differ significantly with the management roles.

In a recent study, Martinsuo, Korhonen and Laine (2014) identified two categories and six sources of uncertainty using an empirical study with interviews. Table 4 illustrates two categories for sources of internal and external uncertainties.

Table 4– Summary of sources of uncertainty for PPM in practice

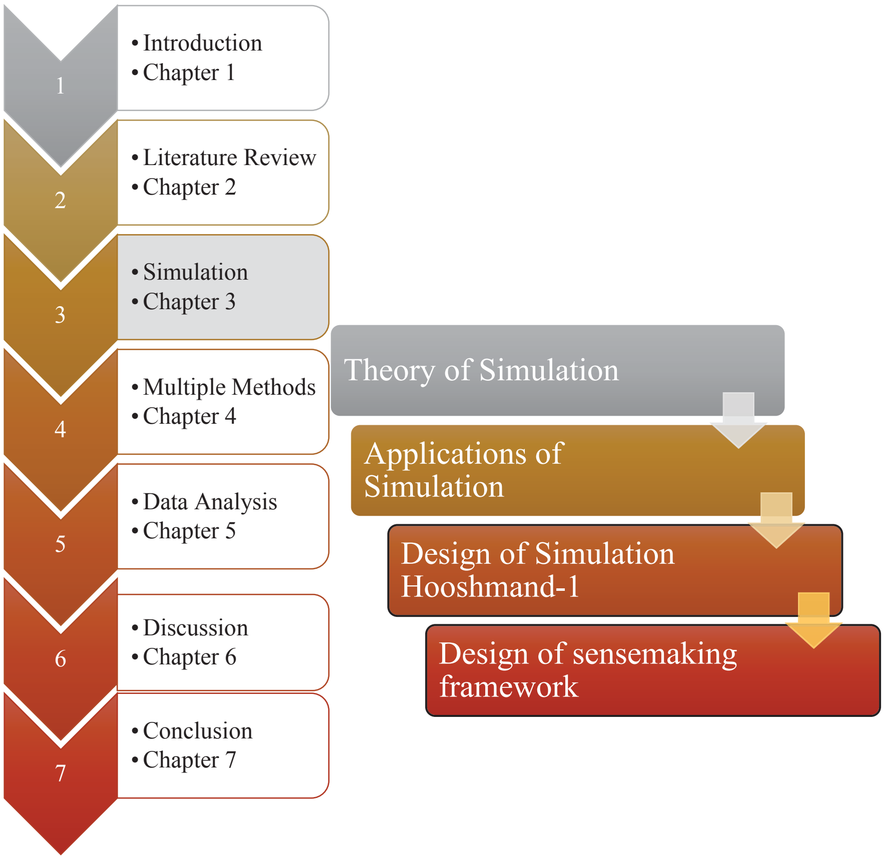
Internal Sources of uncertainty for PPM	External Sources of Uncertainty for PPM
Company or organisational changes	Customers
Portfolio itself (overlaps, dependencies, etc.)	Business Partners and other stakeholders
Single Projects	Industry, supply and delivery network

The second research question addresses aspects of the impact of these sources.

Research question 3—How do decision makers adapt to changes brought about by real-time events and why?

This question focuses on adaptability and the range of emergent patterns of decision makers' perceptions of dynamic environments. Participants' acceptance of changes, and their perceptions about necessary adaptations to changes (Pollack, 2009), are considered. Changes of patterns for individual and group decision making is addressed in regard to the real-time events.

Chapter 3: Simulation



This section discusses simulation concept as theory and practice and presents the designing of a simulation as a research tool. Simulation concept explains theoretical definitions for simulation, while contexts outline the reasons why simulation is used. Simulation using role-play is described as one of the fundamental theories used for design of simulation. Key components of simulations, games and challenges, principles of design, validation and representation of outcomes, are described in sequence. An overview is presented on the application of simulation, broadly to management science and particularly in relation to the research questions for decision making and project portfolio management (PPM). A simulation as a research tool similar to conventional research methods has its own pros and cons. Finally, background to the development of simulation as part of multi-method research design is discussed.

3.1 Simulation concept and contexts

Simulation is 'the abstraction of reality for a purpose' (Leigh 2013, p. 200). It has been in use for thousands of years for many different purposes and in various modes such as war games and board games (Faria et al., 2009). Its use provides a wide range of opportunities for creating time-bounded and space-restricted contexts for research and practice. For convenience, simulation can be considered as a form of ‘magic circle’ (Klabbers, 2007), wherein participants enact activities representative of predefined contexts. It can be used to help in acquiring new skills and knowledge and/or for research purposes. According to de Caluwé, Geurts et al. (2012), application of simulation in the specific context of policy and operations research can be categorised into three groupings: pure research-policy development, policy implementation and organisational change.

Simulation is an attractive tool for training and education where 'what if' questions via the use of pre-determined scenarios can help learners by providing direct engagement with particular issues via experience-based activities (Aldrich, 2005, Banks et al., 1996). Training for performance improvement in risk-oriented contexts such as those experienced by emergency medical crews, fire fighters, surgery and nursing staff is often conducted via simulations which provide relatively safe environments for learning while avoiding making an impact on real-life conditions (Okuda, 2009, Rosen, 2008, Sa. Silva et al., 2011).

Simulation, as a research and exploration tool, is found in technical disciplines including crisis management (Walker et al., 2011) and operations management (Zee & Slomp, 2009). Simulation is also recognised in the human sciences as a means of building formally arranged structures that become temporary knowledge transmission spaces allowing researchers to explore specific aspects of human behaviour (see for example, Silva, Pedrosa et al. 2011). In effect, simulation creates bounded contexts within which actions, occurring in artificially constructed environments, become available for analysis. Such environments are carefully constructed to replicate specific components of recognisable contexts enabling participants to behave 'as if ' the requirements for action and interactions are factual and real.

The contexts within which specific simulations are applied greatly influence the design. For example, entrepreneurship simulation is presented as a viable method to teach complex business interrelationships (Huebscher & Lendner, 2010). NASA used a simulator (which emulated all the key characteristics of the vehicle it represented) to research the fast-developing problems facing the Apollo 13 manned spacecraft mission in 1970 (Leigh, 2013). Similarly the RAAF F111 aircraft simulator at Amberley Air Force base in Australia was used to rehearse the rescue of a damaged aircraft in conditions of extreme uncertainty (Leigh, 2013). Each of these contexts required quite different approaches to simulation and used different forms of technology to achieve desired outcomes.

Computational simulations are used for discrete simulation (Hengst et al., 2007), while role-play simulations are used for strategic decision making, and also the study of decision making in relation to project portfolios, as well as for other educational purposes (Culpin & Scott, 2012, Faria & Wellington, 2004, Hussein, 2007, Keys & Wolfe, 1990, Leigh & Kinder, 2001). Simulations are also used to improve understanding of the nature of complexity (Killen, 2013, Leigh, 2013).

3.1.1 Role-Play Simulation

Role-play is a "technique (used in games and simulations) in which participants act out the parts of other persons or categories of persons" (Leigh & Kinder, 2001, p. 10). Role-play simulation is a 'close to reality' setting that engages participants in experiences through which they can enhance their skill-based capabilities (Clapper, 2010).

Role-play-based simulation is used quite widely to assist in learning how to manage power relationships and forms of communication, including communication of emotions, as well as improvement in cultural and diversity skills for participants (Clapper, 2010). Emotions, for example, have been central to the use of many role-play simulations for emergency crews. Similarly, a pre-nursing school in the UK uses role-play to help students get in touch with their emotions about a potential future career as nurses (Beattie et al., 2014). In educational settings, diversity of team members is getting more attention as the number of geographically and ethnically diverse students is growing in universities (Faria et al., 2009). The increase in diversity is also evident in workplaces. For example, the ability to manage diversity is listed as a key factor for successful decision making in top management teams when dealing with strategic issues

(Shepherd & Rudd, 2014). The application of role-play simulation can be extended to research on project management and decision making (Leigh, 2013).

Role-plays are very effective tools to develop people's understanding about problems. Role-play has been applied to several fields for research, training and education. Role-plays are drawing attention as class activities as a supplementary educational tool to traditional lectures. For example, role-plays are used for postgraduate students to develop their understanding on theories of project management and PPM (Hussein, 2007). Role-plays are common for cause-and-effect research where there are complex incidents such as floods (Huyakorn et al., 2012). Role-plays are also used as training for professional development. For instance, there is evidence of role-plays as tools for medicine residents' skills enhancements in order to improve their performance during emergency operations (Rosen, 2008).

3.1.2 Games, Simulations and Challenges

The terms 'games', 'simulations' and 'challenges' have been used interchangeably in previous research publications. However, Sa. Silva et al. (2011) state that simulation, games and challenges should be considered separately although there are common areas among each pair of the three components. Figure 7 shows the influence of games' rules or predefined challenges on different types of simulation as: 1–*simulation game, non-challenge*; 2–*simulation challenge game;* and, 3–*simulation challenge, non-game*. 4–*game challenge, non-simulation?*

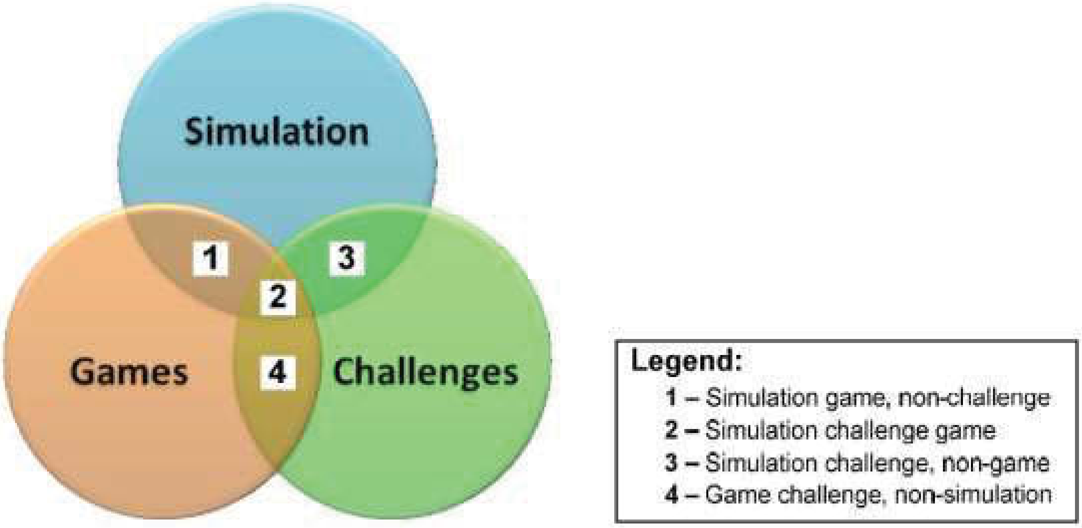


Figure 7 – Simulation, challenges and games relationships (Sa. Silva et al., 2011, P. 66)

Game elements in a simulation include time constraints, being rule bound, and while not overtly competitive, there is a sense that the way the game is played with multiple teams, is competitive. Abt (1971) describes a game as an activity occurring between two or more independent decision makers in order to achieve defined objectives within a pre-set context (Abt, 1971).

Gaming has been applied to various fields such as entertainment, teaching, training, operational analysis and long-range planning (Shubik, 1989). A simulation—as a representative of reality—is often used for conceptualising a model of decision making during the initial design of a game and to support the construction of games through means such as physical settings or software (Zee & Slomp, 2009). For example, a simulation model of reality is used to create a game for training of operations management in production lines (Zee & Slomp, 2009).

Participants must follow the rules on which games are based as they describe participants' domain of play (Shubik, 1989). Games set limits on the simulated environments and participants play by these rules in order to achieve measurable end-states (Sa. Silva et al., 2011). Scenarios are a means of providing participants with starting points as well as providing consistent and plausible situations as background (Walker et al., 2011). "A scenario consists of a set of predefined events that occur during game play" (Van Houten & Verbraek, 2006,p. 2261). Computer technologies are used to apply rule-based scenarios and may provide better dynamics and flexibility than traditional games (Van Houten & Verbraek, 2006).

Challenge is an embedded setting in the design of games that defines how to recognise the desired result of a competition. Rollings & Adams (2003) define challenges as sets of rules that determine an appropriate path to solutions for a conflict or competition. If a challenge is included in a game or simulation design it will be set as a closed activity where participants must reach a result at the end of activity. As Figure 7 shows, *game challenge, non-simulation* are sets of rules that direct participants to a winning end state such as Tetris or Chess (Bragge et al., 2010, Leigh & Kinder, 2001, Sa. Silva et al., 2011).

Simulation elements represent abstraction of real world conditions and complex decision frames. Simulations concern artificial settings, while games may be used to create a competition field for players in their real workplace (Hansen et al., 2009, Joldersma & Geurts, 1998).

Simulation challenge, non-game encourages participants to interact with an imitation of a system without artificial constraints and Flight Simulator is a good example for this type of simulation (Sa. Silva et al., 2011). A flight simulator allows participants to 'fly' an aircraft and even act in dangerous ways to evaluate their skills (Aldrich, 2005). Similarly, in education and learning exercises simulation challenges, such as those presented by Dzeng & Wang (2017), who asserted that the use of 'C-Negotiation' with construction management students improved their understanding of procurement skills and strategies by about 20%. The C-Negotiation is a computer game being used in case study situations for University Students.

Simulation challenge game provides artificial constraints and rules to win or achieve a desired end-state through interaction between participants and the imitation of a system (Sa. Silva et al., 2011). Most commercial games and computer games are identified in this category of simulation (Sa. Silva et al., 2011).

Simulation game, non-challenge engages participants to interact with an imitation of a system from real world settings within defined rules of the game. For example, The Sims game encourages participants through playing in several roles as imitations of the real world, but each role has its own characteristics and rules (Sa. Silva et al., 2011). According to Hussein (2007), there has been little research on using simulation games on project management or on participants responsible for identification and execution strategy of projects in the early planning phase. The simulation Hooshmand-1- mentioned in section 1.4 Simulation as a research instrument, is categorised in this group of simulations as it generates an open-ended learning environment for PPM research where participants play their designated roles without a defined resolution at the end (Shalbafan et al., 2015).

Serious games are artificial settings in which some elements of entertainment are added to the computer games to help participants learn from the designed exercises. Serious games are known as means to convert the experience and reflection of players into learning from experiments (Ahrens, 2015). Serious games provide diverse applications for understanding an emerging reality and identifying the processes, properties and performance within sophisticated problems (Hancock & Algozzine, 2011). Serious games are used to assist learning from experience in complex situations. Serious games have been used in an innovative way for learning across different types of organisations. According to Ahrens (2015), in order for serious games to be used as tools for learning, enterprises expect a serious game to illustrate four characteristics; 1. good representation of reality of organisational processes; 2. use of real corporate data; 3. strong security requirements on access to information; and, 4. adaptability with different workplace situations. For example, the armed forces have been using serious games for education of strategic skills and battle preparedness for a long time (Ahrens, 2015). Such serious games are also known as War Games.

All these kinds of simulations and games are tools to assist managers with training on complex problems, and are also excellent tools for training professionals (Beck & Wade, 2004). For example, LEGO has been used as a neutral language for players to create shared experiences about the collective commitment for problem solving (Hansen et al., 2009). Use of simulations and serious games aims to create an “open-minded sensemaking process and an (sic) efficient communication between participants”

(Hansen et al., 2009, P. 1594). The combination of collective sensemaking and communications results in effective work-based learning. Technological advancements have helped further application of serious games for learning by doing (Ahrens, 2015). Six properties are involving in making an effective serious game or simulation to support work-based learning processes: 1–as an understandable rule system; 2– good learning opportunities; 3– trade-offs; 4–learning from abstract concepts; 5–enactment of the game settings; and, 6–user friendly interfaces (Shute & Ke, 2012).

As an example, gaming simulation, Type 1 and computer simulation, Type 2 are discussed in a case study for decision making in the Netherlands Rail authority. While gaming simulation involves participants in scenarios which happen in a physical environment, computer simulations are known as programmes that generate virtual practice in a computer device for participants. A comparison between Type 2 and Type 1 simulations for assessment of decision makers in complex systems indicated a preference for Type 1 gaming simulation as an effective tool (van den Hoogen & Meijer, 2014).

Gaming simulation is a tool proven to collect diverse insight and allow alternative solutions to be examined in a fairly safe environment (Hofstede et al., 2010, van den Hoogen & Meijer, 2014). Simulation games have proved to be an effective technique for decision makers in ProRail to role-play and assess different strategies and test the results (Meijer et al., 2012).

3.1.3 Design of Simulation

Simulation design has three pillars: a) the context being replicated; b) a carefully selected sub-set of individual components, within and beyond that context; and, c) the objectives which the design is intended to achieve. These three elements of simulation design raise three questions for designers: 1–'what' for the objectives; 2–'how' for individual settings; and, 3–'why' for context (Hofstede et al., 2010). A good design is dependent on the designer having a deep understanding of the content, the objectives which the finished product is intended to achieve, and a skilled capacity to apply design principles to the process of creating a simulation game.

The first question is for the designer to define the objective of the game in the sphere of knowledge. Learning objectives are similarly varied, and a wide array of designs can be found to address the same goals, or quite different ones. This malleability of designs is a feature of the use of simulation and games for learning. In this research, five designs were trialled because they appeared to include parameters that were similar enough to those actually required. The sphere of knowledge concerns lessons that simulation game's participants will learn from playing and sets the range of benefits for participants and their learning experience from playing (Hofstede et al., 2010). Designers' knowledge greatly influences validity of the simulation design (Stainton et al., 2010). For example, real medical 'signs' and 'symptoms', as recorded in medical literature are included in representations created for non-technical medical simulations (Rosen, 2008) and Rosen (2008) reports that Gaumard Scientific Company included a newborn mannequin in their birthing simulator for use in education of perinatal critical events.

The designer of simulations must focus on settings that provide relevant learning experiences for participants. The setting must address the core attention for social aspects and practice (Hofstede et al., 2010). The balance between reality and complexity is a key for effective design as a valid representation of the world in a simulation game (Stainton et al., 2010). 'Representation' relates to the extent to which a simulation provides a realistic impression of selected factors likely to be found in a real-world context. An effective representation in a simulation enables players to experience a realistic impression of the context as it can occur in the real world. A simulation should provide a realistic environment that reminds players of the real business world (Duffy & Cunningham, 1996, Elgood, 1993). Shalbafan et al. (2015) argued a viable model for simulation will replicate known conditions. An effective representation will create a complex and challenging situation within the replication, without confusing participants (Leigh, 2013).

The influence of context on the design of each simulation, can be as varied as a strategic steering committee meeting, a high-tech flight simulator, and 'mission rehearsal' simulations where soldiers enact the plans for a full military action. They include different aspects for participants and designers of simulation games in relation to the

'Why' question. Simulation participants have shown that emotion and social aspects have motivated their participation in a simulation game (Hofstede et al., 2010).

The selection of components for a design will be intimately linked to the way in which the context is intended to be replicated. For example, a 'flight simulator' might be little more than a chair in front of a large TV screen with a panel of buttons, representing a particular set of controls in a plane, positioned alongside the seat. In such a simulation, the buttons must be entirely accurate, but the surrounding context need hardly be representative at all, since the learning outcome is focused on a pilot acquiring automatic responses (keying in certain buttons) to certain conditions. Conversely a 'full flight' simulator will include a motion platform that creates the full sensation of movement including take off, landing and inflight turbulence—because the pilot is now learning (among other things) how to comprehend the sensation of the plane in flight under varied conditions.

Finally, the facilitation process is the key to making the simulation perform to achieve its purpose. The facilitator must achieve a balance between four key areas of attention, 1–knowledge, 2–emotion, 3–social aspects and 4–practice for both researchers and participants (Hofstede et al., 2010). A proper facilitation process motivates participants and they learn about their skills or knowledge weaknesses through engagement in the simulation game (Hofstede et al., 2010). A well-developed facilitation process must balance these three pillars of simulation design. This process can enforce learning experience for researchers and participants through effective implementation (Stainton et al., 2010). In the end a unique design emerges from trials, once the learning and research outcomes are proven to include a unique set of conditions, not matched by any known pre-existing design.

Implementation procedures include the facilitation process guiding the simulation, within a defined context. Time allowances in a simulation need to provide sufficient scope for players' decision-making activities, as well as reflection and discussion of actions and outcomes (Hall, 2004). In some specific forms of simulation the facilitator needs to be a knowledgeable person who can assist participants with relevant technical knowledge (Hall, 2004, Wolfe, 1997). One of the key success factors for the design of an implementation process (Hengst et al., 2007) must consider participant acceptance and understanding of the world as modelled in the simulation, a means of encouraging involvement, and generating efficient participants' action.

3.1.4 Prototyping and design validation

It is most likely that no simulation or game is ever complete at its first trial. Since the aim is to realistically replicate an aspect of some environment or set of events, the sense of realism only becomes 'true' as the design is trialled and adjusted in response to participants' reactions to the way the selected elements are combined within the design. Duke (1974) recommends at least 10 trials of a design to ensure that it is 'freestanding' enough to be facilitated by someone other than the initial designers.

Prototyping and repeated trials are necessary to validate both design and the underlying assumptions. Such prototyping will either reveal repeatable patterns of behaviour and outcomes that are known to be viable in the real context, or demonstrate that the design is not yet 'realistic' enough to feel valid to participants. Changes to design conditions and materials during prototyping are likely to create different results (Lenhard, 2015) and help to refine the final design—and sometimes also contribute to emergence of entirely different design parameters and therefore outcomes.

In the design of the simulation the designer has to set clear criteria for a successful prototype. The criteria should help observers to see the repeating pattern as a sign of success. For example, testing hypotheses or learning aims can be used as criteria for the simulation performance (Hansen et al., 2009). In order to validate prototyping of new design for simulations, criteria shall be linked to the expected outcomes and objectives.

Medical simulations development has placed artificial patients and crisis management at the focus for prototyping new simulations. For example, use of a plastic model was incorporated for simulating mouth-to-mouth resuscitation, and this was based on a mask of a drowning victim in France (Rosen, 2008).

3.2 Applications of simulations to management science

Simulation has received growing attention over the past 50 years. Simulations have been used in various fields such as medical simulation for medical students, flight simulators for training pilots, beer games for supply chain management, and so on (Sa. Silva et al., 2011).

The application of business simulations has expanded to training, education, decision making and crisis management for senior and middle managers (Faria et al., 2009). For example, American Management Association designed Top Management Decision Simulation to use in management seminars (Hodgetts & Kreitner, 1975). Top Management Decision covers key quarterly decisions such as budgets, marketing and R&D decisions and is played as a simulation game in which five teams compete as five firms in a one product industry (Faria et al., 2009). Key objectives of using simulation for policy making in organisations are summarised in three categories; discovery, implementation and testing (Joldersma & Geurts, 1998). Overall, the theory for the application of simulation to management science can be categorised in three factors: a–sections below as policy making, b–project, program, and c–portfolio management and training, education and research.

3.2.1 Policy making

Policy making is a complex process as it deals with strategic directions, broad stakeholders and their behaviour. According to de Caluwé et al. (2012), researchers in The Netherlands have done intensive work to use simulation for policy making. For instance, The Netherlands Government has used the simulation called INFRASTRATEGO, a tailored game for policy exploration, to predict stakeholders' behaviours in regard to the policies for electricity liberalisation (Kuit et al., 2005).

It is evident that four functions of policy making can be achieved; exchanging perspectives, understanding uncertainties, ex-ante evaluation and double learning experiences (de Caluwé et al., 2012). Participants in policy making simulation carry on perspective exchange through role rotation with other participants (de Caluwé et al., 2012). Active involvement in different roles brings a greater depth of understanding for participants from various role perspectives (Clapper, 2010). A simulation can assist policy makers to judge and predict what to expect after exercising different policies and considering all flexibilities and uncertainties (de Caluwé et al., 2012). The participants may choose to create the future and reflect on the consequences of their actions (Zuber-Skerrit, 2002). According to Zuber-Skerrit (2002), the concept of learning by doing can be considered as an Action Learning approach which, in this case, is a hidden factor in the design of simulation for policy making. Ex-ante evaluation in policy development bolsters decision makers to achieve their objectives through optimally transforming existing knowledge into policy insight (de Caluwé et al., 2012). Participants can enhance their learning through participation in a simulation on policy making because of issues being modelled in the simulation, and they try a new approach of interacting with their colleagues in the simulation settings (de Caluwé et al., 2012). According to Culpin & Scott (2012), learning occurs through dialogue with the self and with the facilitator, instead of by the transmission of actual knowledge.

3.2.2 Project, program and portfolio management

Simulations have been developed for specific purposes against certain crietria in project management. Criteria are developed against the objectives with a broad perspective such as leadership, management and teamwork, performance management, project management, negotiation, delegation and team-coaching (Hussein, 2007).

The use of simulation for project management has helped students in postgraduate courses to understand the complexity that can occur during construction projects. For instance, BoBs Building is a software-based simulation that addresses subjects including planning and control, network analysis, risk management, earned value, all for training and education (Hussein, 2007). The Norwegian University of Science and Technology (NTNU) has used a computer format of BoBs Building for teaching fundamentals of project management to students who expressed satisfactory learning experience from participation in the simulations in their classrooms at 82% of success rate (Hussein, 2007). Hussein (2007) also argued that students are encouraged to exchange their knowledge in a high level planning exercise and facilitated learning through this simulation. Use of simulation for training and decision making on programs and project portfolios are rare, and more research work is needed to develop simulations for these fields (Hussein, 2007, Leigh, 2013). The need for business simulations that support organisational changes, learning and decision making on strategic matters are considered essential (Faria et al., 2009, Joldersma & Geurts, 1998). Despite all recent developments, the literature reviewed did not reveal any simulations used in project management research (Cano & Saenz, 2003).

As there was no specific design of simulation to fit for study of decision making in PPM, the researcher designed Hooshmand-1 as a special tool for research on PPM decision making in complex situations (Shalbafan et al., 2016).

3.2.3 Training, education and research

Simulations are used as aids for training, teaching and research.
Simulation has been used for management training and educations in university courses. Criteria such as initiative taking, problem solving, risk taking and the ability to enjoy uncertainty, self-awareness and persuasiveness are considered to measure the success of the simulation (Fones-Evans et al., 2000).

Training and education of executive managers through using role-play, serious games or simulations is growing and is developing a reputation as being a worthwhile way to convey tacit knowledge within organisations (Nonaka & Konno, 1998, Nonaka & von Krogh, 2009).

Simulations are broadly applied to training and education to enhance management skills in business management. The key contributing factors in the development of simulations for training and education is known as a 'theory of experienced-based learning' (Keys & Wolfe, 1990). Experienced-based learning encourages simulation design that allows participants to apply their prior knowledge to the activity (Keys & Wolfe, 1990). Participants make sense of a situation and become aware of their commitments through simulation roles (Keys & Wolfe, 1990). A survey has demonstrated that participants are concerned with the user-friendliness of simulations for business management training and education (Faria & Wellington, 2004). Teachers who use simulations in their educational programs rank simulations as being the most effective tools for education (Faria & Wellington, 2005). For instance, Huebscher &

Lendner (2010) demonstrated that entrepreneurship simulation seminars are a viable educational method for understanding complex business issues.

Simulations have been used for research with various objectives. According to Faria & Wellington (2004), the top five topics of research applications for simulations are: the simulation process, strategy aspects, decision making, learning outcomes, and teamwork. For example, academic staff members in The Netherlands have used simulations for research purposes in organisations' studies and policy sciences (de Caluwé et al., 2012). Participants' behaviour and background may influence the research outcomes. An emotional contract between researchers and simulation participants is essential where the research outcomes rely on participants' behaviours (Faria, 2001). The research participants should undergo a SMART targeted selection process in order to ensure people with relevant real life experience contribute to the research outcomes (de Caluwé et al., 2012).

Simulation performance directly influences the results for research. Key successful factors to apply simulation to research have been reviewed. For example, artificial stress lowers the performance (Parish, 1975) while smaller team sizes and team cohesion improves the performance of simulation and the outcome viability (Biggs, 1975, Hoover, 1976). Simulations have been used in research for other fields such as engineering, science and health services (Leigh, 2013).

3.2.4 Advantages of simulation to research

Simulations are increasingly used for research projects. Simulations are seen to be of benefit for experimentation in environments near to real life, visualisation of alternative futures, interactions between components, uncovering the diversity of participants' responses to events, to support data representation, to create real-time events using slower or faster processes, and for flexibility of testing out factors that cannot otherwise be examined in real-time (Walker et al., 2011). Furthermore, simulations can be of advantage to traditional research practices because of the considerable subject knowledge involved, and the manner in which they can enhance participants' motivation and create opportunity for group discussions (Elgood, 1997).

Simulation can address communication goals, critical thinking skills and emotional awareness as research factors while also providing participants with learning opportunities (Clapper, 2010). Simulations offer opportunities for researchers to compare qualitative and quantitative data at the same time (de Caluwé et al., 2012). Simulations enable researchers to study decisions and activities that are extraordinary, dangerous, risky, or obscure within organisational environments (de Caluwé et al., 2012).

3.2.5 Limitations of simulation to research

As with all research methods, simulations have their limits and constraints. Establishing intended learning boundaries for participants and control groups is one limitation. Ensuring the simulation is a valid representation of real factors emphasising the prototyping process, as noted earlier, and the time required for selecting the volunteers are other important constraint when using simulations in research (de Caluwé et al., 2012, Stainton et al., 2010).

Achieving intended learning outcomes is also challenging for researchers. The researchers need to balance emotions such as special interests in opportunities to learn for participants against the desired opportunities for a research team to learn through implementation of simulation. This is a particular dilemma for research design (de Caluwé et al., 2012). Furthermore, oversimplification of real world cases in the simulation models can limit the learning outcomes while providing relevant research data (Goosen et al., 2001, Keys & Wolfe, 1990).

A limit to generalisation and validation of research results lies in the way the design represents the 'virtual reality'. Representation is an abstraction of reality and the quality of the researchers' ability to achieve a realistic setting within a simulated environment will affect the outcome (Hofstede et al., 2010, Leigh, 2013). Achieving sufficient accuracy in abstracting reality into simulation design are time and cost intensive (de Caluwé et al., 2012). Finally, standardisations of facilitation processes are also important to achieve reliable results for researchers (de Caluwé et al., 2012). A chain of evidence and documentation of procedures can contribute to greater reliability of simulation as a research method (Stainton et al., 2010). However, each iteration is a unique, unrepeatable, event so absolute standardisation is simply not possible, while patterns of ever-increasing similarity will be the result of good design and consistent implementation.

The selection of participants can be a challenge especially when simulation-based research uses professional subjects. It is therefore important to have an adequate trade-off between the time that participants are asked to allocate to the simulation and their motivation. Participants will need to be able to justify the time spent on their contribution towards achieving the research goals (de Caluwé et al., 2012). Participants' prior knowledge can either boost or inhibit learning and research outcomes from simulation based research—and this needs to be taken into consideration in both the design and participant selection stages (Culpin & Scott, 2012). It is important to maximise participants' motivations through a voluntary recruitment process (Shalbafan et al., 2016).

3.3 Multi-methodology background

Multi-methodology is a combination of multiple research methods chosen to achieve specific research objectives. Multi-methodology is a proven approach to guide the research activities along a specific set of paradigmatic assumptions. The process of design and implementation of multi-methodology was accompanied by a shift in the initial research paradigm. The shift from a learning phase to a functional phase occurred while designing the simulation, through the use of sensemaking, and in an emergent manner.

As noted in the Introduction, the use of Action Learning in section 1.6 Multiple Methodology Research, Action Learning (AL) is often used to develop a concept, an understanding or a solution when part of the impact factors is not known. Action Learning is defined as an intellectual, emotional or physical tool of development which asks participants to engage with real complex and stressful problems (Revans, 1982). Action Learning uses a graduated approach of a series of steps where participants enhance their knowledge by doing and reflecting and proceeding to next steps. Action Learning is a learning process through systematic cycles of planning, acting, observing and reflecting to guide a joint effort for complex problems (Revans, 1998). Action

Learning has been used for education and training for students and professionals. For example, University of Glamorgan has used AL to develop a new postgraduate diploma of Entrepreneurial Practice in response to the business needs for professional development in a holistic view (Fones-Evans et al., 2000). Zuber-Skerrit (2002) argued that Action Learning is the process of learning from concrete experience and reflection on that experience, and recommends its use when no one knows the exact answer to a problem.

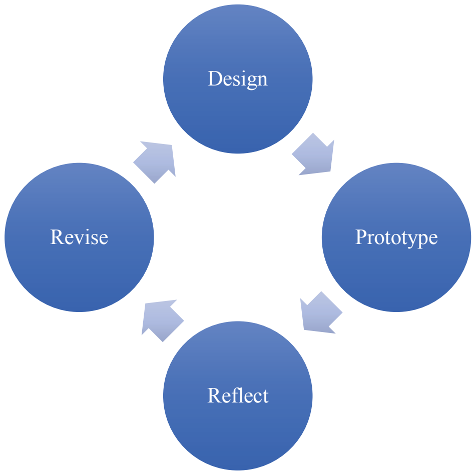


Figure 8 – The cycle of Action Learning adapted for design of research methods

The initial literature review and assessment of opportunities for data collection in this research indicated the need for a controlled environment to repeat experiments. An Action Learning process, shown in Figure 8, was used to learn and understand existing research instruments and how they might be related to the research objectives and purposes. Key factors in this process consist of group discussion, learning from each other, trial and error and discovery. An adapted concept, Design (planning), Prototype (acting), Reflect (observing) and Revise (reflecting) (DPRR) was used to tailor the research methods for the study of PPM decision making in uncertain conditions.

Figure 8 demonstrates the application of Action Learning cycles for the development of multiple research methods. Design of methods occurs after assessing literature, existing methods or assumptions and settings against the research needs. Reflection on personal observation and assessment of documents were the primary research resources. Reflection had three key components: 1–the researcher's presentation on self-reflection; 2–a summary of results and feedback from research participants; and, 3–the supervisors' comments and feedback on the experiment. The outcomes of the third step were used to revise earlier assumptions in the research project and adjust goals and expectations for next cycle of Action Learning.

Multiple methods were assessed and tailored through Action Learning approaches for application during the research. The use of simulation and Cynefin frameworks were the methods which were deemed successful after the initial data collection and data analysis. These multiple methods applied to different phases of research from the design of methods to data analyses.

The use of a sensemaking framework, with a narrative approach, was assessed as the most effective tool to analyse the data. This narrative approach included storytelling and participants writing descriptions of their observations. The biggest advantage of the narrative approach was that the researcher could become more aware of the subject's feelings when an opportunity arose to reveal unexpected findings. Nonetheless, this has been criticised for the likelihood that a researcher could take a biased view of a narrator's experience and paraphrase it to suit an implicitly desired outcome. Sontag (2001) argued that successful narrative research is highly dependent on the interpretation of researchers. Interpretation of available information is deemed to reduce the value of original information in favour of directed interpretation for research audience.

Phenomenology or abductive reasoning which was discussed in section 1.6 Multiple Methodology Research, is a proven and effective tool for analysing data and understanding complex problems. Abductive reasoning does not follow any algorithm to analyse information, and it cannot guarantee truth-preserving results (Lundberg, 2000), although, phenomenology has proven useful for data analysis in connection with serious games used for research and observation. Researchers can use an abductive approach through systematic combining of ideas to generate theory through interactions among case studies, frameworks and the empirical world (Dubois & Gadde, 2002).

The overall research methodology, design, and implementation is shown in Figure 9. The design of the simulation and a sensemaking framework and their applications to data collection and data analysis are two key components in this illustration. The process of design in relation to use of the sensemaking framework lags behind reflections on the early stages of developing the simulation. There were iterations between the two design processes—design of simulation in AL 1 to 6 and design of sensemaking frameworks in AL 1 to 3—each consisting of training, group reflection, literature review, participants' feedback and fragments. Abductive reasoning has strongly supported the development of the research tools through understanding insight as the design process matured. Simulation and sensemaking frameworks were used with each group of participants in a single session to optimise the efficiency of the research methods for data collection and analysis.

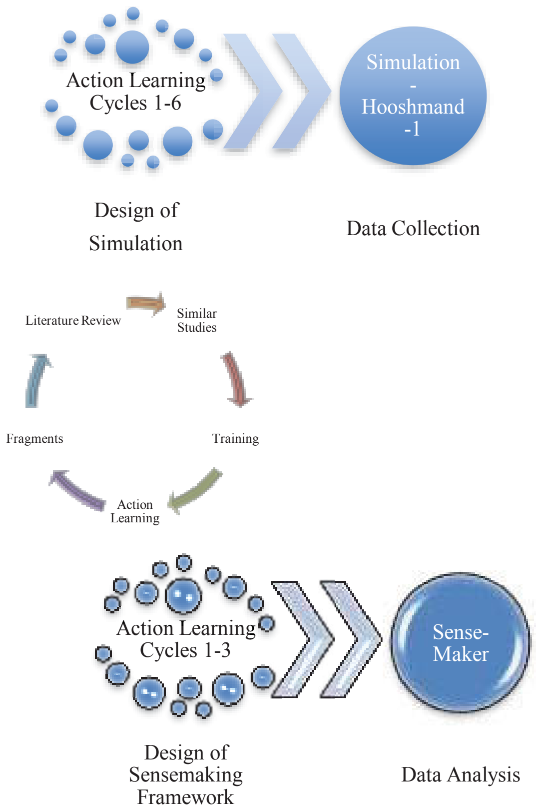


Figure 9 – Overall Process of the research methodology development

Details of the process as shown in Figure 9 are provided here.

3.3.1 Simulation Hooshmand-1

Simulation Hooshmand-1 was the tool specifically which I designed for generating data in this research. The suffix 1 refers to the first generation of this simulation specifically designed for the study of a complex decision-making process in PPM. Details of the simulation are available in section 4.3.1.3 Simulation Hooshmand-1and its attributes.

3.3.2 Principles of simulation design

Design of a simulation concerns abstraction of reality to simulate a simplified world for participants. Models or frameworks with a limited number of variables are the key inputs for the simulation design. The design of the simulation sought to elicit information regarding the influence of complexity and the impact of situating space and time on the decision-making process. It also provided a context in which some factors that inhibit effective decision making would be ameliorated. While deciding on project portfolios, complexity is connected to a range of both internal and external factors. The process of selecting, prioritizing and optimizing the elements in project portfolios is a multiple-objective problem. The main constraints affecting the decision-making processes include conflicting objectives, such as resource assignment between strategic plans, or cost-benefit versus strategic directions. As issues become more complex they must be dealt with in an increasingly holistic manner (Archer & Ghasemzadeh, 1999, Cooper, 1994, Cooper et al., 2001, Cooper & Kleinschmidt, 1995).

The four components of a simulation—which are scenarios, roles, rules and recordings—contribute to the performance of the simulation. Scenarios are used to convey reality in the simulation through describing a hypothetical, but a plausible situation for various purposes (Walker et al., 2011, P.165). Roles are used to animate and inanimate the reality and set constraints on expectations, character, and limitations. Leigh (2013, P.4) stated that roles in a simulation define allowable and non-allowable behaviours guiding participants' activities during simulation. Roles can be defined based on a real organisation’s role description, or they can be fictitious in a virtual world. Both types of positions can be used in the design of simulation.

A facilitator usually oversees a simulation, guiding the process according to predefined rules. Rules are embedded through the simulation design to control some parameters, reducing unintended consequences. The rules define how components of a simulation can operate and interact (Leigh, 2013, P. 3). There is a trade-off between participants’ freedom to act and facilitators’ roles in maintaining the abstracted reality in the simulation.

Recording systems are important components for simulation as they are very helpful for training, education and conduct in research scenarios. The simulation recording systems can be devised as a manual recording on paper or computerised recording or video recording. While recording on paper promotes interactions among simulation participants, computerised recording provides a centralised database for research purposes. For this research, the use of some computerised recording was useful as it provided an efficiently retrievable database of the simulation participants' actions, reflections or opinions. Videos are the most popular recording technique for training as they allow trainers to review content.

As a result of AL 1 to 6 for the development of the simulation, three key concepts, Cynefin framework, concept of Ba, and defensive routines were selected as key factors in the design of Hooshmand-1. Firstly, the development of Hooshmand-1 referred to Kurtz and Snowden's (2003) Cynefin framework, which represents ways that situations can move between simple, complicated, complex, and chaotic states. In particular, I was interested in the constraints which complicated and complex states placed on PPM decision making. In the Cynefin framework, a complicated state is defined as the zone of knowable information where cause and effect are discoverable, although separated by time and space. Complex states involve emergent patterns where cause and effect relationships do not repeat and are only coherent in retrospect (Kurtz & Snowden, 2003). Snowden and Boone (2007) argued that leaders need to pursue innovative approaches to manage changing conditions, and assert that adhering to past patterns of behaviour is unlikely to succeed. To replicate these processes, the simulation was designed to provide situations where participants need to use their creativity to respond to a complicated situation which becomes complex over time.

A second significant principle considered in the simulation design was the concept of 'Ba' , introduced by (Nonaka & Konno, 1998) , as discussed in literature review. They argue that interactions and activities in organisations are sources of knowledge creation. Originating Ba is defined as providing a space for socializing and expressing individual experiences and feelings. Interacting Ba is defined as a space for knowledge creation occupied by selected individuals who collaborate through constructed dialogue. The development of the simulation reported here focused on creating a space for Originating Ba and Interacting Ba.

In addition, the simulation design sought to provide a situation where office politics and defensive routines were by-passed so that insight about decision making under complexity could be studied without having to account for the historical relationship between participants. Argyris describes the nature of these historical relationships thus:

> Defensive routines are any policies or actions that prevent the organization from experiencing pain or threat and simultaneously prevent learning how to correct the causes of the threat in the first place. (Argyris, 1986, P. 541)

Understanding the potentially adverse impacts of defensive routines, the simulation was designed, using Action Learning, with explicit controls to ensure that participants could more readily and honestly access the thinking and emotions influencing their actions without experiencing a need to protect them from admitting error. It is acknowledged that these three key assumptions emerged over time as the research progressed, and as I reached the maturity level to discover them and include mention of their influence on the final design.

3.3.3 Application of Action Learning to Development of Hooshmand-1

Six Action Learning cycles were used to develop the final simulation.

The 1st cycle focused on identifying key project decision factors and principles that should be accounted for in the simulation design, some of which were discussed above. The subsequent cycles added to the knowledge required for the development of the simulation, and its use as a research instrument. Review of previous simulation development revealed two existing simulations that could have potentially served as research instruments. Each of these was reviewed as an Action Learning cycle, which is briefly described below.

3.3.3.1 Wip Wap / Holiday Paradise School: the 2nd Action Learning Cycle

The first review is of a simulation called Wip Wap which is from an unpublished Masters Degree thesis. This simulation was the result of a collaborative venture between the University of Technology Sydney and the University of Tilburg (Naber & van Oort 2005). This simulation explores factors which inhibit communication within an organisational context. The simulation scenario is set in a Jillaroo Jackaroo school in outback Australia and simulates a year of business planning over a three-hour period, during which participants have to attempt to rescue the school from a budget crisis. The purpose of this simulation is to provide a set of experiences to challenge participants' competencies to communicate, collaborate and complete assigned work effectively and on time while accounting for unexpected events. The scenario assists participants to tackle intra-organisational barriers to information sharing, group decision making and achieving consensus on decisions.

For this current research, I redesigned Wip Wap to more closely mirror a portfolio management context. The scenario was redesigned to operate with fewer participants, and the overall simulation duration was reduced. However, the basic participants' role structure of managers, educators, guides, and pioneers was retained. In the redesigned simulations, participants were required to complete twelve different activities. However, when a pilot session of the redesigned simulation was run, it was found that participants did not achieve any of the targets within the stipulated time. Key results from the effort to adapt WipWap included that:

- The context did not sufficiently represent a portfolio management environment;
- The experience helped narrow the focus on decision-making processes and conditions in which they might occur for a project manager;
- The range of behaviour exhibited by participants in response to the simulation was too broad to demonstrate patterns of behaviour; and
- The simulation took too long to complete.

3.3.3.2 Airpower 2100: the 3rd Action Learning Cycle

Australian Air Force base originally developed AirPower2100 as a simulation to improve fleet preparedness in their air fleet in Brisbane (Kearney et al., 2013) which is a very large and diverse work place. The main focus of the simulation was the relationships between four groups: logistics; maintenance; operations; and Aircraft Upgrade Projects (see Figure 10). To represent this space, the simulation used a diagrammatic representation of work tasks and poker-like chips to replicate the workflow involved in keeping the required number of aircraft combat ready.

Figure 11 shows an image of the board and chip set, and indicates the direction of workflow among the four sets of divisional requirements.

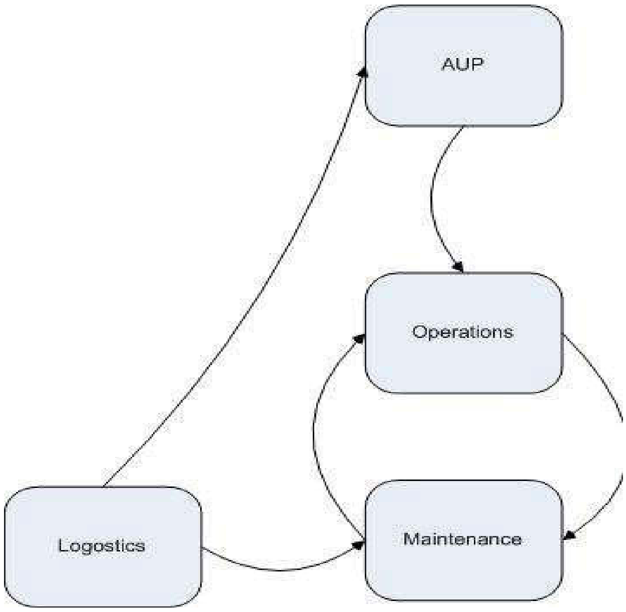


Figure 10 – The relationship between roles in AirPower2100

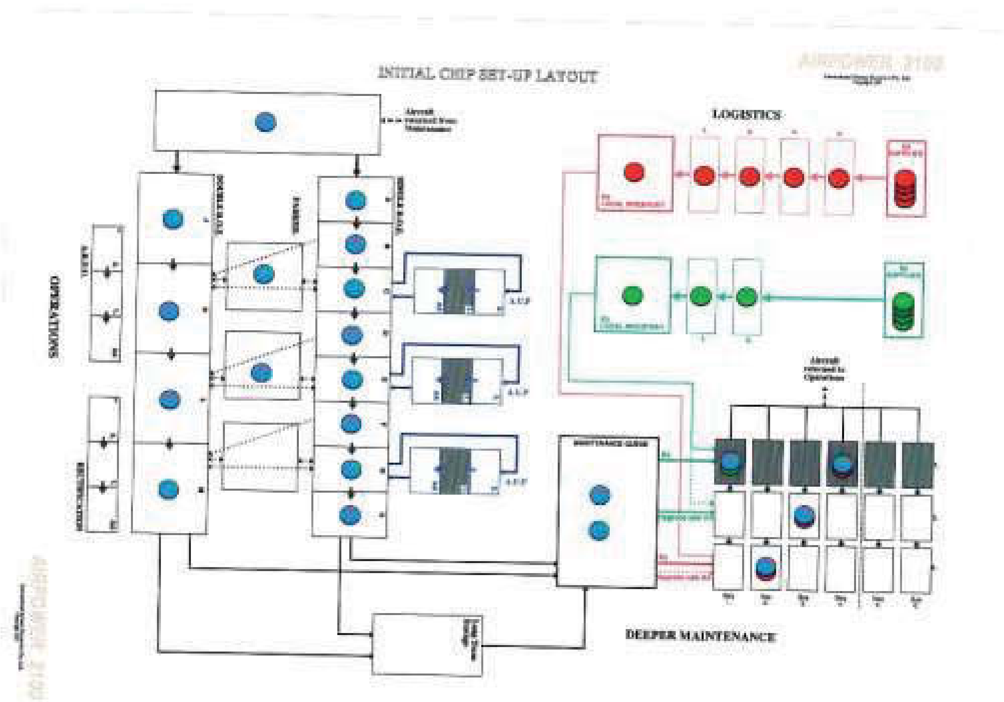


Figure 11 – AirPower2100 playing board

AirPower2100 took three hours to play and was designed as a component in a tailored education program to improve management strategies for ensuring sufficient availability of battle ready aircraft (Kearney et al., 2013P. 1). As the nature of decision making in such a context shared many similarities with portfolio management, AirPower2100 was seen as a possible candidate for researching the impact of complexity on project decision making. However, a ‘play through’ exercise to review its suitability showed that:

- This style of simulation was too structured to allow for customisation;
- The resource flow model was not compatible with a portfolio management environment; and
- The three-hour time frame did not allow for the research processes required.

3.3.3.3 Action Learning 4 Simulation at the portfolio classroom

Portfolio Selection is a classroom exercise for business students. I attended two sessions of play, as an observer and as a player to appreciate the process and explore the knowledge of portfolio selection used. The simulation was designed as a post lecture practice for postgraduate students in the PPM course. The lecturer briefly discussed key concepts, and decision-making processes and tools for management teams. The design of this simulation uses the three decision criteria of strategic fit, cost-benefit and resources and the simulation is also intended to study how the presentation of information changes individual perceptions for making decisions. Groups had 15 minutes to make their decision individually and then discuss with the large group perceptions of how they made their decisions. In each group participants had different formats of the same data. Analysis showed that:

- Key decision criteria were adapted for this research; and
- Average time of 15 minutes for decision making, became an indicative timeframe for this research.

3.3.3.4 Hooshmand-1: The Action Learning Cycles 5 & 6

As an appropriate simulation for understanding complex decision making in portfolio management could not be found, it became necessary to develop a bespoke simulation. The simulation called Hooshmand-1 was developed to study the way decisions are made about PPM, and how the three sources of uncertainty: time pressure; detailed, intricate information; and, the uncertainty of achieving desired outcomes, affect decision makers’ actions and perceptions.

An abductive research approach was used to make sense of all the evidence and fragments collected during the previous Action Learning cycles. A standardised sequence of actions was found to be necessary to allow for reliable, repeatable patterns of behaviour to emerge. To collect sufficient research data and to provide the change of patterns from a stable situation to a dynamic decision environment, it was decided that the simulation should involve two short scenarios, one of which involved real-time disruptions to increase the level of experienced complexity and uncertainty. It was also considered necessary to provide participants with simple decision criteria and a simple organisational structure, to minimise the amount of time wasted during the set-up. Figure 12 – Typical Simulation Process shows the overall process which is simplified in the following steps:

1. Briefing;
2. 1st simulated scenario;
3. Reflection on the 1st scenario;
4. 2nd simulated scenario;
5. Reflection on the 2nd scenario; and
6. Debriefing.

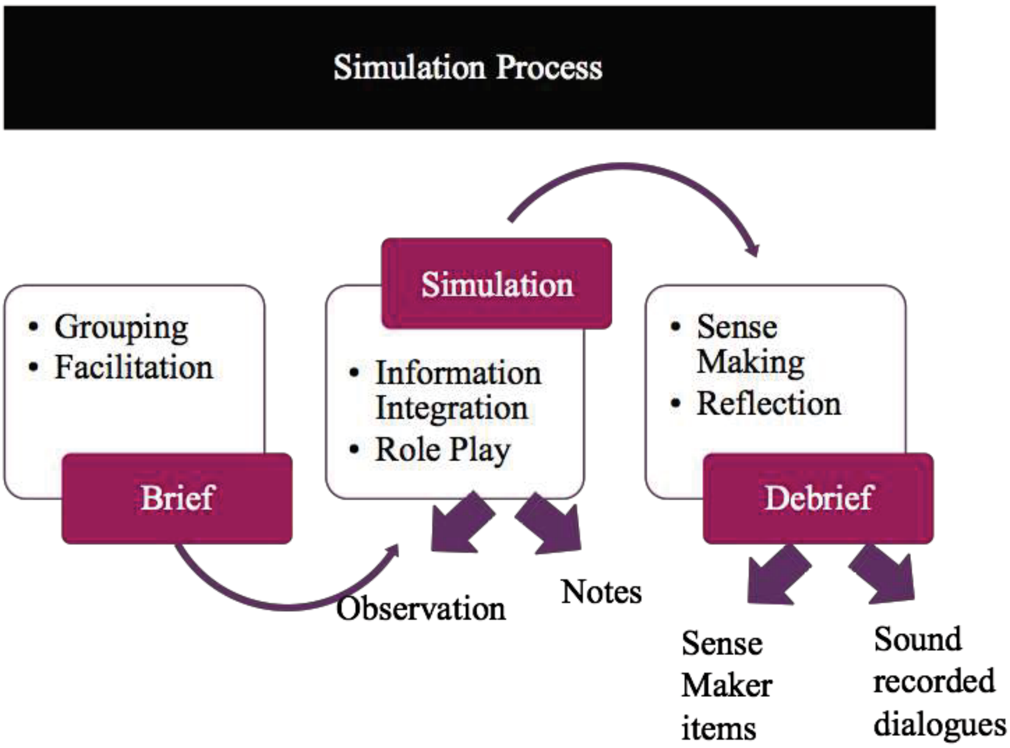


Figure 12 – Typical Simulation Process

Two different scenarios were developed based on data from a case study of IT companies in Canada (Petit, 2012). Both scenarios are set in a fictitious Sydney headquarters of an international IT company in the simulation. The scenario context is a meeting between the project portfolio committee chaired by the headquarter director and attended by the heads of the Application Development and Integration and Verification divisions. The scenarios were written to be dynamic and competitive, with sources of instability related to product content, unstable standards and unclear product requirements from the customers.

Essential dependencies among subprojects and a limited resource pool exacerbated the complexity of the decisions, such that people often need to be allocated to more than one project, because of specific competencies required for each node. The scenarios were written so that projects must overlap to maintain a stable design, and some projects cannot commence or must be delayed if resources are held by higher priority projects. This creates competition among projects to attract expertise, which leads to resource overloads. This issue must be resolved to ensure the smooth progress of all projects. Dependencies between projects were also introduced.

The scenarios represent decision making during a 24-month financial period. The project details provided include indicative figures for resources required and the strategic fit of each project. The first simulated scenario occurs during the first quarter of the two-year investment cycle. In this scenario, the portfolio committee has three months to report how they will adjust their portfolio to reduce costs while maximizing strategic fit and benefits. The second simulated scenario occurs during the second quarter, and the portfolio committee receives a proposed list of projects, which they must prioritise to maximize profits given time and resources constraints.

With respect to time and space, it was considered important to impose a tight timeframe to create the impression of realistic time pressures on the decision makers. Each 10 minutes of action equated to a month of real-time and teams must have the decision ready within three months (i.e. 30 minutes of game time). Space was treated differently to time in the scenarios. No effort was made to simulate the physical space in which portfolio decisions may be made.

The development process also followed principles generally applicable to simulation design. Leigh and Kinder (Leigh & Kinder, 2001) identified five essential components in the creation of a simulation structure:

- Rules: to form the boundaries for action;
- Roles: constructing how participants think and act for the duration of the action;
- Scenario: defining the scene and outlining the story and the setting for the action;
- Recording: focusing attention on what is important for using the simulation; and
- Validity: for assessing the realism of ways in which these factors operate as a whole.

Three steps have also been defined by Leigh and Kinder (2001) as a process for moving participants through the simulation process:

1. Briefing: during which participants are introduced to all the components in a manner relevant to both the needs of the research and the particular format of the design;
2. Action: during which participants are in control of all that happens, with the researcher and facilitator managing the process having the only residual authority to intervene; and
3. Debriefing: during which participants are free to reflect on and encouraged to discuss the events and interactions that they co-created. It is important to note that a form of 'debriefing' can be inserted at more than one point during the action, but that each such insertion must be preceded by a cessation of all of 'Action' which is then re-started at the end of the debriefing episode.

Pilot studies

Before using the simulation as a research instrument, two pilot studies were held, each of which themselves became an Action Learning cycle. The first pilot involved nine participants in an informal and social setting. The participants were given a short briefing and then worked in three groups of three for the allotted 30 minutes. It was found that although there were warnings about time passing, and all teams missed the targeted time for delivering their first set of outcomes. The first simulated scenario lasted two hours and the second lasted 90 minutes; both well above the intended duration. Participants used much of this time to understand the material and explore the meanings in the simulation. This first group of participants provided invaluable feedback and comments, resulting in many changes including reducing the amount of reading material and simplifying the data sets. Observation of the briefing showed that as an Originating Ba these together helped focus attention and emotion on the group's activity within the assigned roles.

In the second pilot, six participants formed two groups of three. The first simulated scenario was allowed 45 minutes. Participants were given an explanation of the materials and the scenario; however, both groups struggled to achieve consensus on their understanding of the data, and spent four hours, not finishing until midnight. This pilot led to further clarification of the documentation of the design for future participants, and development of the way that time is used. Further developments included:

- Contingency was added to the timing, to allow participants to complete their tasks;
- A digital alarm was prominently displayed, also showing the passing simulated calendar months;
- Extended guidelines were provided to accelerate relationship building among team members, who were used to working in teams but not in a simulated context;
- A standard data set was provided to all roles with some necessary exceptions; and
- A reflection/debriefing session was added after each round to capture participants' perceptions. Once the research began in earnest, this was supplemented with the use of the SenseMaker software to capture thoughtful observations and responses.

The findings of these Action Learning cycles proved that using role-play simulation is advantageous for group knowledge sharing and decision making. The simulation creates a reasonably safe, controlled environment and approximately repeatable scenarios that provide researchers with rich mixed data through records of participants' efforts in complex decision-making situations. The role-play simulation places subjects in the context and provides opportunities for observations and interactions.

The simulation helps participants and observers with group interactions, discussions, and final debriefing. In the real world, it is almost impossible to generate statistical data in a qualitative study; however, this is made possible by employing a simulation for complex structured problems (de Caluwé et al., 2012, p. 606). Hooshmand-1 was now ready as a suitable means of generating observable actions and identifying factors affecting decision-making processes in PPM.

3.3.4 Sensemaking framework and data analysis

Cynefin framework is useful for analysing decision-making processes and decision-makers' shifts during transitions in complex problem solving. Cynefin, a sensemaking framework, was adapted to the research method in such a way as to enable the simulation participants to write their narratives in their own words. This approach was proven consistent with the design paradigm assumptions.

SenseMaker is the software package developed to help participants make sense of complexity based on Cynefin frameworks. The software has embedded certain tools that help to generate mixed data in a real-time approach and support research participants to develop their plausibility of what they experience during simulation Hooshmand-1. For example, Triads, as described in the literature review, are triangular shaped tools to cater for three alternative responses to a question. The Triads help people to make a judgement by comparing three dimensions and six questions at the same time, which provides a less biased outcome compared to the traditional view of two-dimensional tools. Furthermore, the qualitative answers convert into quantitative measures for each end point to support a real-time generation of mixed data. Sardon & Wong (2010) described the key benefits of using SenseMaker as follows:

a) It allows a researcher to distribute the analysis load across all participants and makes it possible to analyze the stories in a relatively short time.

b) It reduces the authors' bias that might otherwise be introduced in the interpretation of the stories. In doing so, each story contributor makes sense of their own story.

c) It engages the participants and positively prepares them for the next steps. Involvement is a key success factor for the long-term success of any intervention.

3.3.5 SenseMaker, an application of software

SenseMaker was chosen as the software to develop a sensemaking framework for this research. SenseMaker uses fundamental items including subjects' fragments and assignment of significations to make sense of subjects' perceptions or opinions. A summary of the terminology for SenseMaker is in Table 5.

Table 5 – Terminologies of SenseMaker

Item no	Terminology	Description
0	SenseMaker	Software to monitor a change of paradigms in a complex environment.
1	Widget	The widget is an embedded function in the software that helps a user to choose suitable combinations for the purpose of using SenseMaker.
2	Signifier	Signifiers are signs or symbols that help research subjects to identify the pattern, the paradigm and the change in their perceptions during an experiment.
3	Dyad	A dyad is a two-dimension signifier that assesses the subjects' perception between 0-100. One advantage for the dyad comparing to the Likert scale is that the dyad covers two negative or two positive opinions in one question.
4	Triad	A triad is a three-dimension signifier and assesses the status of six questions at the same time. Each axis of the triangle is measured between 0 and 100 on the two ends.
5	MCQ	Multiple-Choice Queries are the usual method to assess subjects' opinions. SenseMaker uses MCQ to assist researchers with the categorisation of patterns in signifiers.
6	Designer/Demo	Designer or Demo is a toolkit in SenseMaker that helps researchers to design web pages for signification. Please see attachment for details.
7	Collector	The collector is a module of SenseMaker on the Web. The collector can be used on a variety of devices with access to the internet.
8	Explorer	The Explorer is the second module of SenseMaker. The module is used on a desktop or laptop. It is used to analyse signifiers and queries.
9	Micronarratives	Micronarratives are defined as a subject's fragments, such as short stories, images, videos or audios, to make sense of a complex situation without the researcher's intervention.

3.3.6 Development of sensemaking framework with SenseMaker

SenseMaker provided simulation participants with a web-based sensemaking framework that is; in effect, a structured questionnaire to help them to reflect on their experience and provide feedback to me, the researcher. The sensemaking framework uses pre-coded questions embedded in the SenseMaker software to signify participants' understanding of the situation. Furthermore, signifiers are often non-linguistic components of the signs. According to Lesca (2011) the signifier of a sign is a qualitative clue that explains the sensory level as perceptions, feelings or intuitions. Having discussed the essentiality of considering feelings and intuitions for decision making in PPM during uncertain situations, signifiers were found to be useful tools to understand the possibilities of emerging patterns for decision makers' perceptions when they deal with events in their decision-making exercise. Capturing signs or stimuli in an organisational level is a complex cognitive process (Weick, 2001). According to Ilmola and Kuusi (2006), cognitive knowledge structures the managers' mental models in order to make sense of their organisational environment. Furthermore, managers capture the stimuli, reflect on them and compare the message from external sources. Nikander and Eloranta (2001) argued that signals can be ranged between two extremes as a 'gut-feeling' to measurable values throughout the time available for counter actions but, as time passes, the chance of success for counter actions decreases.

SenseMaker's integrated platform demonstrated a great advantage for collecting data and providing analyses from subjects simultaneously. The variety of data provides the opportunity for deeper analysis than traditional methods such as Nvivo and other manual coding systems designed to analyse qualitative data. The final advantage of using SenseMaker is that it has a measuring mechanism that provides quantitative analysis such as distribution diagrams to support qualitative data at the same time. Therefore, SenseMaker has proven to be an efficient tool for data collection and data analysis for the purposes of this research.

SenseMaker has two modules: the Collector and the Explorer. The collector is a module on a web page, which can be made available via a uniform resource locator (URL). The explorer analyses the data sets that the collector creates[1]. The explorer provides variety of tools such as distribution diagrams, correlation diagrams, and micronarrative clusters. Each of these tools can be combined with filters, such as multiple choice criteria, to create different perspectives for the emergent patterns.

[1] - The outcome of data collection, on the web based collector, was extracted as CSV files.

Similar to other web applications, design of the collector consists of a demonstration and a live stage. A variety of tools such as dyads, Triads, and multiple choices, available in the demo, were used to develop a customised sensemaking framework with variables for this research. For the purposes of this research, SenseMaker was introduced as a supplementary research tool to Hooshmand-1. Previous research studies have not reported on the use of SenseMaker to investigate PPM. Action Learning was used to understand how SenseMaker and simulation could work as two pillars of the research process.

One advantage of using Triads is that six cases can be analysed in one Triad as described in Figure 6, Chapter 2. Triads are also powerful tools which identify and analyse emergent patterns in complex situations. Lastly, Triads can be used to generate themes and statistics when used by large numbers of subjects (Snowden, 2010b). Further details for signification widgets are available in the SenseMaker Designer Guidelines included in Appendix 4.1 SenseMaker, the designer guidelines.

Three cycles of Action Learning were used to develop a customised sensemaking framework. The summary of measures, reflections, and learning outcomes are presented for each cycle of Action Learning.

3.3.6.1 1st Cycle

SenseMaker[2] was introduced as a suitable tool for data collection and analysis during the last cycle of AL for the design of simulation for Hooshmand-1. I defined key criteria to assess the suitability of the Software. There was an emphasis on participants to generate their micronarratives and signify their stories through the Sensemaking Framework. SenseMaker proved advantageous with regards to criteria such as flexible design features, fit to narrative research, user-friendly and time efficient.

[2] Cognitive Edge helped my transition of experience from similar studies. Cognitive Edge provided case studies from dental services in Australia using SenseMaker. Furthermore, outcomes of the Action Learning cycles for design and validation of simulation helped the selection process. Sensemaking items (SMI) for the research participants either were selected from previous studies or were created based on observation of pilot studies.

Efficiency was identified as an important factor for the research subjects to address the limited time high profile managers had to participate in the research experiment. SenseMaker was an effective tool to implement simulation and reflection within a reasonable time. Efficiency was important from a research design perspective. A coding system is an indispensable part of a qualitative research tool and SenseMaker uses predefined coding systems. It has provided more flexibility than other tools such as Nvivo and it has been easy to use for most research subjects.

These are the key outcomes of the first cycle of the Action Learning.

1. SenseMaker proved to be a suitable tool to generate sensemaking items from participants' reflection after the simulation;
2. Sensemaking frameworks from similar studies were collected and analysed to select the most suitable signifiers; and,
3. Technical support to operate SenseMaker as a tool was available.

3.3.6.2 2nd Cycle

The second Action Learning cycle consisted of three stages: familiarisation with the designer; literature review and assessment of existing SenseMaker questions; and, tools from other case studies. The Designer Guidelines were used to choose the correct widgets purposefully.

I needed to learn how to operate/use the Designer and its features. SenseMaker's experts directed the mentoring program to improve my skills in a short period. The mentoring program consisted of two weeks for reading the materials, learning by doing and online interactive sessions. This process helped me to understand meanings and applications of tools offered in the Designer.

Having enhanced my knowledge of using the Designer, I reviewed existing sensemaking frameworks from other studies on dental services in Australia and strategic planning in Singapore. Case studies were focused on decision making and they offered SMIs useful for a study of the decision-making process. A brief literature review was conducted to understand existing discussions for team cognition, decision criteria and awareness of the feelings of decision makers and their perceptions of change. The research papers supported assumptions extracted through Action Learning in previous cycles.

The sensemaking framework consisted of the demography of participants, their micronarratives, and sensemaking items related to the research questions. These are the key outcomes from the second cycle of Action Learning:

1. MCQs were selected to collect information, demographic and professional experience, from the subjects;
2. The feeling of subjects was proven important for this decision-making study;
3. Triads were developed to signify their stories for decision-making criteria; and,
4. Dyads were designed to measure change of team versus individual participation during the simulation.

3.3.6.3 3RD Cycle

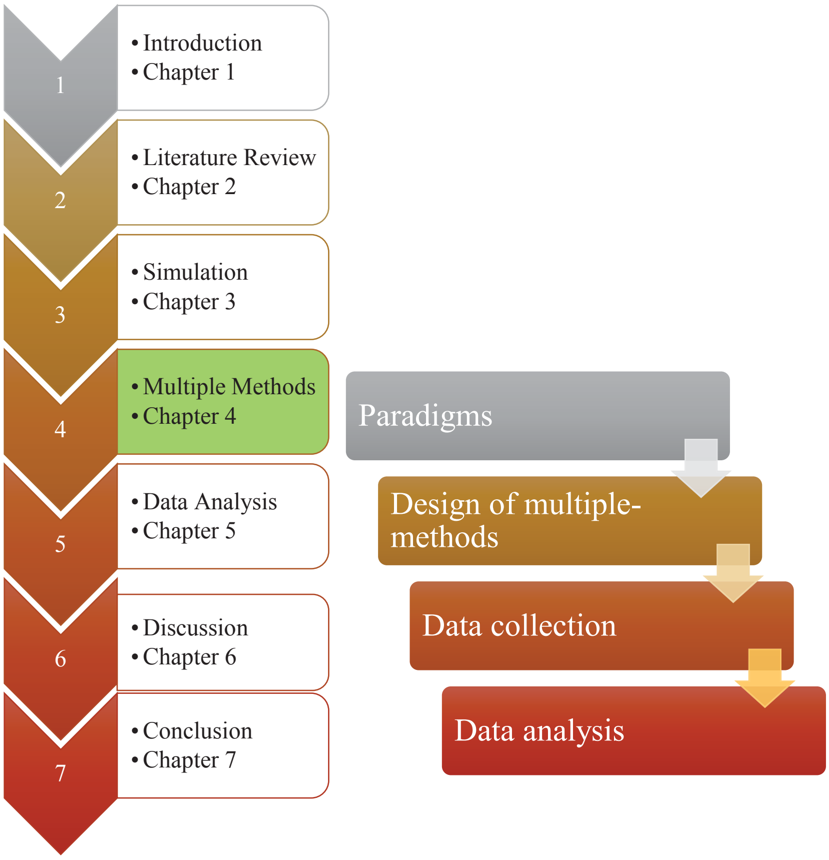
The sensemaking framework for this research was developed with the outcomes of the last Action Learning cycle. The validation of this framework occurred through another cycle of Action Learning. A collaborative reflection was embarked upon with a peer review by experts from Cognitive Edge Pte. Ltd. and my supervisors at the University of Technology Sydney (UTS). Experts' feedback was collected about design assumptions and adjustments were made to address their comments.

The final version of the sensemaking framework designed as a questionnaire for this research and was assessed through a joint workshop with Cognitive Edge. UTS and Cognitive Edge conducted the workshop to address all remaining gaps by interaction between experts and academic staff members. UTS hosted the workshop with a wider community of participants such as SenseMaker practitioners from Australia, consultants, research students and the research supervisors. Several samples from other research studies were discussed, tools of the Explorer were practised and details are in Appendix 3.1. Group discussion during the workshop was very helpful to understand the previous application of SenseMaker as it could be applied to this research. The key outcome for this cycle of Action Learning was that adjustments were made based on feedback and comments received through the workshop.

This chapter explained the concept and context of simulations and their application to the management science. The use of Action Learning to understand the design of a novel simulation as a research tool was elaborated upon. Finally, the chapter briefly discussed narrative research, its limits and how SenseMaker software can overcome those constraints in the research on decision making of PPM. The next chapter discusses the implementation of multiple methods for data collection and data analysis.

“Every firm competing in every industry has a competitive strategy, whether explicit or implicit” (Porter, 1980)

Chapter 4: Methodology



This methodology chapter explains the process of development and application of multiple methodologies and research strategies to data collection and data analysis. Research strategies describe the philosophical assumptions for extant paradigms, epistemology and ontology that supported the development of multiple methods for data collection and analysis. The multiple methodologies include steps, procedures, and publications that contributed to the evolving research methods through the Action Learning cycles as explained in Chapter 3 for data collection and data analysis.

4.1 Research strategies

Research strategies draw on the underlying principles of research including particular paradigms and a researcher's philosophical view of problems.

The paradigm informing a piece of research is based on how a researcher perceives the world. This includes issues as fundamental as what is considered to be true. A researcher's choice of paradigms is influenced by his/her beliefs, background, and experience in their field. Bryman and Bell (2007) defined a research paradigm as a cluster of beliefs. These beliefs can influence what scientists study, how they might carry out the research, and how they interpret their data.

There are three recognised academic research strategies (or reasoning), inductive, deductive and abductive, representing three pillars of research strategies. In deductive research, researchers test existing theories moving from a general understanding to a specific understanding of a problem. In effect, they try to use existing theoretical or conceptual structures and then test them. Collis and Hussey (2009) described a deductive paradigm as moving from the general to the particular. On the other hand, an inductive researcher relies on subjective reality, empirical studies and describes the general inferences, which are induced from particular instances.

An abduction is a different approach to the research from either induction or deduction. Unlike induction, abduction takes the middle ground between induction and deduction and accepts the existing theory as well as loose theoretical frameworks for investigations, which together might improve the theoretical strength of the research. Abduction also allows for a less theory-driven research process than deduction, thereby supporting data-driven theory generation (Järvensivu & Törnroos, 2010). An abductive approach is an emerging research strategy to tackle complex problems. It is useful to develop research methods where the researcher uses novelty as opposed to an approach based on established theories. Abduction is about investigating the relationship between 'everyday language and concepts', which is similar to induction (Dubois & Gadde, 2002, P. 555, O., 1994). Although less well known in comparison to deductive and inductive strategies, in recent times the abductive approach has attracted interest among constructionist researchers whose work is addressing complex problems. Abduction supported the methodological design of this research by using empirical studies and adaptations to develop multiple research methods suitable to the context of the study. This research was driven by an abduction approach to explore new perspectives in the project portfolio management (PPM) context and complex occasions. The multiple methods approach is designed to respond to the research questions as described in Chapters 1 and 2.

4.1.1 Ontology and Epistemology

Epistemology and ontology are two pillars of research paradigms. Epistemology determines the methods of research and validating belief and opinions. Western epistemology often presents a static view of knowledge although acknowledging that science is essentially dynamic (Nonaka et al., 2000). This research draws on two forms of knowledge ordered (complicated) and un-ordered (complex) as presented in their work on the Cynefin framework as used to study described by kurtz and snowden, as used to decision making in fast changing conditions (Kurtz & Snowden, 2003).

Ontology is concerned with where to look for reality in the research process external to the individual actors or actions and perceptions of the research subjects. Multiple ontologies were used to capture the dynamic of movements between ordered and un-ordered domains of the Cynefin framework and to emphasise the fact that methods which work in one domain may not be suitable in another domain (Snowden, 2005). This allowed findings to be captured from emerging knowledge using an iterative process as research progressed (Blaikie & Priest, 2017, Gray, 2014).

An interpretivist paradigm was adopted to focus the research on decision making events emerging directly from participants' experiences and actions (Gray, 2014). Research participants made sense of their actions in the simulation experiments and provided their responses from within their own experiences (a phenomenological approach). Conversely, the researcher used an interpretivist lens to understand their responses. Bryman and Bell (2007, P. 18-19) define phenomenology as:

> Phenomenology[3] is a philosophical view that is concerned with the question of how individuals make sense of the world around them and how, in particular, the philosopher should bracket out pre-conceptions in his or her grasp of that world.

Phenomenology supports a factual approach to research methods that helps researchers to avoid pre-assumptions (Driman, 2000) in their research methods and take an unbiased approach to finding truths. A phenomenological approach pays attention to fundamentals of theories through study on temporal consciousness, experience and intentionality. Temporal consciousness concerns time and

[3] Alfred Schutz (1899-1959) introduced the initial application of Phenomenology

consciousness and the fact that research participants can retrieve memories from past experience to create consciousness in the present. Emotions from past experiences influence the subjects' conclusions and their stories inform the experience at present. Feelings of experience influence research participants' conclusion and their story expressing the experience at present. Intentionality is referred to as the worldview by which each individual understands an object. Applying a phenomenological approach at this point ensured that all the data was derived directly from within participants'' experience.

Perception is fundamentally inter-subjective and focuses on aspects of problems that are not visible (Mooij, 2010). "Intentionality makes the human experience, or consciousness, sense giving or meaningful. The scope of intentionality is not limited to perceiving and feeling, to cognition" (Mooij, 2010, p.5). Intentionality influences human decision making and Judgement. Intentionality is claimed to be a moderating factor for fairness in social decision making (Radke et al., 2012). The observation of behaviour is essential to understand social interactions as it may impact the perception of observers for responsibilities and moralities (Young & Saxe, 2011). Driman (2000) stated that all experience involves a blend of 'present and absent' using a cube as an example. Looking at a cube, you might see an angle or a box depending on the position from which you view the cube. These two statements emphasise that intentionality of a research participants' perception for different aspects of the same object. Multi-ontology sensemaking drove the research design and implementations and it was agreed that knowledge and actions are intertwined (Sinclair, 2005). Using an interpretivist approach enabled objective analysis of participants' reports of their experience.

4.2 Process of selecting participants

Participants were selected through a call for volunteers among research students, professional project managers, portfolio managers and strategic managers. The process involved sending flyers to the email lists in the university, LinkedIn, Engineers Australia and Project Management Institute Sydney Chapter to recruit candidates. Key criteria were developed to select appropriate candidates for the simulation, comprising professional experience, industry background, and experience in management roles, and a project management background. After selection, the grouping process was carried out before the simulation experience. Rules in the simulation protocol mandated that co-workers who came from the same organisation units could not sit together in the same group. The diversity of participants in each group was considered a key factor. Participant were grouped based on their industry, gender, experience and employer backgrounds.

To ensure that the simulations represented a fair abstraction of portfolio decision making, participation was restricted to professional project managers with at least three years' experience. Co-workers were reallocated to separate teams, reducing the probability of existing relationships interfering in the decision process, and participants with similar industry backgrounds were allocated to separate groups to achieve maximum diversity.

4.3 Data collection

Data collection was carried out through direct involvement of research participants in the simulation Hooshmand-1 and use of the sensemaking framework. During 2014, four repetitions of the simulation were conducted using a facilitated process and the sensemaking framework was used each time to collect data from participants. The four simulations involved 33 participants, who generated 66 data sets from two scenarios in each experiment. Two experiments were carried out at UTS, one with PMI Sydney Chapter members and one with a private ICT company based in Tehran. A standardised process of facilitation based on the simulation protocol was used to minimise unwanted noise in the data collection.

The selection process for each simulations' participants was tailored depending on the type of volunteers available and the organiser for each simulation. Participants were recruited from professional networks and postgraduate research students in two simulations that were held at the UTS. The simulation in Tehran was held as part of a middle managers' training and development program. Lastly, PMI Sydney Chapter organised an event for project management professional certificate holders on a Saturday. PMI promoted the role-play workshop with Professional Development Units (PDUs) necessary for PMP holders' training and development to be eligible to renew their certificate within three years.

The simulation protocol, used to guide the facilitation process, helped to improve the standard of the research process. As the research aimed to run the simulation in Tehran, a mentoring plan was implemented during the two first simulations in UTS to ensure the skill set for the facilitator was sustained during the simulation overseas.

Details of the simulation protocol are in Appendix 4.3 Simulation Protocol.
Audio and video recorders were used to capture all evidence during experiments. Audio recorders were very helpful for recording interactive discussions and dialogue between participants and the facilitator during the reflection. These discussions were transcribed as supplementary evidence to the results in SenseMaker.

Simulation subjects answered a prompting question in order to write a fragment or a short story to describe their experience, after the end of each simulation scenario. The facilitator asked participants to describe the key turning points—a major change to the conditions of decision making or situation awareness of decision makers during a decision-making event—during each scenario of the decision making and participants 'made sense of' their story through a sensemaking framework.

4.3.1 Classification of data

Data sets were grouped according to personal information from the subjects, their roles and groups in the simulation, and attributes of the simulation Hooshmand-1.

4.3.1.1 Personal information

Questionaires for personal information were given to the participants in the first section of the sensemaking framework. The purpose of this was to provide further analysis on the experimental data from a demographic perspective. The diversity of the research participants was important to help make sense of the complex situation with a comprehensive view. Questions 3, 4 and 5 asked for age, gender and industry of the respondents.

4.3.1.2 Participant roles and groups

Roles and groups were coded in the simulation protocol and workshop materials for participants in order to de-identify the process of data collection. Each group had a colour of red, green, gold or white. Participants in each group were assigned one of the roles numbered 1, 2 and 3, using a randomised process. The facilitator asked the participants to throw a dice until they matched the number on the dice and a number on the role folders on their groups' desk. The first person who received a folder for the role description was out of the game and the two remaining members continued to find their role.

Questions 6, 7 and 12 asked participants for the group colour and roles. Questions 8 and 13 asked participants about the importance of the role from their perspective in each scenario of simulation. Details of this questionnaire are in Appendix 4.2.

4.3.1.3 Simulation Hooshmand-1and its attributes

Simulation Hooshmand-1 created an abstraction of the real decision-making process for project portfolios selection and prioritisations. Attributes of simulation Hooshmand-1 were used to develop signifiers for the sensemaking framework. These attributes were defined as check points for design of simulation and its validation or participants' perceptions from their research experiments.

Hooshmand-1 uses two scenarios of decision making as context 1 and context 2. Each Context has a separate scenario that creates a complicated domain of knowledge; for decisions makers in the context 1 and a complex domain of knowledge for decision makers in the context 2. The first scenario (SC 1) engages participants with a cost saving exercise on a pre-set portfolio road map where they need to find the most suitable projects to defer or terminate. The second scenario (SC 2) asks participants to devise a profit maximisation strategy that delivers market expansion with additional projects in the portfolio road map. The SC 2 also provides two Black Swan events: 1- project cancellation by the client; and, 2- an unexpected organisational change. These were introduced to assess their impact on decision-making processes and decision makers' Judgement as individuals and groups.

Groups of three play the role of a firm in Sydney which receives direction from its headquarters in Northern America. Further details are in Appendix 4.3 Simulation Protocol.

Simulation attributes were categorised depending on the nature of the query, dependency on the research questions and the scenarios. Table 6 illustrates dependency between signifiers and research questions. Signifiers are qualitative clues that sense feeling, intuition and perceptions of participants with regards to their experience in the simulation. The first two columns from left, refer to the question codes and descriptions in the sense making framework. The source indicates the reference and similar studies which I have used to define question criteria. The last column in the right, shows relevance of each question to different aspects of my research such as research question, participants' demography and simulation design index.

Table 6 – Relationship between attributes of simulation and research questions

Code	Description of Multiple Choice Queries and Dyads	Criteria	Source	Relation to Research
Q1	Similarity of Simulation exercise to previous work experience	1-One time occurrence 2-somewhat common 3-rare but not isolated 4-very common 5-Not sure	Similar research with Cynefin	Indicator for simulation design validation
Q2	Years of experience with decision making as a manager		Similar research with Cynefin	Demography
Q3	Participants' gender		Similar research with Cynefin	Demography
Q4	Participants' age		Similar research with Cynefin	Demography
Q5	Participants' industry			Demography
Q7	Participants' role in simulation	De-identifiers	Hooshmand-1	RQ 1 & RQ 2
Q8	Participants' role importance for final decision	1 Not relevant at all 2 quite important 3 Not sure 4 somewhat important 5 critical	Hooshmand-1, (Koh & Crawford, 2012)	Simulation engagement index
Q9 & Q14	Participants' feeling	1 Glad 2 Angry 3 Frustrated 4 Stressed 5 Uncertain 6 Not sure	Similar research with Cynefin + (Brown & Jones, 1998), (Hansen et al., 2009)	RQ 2 – SC 1 & SC 2

Code	Description of Multiple Choice Queries and Dyads	Criteria	Source	Relation to Research
Q10 & Q15	Perception of biggest challenges for participants	1 Decision-making process 2 Individual experience 3 Team work 4 Apply portfolio road map as a tool 5 Understanding your role in the team 6 Informal communication	Similar research with Cynefin + Hooshmand-1 + (Costantino et al., 2015), (Project Management Institute, 2012),	RQ 1 & RQ 2 – SC 1 & SC 2
D1 & D2	The focus of task on Team versus Individual	Team versus Individual	(Sommer & Pearson, 2007), (Quarantelli, 1988)	RQ 2 & RQ 3 – SC 1& SC 2
Q16	Perception of impact on decision makers for the first real-time event	1 Positively, helping to achieve strategic objectives 2 Negatively interfering and no help for final decision 3 Neutrally, having no impact	Similar research with Cynefin + Hooshmand-1, (Petit & Hobbs, 2010)	RQ 2 – SC 2
Q17	Perception of impact on decision makers for the second real-time event	1 Positively, helping to achieve strategic objectives 2 Negatively interfering and no help for final decision 3 Neutrally, having no impact	Similar research with Cynefin + Hooshmand-1, (Petit & Hobbs, 2010)	RQ 2 – SC 2
T1	Criteria of Decision Making	Resources availability – Business strategy – Cost-Benefit	(Engwall & Jerbrant, 2003), (Rungi, 2010), (Christiansen & Varnes, 2008), (Ghasemzadeh & Archer, 2000), (Unger et al., 2012b)	RQ 1- SC 1
T2 & T6	Drivers for individual decision making	PPM process – Rational - Emotion	(Korhonen et al., 2013), (Kester et al., 2009), (Martinsuo et al., 2014), (Arlt, 2010), (Martinsuo, 2013)	RQ 2 – SC & SC 2
T3 & T12	Perception for sources of uncertainty	Time pressure – Inadequate information – Inadequate skills	(Unger et al., 2012b) (Martinsuo et al., 2014)	RQ 2 – SC 1 & SC 2

Code	Description of Multiple Choice Queries and Dyads	Criteria	Source	Relation to Research
T4 & T13	Perception of Final Group Decision	Optimised solution – Suboptimal solution with team consensus – Leading person's preference and other's compromise	(Ghasemzadeh et al., 1999), (Müller et al., 2008), (Yuming et al., 2007)	RQ 2 – SC 1 & SC 2
T5 & T10	Group Adaptation to Decision-Making Process	Unchanging principles – They just did it, no reason – Adapted to realities of the situation	(Shepherd & Rudd, 2014), Similar research with Cynefin, (Biedenbach & Müller, 2012)	RQ 3 – SC 1 & SC 2
T7, T8 & T9	Shift of Criteria for decision making because of real-time events	Cr Resources availability – Business strategy – Cost-Benefit	(Taleb, 2007), (Engwall & Jerbrant, 2003), (Rungi, 2010), (Christiansen & Varnes, 2008), (Ghasemzadeh & Archer, 2000), (Unger et al., 2012b)	RQ 1 – SC 2
T11	Individual perception for factors to overcome changes on decision-making process	Innovative collaboration – Individual experience – Knowledge of PPM	(Easterby-Smith & Prieto, 2007a), (Martinsuo & Lehtonen, 2007), (Arlt, 2010), Hooshmand-1, (Biedenbach & Müller, 2012), (Sommer & Pearson, 2007)	RQ 3 – SC 2

Participants’ feelings were used as an important factor to assess performance and perceptions in decision-making studies (Cognitive-Edge. & Cognia., 2011). Participants’ feelings were used as a filter to identify differences between generated patterns and micronarratives. Further analysis on differences and similarities of individuals’ responses helped categorise the influence of real-time events on decision-making processes. In addition, changes in participants’ feelings over different scenarios were interpreted as an indicator of responses to external changes and uncertainty for decision makers. Participants responded to Questions 9 and 14 to describe their feeling in scenarios 1 and 2. The participants could choose up to three choices from five to describe their feelings.

Decision criteria in relation to RQ1 were assessed as a changing nature in the process of decision making where individual decision makers dealt with unknown problems in complex conditions. Strategic fit, resource availability and cost / benefit were chosen as decision criteria for PPM. Participants responded to this Triad while they experienced two different scenarios.

Individual drivers for the final decision were assessed based on emotion, rational or PPM process in Triad 2 for SC 1 and Triad 6 for SC 2. The purpose of this was to assess any influence from real-time events on the perception of individual decision makers for PPM during scenarios one and two.

The main source of uncertainty from the participants' perspective was measured for two scenarios to study any shift in emerging patterns about research question 2 in Triad 3 for SC 1 and Triad 12 for SC 2. Sources of uncertainty for the PPM decision study were elaborated in Chapter 2 as an area for further research on impacts on the decision-making process. Perception of participants about information, time and skills were asked after each scenario to assess trends in the pattern for individuals' perceptions.

Optimised versus satisfied decisions for PPM were assessed to study the influence of real-time events on decision makers' perceptions of the nature of their final decision. Questions about the on-going debate in PPM about optimized, satisfied and suboptimal solutions were asked during the two rounds of reflections to understand how decision makers perceive their final decisions in regards to the changes in the complex situation.

The adaptation process was addressed in a Triad focusing on research question 3 in Triad 5 for SC 1 and Triad 10 for SC 2. Adaptation is at the centre of discussions for complexity studies, and this Triad was designed to capture any shift between three opinions extracted from other studies for decision making in complex situations. The reasoning, adapted to reality and principles were chosen to measure subjects' perceptions for any shift between two scenarios. Furthermore, this Triad helped to understand the reasoning of project managers while they were facing artificial uncertainty in the simulation.

A Triad was designed to capture opinions of participants during reflection after the second scenario. Participants assessed their position in relation to the most important factor when responding to the real-time events. The second scenario was more relevant to a complex changing environment. Three key factors, experience, knowledge, and innovation, were used to understand the adaptation process in Triad 11.

Finally, the participants were asked for their feeling about the influence of real-time events on their decision. Three feelings; positive, negative and no impact, were used in questions 16 and 17 to recognise Triads for the second reflection based on the simulation participants' perceptions.

4.3.1.4 Debrief

Further to explanation in section *3.3.3.3 Action Learning 4 Simulation at the portfolio classroom*, participants had an opportunity for a facilitated discussion after completion of reflection 2. The facilitator encouraged constructive discussions through dialogue between participants. Debrief discussions were audio recorded, and the highlights from each debrief were transcribed.

4.4 Data analysis

Data analysis was carried out in two stages, during and after simulations. During the simulation (stage 1), participants analysed their micronarratives. They used the sensemaking framework to signify their lessons learned from the simulation. At this stage, key sources for analysing data were: micronarratives; patterns; Triads; distribution-dyads; and, experiment related multiple choice questions. These types of data were recorded in the central database of SenseMaker. Participants' notes and reports were considered as supplementary sources of data for this stage. After the simulations (stage 2), a facilitated dialogue between participants—that is during the debriefing—was used to support results of the data analysis with additional descriptive information. Participants' discussions were audio recorded and transcribed for further analysis. Review of the literature to support initial findings of data analysis helped to generate discussions. Finally, a data triangulation was arranged using Nvivo analysis of debriefing transcriptions to verify earlier findings from stage 1 of the data analysis.

4.4.1 Participants' analysis - stage 1

Participants were placed at the centre of the data analysis to reduce biases and to access their experience during the simulation.

4.4.1.1 Patterns – Triads

Patterns were generated based on answers from participants using a cluster tool in the SenseMaker explorer software. The cluster tool recreates Triads to report opinions of all participants in all four rounds of the simulations. The patterns of these Triads are called 'base or reference' patterns and indicate the collective opinions of all simulation participants. Analysis of each pattern is based on the number of points around each of three criteria in the Triads to a total number of opinions reported in the simulation. A visual representation of this is presented here.

Figure 13- a sample Triad

Triads have both qualitative and quantitative aspects of data. Quantitative data as discussed in the literature review - 2.11 SenseMaker (SM) - were available as scores for each criterion in the triangles in tables extracted from the central database.

The patterns' shape was treated as qualitative data and provided insight into identification of the majority of opinions and those opinions which were in isolation from the majority. The patterns' analyses described findings for overall patterns for each Triad. Furthermore, the filtered patterns with MCQs were reconstructed and - compared pairwise with the reference pattern for each Triad to identify and indicate changes or shifts for the impact factors. The Combinational filters with Multiple Choices Questions—as described and categorised in Table 6—were considered to be an effective tool to cross check patterns against different impacting factors. Each criterion of MCQs was used as a filter to create a filtered pattern in the Triads. Comparison of the filtered patterns with the reference pattern, e.g. Triad 1–filtered by roles versus Triad 1–reference pattern, revealed which criteria of MCQs were identified as the impact factor for the Triads' criteria and their attributes in the simulation in relation to each research question.

4.4.1.2 Distribution – Dyads

Dyad data, for measuring teamwork versus individualism, was analysed by a distribution function in the SenseMaker Explorer. The distribution converts responses to the dyad or slider to a statistical distribution where a quantitative analysis on statistical parameters is possible. Large volumes of data can generate viable results for analysis. The distribution was used as a tool to study shifts between team versus individual orientation while participants were in transition from scenario 1 to scenario 2.

4.4.1.3 Experiment – Multiple Choices Questions

Experiments with MCQs are useful for queries which have a limited number of answers. During design of the simulation, some factors were nominated as criteria for the experiment MCQ to cross-check results of pattern analysis on Triads. Findings of patterns with filters from MCQ criteria were compared with the base pattern recreated from SM, and some of these criteria were identified as key impact factors on the attributes of simulation (Table 6).

4.4.1.4 Pie Charts – Multiple Choices

Multiple choices in the first section of the sensemaking framework provided personal and demographic information. Pie charts were used to summarise this group of data, were useful to show the diversity of participants, and can be used for generalisation of findings where mega data is collected. This research has excluded this demographic information because of the limited number of research participants.

4.4.2 The researcher's analysis – stage-2

The researcher was at the centre of the data analysis for the second stage which used participants' stories and transcriptions from debrief facilitated dialogue. This reciprocal research process was arranged to conclude two sides' perspectives, the research participants and the researcher. When the researcher becomes the centre of data analysis, the background is an important factor for validity of the results.

4.4.2.1 My background

My background has an influence because of my role in interpreting data in the second stage of data analysis. I had worked as an industrial engineer in different engineering, consultancy and management roles. This provided a solid experience in analysing complex problems within and outside Australia. Familiarity with a different culture, history and rituals played a key role in bringing forward the research questions for practitioners and academic staff members. I am currently working in Jacobs Engineering as a senior consultant, and before moving to Australia in 2009, had worked in Iran for ten years in a manufacturing complex for a Peugeot JV, which provided a lot of experience in using quality circles for problem solving. Having reviewed the principles of Action Learning, it became clear that the origins of this research approach is based on the quality circle. Professor Deming introduced the quality circle with an emphasis on Plan-Do-Check-Act (PDCA). This approach was found consistent with my desire to discover underlying factors for flawed decision making at the organisation management level.

I have used Theming on participants 'micronarratives and Triangulation methodologies based on transcriptions of debriefing dialogues to carry out stage-2 of data analysis.

4.4.2.2 Theming - micronarratives and categorisation

Theming is a common process used in grounded theory to derive new theories. Theming can be used to understand differences with existing views in theory and practice. Theming, classification and categorization were used to analyse micronarratives and debriefing transcripts. I carried out theming of individuals' fragments extracted from micronarratives to identify Cynefin domains of knowledge as per participants' perceptions during the simulation. In doing so, I noted each one's judgement via recording in a spreadsheet and tried to allocate each fragment to the relevant Cynefin domain. The characteristics of Cynefin domains (Table 9) were very important for matching the theme of each fragment to indicate that participants were making decisions in different domains over time.

Another key factor in the adapted method for analysis was to consider the chronology of turning points. As explained earlier, turning points refer to a major change to the conditions of decision making or situation awareness of decision makers during a decision-making event. As participants were asked to list turning points in their decision-making processes with a future backward approach (2.11 SenseMaker (SM)), it was helpful to list the perceptions chronologically. The results of theming are illustrated in a Cynefin framework to manifest movements between Cynefin domains and assess changes of decision-making approaches accordingly.

I categorised the findings from participants against criteria such as identification of real-time events or turning points as influential factors, versus individuals who claimed no impact from the real-time events. Categorisation resulted in clusters of participants with similar views. However, classification concentrated on the type of core information and themes in texts such as stress, anxiety, loss of time or collaboration.

I assessed the correlations between patterns and fragments. The categorisation is based on participants who claimed to change their decision-making process to respond to changes, and participants who created outliers in the patterns. Outliers were defined as points in the patterns which represented an isolated opinion in comparison to the major trend of patterns. The quantities were extracted from SenseMaker which were associated with points in Triads. The categorisation resulted in two additional clusters with a focus on quantities associated with participants' opinions in Triads.

4.4.2.3 Findings and Triangulations

Five clusters created a list of findings through different perspectives and analysis methods. The findings from each cluster were treated as fragments associated with research questions. I categorised them based on the similarity, consistency and majority trends into separate findings, which produced a graphical model of thoughts at the end of data analysis.

Triangulation is used to apply a different perspective to data analysis in order to improve confidence in the validity of the findings. A triangulation was carried out to support these findings. Debriefing discussions and dialogue had been recorded at the end of each simulation. The audio records were transcribed as a source of data for triangulation. Transcriptions were analysed for each finding via Nvivo. The transcriptions were coded in Nvivo, based on filters set in multiple choices and earlier findings, to understand the consistency and correlation between the findings from my analyses and analyses participants created in SenseMaker. The cluster analysis was used to understand the correlation between filters that were earlier identified as being relevant to the patterns. The triangulation supported a majority of the findings and, based on the level of confidence in them, propositions for further research are offered.

4.5 Credibility of qualitative research

The credibility of this qualitative research is confirmed through a rigorous design of multiple methods and rigorous data analysis. Truth value, consistency and applicability (Nobel & Smith, 2015) are three criteria used to assess credibility of the research verifications (Lewis, 2009, Morse et al., 2002). The first section of research deals with designing multiple methods which are used to collect data for research questions in this research. As explained in Chapters 3 and 4, the truth value of the multiple methods for reflexivity and representativeness sub-criteria were verified through a rigorous process of action learning. The data analysis went through a rigorous process of self reflection as research participants provided their fragments from their real experiences during the simulation, and then went on to use a sensemaking framework to reflect on their stories. Finally they engaged in a facilitated dialogue during the debrief to validate their understanding of the experiment with their peers in the simulation. The sequence of reflections provided truth value through reflexivity while the debrief generated audio recorded dialogue which support representativeness of data analysis results.

The process of simulation and reflection after each scenario became standardised at the end of the AL cycles which are outlined in the simulation protocol and sensemaking framework. The sensemaking framework and the simulation protocol are two of the best strategies which support the consistency of design processes for multiple methodology research. These were reached through several discussions with experts and the research team in the process of AL. The concurrency of data collection and data analysis (Morse et al., 2002) that participants provided in SenseMaker software, was another verification strategy for this research. The consistency of results was also assessed through applying a different method using Nvivo as a data analysis process resulting in triangulation to compare the results of data analysis.

Feedback was also sought during the research with peers at several conference presentations (Copenhagen Danish Project Management 2nd Conference 2016 and Sydney- Apros Egos 2015) and papers submitted to journals which further strengthened the rigour of this research.

4.6 Ethical Considerations

This research used human subjects to generate data. Hence UTS standards and guidelines were used to apply for ethical approval through UTS HREC Approval Number: 2012-230A. The approval addressed specific consideration to the subjects as listed in the below:

1- Subjects' conversations and actions were recorded with a video camera and an audio recorder for studying after the simulation. The participants were informed regarding the conditions through invitation and signed the consent form before the attendance list was locked for each simulation;
2- Subjects were informed that all recorded data and their participation in the research would remain de-identified;

3- Data storage according to UTS requirements and standards was addressed in the ethical application;
4- All hard copies for communications with the subjects were produced on UTS official letterheads;
5- Invitations and consent forms approved by the Ethics Committee were used to communicate with subjects; and,
6- Group coding and role allocation were used to de-identify participants during data analysis.

In addition, an annual Ethics Report was provided to update the Ethics Committee at UTS with any changes made during the research process.

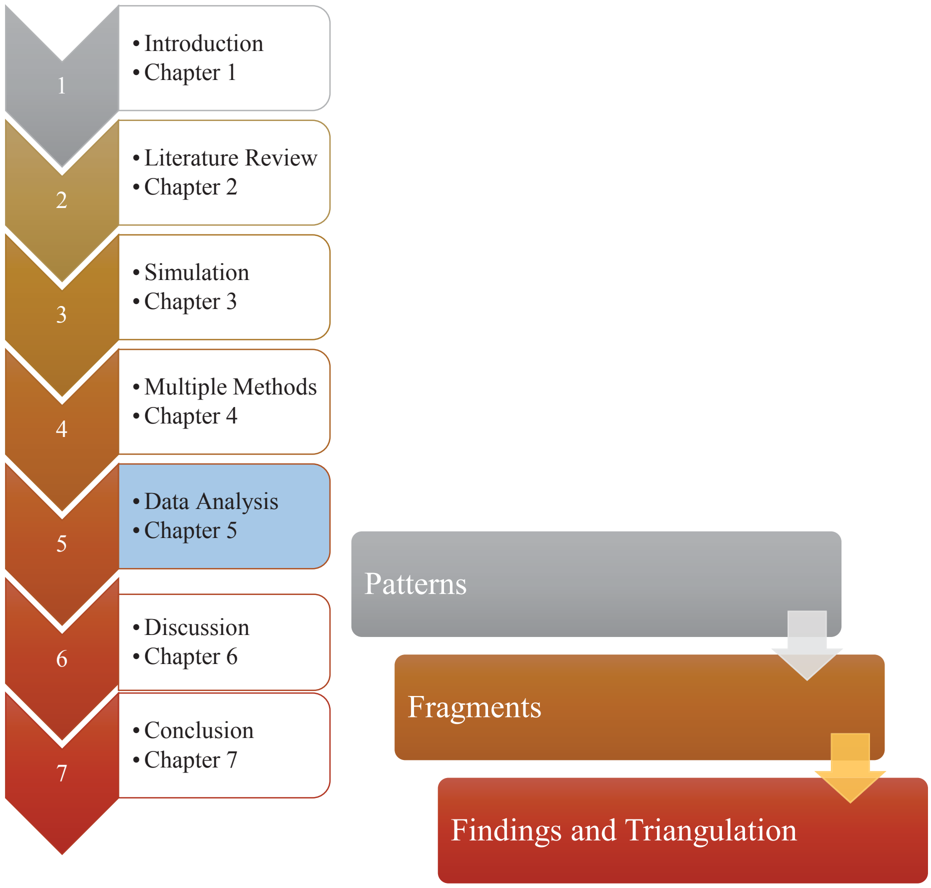
4.7 Mitigation of research bias

I have created several witness points to mitigate potential bias during design and implementation of my research. I have used several action learning to not only improve my understanding of different elements of existing games and how they could help my study aims, but also, to use diversified views of academic scholars, practitioners and expertise who attended action learning workshops. In addition, I tried to prototype the final design of simulation Hooshmand-1, twice to ensure I understand feedback from participants before applying Hooshmand-1 for data collection.

During implementation, I have set up a strict simulation protocol and used an independent facilitator to remove chance of influence from me on research participants. My role was mainly recording evidence as a silent observer other than guiding participants through briefing to the game and the computer lab for their self reflection.

The key mitigation measure for bias during data analysis, were use of SenseMaker and Nvivo with two separate sets of data and different methods to analyse them.

Chapter 5: Data analysis



Chapter 5 presents data analyses and findings arising from the research.

As described in the methodology chapter, the data analyses are presented in four categories

- Patterns: Distribution of participants' opinions in Triads and Dyads;
- Micronarratives: simulation participants provide fragments on their experience in each scenario of simulation. The prompt question for them is to list turning points in their decision-making experience and identify influential real-time events in their stories from the end to the beginning (chronologically);
- Correlations between analysis of patterns and analysis of micronarratives; and
- Triangulation through interpreting audio transcriptions from debriefing sessions at the end of each simulation.

This chapter presents the findings from the data analyses and records the results of the data triangulation process. It summarises the outcomes of each research question which are further elaborated upon in the discussion chapter.

As stated in the introduction and literature review, the research questions being addressed are:

RQ1 - how do decision makers change their decision criteria for selection and prioritisation in a project portfolio when conditions are uncertain?

RQ2 - how do real-time events or turning points influence the decision-making process for project portfolio management?

RQ3 - How do decision makers adapt to changes brought about by real-time events, and why?

Figure 14 shows the key steps and processes for this research from data collection to data analysis.

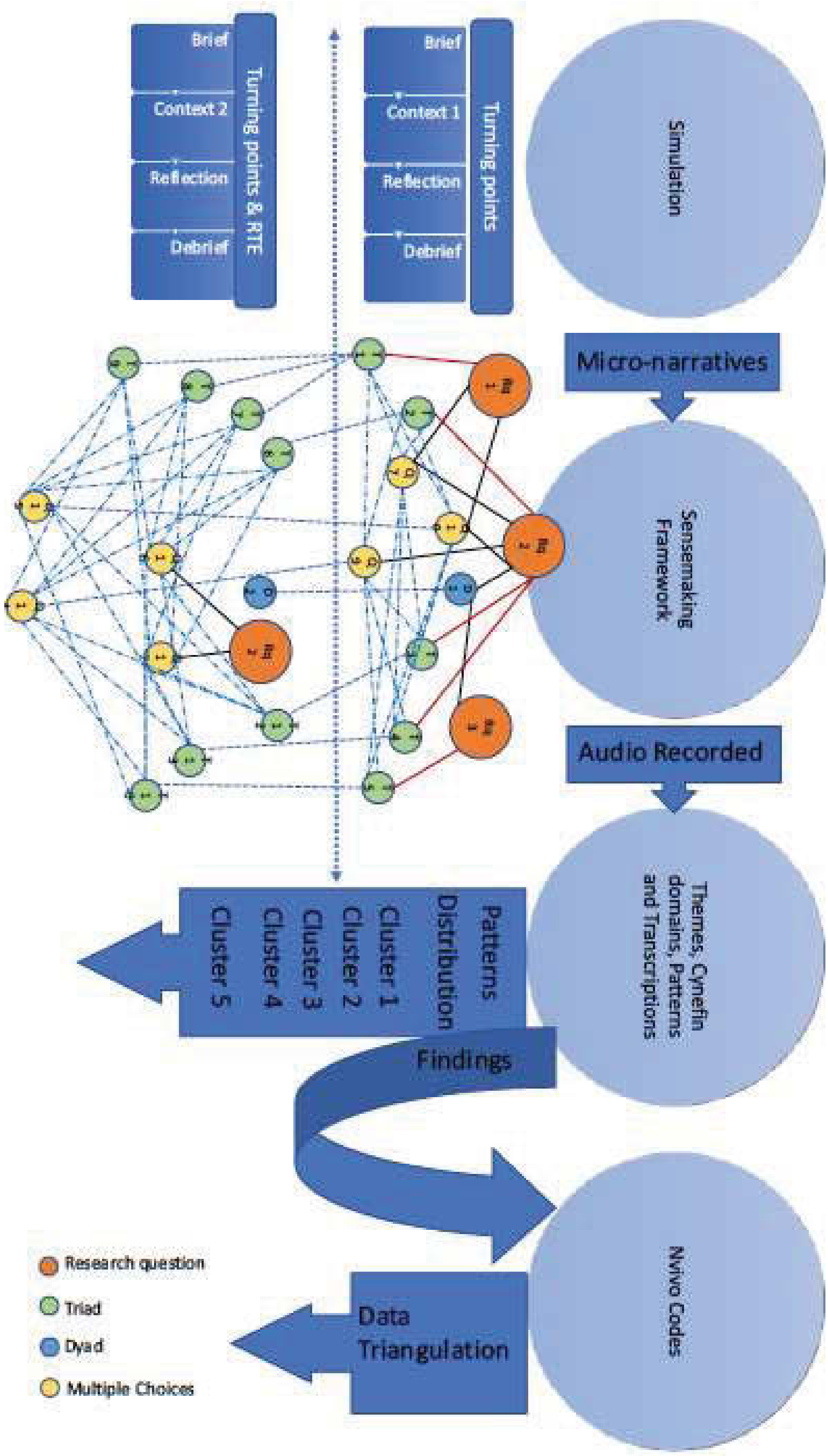


Figure 14 – The research method's process chart (Shalbafan et al., 2017)

In the simulation—Hooshmand 1—participants encountered two scenarios called Context 1 and Context 2. As Figure 14 shows, each participant answered significant questions using multiple choices, Dyads and Triads to show the significance of their opinion based on their story of decision making during the simulation. The details of signifiers (Appendix 4.2 Sensemaking Framework) and their relationship to the research questions are in Sections 3.3.4, 3.3.5 and 4.3.1.3. The signifiers have addressed areas of concern to PPM decision making such as decision makers' knowledge, emotions, decision criteria, team consensus and team versus individual cognition. These criteria were selected carefully in relation to the research questions. Relationships between individual signifiers and research questions are shown in Figure 14. The research method was based on a complex network of interdependent indicators including Multiple Choice Questions (MCQs), Triads and Dyads to investigate the three research questions. All Triads, MCQs and Dyads were organized for two contexts of the simulation to provide opportunities to explore comparable patterns between two contexts—defined as 'complicated' in the Cynefin domains for Context 1 and 'complex' for Context 2.

The patterns, generated from SenseMaker, were the results of using a signification framework as described in Section 3.3.6, drawing on reflections to inform the questioning process following participation in the simulation. Simulation participants indicated the significance of their perceptions, emotions and knowledge which were presumed relevant to their decision-making experiment in the simulation. As discussed in the methodology chapter, the questionnaire was available to simulation participants at the end of each scenario (context). The Patterns summarised the collective view of all participants across four simulations. After providing description of the patterns identified for each scenario, future emerging patterns and multiple-choice queries were analysed together to crosscheck the influence of real-time events as well as the turning points in decision makers' perceptions

The MCQs enabled simulation participants to select multiple options to signify their opinions on the questions in the questionnaire. The SenseMaker has a feature to recreate patterns with combined filters. In doing so, the combined filter between answers to MCQs and Triads generated extracted patterns from the full patterns. The filtered patterns were compared with the full pattern to understand any significant shift in relation to selected MCQs. Section 5.1 describes patterns for Triads that were completed at the end of simulation Context 1. Section 5.2 provides a summary of findings for patterns for the Triads that were used at the end of simulation Context 2.

Micronarratives refer to fragmented stories that participants wrote in the section provided at the beginning of the questionnaire. The provided list of turning points to decision making, as per their observation during simulation and real-time events which influenced their final decisions. As the micronarratives were written from the end to the beginning of the story anti-chronologically, it elicited a rich source of information which enabled monitoring how the domain of knowledge moved and evolved over time during simulation. The specific features of Cynefin domains were used as indicators to categorise themes in each fragment and allocate the categories to a graphic based on the Cynefin framework. The results of this analysis categorised simulation participants into three clusters based on their rationalization approach to turning points and real-time events and the influence on their decision processes. Section 5.3 describes this analysis and its results.

Furthermore, the results of micronarratives analysis in Clusters 1 to 3 were used to analyse results of patterns for those participants with similar approaches to the impact of real-time events. SenseMaker assigned a quantity to the location in the Triad when the participants positioned their answer in each signifier. Tables for chosen participants were collected from SenseMaker explorer to assess trends in the quantities among those participants' opinions in Section 5.4.1. Participants categorized in this section are identified as cluster 4.

Participants' responses showed up as 'outliers' which were created in the Triad patterns indicated a divergent opinion from majority of participants' view to the domain of knowledge in the Cynefin framework. The details of opinions for outliers were compared and the finding of analysis is presented in Section 5.4.2 as the cluster 5.

The summary of findings from the five clusters of participants was illustrated graphically and the triangulation was used to provide support to these findings. The source of data for this triangulation was the audio recorded discussions from the four simulation debriefs. The transcription of these facilitated dialogue at the end of each simulation was analysed using NVivo to run a cluster analysis and produce the graphics showing the number of nodes per coded items. Section 5.5 presents the results of this work, including their relationships to the research questions and triangulation.

5.1 Patterns – 1ST Scenario of the Simulation Hooshmand-1

Patterns shown are the distribution of participants' opinions, which are presented as points within the Triad. Images are provided below for four Triads, and four filters were extracted from the findings of scenario 1 of Hooshmand-1. Patterns for Triads 1, 2, 3 and 4 summarise participants' reflections after the first scenario. The Figures 14, 15, 16 and 17 show the patterns for these four Triads.

Triad 1- Criteria of decision making in your team tends to … ?

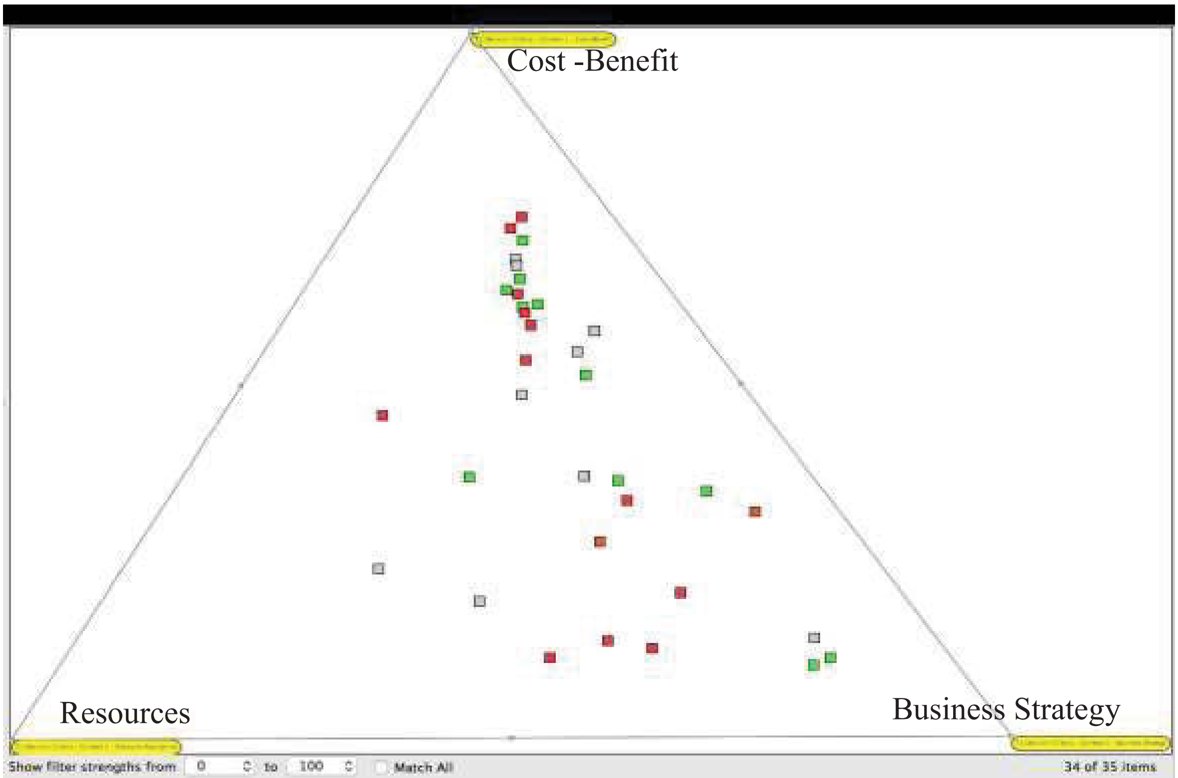


Figure 15 – Patterns for participants' opinions on preferred decision criteria in their group

Figure 15 illustrates an emerging gap between theory and practice in the pattern of Triad-1 which was designed to indicate preferred decision criteria in participants' perceptions after involvement in the simulation Hooshmand-1. The same query as of Triad 1 can be found in Triads 7,8 and 9 in the Context2 of Hooshmand-1 to assess potential shifts because of the impact of real-time events and their influence on decision making. The points in this Triad were Cost-Benefit, Business Strategy, and Resources Availability, and participants were asked to choose a point in the Triad via SM on the Web application which, in their opinions, best describes the decision-making criteria their teams actually used. The pattern in Triad-1 illustrates a clear concentration on two of the criteria—business strategy and cost-benefit—and notably "resource availability" is given little attention.

The data collected on Triad 1 was reported as part of a conference paper (Shalbafan et al., 2016) in a workshop discussion with conference participants in Copenhagen in 2016. That discussion suggested that a close analysis of resource availability with an emphasis on expertise and skill sets to carry on the projects and programs in the portfolio should be a high priority before committing to any additional projects. However, practitioners from manufacturing, systems and software production companies stated the pattern, as revealed, was a reflection of their reality and very close to their workplaces' experiences. Poor consideration of availability of resources meant they were all too frequently trapped with several projects in the pipeline and work overload drawing on limited availability of expertise. While theory proposes that all three be given equal attention, it is clear from those participants' responses that this does not happen in real time.

Triad 2- your individual decision is driven by what factor …?

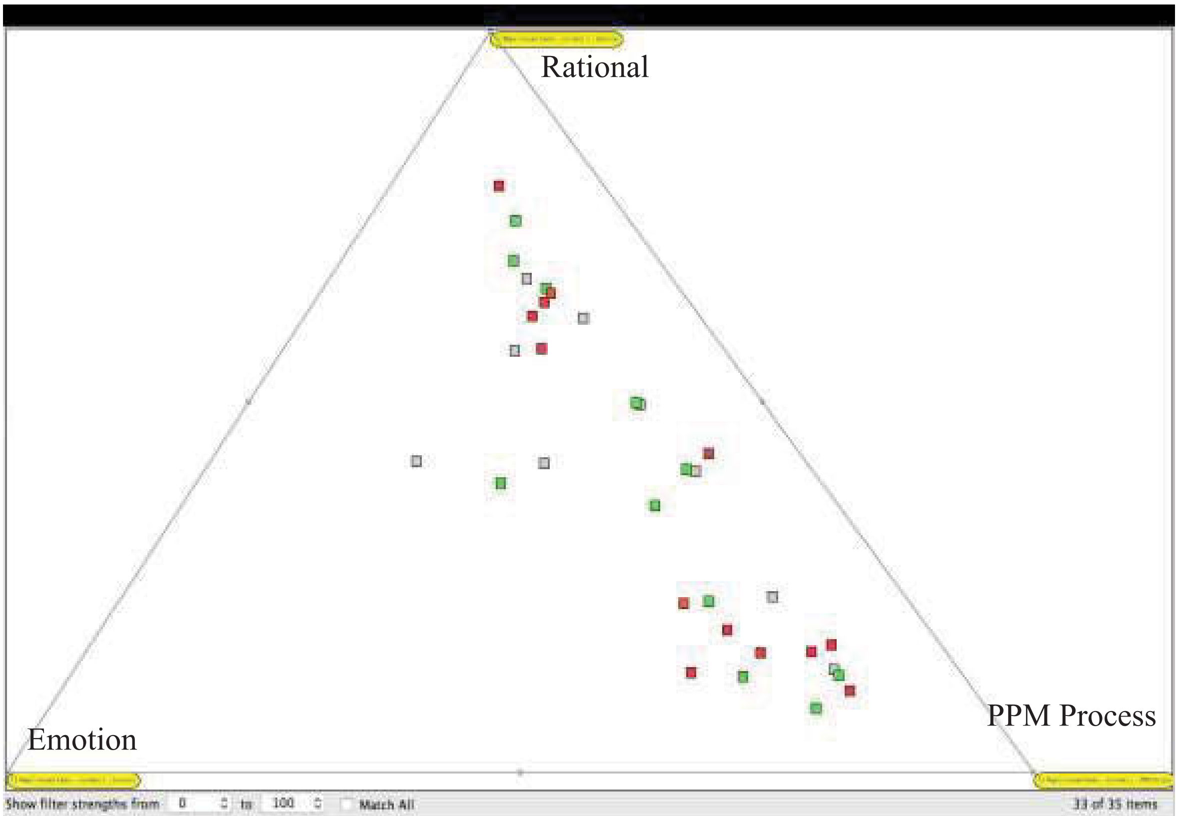


Figure 16 – Pattern for key impact factors on individual decisions

The Figure 16 illustrates data collected in Triad-2 showing how responses were clustered when the three potential impact factors of emotion, knowledge of PPM process, and rationale were considered in regard to personal decision making. Triad-2 shifts the focus from a team view to an individual view on the decision-making process. In this Triad, individual participants recorded what they saw as the key driver for their position in regard to their final decisions. Asked to choose among the three drivers of emotion, rationale and tactical decisions (i.e. use of project portfolio processes), the pattern reflected an absence of attention to any emotional basis for decision making. The pattern emphasised participants' belief that rational thinking would find the solution to the problems posed by the simulation.

Triad 3 - Main source of uncertainty in this experiment in your personal opinion is…?

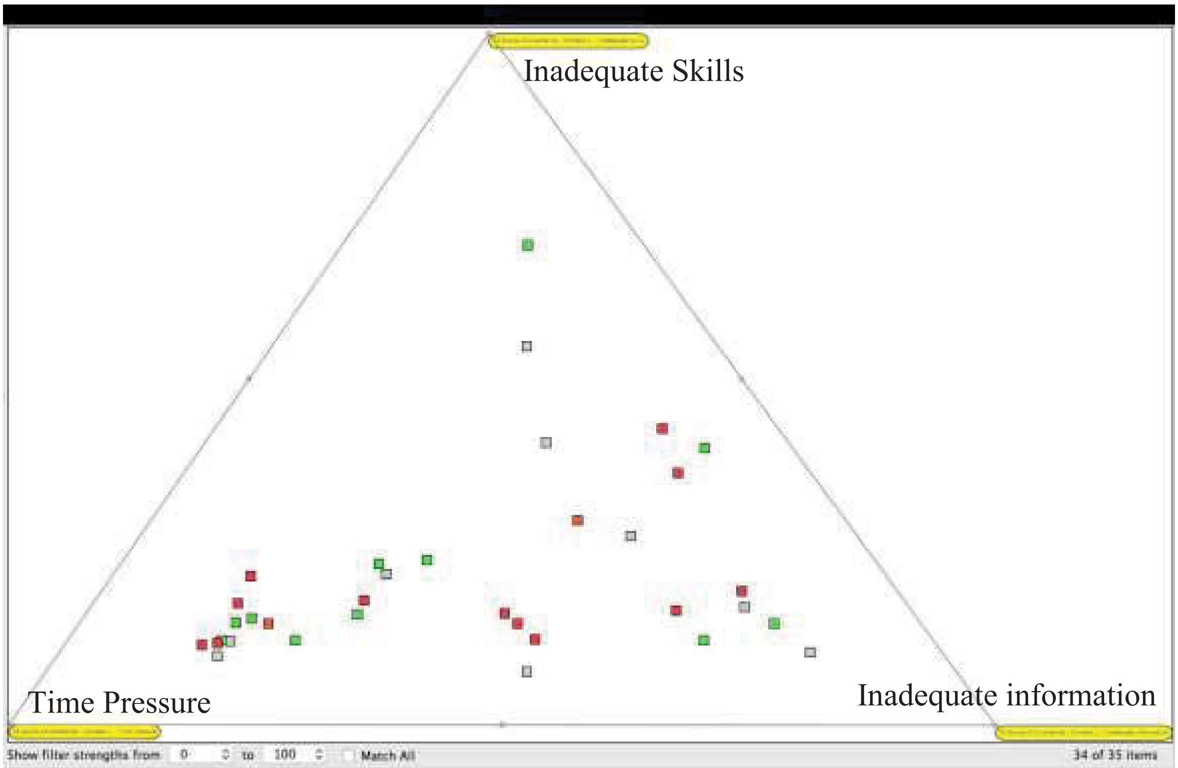


Figure 17 – Pattern for participants' perception on sources of uncertainty – Context 1

The Figure 17 shows participants' opinion on their perception of sources of uncertainty in Triad-3.

Triad-3 asked participants for their perception about the causes of any uncertainty they felt during the first scenario of the simulation. Time pressure, inadequate information and inadequate skills were the three criteria. Triad-3 illustrates a focus on time pressure and insufficient information. Only two out of 33 participants acknowledged that they felt inadequately skilled.

Triad 4 - Final decision in your group is focused on … ?

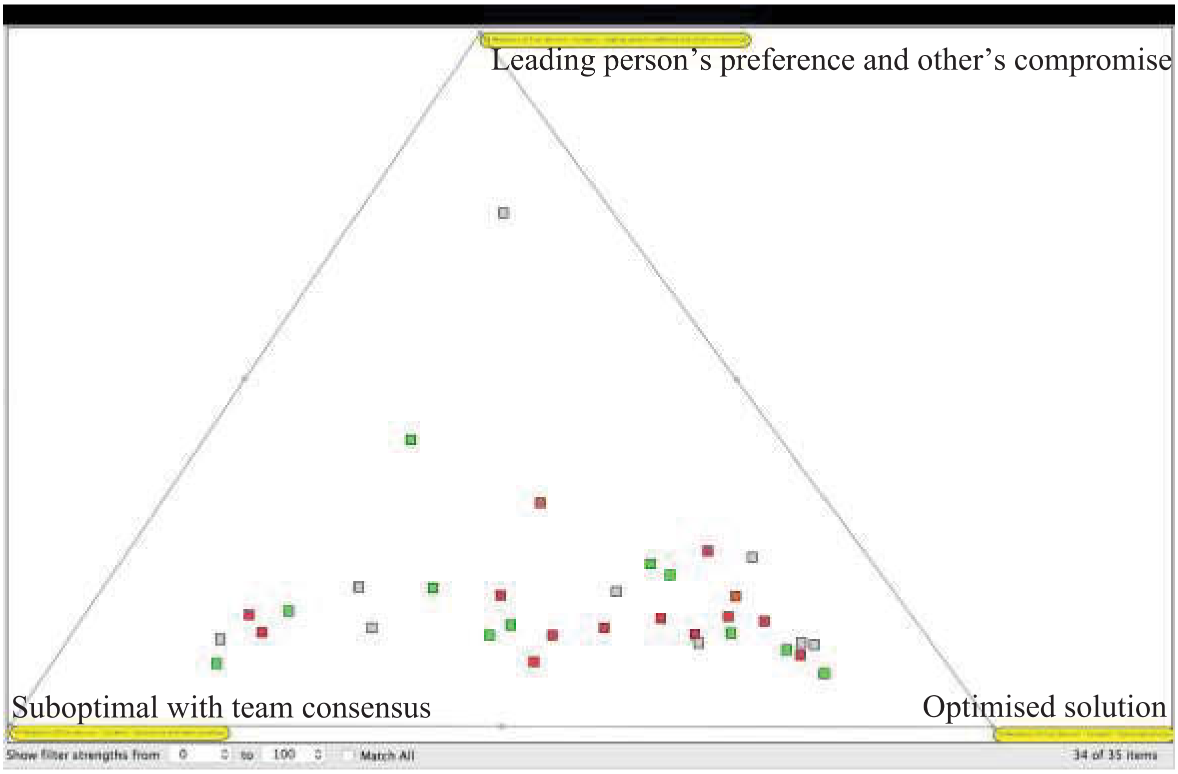


Figure 18 – Pattern for participants' perception on nature of the group decisions – Context 1

Figure 18 shows participants' perceptions of the nature of their final group decisions. Triad-4 asked participants to assess the key-driving factor for their group's final decision using three criteria of a - designated leaders' preference, b - team consensus and c - suboptimal or optimised solutions. Triad 4 illustrates an emphasis on optimised and suboptimal solutions. They reported that the leader's preferences did not have much influence on their final decisions.

A summary of findings in the Figures 14, 15, 16 and 17 illustrates the traditional view of rational decision makers who use rational tools such as cost-benefit to make optimised decisions in a complicated situation. This conclusion could be confirmed, or disconfirmed, through cross checks against pattern responses to multiple choice questions. The patterns after cross checks were compared with base patterns and those cross-check patterns with significant differences against the base pattern were selected for the data analysis. The combined filters were made of each of four Triads and multiple-choice queries as listed from Appendix 4.2 Sensemaking Framework. In doing so, each criterion in a MCQs works as a filter to generate patterns for Triads. This can generate several patterns that must be compared pairwise with the overall pattern of each Triad (without filters) to understand changes to patterns as a result of filters. Those multiple-choice queries that created significant differences in the patterns of Context 1 are listed here:

Participants expressed their feeling in regards to their experience in the simulation in MCQ9. Each feeling was used as a criterion to create a six-filtered pattern for each Triad.

Q9. This simulation makes you feel (Pick up to three)

- ☐ Glad
- ☐ Angry
- ☐ Frustrated
- ☐ Stressed
- ☐ Uncertain
- ☐ Not Sure

MCQ9 was designed to indicate changes of participants' emotions in Context 1 and Context 2 and the impact of emotions on personal decision making.

Participants expressed their perceptions in regards to the challenges that they realised in the Context 1 of the simulation in MCQ10. Each challenge was used as a criterion to create a six-filtered pattern for each Triad.

Q10. Biggest challenges for your group to make final decision is (Pick up to three)

- ☐ Decision making process
- ☐ Individual experience
- ☐ Team work
- ☐ Apply portfolio road map as a tool
- ☐ Understanding your role in the team
- ☐ Informal communication

The MCQ10 has indicated the participants' perceptions on the most important challenges that their group had to undertake during simulation in Context 1. It was also intended to find out responses to this question in Context 2.

In MCQ1, participants remembered their prior experience in the workplace when they tackled situations similar to the scenarios of Hooshmand-1. The five possible answers for MCQ1 was used to create five filtered patterns for each Triad.

Q1. How common is this experience in your organisation?

- One time occurrence
- Somewhat common
- Rare but not isolated
- Very common
- Not Sure

The MCQ 1 has indicated the participants' opinion on any similarity between the experience in the simulation in Context 1 and their previous experience in the workplace. It was intended to find out responses to this question as an indicator of the influence of past work experience on participants' thinking during simulation.

Q7. Your role in simulation Hooshmand 1

- Product Development Unit - PDU Director
- Head of Department Integration and Verification
- Head of Department of Application Development

Participants identified their assigned roles in Context 1 of Hooshmand-1 by choosing one of three roles in the MCQ7. Three filtered patterns of each Triad were created through applying roles to each Triad. It was also intended to find out responses to this question in Context 2. MCQ7 was used to identify shifts of individual opinions because of their roles in the simulation.

The combination of MCQ9, 10, 1 and 7 with Triads 1, 2, 3 and 4 created 16 patterns that were used to cross check against the overall pattern for these Triads. Table 7 summarises 16 patterns where the rows present Triads and the columns present filters from multiple-choice queries. The findings are assessed as "Yes – [Y] or No – [N]" status to illustrate the influence of selected filters in the patterns. The letter "N" indicates that the patterns of the Triad are not sensitive or do not show meaningful change of patterns as a result of using MCQ choices as the filters. Further detail on the Triads' patterns is in Appendix 5.1.

Table 7 – Summary of pattern analyses for Simulation Context 1 with multiple-choice filters

Context1		Signifiers codes	1	2	3	4
	Triad Code	Description of signifiers	Filter – Feeling of the experiment	Filter - Major challenges perception	Filter - Similar previous experience	Filter - Role in the experiment
Pattern Description Per Filter	1	Criteria of decision making in your team tends to	Yes	Yes	Yes	Yes
	2	Your individual decision is driven by	No	Yes	Yes	Yes
	3	Main source of uncertainty in this experiment in your personal opinion is	No	Yes	Yes	Yes
	4	Final decision in your group is focused on	No	Yes	Yes	Yes

The following sections further describe each column of Table 7 and the impacts of the filters on the selected Triads in this table.

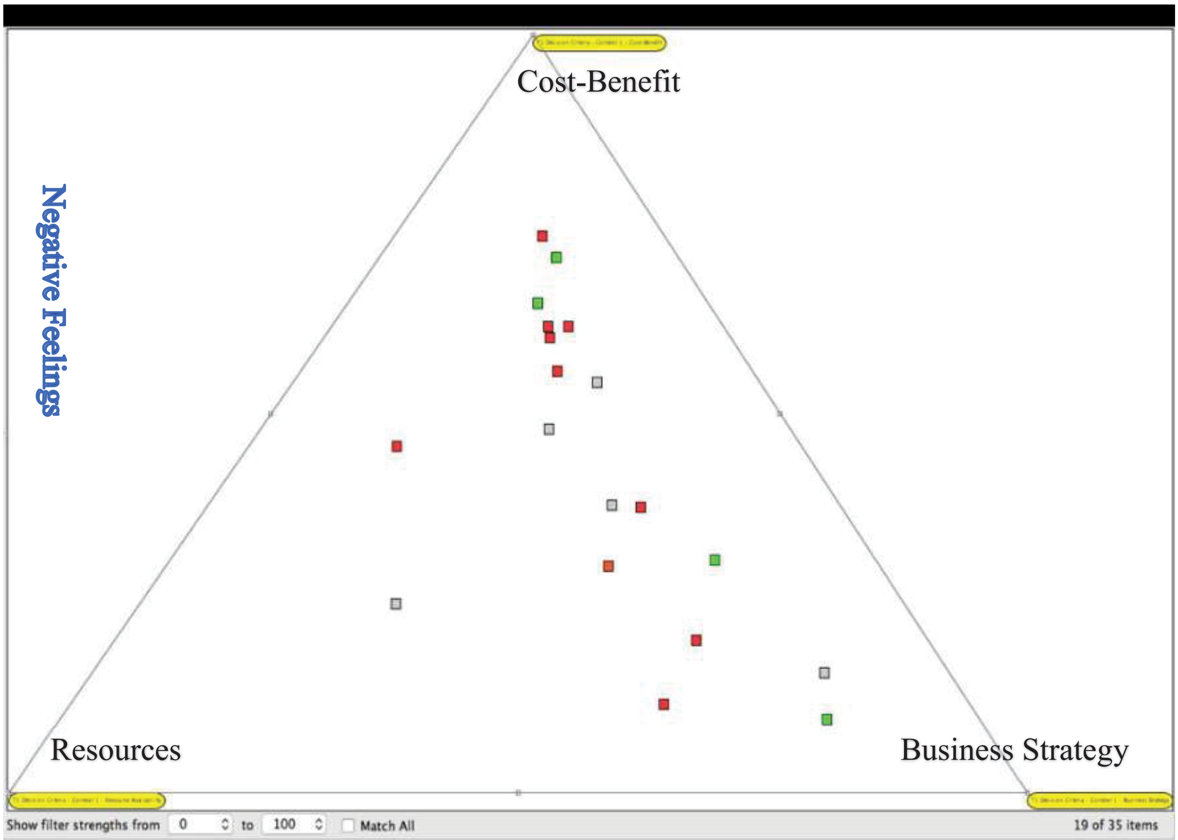
5.1.1 Column 1 - Feeling of participants after decision making in simulation Context1

As evident in Appendix 5.1 Cross Checks between Multiple Choices Queries and Triads, by the degree to which clustering of points differs when compared across specific filters of participants' feelings because of playing in the simulation (Q9) for the

Triads 1, 2, 3 and 4, the data provides support to the theory that feeling influences decision-making behaviour to some extent.

In the multiple choice self-signifier questions, participants were asked to choose a maximum of three choices from a list of five arising feelings—glad, frustrated, stressed, uncertain and not sure—to indicate how they felt in relation to their experience during the simulation. To compare differences in data point patterns related to feeling, separate Triads were constructed for all the narratives self-signified (refer to 4.3.1.3 Simulation Hooshmand-1) under each group of feelings for the first scenario of the simulation. Positive/Neutral feelings—i.e. Glad and Uncertain—were grouped and used as a filter and were compared with negative feelings—angry, frustrated and stressed. Triads 1, 2, 3 and 4 were reconstructed for each group of participants' feelings. After comparing paired patterns with negative and positive feelings for each Triad, changes of patterns were found to be negligible in Triads 2, 3 and 4. Figure 19 illustrates that the pattern of positive feelings shifted towards the centre of Triad 1. This finding could support the theory that emotion has a moderating influence on people's judgment and decision making.

Because the pattern of decision criteria shifted towards the centre of Triad 1, the Triad became more balanced in regard to the relationship among three factors when the negative feelings were changing to positive.


Cost-Benefit
Negative Feelings
Resources
Business Strategy
Show filter strengths from 0 to 100
Match All
19 of 35 items

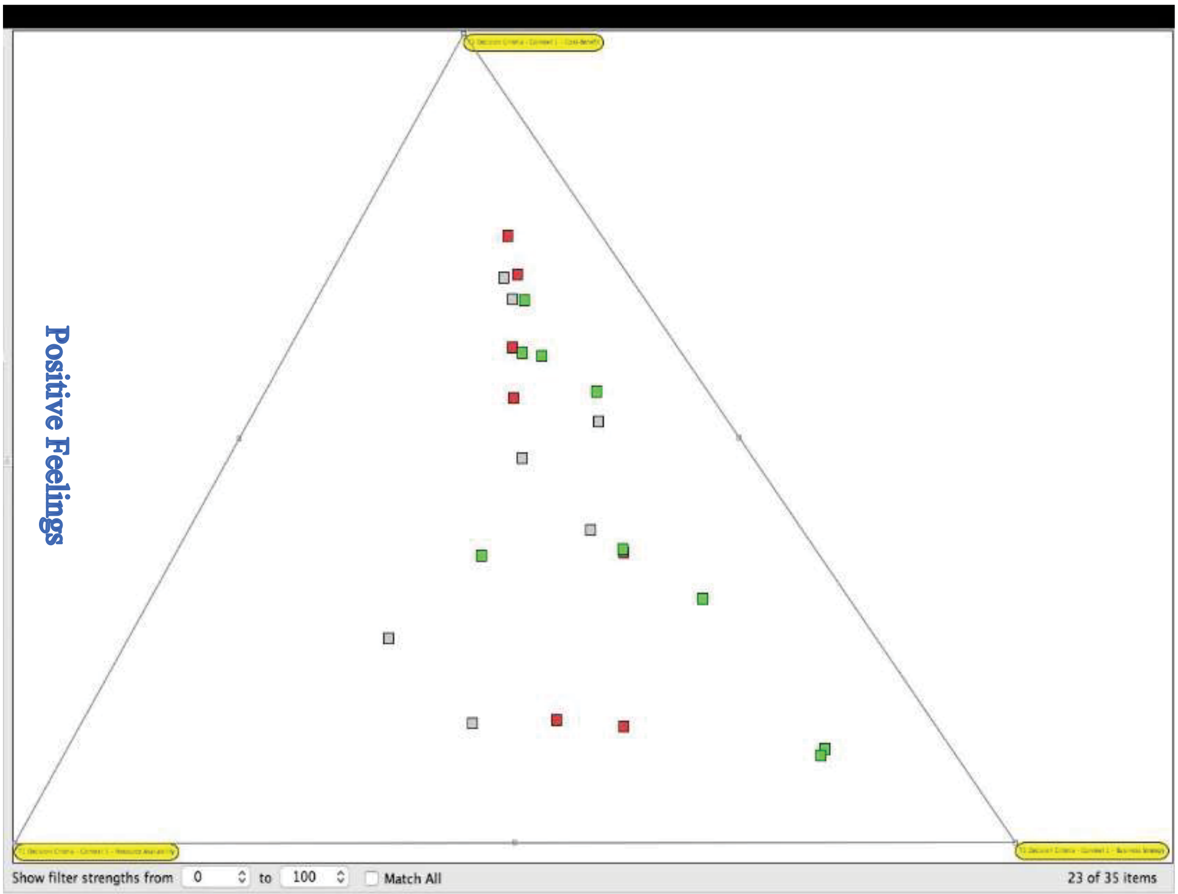


Figure 19 – Paired comparison of negative feelings and positive feelings for Triad 1

5.1.2 Column 2 - Participants' perceptions of major challenges in Context 1

As shown by the degree to which clustering of points differs when compared across specific filters of the perception for major challenges (Q10) for the Triads 1, 2, 3 and 4 (Appendix 5.1 Cross Checks between Multiple Choices Queries and Triads), the data supports the theory that an understanding of roles in the simulation and informal communications among participants influences decision-making behaviour to some extent.

In the multiple choice self-signifier questions, participants were asked to choose a maximum of three from a list of Six phrases—decision-making process, individual experience, team work, use of roadmap, understanding the role and informal communication—to indicate how they perceived challenges in relation to their experience during simulation. To compare differences in data point patterns related to perceptions of challenges, separate Triads were constructed for all the narratives self-signified under each challenge for the first scenario of the simulation. Triads 1, 2, 3 and 4 were reconstructed for each group of participants' perceptions of the biggest challenges they experienced. After comparing each of six filtered patterns with the overall pattern for each Triad, the results highlighted outlier patterns (*4.4.2.2 Theming - micronarratives and categorisation*) for the two filters of informal communications and role understanding across the overall patterns for all Triads; while the other filters—decision-making process, individual experience, team work, use of roadmap—were close to the overall Triads' patterns.

Because the pattern of Triads 1, 2, 3 and 4 is shifting towards the sides of Triads, the Triads are becoming biased in regard to relationships between the three factors when the participants have perceived informal communication among their teams and understanding of their roles in the simulation as key challenges.

5.1.3 Column 3 - Participants' perceptions of simulation Context 1 as similar to their prior experience

This is evidenced by the degree to which clustering of points differs when compared across specific filters of the similar experience in workplaces (Q1) for the Triads 1, 2, 3 and 4 (Appendix 5.1). The data logically supports the concept that prior work experience somehow influences decision-making patterns.

In the multiple choice self-signifier questions, participants were asked to choose one item from a list of five—one-time occurrence, somewhat common, rare but not isolated, very common, not sure—to indicate how they perceived the simulation in relation to their work experience. To compare differences in data point patterns related to previous work experience, separate Triads were constructed for all the narratives self-signified under each challenge for the first scenario of the simulation. Triads 1, 2, 3 and 4 were reconstructed in regard to each group of participants' perceptions for having similar experience to the simulation in their work place. After comparing paired filtered patterns with the overall pattern for each Triad, there was a change in the patterns indicated a slight shift in patterns for the filter 'rare but not isolated' from the overall patterns for all Triads.

Because the filtered pattern of Triads against all other choices in Q1 did not show a significant shift from the overall patterns for Triads 1, 2, 3 and 4, the relationship among three factors for these Triads were approximately insensitive to different choices in Q1. Hence, findings of filtered patterns for other criteria of MCQ1 are insignificant.

5.1.4 Column 4 - Influence of simulation roles on decision-making patterns

It is evident from the degree to which clustering of points differs when compared across specific filters of the roles in Hooshmand-1(Q7) for the Triads 1, 2, 3 and 4 (Appendix 5.1 Cross Checks between Multiple Choices Queries and Triads), the data supported the theory as reported in the simulation chapter that roles may influence decision-making behaviour.

In the multiple choice self-signifier questions, participants were asked to identify their assigned role from the list of three roles—Application Development (AD) Leader, Inspection and Verification (I&V) Leader and Product Development Unit (PDU). They indicated how their roles influenced their decision-making patterns during the simulation. To compare differences in data point patterns related to simulation roles, separate Triads were constructed for all the narratives self-signified under each role for the first scenario of the simulation. Triads 1, 2, 3 and 4 were reconstructed for each role that participants played in simulation Context 1. After comparing filtered patterns with the overall pattern for each Triad, change of patterns indicated that participants in the role of PDU, chose answers close to the three lines of Triads. The patterns filtered, based on other roles—IV and AD—were close to the overall Triads' patterns and diverted to the centre of Triads.

Because the change of filter to the role of PDU shifted the pattern of Triads 1, 2, 3 and 4 to a broader pattern than the overall patterns, the relationship among three factors for these Triads became balanced for participants in the PDU role.

The pattern analysis of results in Section 5.1, showed a rational approach to problem solving occurred when decision making was happening in the complicated domain of knowledge.

Further cross checking against MCQs revealed new findings. The first significant finding was that 'feeling' as an indicator of participants' responses during decision making, played an influential role in the emerging patterns of opinions in relation to decisions and the decision-making process in PPM in the first scenario of the simulation. Participants taking part in the first scenario for the first time claimed that having an understanding of their role requirements, and communications within their team with other team members, appeared as the biggest challenges for them when making final decisions. As far as the prior experience of participants was concerned, it was not shown as having a significant impact on patterns of opinions for decision matters. Lastly, but not least, having a role had an impact on the patterns for people who played as a director of Product Development Unit (PDU), who demonstrated a different pattern of opinions in relation to decision-making processes and final decisions compared to the two other roles in each group of the simulation in Context 1.

5.2 Patterns - 2nd Scenario of Simulation

The findings of scenario two are summarised in the Figures 19 to 24 which present the results of Triads 6 to 13. Some of these Triads are repeated from the first scenario (Context 1) to compare and understand shifts as a result of changes of environment between Context 1 and Context 2.

Triad 6 – Your individual decision is driven by… ?

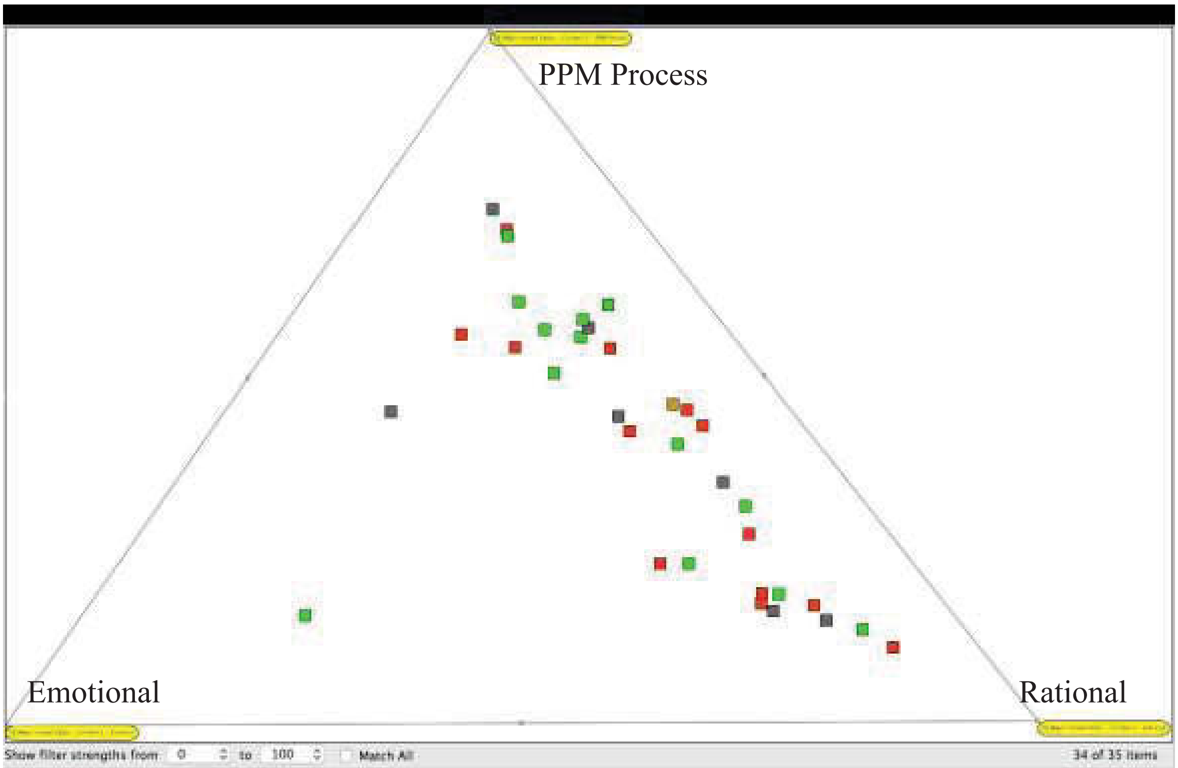
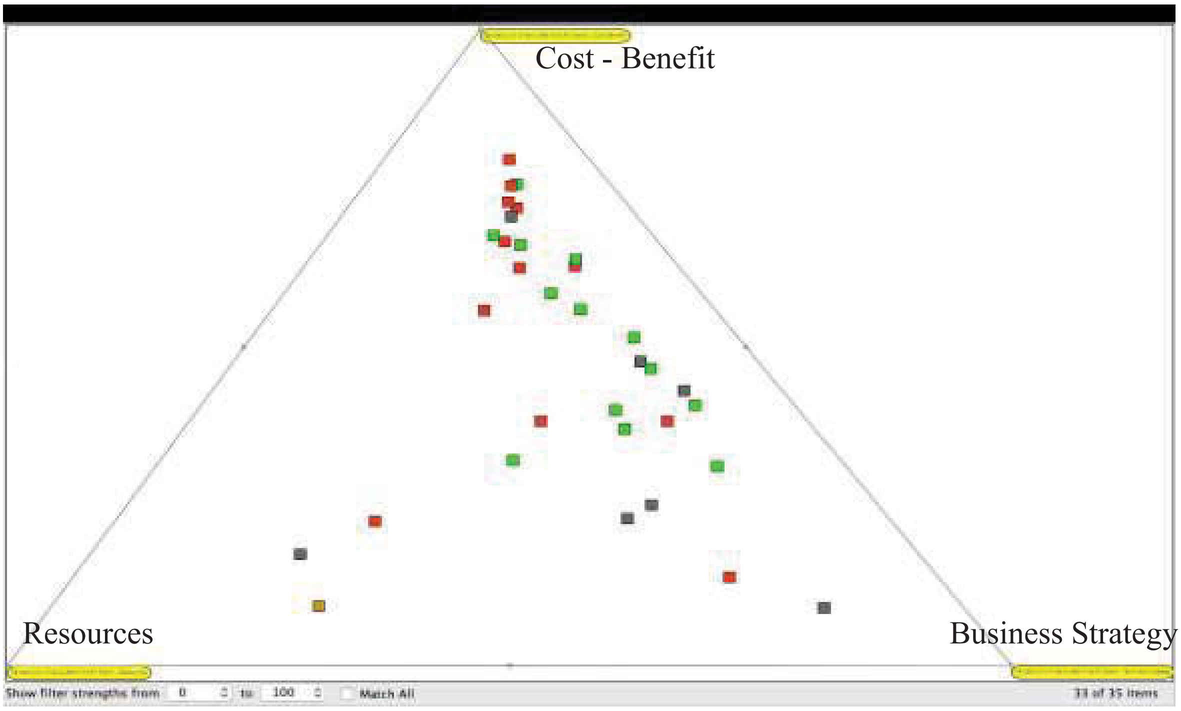


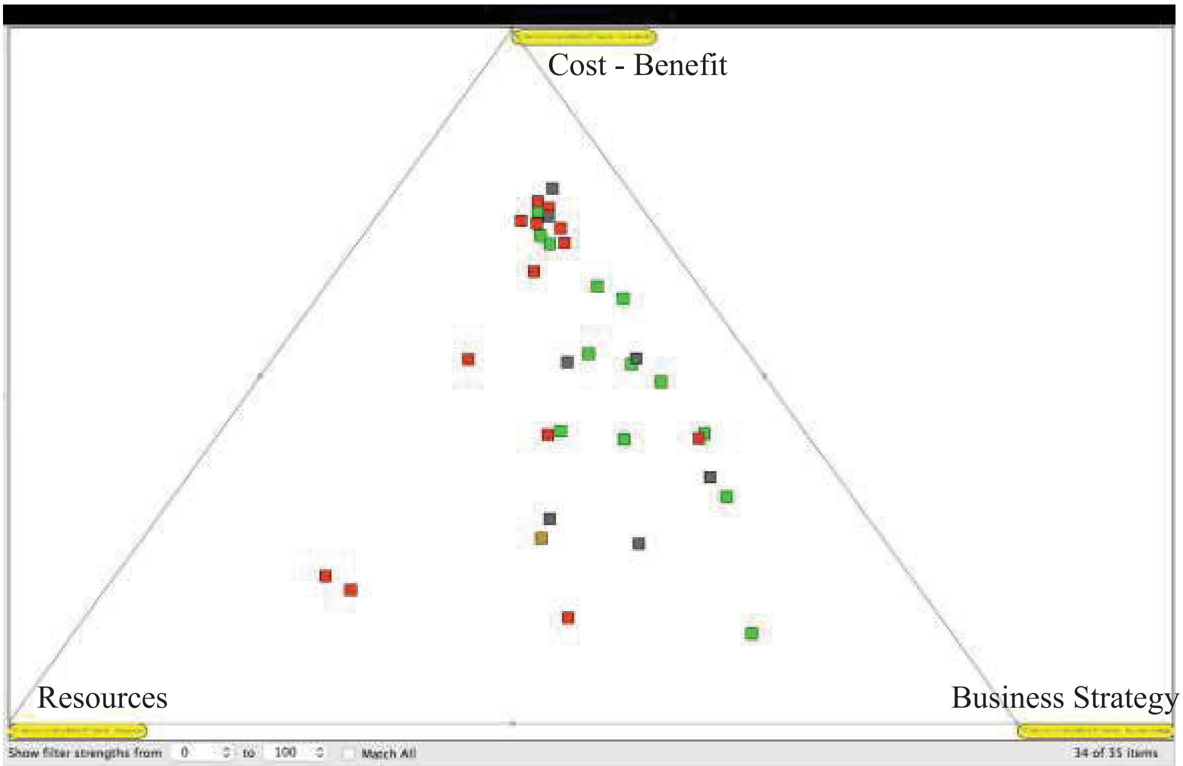
Figure 20 – Pattern shows impact factors on individual decisions in Context2

Figure 20 shows the key impact factors which could have influenced personal decision making in Context 2 of the simulation as recorded in Triad-6. The findings for this Triad were close to the pattern of Triad-2 from the first scenario and the majority of participants chose a position between tactical decision making (PPM process) and rationale. As a result, participants appeared to declare that emotion did not influence their final decisions according to their individual perceptions.

Triad 7 – Criteria of decision making in your team in the beginning are focused on… ?



Triad 8 – Criteria of decision making in your team after cancellation of project by the client shift to … ?



Triad 9 – Criteria of decision making in your team after Organisational changes shift to …?

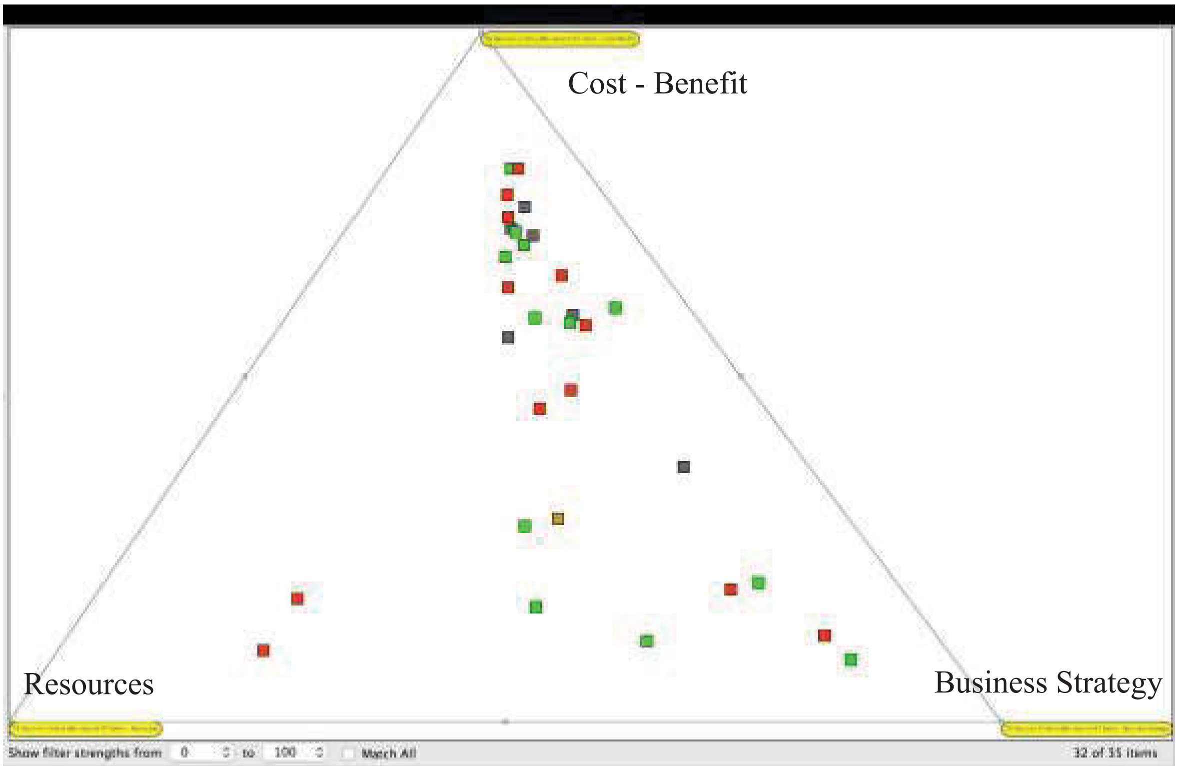


Figure 21 – Patterns for participants' opinions on preferred decision criteria in their group – Context2

Figure 21 shows participants' opinions in the Context 2 of Hooshmand-1 as recorded in Triads 7, 8 and 9. The repeating Triads were meant to be used as an indicator to collect participants' opinions after placing them in different situations (occasions) in Context 2 of the simulation.

Triad-7 asked for participants' opinion for decision criteria of the second scenario. A clear shift of patterns from Triad 1 to Triad 7 was visible. The majority of participants shifted their preference to some extent towards cost – benefit. The pattern of Triad 7 remains almost constant in Triads 8 and 9.

Triads 8 and 9 re-assessed participants' opinions for decision criteria after each of the two real-time events a - cancellation of a project and b - change of company leader. As evident by the degree to which clustering of points differ when compared across Context 1 and 2 of the perception for decision criteria for the Triads 1, 7, 8 and 9, the data supports the observation of a change of objective between the two scenarios from a cost saving strategy in scenario 1 to a profit maximisation strategy in scenario 2.

Nevertheless, the real-time events do not appear to change the patterns in the second scenario of the simulation Hooshmand-1.

Triad 10 – My groups adopts decision-making Processes because… ?

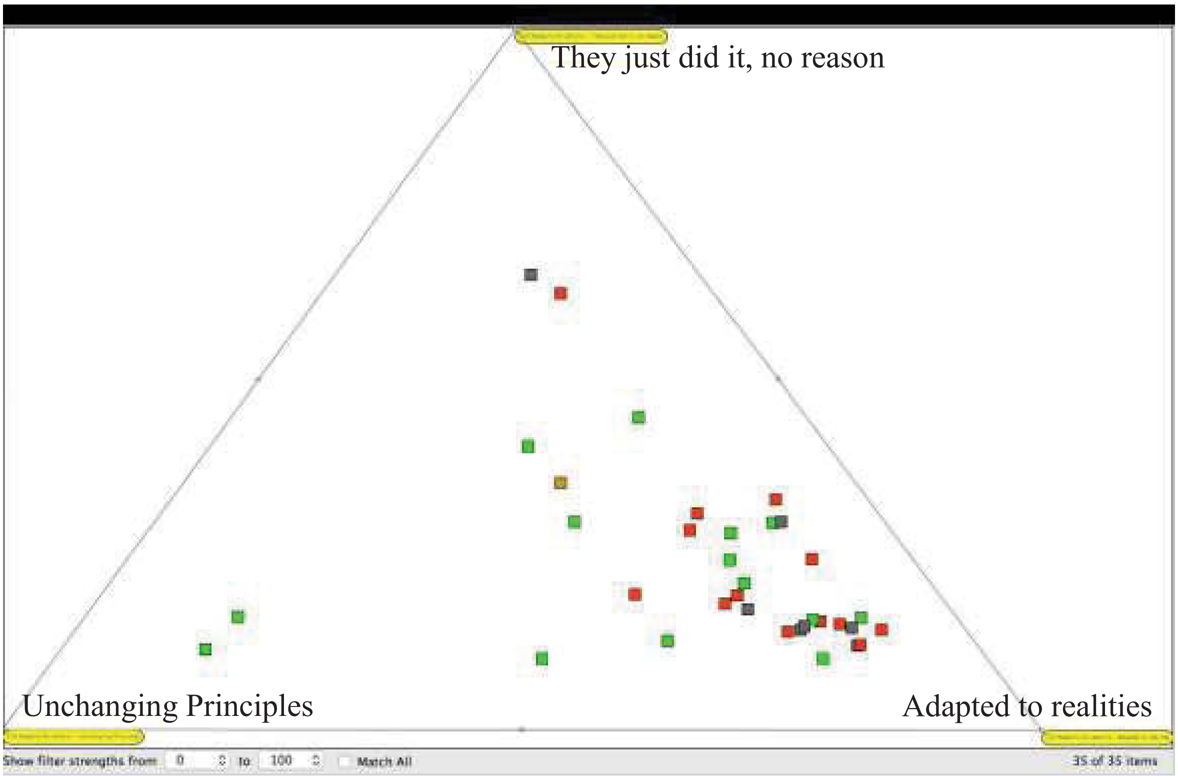


Figure 22 – Individual perception on their group adaptation to changes

Figure 22 shows the pattern for individual opinions on how their groups reacted to the changing situations in Context 2 of the simulation as recorded in Triad 10. Triad 10 was an indicator to assess the source of resilience in the group decision making during the simulation. Most participants expressed their preference was to adapt to change during decision making. This was evident by the number of opinions close to the pole—adapted to reality—as shown in Figure 9. Only two of 33 participants selected a view to either Unchanging Principles or the third pole of Triad 10.

Triad 11 – My perception is that the most important factor to overcome real-time events…?

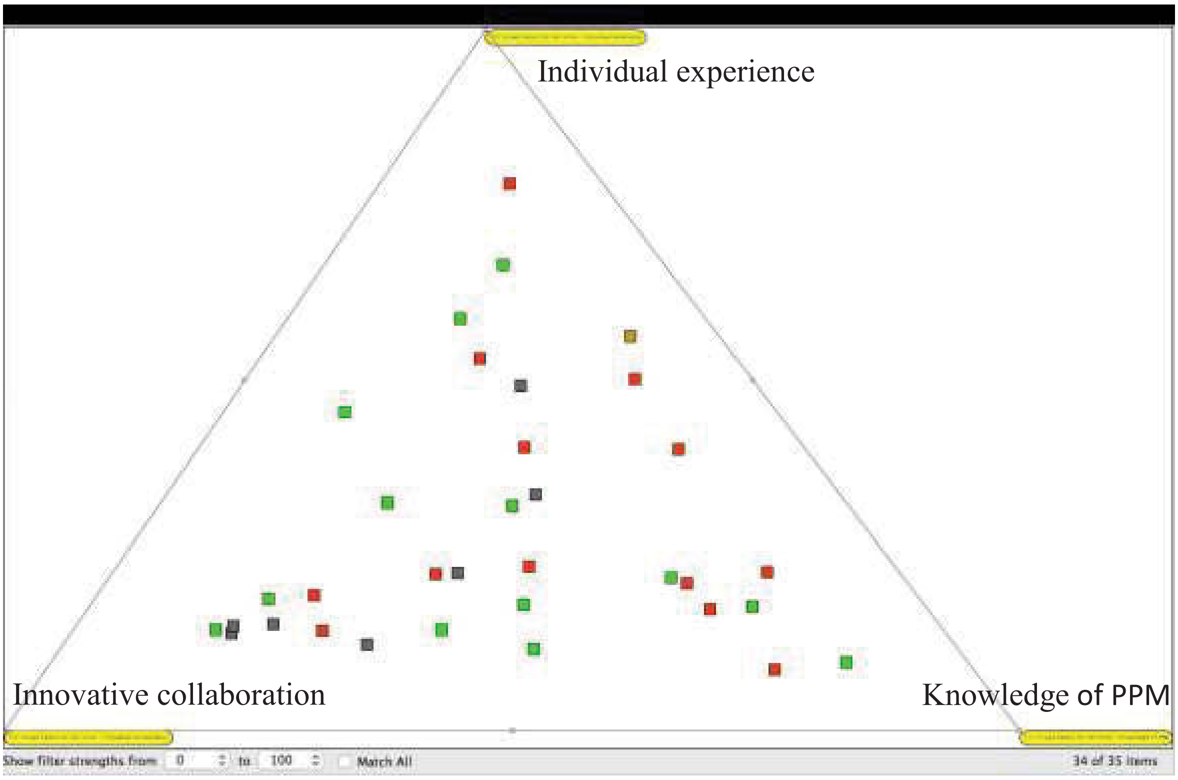


Figure 23 – Pattern of perceptions for aiding factors to overcome real-time events

Figure 23 shows the results of participants' perceptions as recorded in Triad-11. Triad 11 reported on perceptions about the most important factor that helped them manage real-time events. Although the pattern is quite scattered, there are some apparent tendencies towards innovative collaboration as a key factor to overcome uncertainty during decision making.

Triad 12 - Main source of uncertainty in this experiment in your opinion is …?

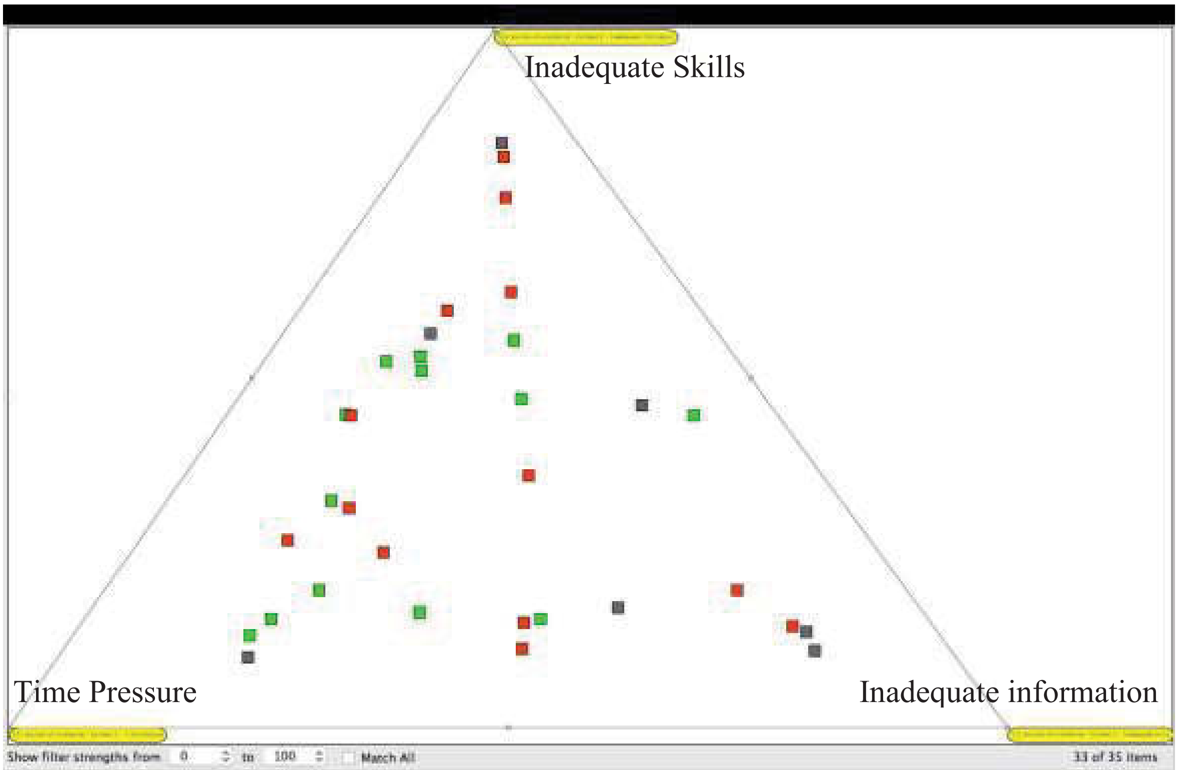


Figure 24 – Pattern for participants' perception on sources of uncertainty – Context 2

The Figure 24 depicts Triad-12 which shows the pattern of personal opinions on how they saw sources of uncertainty in the second scenario of the simulation. This Triad was designed to assess participants' perception about the way they understood factors influencing their degree of uncertainty during the simulation. Additionally, Triad-12 was a tracker for patterns of Triad-3.

Triad-12 reported participants' personal opinions on the main sources of uncertainty during the decision-making process. The responses demonstrated more emphasis on inadequate information and time pressure, than on the skills of participants. However, having compared the pattern of Triad-12 and Triad-3, participants indicated more significance relating to the role of decision-makers' skills in the second scenario than that shown in the pattern of Triad-3.

Triad 13 – Final decision in your group is focused on…?

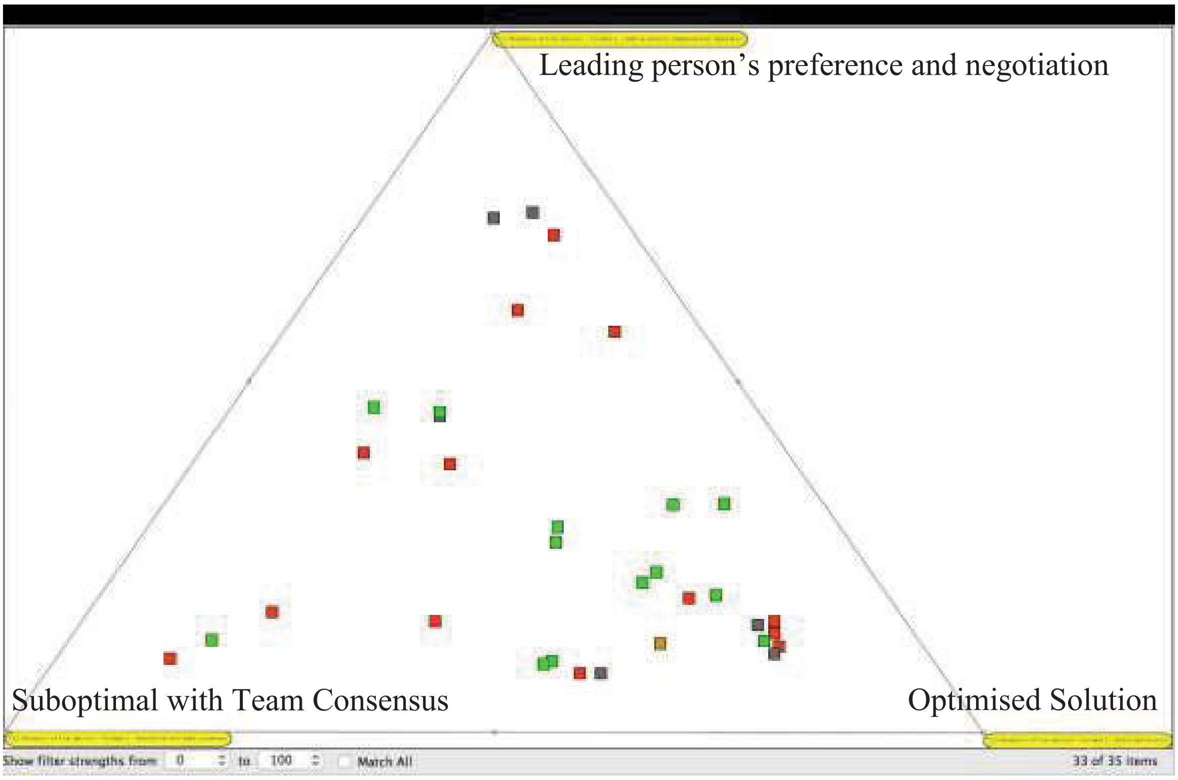


Figure 25 – Pattern for participants' perception on nature of the group decisions – Context 2

Figure 25 depicts Triad-13 and shows the summary of participants' perceptions in relation to group decision making in the second scenario of the simulation. Triad-13 also provided a tracking pattern for Triad-4 in order to understand potential shifts in the participants' opinions when they made decisions in an uncertain situation.

Triad-13 reported participants' perceptions of their final decision in the simulation, and the result was unevenly distributed among the three criteria of a - as the leaders' preference, b - optimal and c - suboptimal. However, there was more concentration on optimised solutions than on the two other poles. As there was a correlation between rational decision making and optimised thinking, the findings correlated with Triad-6 where the majority of people point to rational decision making.

Comparing the patterns of Triad-13 to Triad-4, indicates that participants allocated more significance to the role of the leading person's preference and power of negotiation during uncertainty (a complex situation) than is shown in Triad-3, which depicts responses within a complicated situation.

In summary, findings of Triads and MCQs in the Figures above show that real-time events and uncertainty about making decisions in a complex situation influences the decision process, final decisions and decision makers' perceptions. Other key findings emphasised decision-makers' skills, capacity for collaboration under pressure, leadership and power of negotiation.

This conclusion could be confirmed or disconfirmed through cross checks against patterns of responses in the multiple-choice questions. The combined filters were made of each of eight Triads and five multiple choice queries as listed from Appendix 4.2 Sensemaking Framework.

Participants expressed their feeling in regards to their experience in the Context 2 of the simulation in MCQ14. Each feeling has been used as a criterion to create six filtered patterns for each Triad.

Q14. This simulation makes you feel (pick up to three)

- ☐ Glad
- ☐ Stressed
- ☐ Angry
- ☐ Uncertain
- ☐ Frustrated
- ☐ Not sure

The MCQ 14 was designed to indicate changes of participants' emotions in Context 2 and the impact of emotion on personal decision making.

Participants expressed their perceptions for what they realised as key challenges in the Context 2 of the simulation in MCQ15. Each challenge has been used as a criterion to create six filtered patterns for each Triad.

Q15. Biggest challenges for your group for making final decision is (pick up to three)

- ○ Decision making process
- ○ Individual experience
- ○ Team work
- ○ Apply portfolio road map as a tool
- ○ Understanding your role in the team
- ○ Informal communication

The MCQ15 has indicated the participants' perceptions on the most important challenges that their group had to undertake during simulation in Context 2.

Participants expressed their perceptions for what they experienced after organization change as a real-time event in Context 2 of the simulation in MCQ17. Each answer was used as a criterion to create three filtered patterns for each Triad.

Q17. My perception is that real-time event; organisation change, influences decision-making process

- Positively, helping to achieve strategic objectives
- Negatively, interfering and no help for final decision
- Neutrally, having no impact

The MCQ17 has indicated the participants' opinion on the impact of organisation change on decision-making processes in Context 2. It was intended to discover responses to this question as an indicator to understand the type of impact that participants perceived because of unexpected change in the organisation management team.

Participants identified their assigned roles in Context 2 of Hooshmand-1 by choosing one of three roles in the MCQ12. Three filtered patterns of each Triad, which were used after Context 2 of the simulation, were created through applying roles to each Triad.

Q12. Your role in context 2 of simulation Hooshmand 1

- Product Development Unit - PDU Director
- Head of Department Integration and Verification
- Head of Department Application Development

The MCQ12 was used to identify shifts of individual opinions because of participants' roles in the simulation.

Participants expressed their perceptions for what they experienced after the cancellation of a project by the client as a real-time event in Context 2 of the simulation in MCQ16. Each answer was used as a criterion to create three filtered patterns for each Triad.

Q16. My perception is that real-time event; cancellation of project, influences decion-making process

- ○ Positively, helping to achieve strategic objectives
- ○ Negatively, interfering and no help for final decision
- ○ Neutrally, having no impact

The MCQ 16 indicated the participants' opinion on the impact of project cancellation on decision-making processes in Context 2. It was intended to find out responses to this question as an indicator to understand the type of impact that participants perceived because of unexpected project cancellation by the client.

For the second scenario, six selected Triads and five filters are extracted from the findings. Thirty patterns are illustrated through the rows for Triads and the columns for filters from multiple choices in Table 9. The findings were assessed as "Yes (Y) or No (N)" to illustrate the influence of selected filters on the patterns. The letter "N" meant that the patterns of the Triads were not sensitive to the relevant filters in the columns.

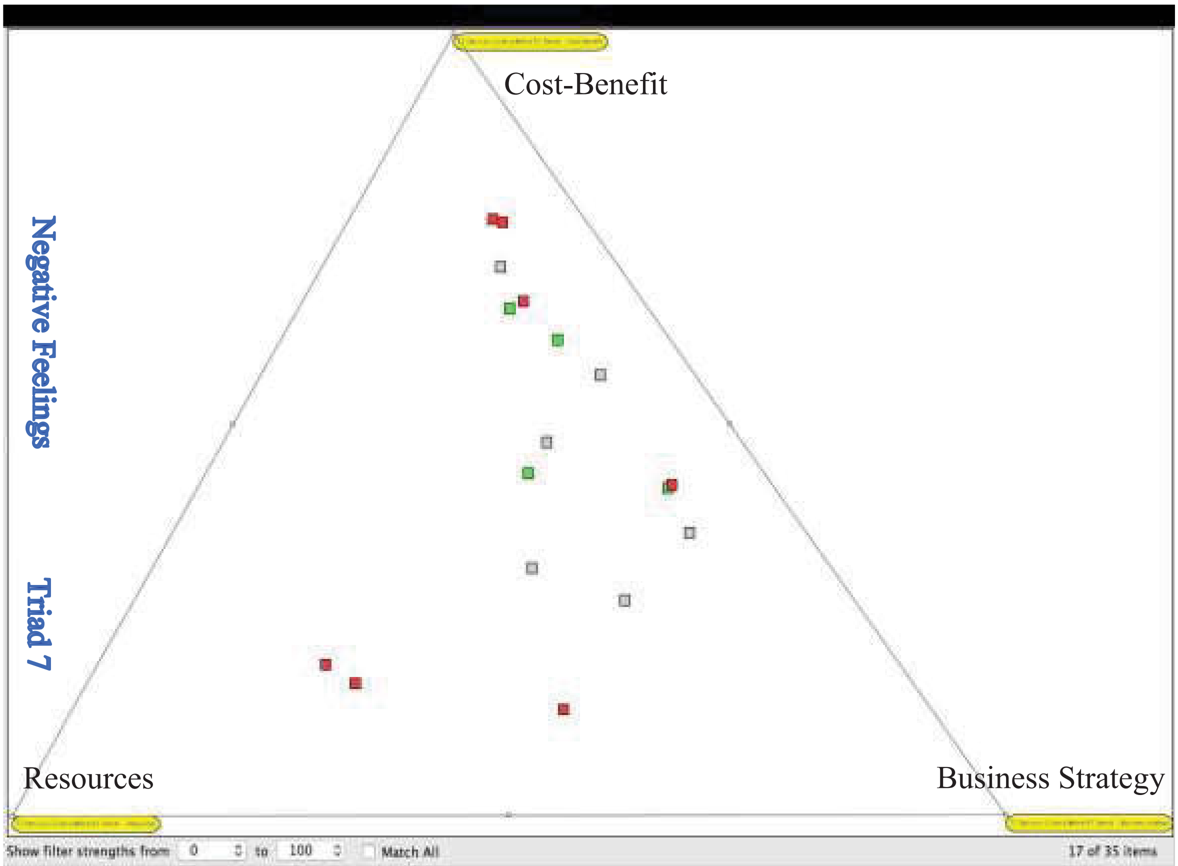
Context2		Signifiers codes	1	2	3	4	5
	Triad Code	Description of signifiers	Filter –Feeling of the experiment	Filter - Major challenges perception	Filter – Organisation change	Filter -Role in the experiment	Filter - Cancellation of a project
Pattern Description Per Filter	6	Your individual decision is driven by	No	Yes	No	Yes	No
	7	Criteria of decision making in your team in the beginning are focused on	Yes	Yes	No	Yes	No
	8	Criteria of decision making in your team after cancellation of projects by clients shift to	Yes	Yes	No	Yes	No
	9	Criteria of decision making in your team after organisation change shift to	Yes	Yes	No	Yes	No
	10	My group adopts decision-making process because	Yes	Yes	No	Yes	No
	11	My perception is that the most important factor to overcome real-time events	Yes	Yes	No	Yes	No
	12	Main source of uncertainty in this experiment in your personal opinion is	Yes	Yes	No	Yes	No
	13	Final decision in your group is focused on	Yes	Yes	No	Yes	No

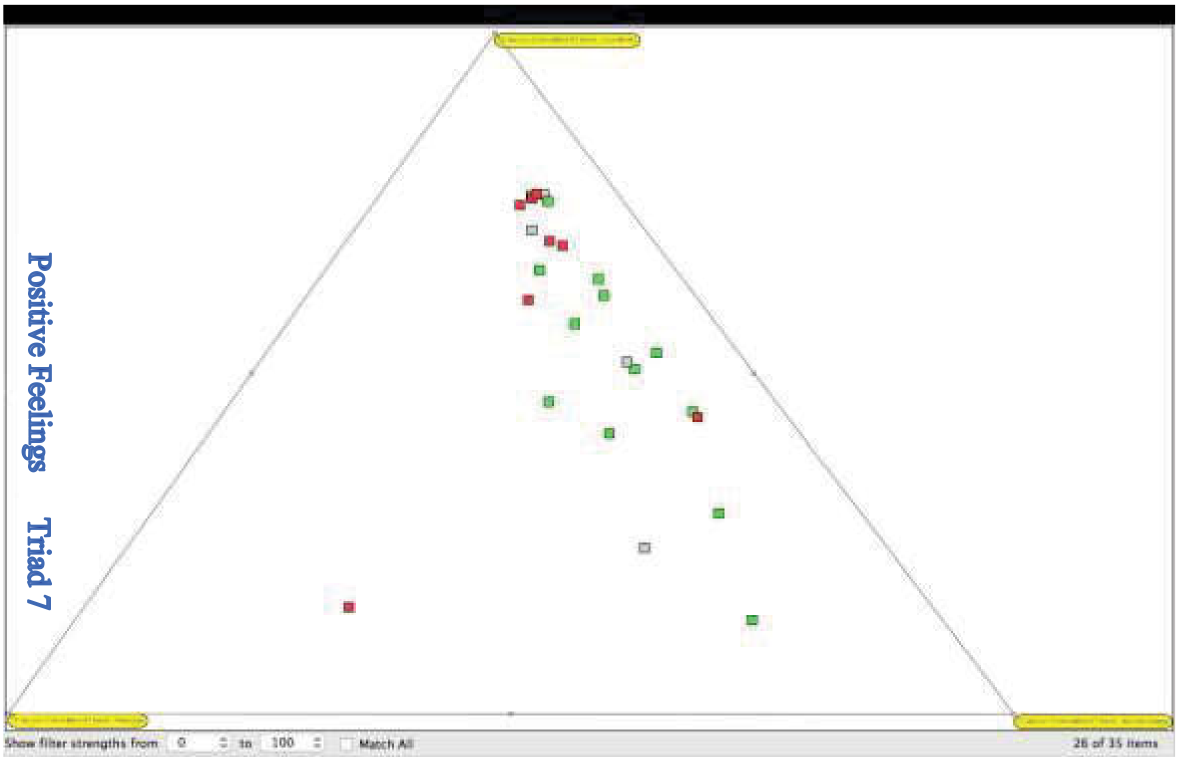
Table 8 – Summary Findings – Scenario 2

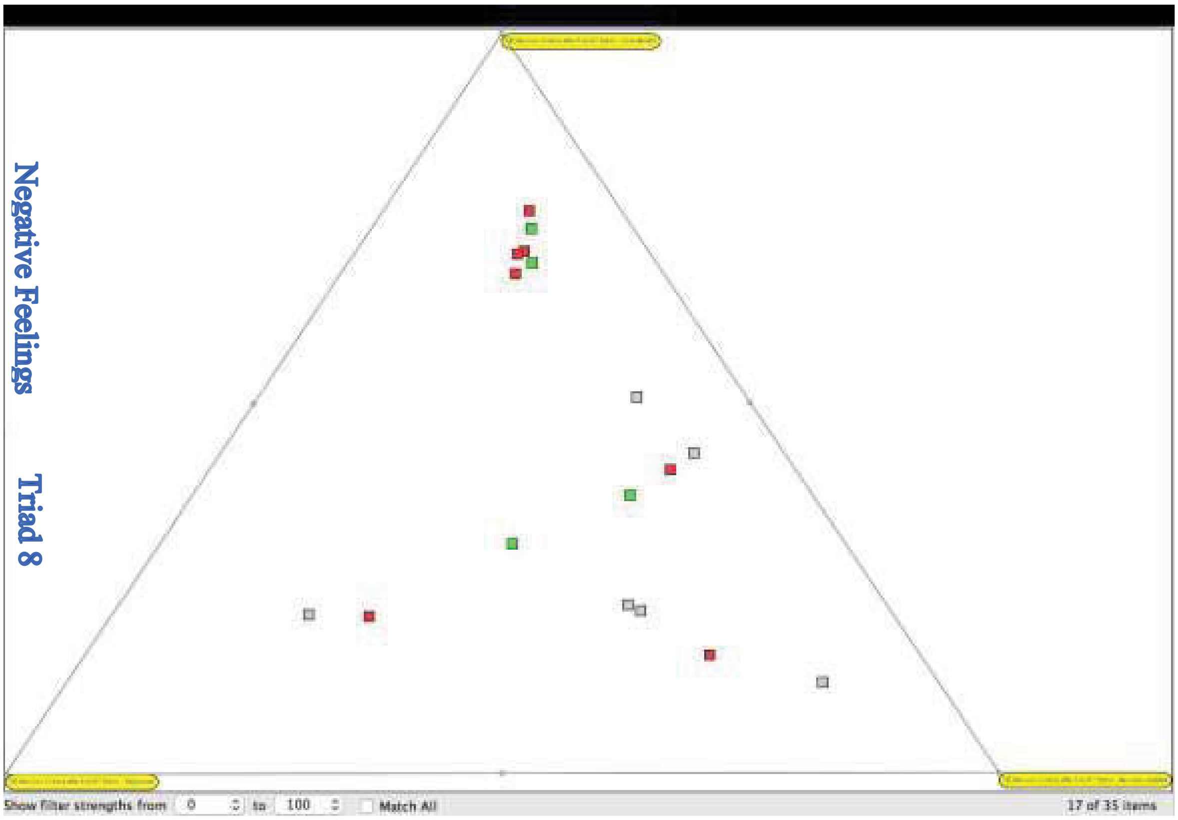
5.2.1 Column 1 - Feeling of participants during decision making in Context2

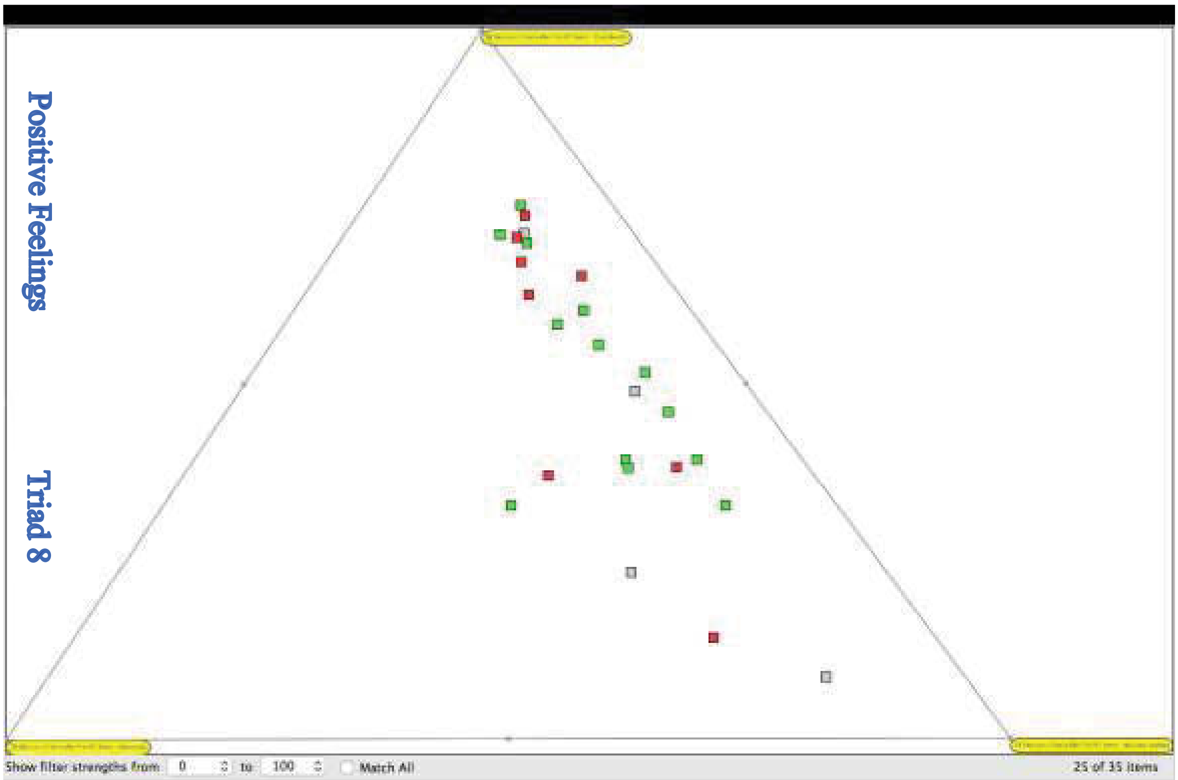
As evident by the degree to which clustering of points differs, when compared across specific feeling filters for the Triads 6 to 13, the data supports the theory that feeling influences decision-making behaviour. The influence of feeling on decision making was more significant in Context 2 than in the responses to Context 1.

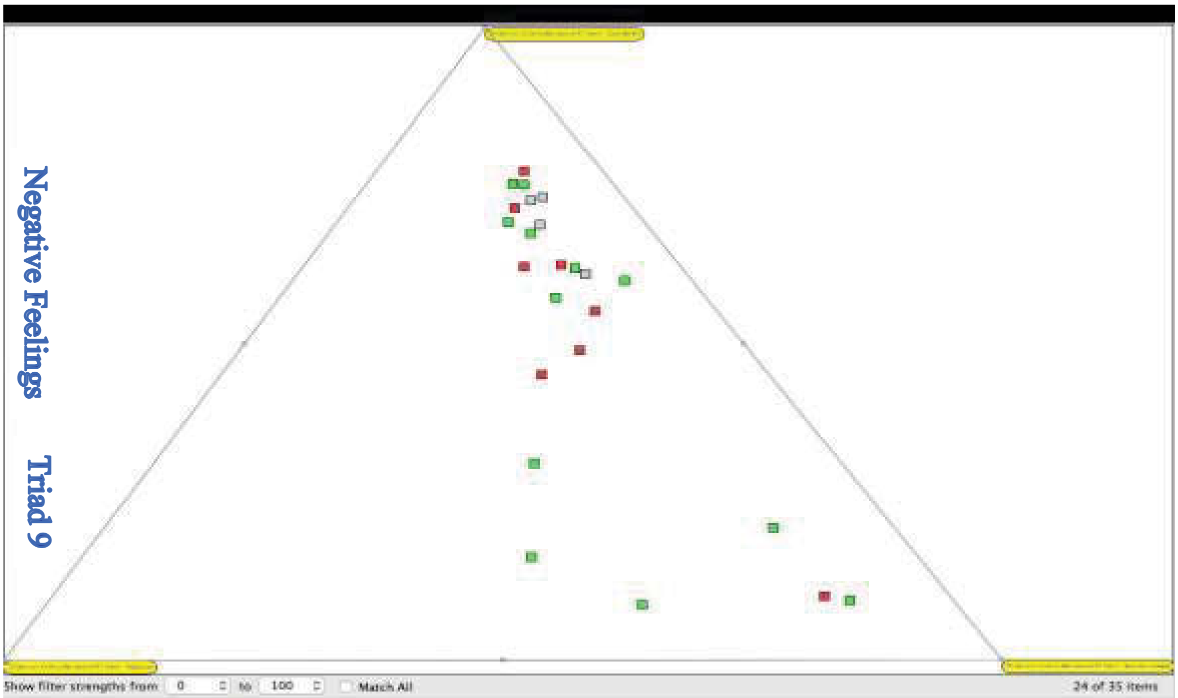
In the multiple choice self-signifier questions, participants were asked to choose a maximum of three words from a list of five (glad, frustrated, stressed, uncertain and not sure) to indicate how they felt in relation to their experience during the simulation. To compare differences in data point patterns related to feeling, separate Triads were constructed for all the narratives self-signified under each group of feelings for the first scenario of the simulation. Positive/Neutral feelings—Glad and Uncertain—were grouped and used as a filter versus negative feelings—angry, frustrated and stressed. Triads 6 to 13 were reconstructed for each group of participants' feeling. After comparing paired patterns with negative and positive feelings for each Triad, changes of patterns were found to be negligible in Triad 6.




Positive Feelings
Triad 7
Show filter strengths from 0 to 100 Match All
26 of 35 items


Negative Feelings
Triad 8
Show filter strengths from 0 to 100 Match All
17 of 35 items


Positive Feelings
Triad 8
Show filter strengths from 0 to 100
Match All
25 of 35 items


Negative Feelings
Triad 9
Show filter strengths from 0 to 100
Match All
24 of 35 items

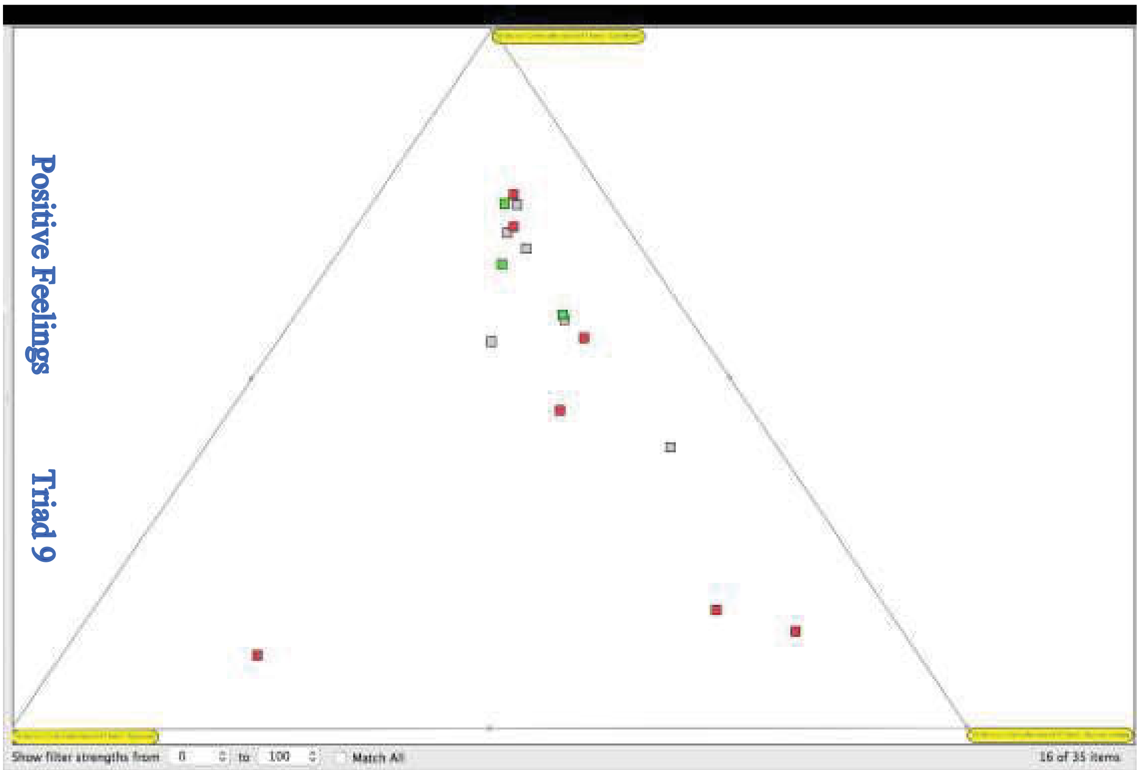


Figure 26 – Comparison of positive vs. negative feelings and their impacts on decision-making patterns

Figure 26 illustrates that positive feelings shifted the pattern to the top of Triads 7 and 8 (Cost Benefit) while Triad 9 had a different pattern change to the bottom (Business Strategy or Resources Availability). As Triad 9 asked questions about the impact of the second real-time event, the data showed a shift of patterns with the changes of feelings from the first event to the second event of Context 2 of the simulation. Furthermore, positive feelings shifted the pattern to the bottom centre of Triads 10, 11, 12 and 13 (Figures are available in the Appendix 5.1). These findings support the theory that emotion has a moderating influence on people's judgment and decision making.

5.2.2 Column 2 - Participants' perceptions of major challenges in simulation Context2

As evident by the degree to which clustering of points differs when compared across specific filters of the perception for major challenges in regard to the Triads 6 to 13 (Appendix 5.1), the data provided evidence that understanding of roles in simulation, teamwork and communications may influence decision-making behaviour.

In the multiple choice self-signifier questions, participants were asked to choose a maximum of three words from a list of six (decision-making process, individual experience, team work, use of roadmap, understanding the role and informal communication) to indicate how they perceived challenges in relation to their experience during the second scenario of simulation. To compare differences in data point patterns related to perceptions of challenges, separate Triads were constructed for all the narratives self-signified under each challenge for the first scenario of the simulation. Triads 6 to 13 were reconstructed for each group of participants' perceptions of the biggest challenges they experienced. After comparing paired filtered patterns with the overall pattern for each Triad, the results indicated outlier patterns for filters team work, communications and role understanding from the overall patterns for all Triads while other filters—decision-making process, individual experience and use of roadmap—were close to the overall Triads' patterns.

For example, Triad 9 has an overall scattered pattern among three poles. After applying filters teamwork and role understanding distinctly, the reconstructed patterns illustrated a shift to the top of the Triad. The data indicates a focus on cost benefit as the preferred decision criteria for participants who perceived the teamwork or role understanding as key challenges for their decision making.

5.2.3 Column 3 - Participants' perceptions of real-time event – organisation change – in simulation Context 2

As evident by the degree to which clustering of points does not differ when compared across specific filters of the perception for organisation change for the Triads 6 to 13 (Appendix 5.1), the data provided evidence that the perception of organisation change did not influence the pattern generated in these Triads.

In the multiple choice self-signifier questions, participants were asked to choose one of three choices from a list: positively, helping to achieve strategic objectives; negatively, interfering and no help for final decision; and, neutrally, having no impact. This indicated how they perceived the impact of organisational change in relation to their experience during the second scenario of simulation. To compare differences in data point patterns related to perceptions for the organisation change and its impact on decision-making processes, separate Triads were constructed for all the narratives self-signified under each challenge for the first scenario of the simulation. Triads 6 to 13 were reconstructed for each group of participants' perceptions for the biggest challenges they experienced. After comparing paired filtered patterns with the overall pattern for each Triad, the results indicated no significant change in these patterns. Nevertheless, the limited number of participants perceived the organisational change as a neutral real-time event.

Because the pattern of Triads 8 and 9 shifted towards resources availability, the Triads became balanced in regard to the relationship among three factors when the participants had perceived impacts of project cancellation as positive, and impacts of organisation change as negative, in the second context of the simulation.

5.2.4 Column 4 - Influence of simulation roles on decision-making patterns

As evident by the degree to which clustering of points differed when compared across specific filters of the perception for major challenges for the Triads 6 to 13 (Appendix 5.1), the data supported the theory that participants' professional background may influence decision makers' behaviour.

In the multiple-choice self-signifier questions, participants were asked to identify the assigned role from a list—AD or Application Development Unit Leader, IV or Inspection and Verification Unit Leader and PDU or Product Development Unit PMO (Project Management Office) —to indicate how their roles influenced their decision-making patterns during simulation. To compare differences in data point patterns related to simulation roles, separate Triads were constructed for all the narratives self-signified under each role for the first scenario of the simulation. Triads 6 to 13 were reconstructed for each role that participants played in the simulation Context 2. After comparing paired filtered patterns with the overall pattern for each Triad, the change of patterns indicated that participants in the role of AD, with broader patterns than the overall patterns for all Triads, while other filters—IV and PDU—were close to the overall Triads' patterns.

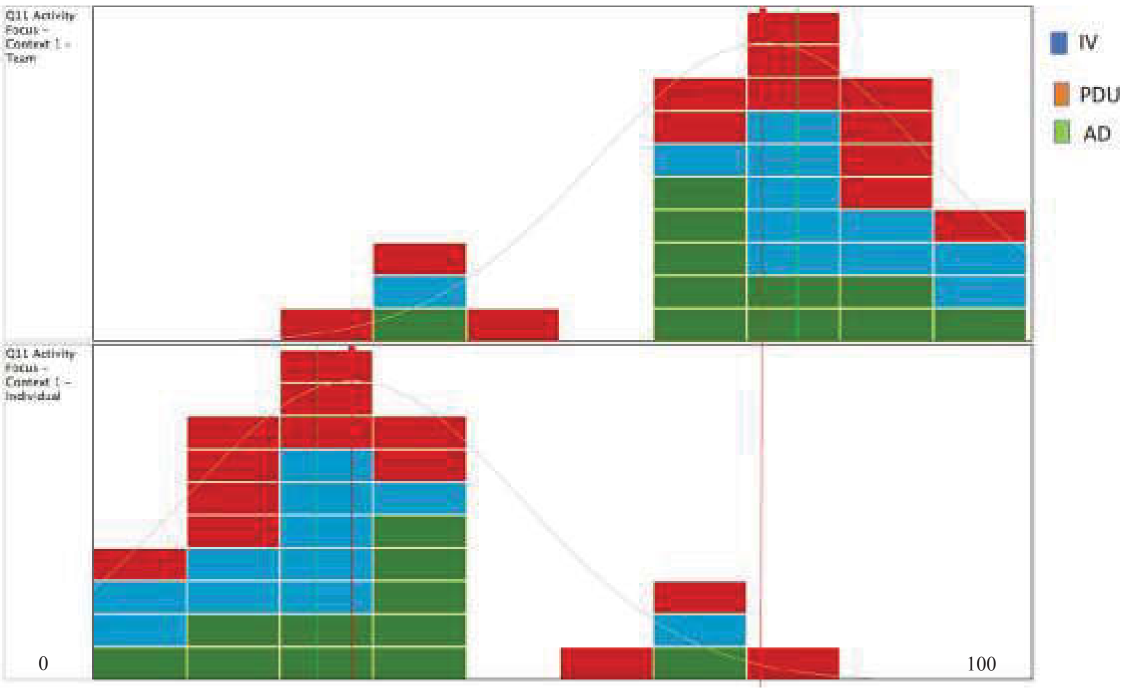
As a role rotation occurred in the beginning of Context 2, the shift of patterns from PDU to AD between Context 1 and Context 2, perhaps indicated the influence of individual background to the roles and decision-making patterns.

5.2.5 Column 5 - Participants' perceptions of real-time event – cancellation of project - in simulation Context 2

As evident by the degree to which clustering of points does not differ when compared across specific filters of the perception for cancellation of the project by the client for the Triads 6 to 13 (Appendix 5.1), the data provided evidence that the perception of cancellation of project by a client does not have significant influence on the patterns generated in these Triads.

In summary, emotion was proven to be an influential factor in decision-makers' Judgement. This was supported by the moderating impact of real-time events in the simulation on decision-makers' views on decision criteria. Influence of individual background to the roles they played as an impact on decision making was evident.

5.2.6 Dyad - 2 Distributions



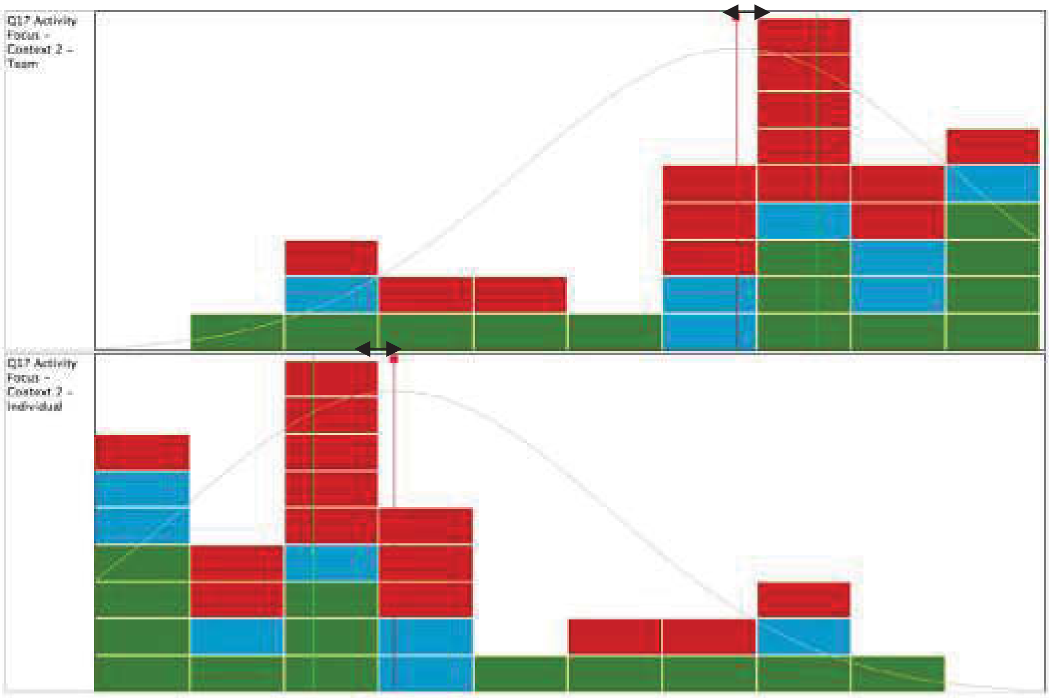


Figure 27 – Focus of team vs individuals in Context1 and Context2

The two Dyads items of Questions 11 and 17 (repeated twice in the questionnaire), were used as indicators for any change to team work because of different contexts in the simulation Hooshmand-1. Each distribution showed how participants perceived team work versus individualism as the core of activity they experienced in each context of Hooshmand-1. Comparison of histograms in Questions 11 and 17 showed the mean of participants who claimed team at the centre of decision-making activity was significantly greater than individuals, regardless of the context in simulation. However, Figure 27 shows a slight decrease to the mean of distribution in Context 2 in comparison to Context 1. This indicated a slight shift to individualism when groups were exposed to real-time events such as the group leader rotation, or cancellation of projects by clients.

5.3 Micronarratives and fragments

As noted in Chapter 4, section *4.4.2.2 Theming - micronarratives and categorisation*, the fragments were extracted from micronarratives (stories provided by the simulation participants for their experience of turning points in the simulation) and assessed against the characteristic of Cynefin domains as shown in Table 9. These characteristics were used as a source of themes to allocate fragments to Cynefin domains. Fragments were extracted from participants' micronarratives and reflected their views on their experiences during simulation Contexts 1 and 2. Included in Appendix 5.2, individual fragments were drawn from the micronarratives. The fragments were considered in relation to three parameters: a) Cynefin domains of knowledge used for decision making; b) experience of real-time events; and, c) turning points, within those events. Participants provided a name to their micronarrative, a list of the turning points to decision making and some short descriptions for the experience at the end of each simulation scenario. The criteria for selecting micronarratives were based on the quality of micronarratives including: 1–identification of turning points; 2–identification of real-time events; and, 3–a clear fragment for each turning point or real time event. After reviewing 66 data sets, 21 data sets were selected for the micronarrative analysis. Twenty-one participants who provided micronarratives that were suitable for theming analysis, are listed in the Table 10 . These fragments were assessed to identify three distinct clusters:

1. Cluster 1–people identified real-time events and noted the influence on the decision-making process; e.g. " Before the cancellation of program 4, we had a list of potential projects that we wanted to choose for this exercise" was in the simple domain of known information. "After briefing the CEO and explaining them the situation, we came to a disagreement" indicated the dis-ordered domain.
2. Cluster 2–people identifed turning points other than real-time events and named their impacts on the decision-making process; e.g. " initially it was not clear for me that the first thing we needed to do was calculate the total numbers", was assessed as the Chaos domain. Or "we could go easier with the second-year projects", indicated the complicated domain.
3. Cluster 3–People identified turning points other than real-time events, but did not indicate that these had any impact on the decision process. e.g. "Interpreting the data and the interdependencies on the spreadsheet was most difficult", or, "we've focused on scheduling of programs with high NPV. ENPV and Resource fit", were understood as indicating the complicated domain.

These analyses were constructed on the basis of David Snowden's table for leadership styles **(Snowden & Boone, 2007, p. 73)** and Cynefin domains as presented in Table 9.

Table 9 – A Leader's Framework for Decision Making (Snowden & Boone, 2007, p. 73)

	THE CONTEXT'S CHARACTERISTICS	THE LEADER'S JOB	DANGER SIGNALS	RESPONSE TO DANGER SIGNALS
SIMPLE	Repeating patterns and consistent events Clear cause-and-effect relationships evident to every-one; right answer exists Known knowns Fact-based management	Sense, categorize, respond Ensure that proper processes are in place Delegate Use best practices Communicate in clear, direct ways Understand that extensive interactive communication may not be necessary	Complacency and comfort Desire to make complex problems simple Entrained thinking No challenge of received wisdom Overreliance on best practice if context shifts	Create communication channels to challenge orthodoxy Stay connected without micromanaging Don't assume things are simple Recognize both the value and the limitations of best practice
COMPLICATED	Expert diagnosis required Cause-and-effect relationships discoverable but not immediately apparent to everyone; more than one right answer possible Known unknowns Fact-based management	Sense, analyze, respond Create panels of experts Listen to conflicting advice	Experts overconfident in their own solutions or in the efficacy of past solutions Analysis paralysis Expert panels Viewpoints of nonexperts excluded	Encourage external and internal stakeholders to challenge expert opinions to combat entrained thinking Use experiments and games to force people to think outside the familiar
COMPLEX	Flux and unpredictability No right answers; emergent instructive patterns Unknown unknowns Many competing ideas A need for creative and innova-tive approaches Pattern-based leadership	Probe, sense, respond Create environments and experiments that allow patterns to emerge Increase levels of interaction and communication Use methods that can help gener-ate ideas: Open up discussion (as through large group methods); set barriers; stimulate attractors; encourage dissent and diversity; and manage starting conditions and monitor for emergence	Temptation to fall back into habitual, command-and-control mode Temptation to look for facts rather than allowing patterns to emerge Desire for accelerated resolution of problems or exploitation of opportunities	Be patient and allow time for reflection Use approaches that encourage interaction so patterns can emerge
CHAOTIC	High turbulence No clear cause-and-effect rela-tionships, so no point in looking for right answers Unknowables Many decisions to make and no time to think High tension Pattern-based leadership	Act, sense, respond Look for what works instead of seeking right answers Take immediate action to reestablish order (command and control) Provide clear, direct communication	Applying a command-and-control approach longer than needed "Cult of the leader" Missed opportunity for innovation Chaos unabated	Set up mechanisms (such as parallel teams) to take advantage of opportunities afforded by a chaotic environment Encourage advisers to challenge your point of view once the crisis has abated Work to shift the context from chaotic to complex

Effective leaders adapt their decision style to suit the domain of knowledge they experience at specific moments (Snowden & Boone, 2007). Table 9 describes what characteristics decision makers should pursue in each domain of knowledge in the Cynefin framework. The first column of the table explains some characteristics that are associated with each domain of knowledge in the Cynefin framework. The second column, Leaders' Job, outlines approaches and key actions on which a leader should embark to reach an effective decision. The third column, Danger Signals, explains some of signs that shows a wrong direction in each related domain of knowledge. The last column describes key actions that a leader for a decision-making practice should take to counter those danger signals and reduce unintended consequences of decision making in a changing environment. These characteristics were used as themes to interpret and categorise fragments for each turning point in the micronarratives. The details are available in Appendix 5.2.

Table 10 shows the codes assigned to 21 selected participants in the micronarrative analysis to make it easier to reference and to explain the individual stories which are categorised in clusters 1, 2 and 3. The first column shows the code that is used in text. The second column shows the group colour that each participant played in the simulation. The third column from left shows the role assigned to each player in the simulation scenario about which they provided micronarratives. The fourth column from left shows the number of simulations which the participants played which should be a numbered from 1 to 4. The last column shows the number of clusters that participants were categorised into as based on criteria described in the introduction of Section 5.3 Micronarratives and fragments.

Table 10 – List of participants selected for three clusters

Code Either number or pseudonym	Group Colour	Role	Workshop number	Cluster
1	White	AD	1	1
2	Green	IV	2	
3	Green	AD	3	
4	White	AD	3	
5	Green	IV	4	
6	Green	PDU	4	
7	White	PDU	1	2
8	Red	IV	1	
9	White	IV	1	
10	Green	IV	2	
11	White	AD	2	
12	Red	PDU	2	
13	Green	IV	3	
14	White	IV	3	
15	Red	AD	4	
16	Green	IV	4	
17	Green	AD	4	
18	Gold	PDU	4	
19	Green	PDU	1	3
20	Red	PDU	3	
21	Green	PDU	4	

5.3.1 Cluster 1 - participants describe the influence of real-time events

Shifts and movements between Cynefin domains are considered significant as they affect the decision process. Participants whose responses contributed to the first cluster were able to recognise that events occurring during the simulation had impacts on the decision making. The six participants, whose responses are in this cluster, described different sequences of changes in decision making as a result of real-time events. While these participants were not aware of the domains of Cynefin framework, their micronarratives described an awareness of events and influences on their decision making.

5.3.1.1 Shift from Simple domain to Chaos

Analysis of fragments from all participants are presented in detail in Appendix 5.2. As an example, the step-by-step analysis for fragments of Participant 1 is presented. The details of fragments are as follow:

*Name of Narrative***:** *Positive and negative aspects of change*

Turning Points:

1. cancellation of program 4 2. change of CEO

Fragments associated with each turning points in order of time:

1-1 Before the cancellation of program 4, we *<u>had a list of potential projects</u>* *that we wanted to choose for this exercise. (Referring to known condition or Simple Domain)*

1-2 We quickly *<u>discussed</u>* *the* *<u>changes</u>* *and decided on a strategy to move forward. (Discussion and Changing environment outline Complex Domain)*

1-3 We started *<u>prioritising</u>* *them (using techniques such as prioritisation is specific to complicated domain)*

2-1 After briefing the CEO and explaining the situation to them, we came to a *<u>disagreement</u>* *(Disagreement points out dis-order)*

2-2 so that we *<u>could not move forward</u>* *and fully complete the task (Lack of progress because of conflicts and high tensions outlines a Chaotic domain)*

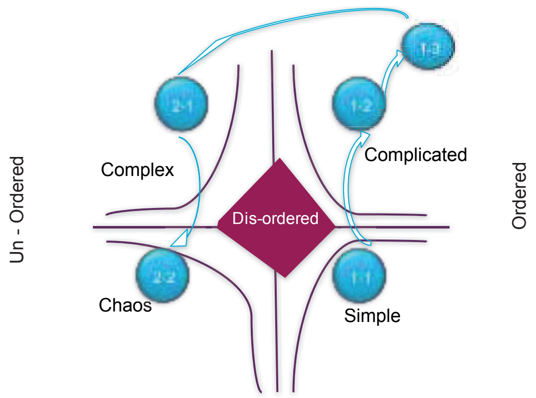


Figure 28 – Transition of domains from simple to chaos

Figure 28 demonstrates these movements among the different domains, which indicate changes of decision-making approaches as a result of real-time events.

Participant 1 recorded two real-time events in the second scenario of Hooshmand-1. The known situation as indicated in the underlined text of Section 1-1 outlines the simple domain in the beginning. The cancellation of a project triggers a shift to the complex domain where discussions among teammates help raise awareness on the changing situation in as described in Section 1-2. The increased understanding moved them to the complicated domain where prioritising techniques helped decide outcomes. The second real-time event–change of lead–shifted them to the Complex and Chaos domains and agreement was not reached. As per fragments 2-1 and 2-2 which described turning points after second real-time events, the group engaged in an endless discussion which indicated the Chaos domain.

5.3.1.2 Shift from Complicated domain to Complex

Participant 2 identified real-time events in the sequence shown in Figure 29. The first real-time event forced the team to re-evaluate their work because of the emerging situation. The decision-making domain shifted to the Complicated domain when an analytic approach was adopted. Figure 29 demonstrates the movements in different domains, and indicates a change of decision-making approach because of the real-time events.

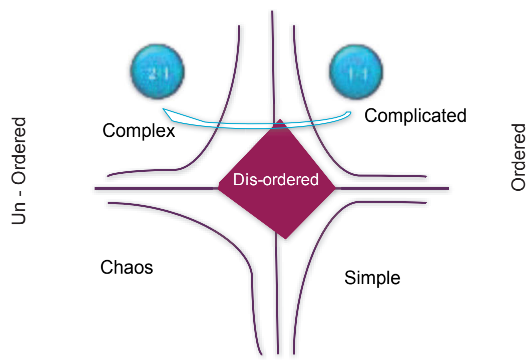


Figure 29 – Transition domains from complicated to complex

5.3.1.3 Movements between complicated and complex domains

Participant 3 recorded two real-time events. The future backwards approach (see Table 3)—the method that lists chronological events from end to the beginning of an event (details in Chapter 2)—is used to list the turning points. The group commenced the work in the Complicated domain where the expectation from headquarters was known to teammates, and they needed to use their analytical expertise to find the solution. The change of team leader shifted the domain to complex as the new member had different expectations that emerged as a new strategy. However, the group shifted back to the complicated domain through discussion and knowledge sharing. For the follow-on steps and cancellation of a project as the second turning point, the group kept their decision making consistently in the complicated domain.

.

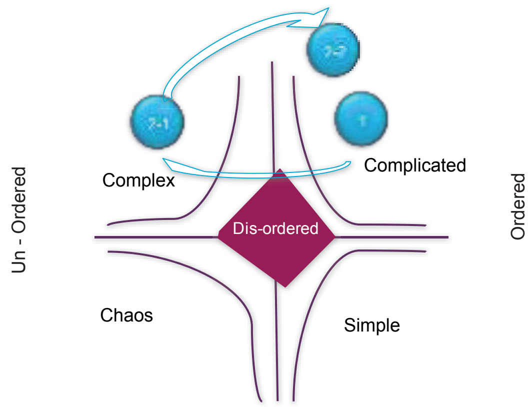


Figure 30 – Transition domains between complicated and complex

Figure 30 demonstrates movements between the different domains, indicating changes of decision-making approaches because of real-time events.

5.3.1.4 Shift from Chaos to Dis-ordered domains

Participant 4 identified that there were two real-time events and used the future backwards approach to list turning points and fragments. In the beginning, self-confidence helped this participant to use the known elements in the next context; hence it resembled a simple domain. Because cancellation of the project was a real-time event, the group wasted time to recalculate, which indicated working in the chaos domain. When the new team leader arrived, it shifted the decision making into the dis-order domain as the conflict arose with different perspectives to find solutions.

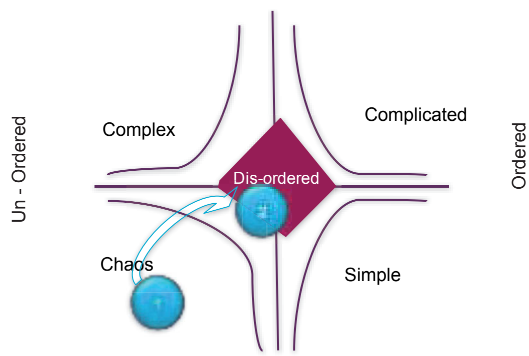


Figure 31 – Transition domains from chaos to dis-order

Figure 31 demonstrates transition from the chaos to the disorder domain indicating a change of decision-making approach because of real-time events.

5.3.1.5 Shift from dis-ordered to complicated domains

Participant 5 recorded two real-time events, but the fragments described the impact of only one of the two on the decision process. The cancellation of a project shifted the group from confusion and conflict on a side-line matter (how to define probability), to a more relevant practice in the simulation that moved the decision making from disorder to the complicated domain where they started working on known information with analytical tools. Figure 32 demonstrates the movements in different domains, which outlines a change of decision-making approach because of the real-time events.

.

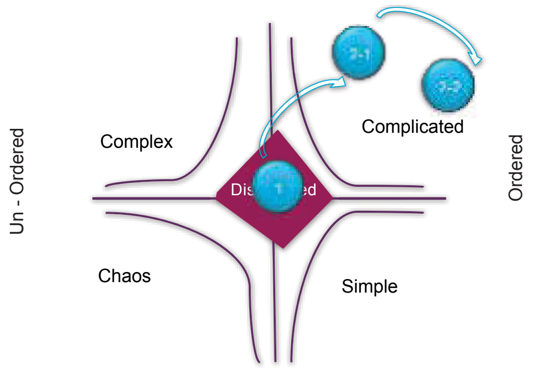


Figure 32 – Shift domains from dis-order to complicated

5.3.1.6 Movements between Complicated and Complex domains

Participant 6 reported two real-time events. The future backwards approach was used to write the fragments. The cancellation of a project was treated positively, hence there was no change to the Complicated domain to use analysis and expertise to find the best solutions. But the second real-time event moved the new group into Complex, as the PDU could not cope with the change properly. Eventually the group ended up with final decisions in the complicated domain. Figure 33 demonstrates the movements between two domains, indicating changes of decision-making approaches because of the real-time events.

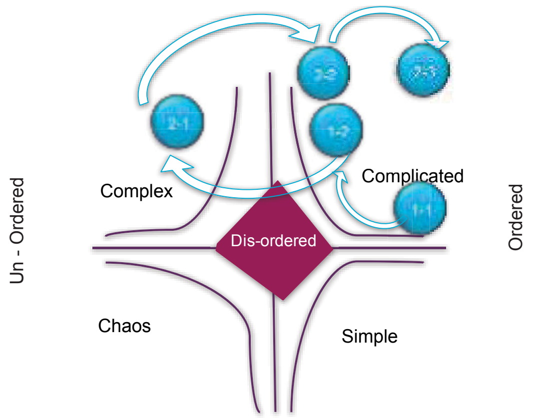


Figure 33 – Shift domains between Complicated and Complex

In summary, the six participants who provided information for the cluster 1 identified two real-time events (organisation change and cancellation of projects) which were designed in the second scenario of simulation to disrupt the decision-making process.

The approach of individuals to resolve uncertainty during decision making had been very different. The overall observation on the movements in the diagrams in this cluster is evident for a changing decision-making approach through moments of moving between domains of knowledge in the Cynefin framework. A further detailed finding emphasises that team leaders or PDUs had a key role in guiding the group decision making through fruitful processes. While some groups could overcome the uncertainty as a result of real-time events and re-settle the decision-making process such as Figure 18, some groups just lost direction and could not make any progress such as Figure 16. This is also evidence for the importance of Group Decision-making skills and Team Cognition as critical success factors in the PPM committees while they faced uncertainties during decision making. This will be discussed further in the discussion Chapter 6.

5.3.2 Cluster 2 - participants claim the influence of turning points

The second cluster of fragments are from participants who understood the turning points in the first scenario of the simulation and explained the impacts on their decision processes. Twelve participants recognised the influence but described different patterns of change in the decision-making process as a result of turning points.

5.3.2.1 Shift from Chaos to Complicated domain

Participant 7 reported the lack of clear direction in the beginning, indicating the group commenced their work in Chaos. Through the following patterns, the decision process shifted from Chaos to Complex where the group followed patterns and finally the analysis occured in the Complicated domain. Figure 34 demonstrates the movements in different domains, which outlines a change of decision-making approach because of the turning points.

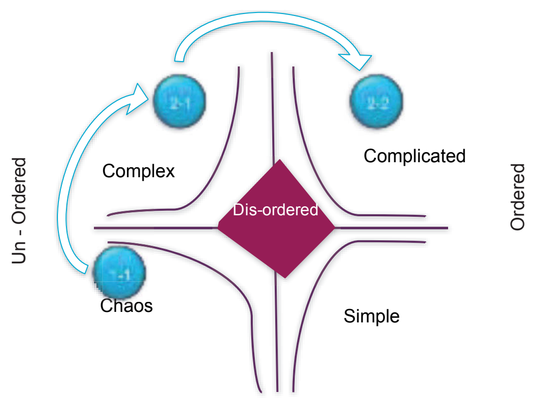


Figure 34 – Shift from Chaos to Complicated domain

5.3.2.2 Transition from Chaos to Complicated domain

Participant 8 indicated a chaotic start in which the group experienced no clear direction and lost time finding out how to move on. Lack of knowledge and expertise in the team leader was named. The group started agreeing on certain principles and strategies and moved decision making from Chaos to Complex domain. A simplified process pointed out the analysis in a knowable or Complicated domain. Figure 35 demonstrates the movements among different domains and indicates changes of decision-making approaches because of the turning points. The highlight of the illustration is the spiral movements and the expression of the participant about the weakness of leadership.

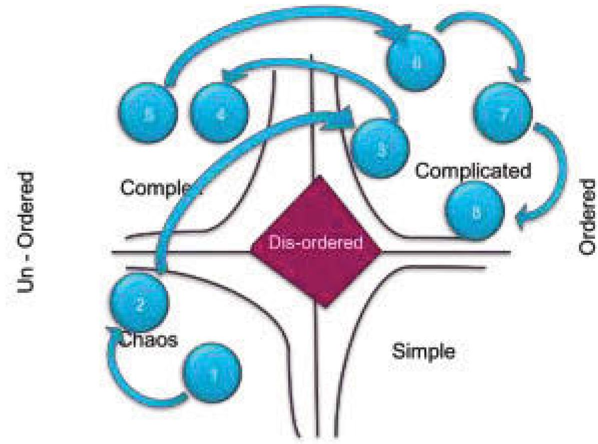


Figure 35 – Movements of domains among chaos, complex and complicated

5.3.2.3 Shift from Chaos to Simple domains

Participant 9 indicated a chaotic start with no clear direction and the group lost time finding out how to move on. Growing awareness shifted decision making from the Chaos to Complex domain. The group moved to a mature stage to use available tools and information to analyse and respond in a complicated domain. Final agreement was based on categorising knowns and indicated the simple domain. Figure 36 demonstrates the movements in different domains and outlines changes of decision-making approaches because of the turning points.

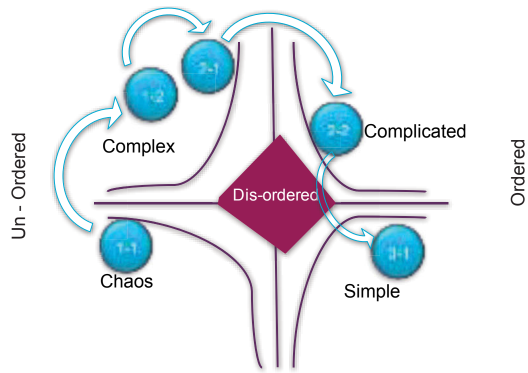


Figure 36 – Transition domains from chaos to simple

5.3.2.5 Shift from Complicated to Complex domain

Participant 10acknowledged that decision making had to continue with available data and further analysis. While the Complicated domain allowed for development of methodology and technical analysis, the pattern shifted to Complex as a result of data overload. Figure 37 demonstrates the movements in different domains and outlines changes of decision-making approaches because of the turning points.

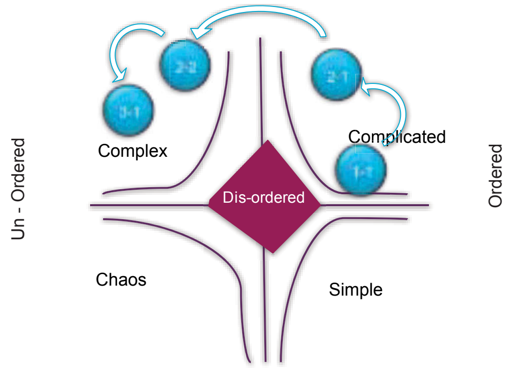


Figure 37 – Shift domains from Complicated to Complex

5.3.2.6 Shift from Simple to Complex domain

Participant 11 used future backwards method correctly to explain the most recent events in the beginning and continue to the start point. The first turning point outlined known data that is categorised in the Simple domain. The majority of turning points implied the knowable or Complicated domain, and they focused on analytical works. Decision-making processes finished in a single domain, which was featured, with quick agreement among teammates. Figure 38 demonstrates the movements in different domains, and indicates changes of decision-making approaches because of the turning points.

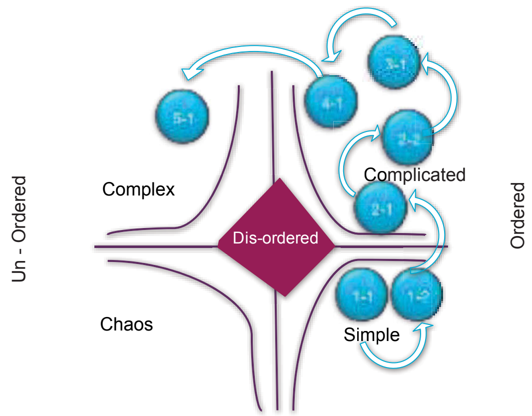


Figure 38 – Transition domains from Simple to Complex

5.3.2.7 Movements between Complex and Complicated domains

Participant 12 used future backwards method correctly to explain the most recent events in the beginning and continued to the start point. The first turning point outlined a knowledge of making a balanced decision between two departments. The majority of turning points implied the knowable or Complicated domain as they were analytical works. Decision-making processes finished in a simple domain, which was featured, with a quick agreement for the final findings. Figure 39 demonstrates the movements in different domains and outlines changes of decision-making approaches because of the turning points.

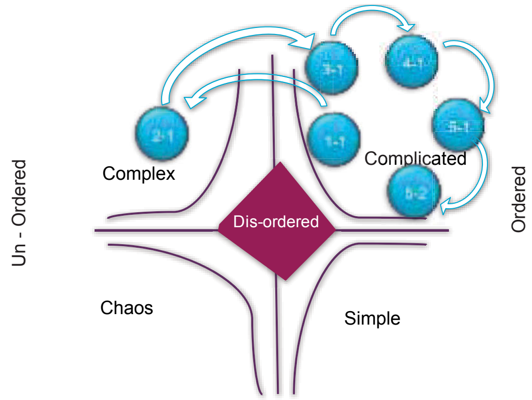


Figure 39 – Changing domains between Complicated and Complex

5.3.2.8 Shift from Chaos to Complex domain

Participant 13 indicated emerging situations and used the future backwards method. The first turning point characterised the Chaos domain where the participants lost time in finding a way out strategy. The fragments in follow-on turning points outlined the emerging nature of decisions through several trial and error attempts, indicating the Complex domain. Finally, team discussion occurred in the complex domain to fill the gaps of information through knowledge sharing exercises. Figure 40 demonstrates the movements in different domains and outlines changes of decision-making approaches because of the turning points.

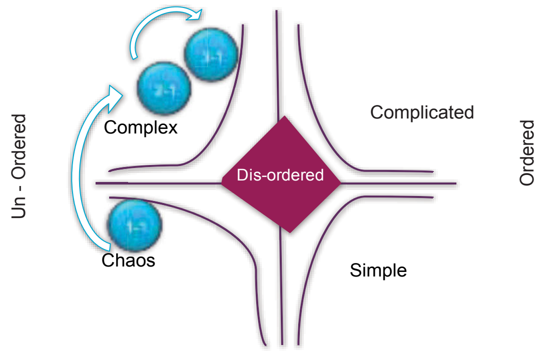


Figure 40 – Shift domains from Chaos to Complex

5.3.2.9 Shift from Chaos to Complex domain

Participant 14 indicated assignments under time pressure, late situation awareness, and a lot of changes in the beginning, which characterises Chaos domain. Then, team discussion shifted the decision making to the Complex domain. Figure 41 demonstrates the movements in different domains, which outlines changes of decision-making approaches because of the turning points.

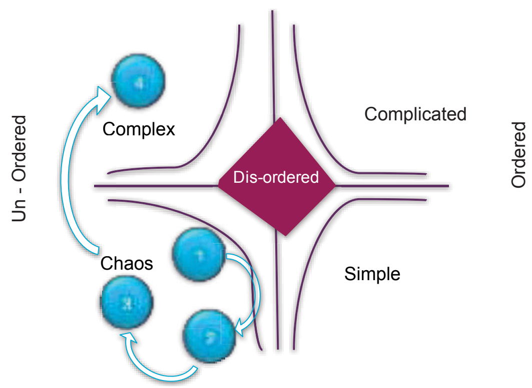


Figure 41 – Shift domains from Chaos to Complex

5.3.2.10 Movements among Chaos, Complex and Complicated domains

Participant 15 indicated the fragments and turning points. The joint discussion occurred in the Complex domain where the group made an effort to enhance their understanding of the situation. It helped to shift to the Complicated domain where the team agreed on principles based on discussion. Lack of knowledge of analysis techniques to accomplish the task resulted in a shift to the Complex domain, and further frustration on group placed them in Chaos where they pointed the responsibility to the other person. Finally, the group ended the task with some exploration in a complex domain. Figure 42 demonstrates the movements in different domains, which outlines changes of decision-making approaches because of the turning points.

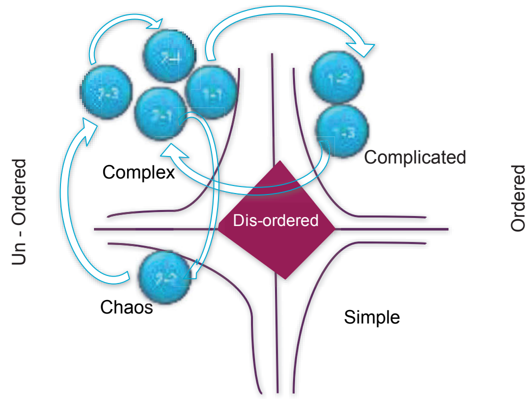


Figure 42 – Changing between Chaos and Complex/Complex and Complicated domains

5.3.2.11 Shift from Chaos to Complicated domain

Participant 16 indicated loss of time to increase situation awareness in the chaotic domain. A gradual increase in awareness of the situation shifted the group discussion into the complex and complicated domain. Figure 43 demonstrates the movements in different domains, which outlines changes of decision-making approaches because of the turning points.

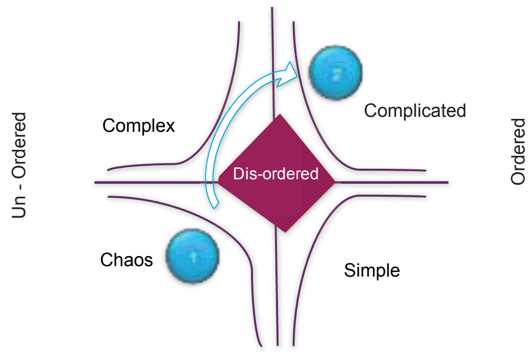


Figure 43 – Shift of domains from Chaos to Complicated

5.3.2.12 Shift from Chaos to Complicated domain

Participant 17 indicated loss of time to increase situation awareness in the chaotic domain. Further discussion with teammates and increased awareness shifted the decision making to the Complex domain. Figure 44 demonstrates the movements in different domains, which outlines changes of decision-making approaches because of the turning points.

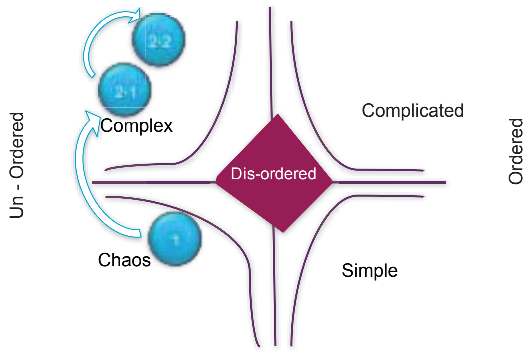


Figure 44 – Shift of domains from Chaos to Complex

5.3.2.12 Shift from Complicated to Complex domain

Participant 18 indicated how the understanding of the objectives for the first scenario of simulation, became so Complex, when narratives did not exist, and people had a different interpretation on quantities. Furthermore, analysis occurred in a Complicated domain to find out solutions. Figure 45 demonstrates the movements in various domains and outlines changes of decision-making approaches because of the turning points.

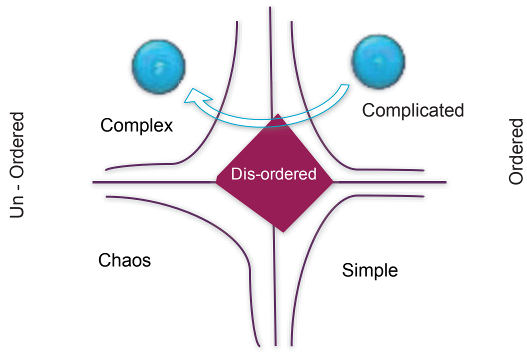


Figure 45 – Shift of domains from Complicated to Complex

5.3.3 Cluster 3 - participants rejected the influence of turning points

The third cluster of participants is categorised with participants' understanding of the turning points and real-time events. Although these participants recognised the existence of turning points and real-time events, they expressed that the decision process was insensitive against turning points. The common point was that all participants with this view were team leaders or PDUs. Three participants had different perspectives on how decision-making processes continue consistently without any change as a result of real-time events or turning points. Two of them assessed decision processes in their groups as being in the Complicated domain and the last person observed the decision process in the Complex domain.

Participant 19 indicated high awareness of the group result in carrying on the analysis in the complicated domain. Participant 20 recorded two real-time events, but the fragments were enforcing working in a knowable domain, Complicated, where the group reached a quick solution. Participant 21 indicated how the understanding of turning points kept the emerging decisions in the Complex domain. Lack of expertise and knowledge set the group decision process in the complexity domain.

In summary, the 12 participants provided information for the cluster 2 identifying list of turning points in both scenario 1 and scenario 2 of the simulation. These participants acknowledged disruption of the decision-making process because of turning points. The overall observation on the movements in the diagrams in cluster 2 is evidence for a stabilising decision-making approach through moments of moving between domains of knowledge in the Cynefin framework. A further detailed finding emphasises team discussions, group awareness and communications as key factors to achieving a final decision through several turning points. This is also evidence for the importance of a Two Model Theory to explain how individual participants contributed to the group and situation awareness. This will be discussed further in the discussion in Chapter 6.

5.4 Correlation between fragments and patterns

Clusters 4 and 5 are summaries of data analyses to cross-check findings between patterns and fragments.

Cluster 4 categorises participants who expressed their opinions for real-time events as having an effect or having no effect on decision making. For these participants, the correlation among their responses in the Triads and the Dyad and their fragments are described.

Cluster 5 describes the outliers in the Triads' patterns. Outliers are referred to as participants who showed a significantly different opinion from the majority of responses in the Triads' patterns. These selected participants' fragments and perceptions for decision-making processes are compared in cluster 5.

5.4.1 Cluster 4 - correlation between fragments and patterns

The influence of real-time events is at the centre of research questions 2 and 3. Four participants express the impact of real-time events on the decision-making process in Figure 29, Figure 30 and Figure 33. In the opposite view, three PDUs claimed there was no impact from real-time events in the decision-making process. As they demonstrated similar views but they did not contribute to the research questions, they were precluded in this cluster, too. The four participants believed real-time events shifted decision-making processes from the complicated to the complex domain in the second scenario of simulation Hooshmand-1. The details of the findings from four participants are categorised in four Tables 11, 12, 13 and 14.

Group colour	Role	Title	Turning Points 2	Fragment
White1	AD	Positive and negative aspects of change	1. cancellation of program 4 2. change of CEO	1. cancellation of program 4 Before the cancellation of program 4, we had a list of potential projects that we wanted to choose for this exercise. We were of the understanding that by cancelling project 4, all other projects that had project 4 as a deliverable could NOT be realised. We quickly discussed the changes and decided on a strategy to move forward. More precisely, we reassessed and re-evaluated the potential projects and came up with a list of four different projects that were possible to achieve. We started prioritising them based on cost and benefits to choose the three projects that would maximise profit and minimise cost, as requested in the task objectives. Then, something happened.... 2. change of CEO ... and we got a new CEO. After briefing the CEO and explaining them the situation, we came to a disagreement about whether the project that had project 4 as a deliverable could still be realised. This discussion, even though it was based on assumption and unnecessary at this stage, took up most of our time, so that we could not move forward and fully complete the task.

Group colour	Role	Title	Turning Points 2	Fragment
Green1	IV	New perspective	The removal of the team leader at the late stage of the project caused confusion and delayed the decision-making process. However, the new team leader did bring new insights and how to address the issues at hand. When the City of Sydney cancelled the project, this caused the team to re-evaluate the projects that needed to be added and adjust accordingly. On this occasion, I took the time to look at my role and what I was being measured on and the focus areas of my department.	With the removal of the team leader this did cause confusion and concern that our project would be impacted. However, the new team leader brought eight them a new perspective and way to look at what was in front of us. We managed to identify the projects that would bring the most profit and minimise our costs. With the cancellation of the project by City of Sydney it required us to re-assess our position and determine which projects would be suitable to add to the portfolio. Upon reflection taking the time on this occasion to first look at what my role was and KPI's associated with the role before jumping into solution mode made a significant difference to the way I viewed the projects.

Group colour	Role	Title	Turning Points 2	Fragment
Green1	AD	No title	1- Changes to cost - benefit 2- Organisation Change 3- Elimination of a project 4- Elimination of low profit projects 5- Calculate ratio profit / investment	1- Changes to cost - benefit All calculations were carried out according to headquarter expectations 2- Organisation Change One of team mates changed and knowledge sharing helped to improve decision. 3- Elimination of a project Elimination of the project did not impact the process 4- Elimination of low profit projects To achieve objectives, we had to delete projects with low profit / investment considering the predecessor projects' benefits 5- Calculate ratio profit / investment First, ratio for profit /investment was calculated and project dependencies were reviewed
Green1	PDU	Steering Committee second scenario	Change of the PPM / PMO manager to a different group Project put on hold.	In regard to changing groups, I found it a bit challenging to join a new group, especially because I was the PPM. However, once I joined the new group I found that the member of the new team had progressed with the analysis of the work and it was easy for me to finish the assessment and the creation of the report. When a project was removed from the list of projects, our group took it in a positive way. We were able to add a new project that would increase profitability.

Table 11 – Narratives for participants claim changing decision making because of real-time events

Table 11 demonstrates the roles and a summary of participants' fragments for the major turning points. All participants with various roles in different simulations clearly outlined turning points in the same approach. Furthermore,

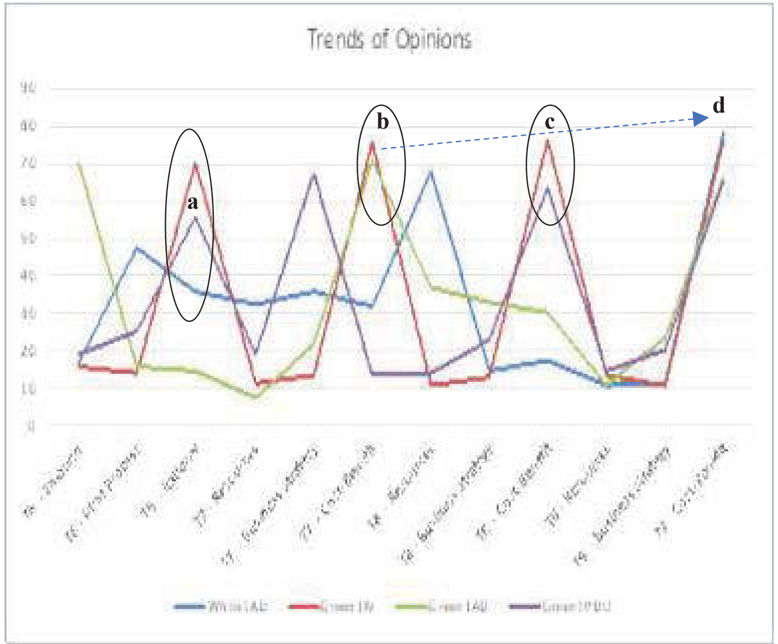
Table 12 demonstrates similarities and differences for the selected participants in this cluster. The majority (three of four) of participants in the group acknowledged the role (Q13) that they had in the simulation was influential in the decision-making process as well as that understanding the decision-making processes for key factors of major challenges (Q15) that they faced during simulation. The majority of participants in the cluster also acknowledged the two real-time events—cancellation of project and organisation change—influenced the decision-making process positively. The Application Development Manager (AD) of the white group of the first simulation indicated that the group underperformed to achieve targets in the simulation. The negative view of the event and frustration of the participant seemed to correlate with earlier findings from the fragment.

Group colour	Role	Q13 Role Importance - Context2	Q14 Feeling Context 2	Q15 Major Challenges - Context 2	Q16 Cancellation of Project impact	Q17 Organisation Change Impact
White1	AD	Not relevant at all	Frustrated	Decision making process	Positive Impact	Negative Impact
Green1	IV	Critical	Uncertain|Frustrated|Not sure	Decision making process|Individual experience|Team work	Positive Impact	Positive Impact
Green1	AD	Somewhat important	Glad|Stressed	Role Understanding	No Impact	Positive Impact
Green1	PDU	Critical	Glad	Decision making process|Road Map	Positive Impact	Positive Impact

Table 12 – participants' findings for multiple-choice queries

Table 13 demonstrates the findings of the perceptions of selected participants in the cluster. The SenseMaker allocates a number between 0-100 to each point inside the Triad. The closer is the point to a pole, the bigger is the score. The trend of quantities in sections b, c and d for Triads 7, 8 and 9 illustrates fluctuations that finish by shifting the decision criteria to cost-benefit aligned with the increase of complexity. Two participants (second and forth from top row) tended to show that they were the rational decision maker (section a–red and purple lines) in the simulation, while one (third from top row) expresses emotion (section a-green line) as key driver of their decision making in the group.

Participant	T6 - Emotion	T6 - PPM Process	T6 - Rational	T7 - Resources	T7 - Business strategy	T7 - Cost-Benefit	T8 - Resources	T8 - Business strategy	T8 - Cost-Benefit	T9 - Resources	T9 - Business strategy	T9 - Cost-Benefit
White1AD	16.80	47.37	35.83	32.55	35.83	31.62	67.99	14.58	17.42	10.67	11.25	78.08
Green1IV	15.62	14.21	70.17	11.32	13.33	75.35	10.81	12.92	76.28	13.65	10.83	75.52
Green1AD	69.83	15.79	14.38	7.30	22.08	70.61	36.78	32.92	30.30	10.64	23.33	66.03
Green1PDU	19.07	25.26	55.66	18.88	67.50	13.62	13.83	22.92	63.25	14.72	20.42	64.86



c

Table 13 – participants' findings for Triads (Continued)

Table 14 demonstrates the widespread view of the selected participants for this cluster. The graph which is attached to Table 14, shows trends of individual opinions in different Triads' criteria. For Triad 10, two participants (purple and red lines – section a) stated that their groups' action were an adaptation to reality.

However, one participant (blue line – section a) claimed the group acted without any rationale and chose a smaller score on rationale in Triad 6. The participant's answers in Triads 6 and 10 were correlated, to some extent.

Another participant (green line – section a) believed in actions based on unchanging principles and chose a high score on emotion in Triad 6. Therefore, the correlation may exist between people's perspectives to decision making and their perception on actions during uncertain situations.

Moreover, for Triad 11, two participants (purple and green lines - section b) claimed individual experience as their key factor to demonstrate resilience to overcome the change. They believed the time pressure (Triad 12) was the source of uncertainty for their practice in the simulation (purple and green lines–section c). Two other participants (blue and red lines) though demonstrated that innovative collaboration helped to overcome changes, but the uncertainty was related to the group members' skill sets.

For Triad 13, three participants (purple, red and green–section d) chose high score for optimised solution. However, another participant (blue line) sided with the leading person's opinion in his or her group.

For the only Dyad in Table 14, three participants perceived that concentration of activities shifted from individuals to teams when uncertainty arose. These opinions were against the findings from the majority of participants in Figure 27.

In summary, real-time events influence participants' judgement and team work becomes paramount as the uncertainty intensifies during the decision-making process. Also, the role of emotion in decision making is seen as an outlier which shows off as a signal that the majority of people tried to ignore the role of their emotions and suboptimal solutions in the decision-making process and insist that their decisions are rational only. This has triggered further investigation to understand outliers as those opinions that are out of dominant pattern in Triads. The following section will discuss the analysis of outliers in detail.

Participant	T10 Reasons for actions - Unchanging Principles	T10 Reasons for actions - They just did it, no reason	T10 Reasons for actions - Adapted to realities	T11 Impact Factors for resilience - Innovative collaboration	T11 Impact Factors for resilience - Individual experience	T11 Impact Factors for resilience - Knowledge of PPM	T12 Sources of uncertainty - Context 2 - Time pressure	T12 Sources of uncertainty - Context 2 - Inadequate information	T12 Sources of uncertainty - Context 2 - Inadequate skills	T13 Perception of final decision - Context 2 - Suboptimal with team consensus	T13 Perception of final decision - Context 2 - Optimised solution	T13 Perception of final decision - Context 2 - Leading person's preference	Q17 Activity Focus - Context 2 - Team	Q17 Activity Focus - Context 2 - Individual
White1AD	14.93	73.85	11.22	47.24	20.83	31.92	30.44	17.63	51.93	4.20	0.00	95.80	17.05	82.95
Green1IV	13.94	12.55	73.51	74.63	13.33	12.04	40.25	15.45	44.30	23.71	55.83	20.46	80.92	19.08
Green1AD	76.58	15.06	8.35	26.10	62.92	10.99	73.58	13.73	12.69	44.37	49.17	6.46	77.46	22.54
Green1PDU	17.78	20.29	61.93	14.82	74.17	11.01	66.40	18.06	15.55	15.93	72.92	11.16	81.89	18.11

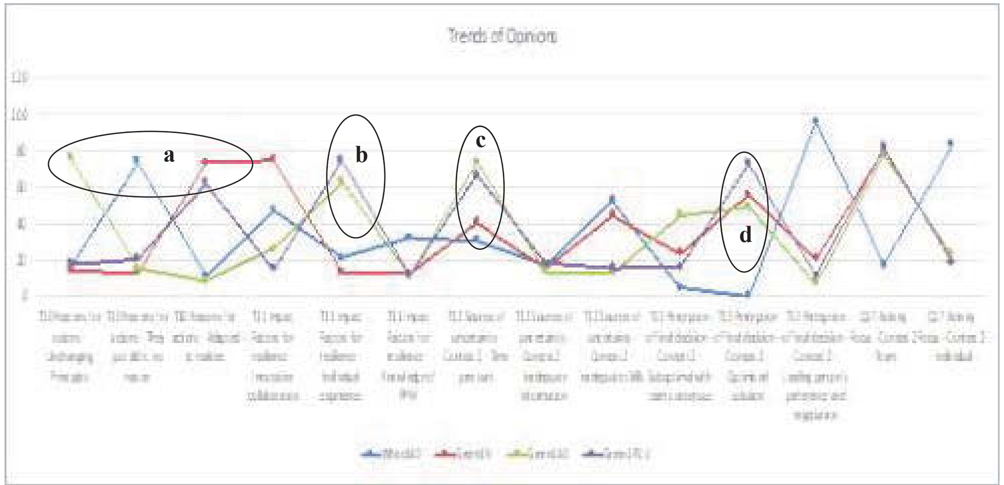


Table 14 – participants' findings for Triads & the Dyad

5.4.2 Cluster 5 - correlation between outliers and fragments

A different group of nine participants were selected based on their replies to Triads. These participants chose a position significantly different from the pattern that the majority of people selected in Triads during Context 2. These participants were selected with outliers in one or more Triads after reviewing the finding of Triads from Context 2. Tables 15, 16, 17 and 18 demonstrate similarities and differences of viewpoints among the selected participants.

Table 15 (next page) demonstrates the participants' roles in the simulation and a summary of their fragments for the major turning points. All participants, with various roles in different simulations, clearly identified turning points and provided fragments for each turning point.

Three participants clearly identified the influence of real-time events on decision-making processes while two participants claimed no impact for the real-time event. The remaining four participants did not recognise the real-time events.

Table 15 – Narratives for participants claim outliers

Group Colour	Role	Outliers	Title	Turning Points 2	Fragment
Red1	AD	T9	TP 1 - 4	TP 1. Exclude dependencies TP 2. Consider Horizon TP 3. Consider resource needs/availability (against designated timeline TP 4. NPV	TP 1. Exclusion narrows down the projects under consideration TP 2 + 3. Duration and Reqd by month impacts resource availability TP 4. Assumed benefits would be realised earlier (and profit increased), if projects completed and delivered to market/client within reported timeframe. Assumed the prompt delivery would also improve the strategic positioning of the company, as it would gain a reputation of prompt delivery. Assumption: ignored cost reduction exercise from Context 1.
Red1	PDU	T7&T8	No title provided	Reading the notes carefully and interpret the requirements Deciding the project selection criteria	Initially the late note was interpreted in a way the team did not agree to, once all agreed to the wording and what it means the solution changed completely. The note included the word program, the list of projects did not include any programs, hence the note did not impact the list. Everyone on the team had different views on the selection criteria, collaboration between team members resulted in agreement and commitment to the project selection
White1	AD	T8, T10, T13	Positive and negative aspects of change	1. cancellation of program 4 2. change of CEO	1. cancellation of program 4 Before the cancellation of program 4, we had a list of potential projects that we wanted to choose for this exercise. We were of the understanding that by cancelling project 4, all other projects that had project 4 as a deliverable could NOT be realised. We quickly discussed the changes and decided on a strategy to move forward. More precisely, we reassessed and re-evaluated the potential projects and came up with a list of four different projects that were possible to achieve. We started prioritising them based on cost and benefits to choose the three projects that would maximise profit and minimise cost, as requested in the task objectives. Then, something happened....

Group Colour	Role	Outliers	Title	Turning Points 2	Fragment
					2. change of CEO ... and we got a new CEO. After briefing the CEO and explaining them the situation, we came to a disagreement about whether the project that had project 4 as a deliverable could still be realised. This discussion, even though it was based on assumption and unnecessary at this stage, took up most of our time, so that we could not move forward and fully complete the task.
White1	IV	T12	management chaos	IV program profits not addressed till late after AD projects sorted change of PMO director deferral of project causing reassessment of program identifying additional projects to be added that had max $ and least coordination impact	new PMO had no influence on planning deferral of project was readily catered for worked thru options for replacement projects. Initial requirement for identifying new projects to include was undertaken without knowledge of the resource impact which in reality would not be done. In hurry to deal with main profitability on AD projects overlooked the requirement to sustain the profitability of the IV projects which was quickly dealt with at end however incomplete.
Green1	PDU	T11, T12, T13	No title provided	1- It was good performance for projects analysis and facing changes but the conclusion was mis-coordinated. 2- The analysis method was different for old and new groups but the new team mates could clarify things better than old group and it helped a quicker conclusion. 3- I found new competencies in myself which helped team in decision making.	1- It was good performance for projects analysis and facing changes but the conclusion was mis-coordinated. I obtained a new understanding for projects and the analysis method. But this delayed the final conclusion. 2- The analysis method was different for old and new groups but the new team mates could clarify things better than old group and it helped a quicker conclusion. I was more comfortable with the analysis method of the new group than the old one. It was a good team work in the new team. 3- I found new competencies in myself which helped team in decision making. After finding my strengths and weaknesses for analysing projects, I could help the team and I found myself confident.

Group Colour	Role	Outliers	Title	Turning Points 2	Fragment
Green1	AD	T6, T10	No title	1- Changes to cost - benefit 2- Organisation Change 3- Elimination of a project 4- Elimination of low profit projects 5- Calculate ratio profit / investment	1- Changes to cost - benefit All calculations was carried out according to headquarter expectations 2- Organisation Change One of team mates changed and knowledge sharing helped to improve decision. 3- Elimination of a project Elimination of the project did not impact the process 4- Elimination of low profit projects To achieve objectives, we had to delete projects with low profit / investment considering the predecessor projects' benefits 5- Calculate ratio profit / investment First, ratio for profit /investment was calculated and project dependencies were reviewed
Red1	IV	T9	no title provided	1- Calculate cost-benefit and stop a project 2- Choose a few profitable projects 3- Review road map with a focus on profitability	1- Calculate cost-benefit and stop a project Prepare report for works carried out against stop of a project and additional projects to the portfolio 2- Choose a few profitable projects Review and choose projects with profitability and consistent with the road map 3- Review road map with a focus on profitability Review projects in progress and new projects and discuss in the meeting to revise the road map
White1	AD	T6	No title provided	1- Delay because of change organisation 2- Obstacle due to plan change 3- Self Confidence	1- Delay because of change organisation Obstacle due to organisation change: when new person come to the team, it takes time to be aligned with each other as she was working with different plan in her previous team. 2- Obstacle due to plan change When plan was changed, calculated the figures from beginning which

Group Colour	Role	Outliers	Title	Turning Points 2	Fragment
					wasted time 3- Self Confidence As I had experience in context 1, I was more confident to cope with new challenges in context2.
Green1	AD	T10, T11	Growing Business	1. Understanding the context 2. Cancellation of project 3. Change of Role 1	We understood the context and its objectives. Selected projects that were most profitable. There was some confusion in regards to how to judge profitability. In the end, we were able to select 3 new and fourth to replace cancelled project. We also tried to optimise resource utilisation.

Table 16 demonstrates a summary of participants' responses to the multiple-choice questions. For each question, the number of similar choices indicated a fact for participants' perceptions of their experience in the simulation. The majority of the participants demonstrated that their roles (Q13) in the simulation were important as well as perceiving decision-making processes for the primary challenge (Q15) during the simulation. The majority of them felt stressed (Q14) and saw the negative impact on decision making because of real-time events (Q16 and Q17).

Table 16 – participants' findings for multiple-choice queries

Q13 Role Importance - Context2	Q14 Feeling Context 2	Q15 Major Challenges - Context 2	Q16 Cancellation of Project impact	Q17 Organisation Change Impact
Not relevant at all	Not sure	Decision making process	Positive Impact	Negative Impact
Critical	Stressed	Individual experience	Positive Impact	Positive Impact
Not relevant at all	Frustrated	Decision making process	Positive Impact	Negative Impact
Somewhat important	Stressed|Uncertain	Decision making process|Road Map	Negative Impact	Negative Impact
Quite important	Glad	Decision making process	Negative Impact	Positive Impact
Somewhat important	Glad|Stressed	Role Understanding	No Impact	Positive Impact
Critical	Stressed|Frustrated	Team work|Road Map	Negative Impact	Negative Impact
Somewhat important	Stressed	Decision making process|Team work|Role Understanding	Negative Impact	Negative Impact
Quite important	Glad|Stressed|Uncertain	Decision making process|Team work|Role Understanding	Positive Impact	Positive Impact

Table 17 – participants' findings for Triads 6 to 9

Group colour	Role	Outliers	T6 Major Impact Factor - Context 2 - Emotion	T6 Major Impact Factor - Context 2 - PPM Process	T6 Major Impact Factor - Context 2 - Rational	T7 Decision Criteria Before RT Events - Resources	T7 Decision Criteria Before RT Events - Business strategy	T7 Decision Criteria Before RT Events - Cost-Benefit	T8 Decision Criteria after first RT Event - Resources	T8 Decision Criteria after first RT Event - Business strategy	T8 Decision Criteria after first RT Event - Cost-Benefit	T9 Decision Criteria after second RT Event - Resources	T9 Decision Criteria after second RT Event - Business strategy	T9 Decision Criteria after second RT Event - Cost-Benefit
Red1	AD	T9	16.95	16.84	66.21	26.95	12.50	60.55	24.66	17.08	58.26	69.59	15.00	15.41
Red1	PDU	T7&T8	21.42	59.47	19.10	66.08	16.25	17.67	58.45	20.00	21.55	16.77	66.67	16.56
White1	AD	T8, T10, T13	16.80	47.37	35.83	32.55	35.83	31.62	67.99	14.58	17.42	10.67	11.25	78.08
White1	IV	T12	13.37	60.53	26.10	25.00	50.00	25.00	25.00	50.00	25.00	9.50	24.17	66.33
Green1	PDU	T11, T12, T13	14.45	74.74	10.81	7.17	10.83	81.99	13.88	7.50	78.62	9.66	85.00	5.34
Green1	AD	T6, T10	69.83	15.79	14.38	7.30	22.08	70.61	36.78	32.92	30.30	10.64	23.33	66.03
Red1	IV	T9	12.06	13.16	74.78	40.64	47.50	11.86	10.62	10.42	78.96	77.66	13.75	8.59
White1	AD	T6	42.49	46.84	10.67	10.04	50.42	39.54	8.89	46.25	44.86	10.04	50.42	39.54
Green1	AD	T10, T11	9.13	8.95	81.92	7.05	45.83	47.12	7.36	7.08	85.56	6.70	6.25	87.05

Table 17 demonstrates participants' views on Triads 6 to 9. Each Triad is presented by three criteria and the measures extracted from SenseMaker software. The SenseMaker is set to measure positions in Triads with a number between 0-100 where the closer position to one criterion creates bigger numbers in approximate of 100. For Triad 6, three participants emphasised the rational decision (numbers higher than 50) while other three participants indicated the PPM process was at the centre of their decisions. Nevertheless, one person identified emotion as the source of the decision. Triads 7 to 9 assess changes of patterns for preferred decision criteria while participants compared the impact of real-time events on the decision criteria. The overall trend of the selected group of participants repeated the previous findings where they illustrated an increase (from three to four participants) to use cost-benefit as a single criterion for decision making under uncertainty.

Group colour	Role	Outliers	T10 Reasons for actions - Unchanging Principles	T10 Reasons for actions - They just did it, no reason	T10 Reasons for actions - Adapted to realities	T11 Impact Factors for resilience - Innovative collaboration	T11 Impact Factors for resilience - Individual experience	T11 Impact Factors for resilience - Knowledge of PPM	T12 Sources of uncertainty - Context 2 - Time pressure	T12 Sources of uncertainty - Context 2 - Inadequate information	T12 Sources of uncertainty - Context 2 - Inadequate skills	T13 Perception of final decision - Context 2 - Suboptimal with team consensus	T13 Perception of final decision - Context 2 - Optimised solution	T13 Perception of final decision - Context 2 - Leading person's preference and negotiation
Red1	AD	T9	21.28	14.02	64.71	22.73	13.75	63.52	47.03	44.98	7.99	39.48	54.58	5.93
Red1	PDU	T7&T8	20.68	17.36	61.95	68.09	15.83	16.08	16.13	70.62	13.25	16.20	16.25	67.55
White1	AD	T8, T10, T13	14.93	73.85	11.22	47.24	20.83	31.92	30.44	17.63	51.93	4.20	0.00	95.80
White1	IV	T12	13.46	14.23	72.31	25.00	50.00	25.00	4.30	93.99	1.71	15.64	71.25	13.11
Green1	PDU	T11, T12, T13	13.41	7.11	79.48	9.24	9.58	81.18	79.84	8.58	11.58	83.25	7.50	9.25
Green1	AD	T6, T10	76.58	15.06	8.35	26.10	62.92	10.99	73.58	13.73	12.69	44.37	49.17	6.46
Red1	IV	T9	8.92	22.59	68.49	10.80	44.58	44.61	44.06	13.73	42.21	39.35	21.67	38.99
White1	AD	T6	8.84	26.36	64.80	32.41	33.75	33.84	78.83	9.87	11.30	14.43	75.83	9.74
Green1	AD	T10, T11	84.70	7.32	7.98	83.65	9.17	7.18	49.09	44.55	6.36	43.39	7.92	48.69

Table 18 – participants' outcomes for Triads 10 to 13

Table 18 demonstrates findings for Triads 10 to 13. For Triad 10, six participants claimed “adaptation to reality” as a key factor for the team’s actions when they faced real-time events. The majority of responses to Triad 11 for key impact factors for resilience outlined the knowledge of PPM and innovative collaboration as key factors, and only one participant pointed out the individual experience as the key element for resilience in the simulation. Three participants demonstrated time pressure as the principal source of uncertainty in the second scenario of simulation in Triad 12. Triad 13 demonstrates divided opinions where one participant described the final decision as suboptimal with team consensus; another two participants described the final decision as the preference of the leading teammate and the output of negotiation. The last three participants claimed their groups’ final solutions as optimised.

The findings of each cluster are treated as a fragment and, in order to make sense of them, the findings that make sense together are presented in a model. The summary of findings for clusters 1-5 and pattern analysis for Context 1 and 2 are demonstrated in Section 5.5.

5.5 Findings and data triangulations with debriefing audios

Four audio-recorded dialogue are the source of data triangulation to validate the earlier findings. Each facilitated discussion occurred at the end of the two simulation scenarios and the facilitator guided participants through de-briefing on their experience in the simulation. Each figure comprises of four key elements: 1) the centre that refers to the key query in relation to a research question; 2) the key impact factors that influence the central query responses; 3) factor of changes in decision making can be either a turning point or a real-time event; and, 4) the sources of findings from data analysis which are visible in the outer ring of each figure. The transcribed comments are categorised in NVivo to support the summary findings in figures below. Findings of data analysis and parameters in the SenseMaker such as scenarios, real-time events and turning points were used to define 14 codes as nodes in NVivo as listed in below.

1. Adaptation
2. Cancellation of project
3. Change of decision-making process because of real-time events

4. Change of decision making – Turning Points
5. Decision Criteria
6. Feeling
7. First Scenario
8. Organisation Change
9. Resilience
10. Second Scenario
11. Similarity to workplace
12. Simulation Role
13. Team Work
14. Time pressure

Transcription of audio recorded discussions at the end of each simulation (workshops 1-4) were added to NVivo as sources of text. The Text has been coded against 14 codes. The cluster analysis and the number of fragments assigned to codes are used to understand the support of NVivo analysis as a data triangulation to findings in relation to each research question.

5.5.1 Finding1 - Research Question 1

RQ1—How do decision makers change their decision criteria for selection and prioritisation in a project portfolio when conditions are uncertain?

Decision makers, perhaps, select decision criteria after considering several factors about the business context and business environment. Finding 1 summarises the earlier findings from data analyses in patterns of Context 1, patterns of Context 2, and clusters 4 and 5. The data analyses demonstrate that turning points in the first context and real-time events in the second context of simulation influence the decision criteria. The findings identify the impact factors on decision criteria as feeling, previous experience, simulation roles and perceptions of the major challenge. Figure 46 illustrates a summary of Finding 1. The green outer circle presents the source of information for the model. The blue middle circle shows the source of variables identified in the model. The inner circle presents key variables demonstrating an influence on decision-making criteria during the simulation. According to this model, participants' perceptions of major challenges, their previous experience in the workplace dealing with similar challenges to the simulation events, their assigned roles in the simulation, and their personal emotions towards decision-making events were key influential factors on their judgement for preferred decision-making criteria.

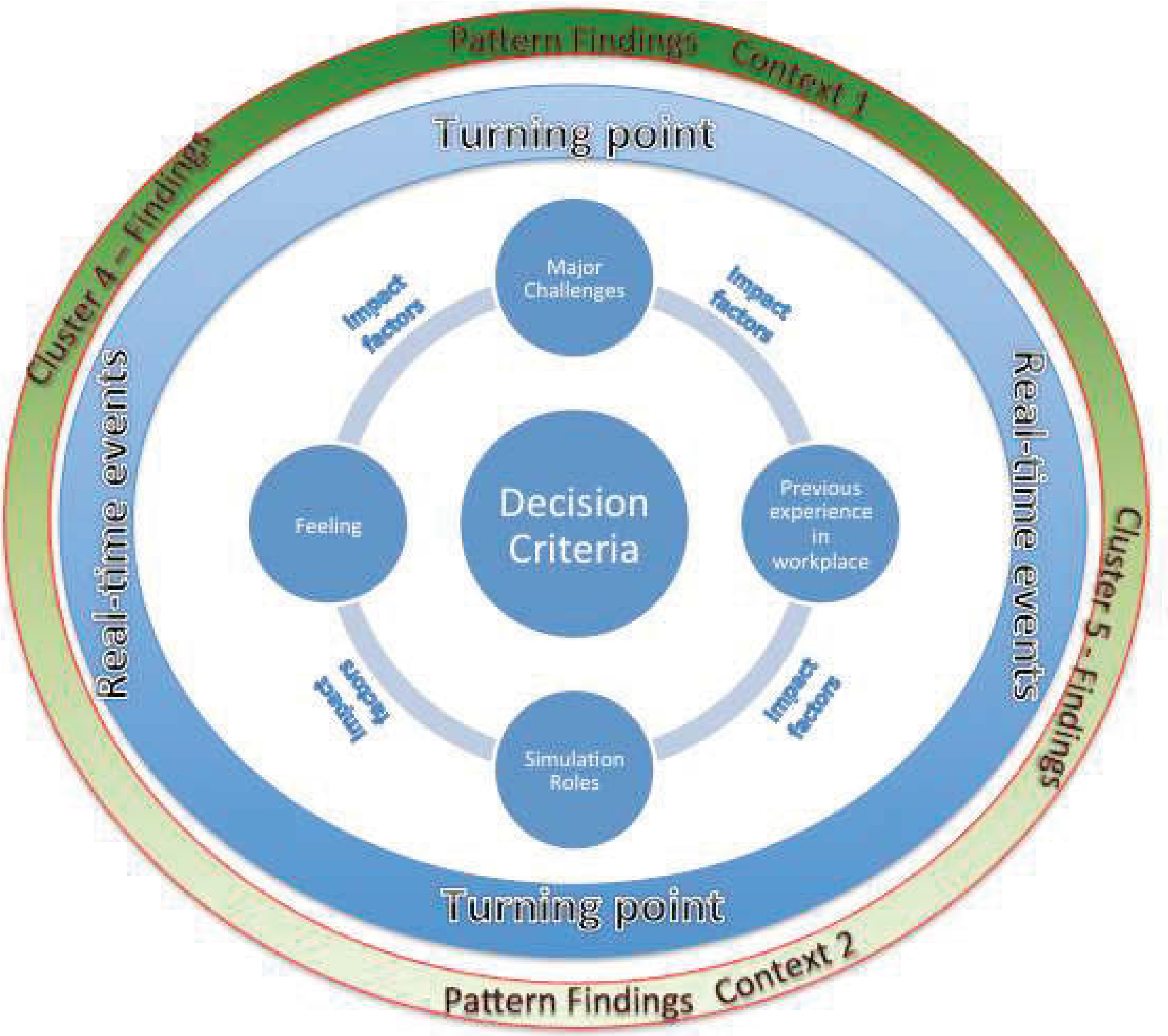


Figure 46 – The model for selecting decision criteria in uncertainty

Further assessment of audio-recorded transcriptions provides discourse to support variables in Figure 46.

demonstrates the number of quotes from participants' or facilitator's observations and descriptions, as well as results of cluster analyses on the variables. The left side of the figure indicates the support from transcriptions to each NVivo code, by coloured areas. The similarity to the workplace most significantly supports the previous work experience as an impact factor. Teamwork has a significant number of quotes which show it to be a major challenge as an impact factor. Also, feeling and simulation roles are directly supported by findings from triangulations (Appendix 5.3 Transcriptions of audio recorded files). Codes of NVivo are assigned to each impact factor as shown in the Figure 46. Teamwork is identified as the outstanding challenge from earlier analysis. The Nvivo node cluster analysis measure is based on transcriptions' words similarity in the allocated texts and resulted in

. The number of fragments assigned to each code identifies the coloured area for each code. Therefore, work experience, turning points and real-time events have received great attention in the debriefing discussions. In this figure, team work received little attention which supported earlier evidence for a shift to participants' perception at the end of simulation in Figure 27.

Furthermore, cluster analyses demonstrate significant correlations among participants' feelings, their roles in the simulation, and teamwork as a major challenge.

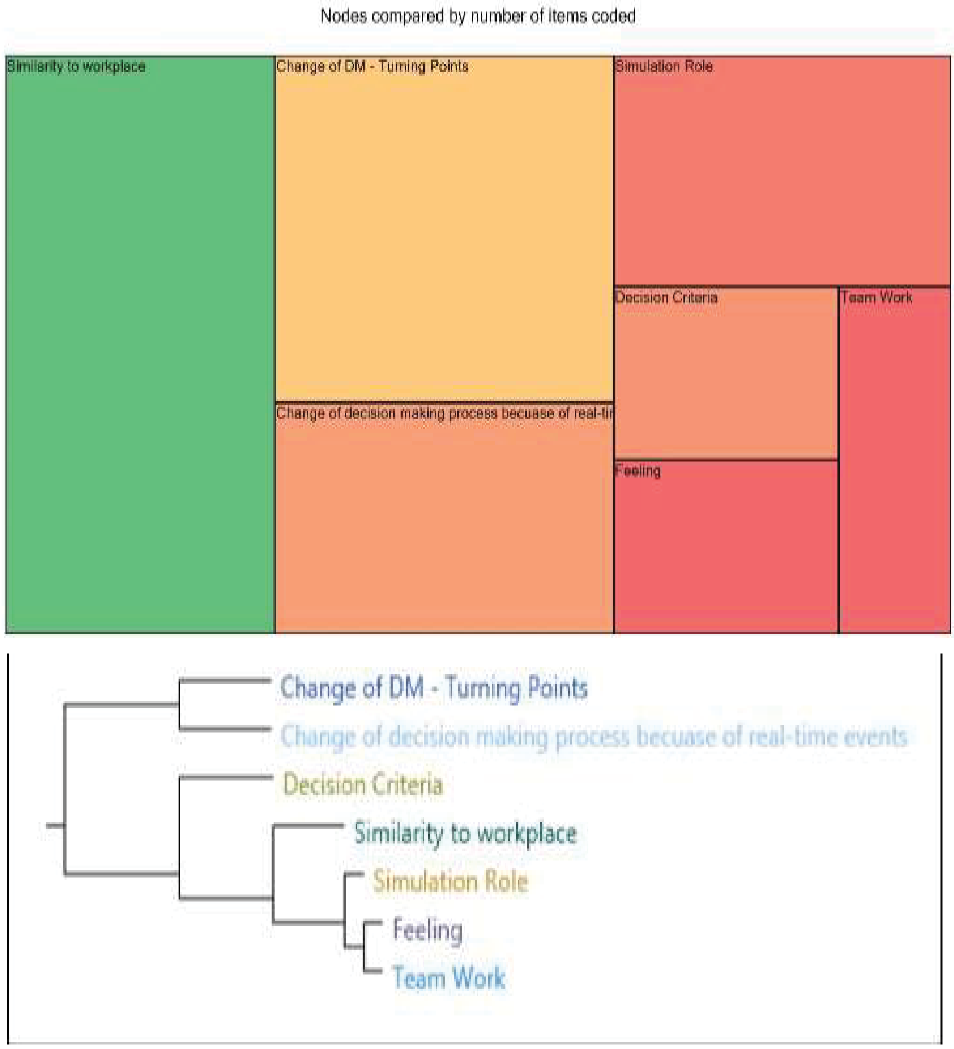


Figure 47 – The debriefing analyses

Lastly, the cluster analyses exhibit no significant correlation to the remaining factors, but a selection of decision-making criteria is more correlated to the workplace similarity than to other factors. Another finding in the pattern, is the lack of attention to the resources, expertise and human capital in favour of maximising profits. This is supported by additional feedback received from practitioners and academic staff members who endorsed the findings and declared there was a gap between theory and current practice. Also, quotes selected in

support that resources are the least noted criterion and monetary criteria are the most developed areas.

For example, one participant described the decision making in the workplace when they dealt with budget cuts as follows:

> "*I look at the fund availability to make a decision in my real-life assignments and the human aspects are not taking (sic) into account. It works until the end of each financial year as resources come through. 80% of work force is contractors, so they can do that by laying off, etc. to cover 10% or 5% budget cut*"

5.5.2 Findings - Research question 2

RQ2–How do real-time events or turning points influence decision-making processes for?

Data analyses on turning points in Context 1, and real-time events in Context 2, conclude findings for research question 2 with three key indicators, the perception of uncertainty, key drivers and final group decisions and perceptions of the decision-making process. Figure 48 demonstrates the summary of findings for research question 2 followed by the further detailed findings.

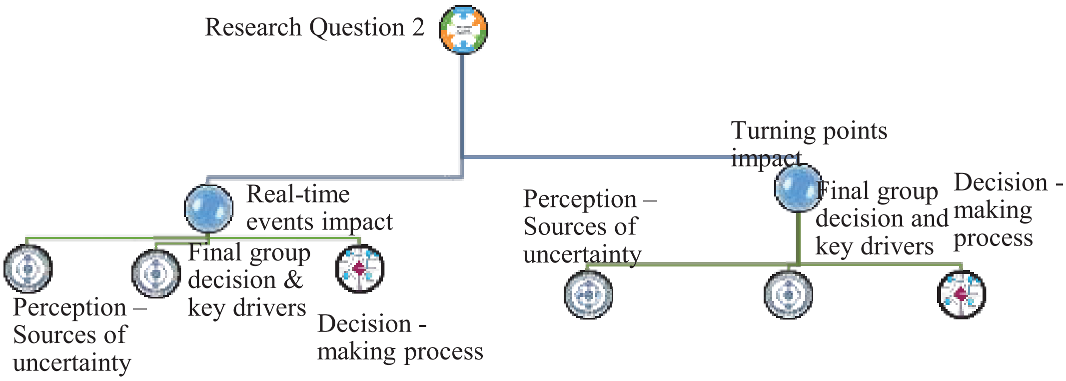


Figure 48 – The debriefings analyses

Findings 2 and 3 are related to the right side of the figure above and Findings 4 and 5 are related to the left side of the image above. The last result is connected to both real-time events and turning points.

5.5.2.1 Finding 2 – Research question 2

Decision makers perceive the sources of uncertainty in a changing environment after considering an excess of variables. The perception is influenced by turning points during decision making in Context 1. Impact factors such as individual feelings, experience, their understanding of their own roles, and their perceptions of major challenges, can influence their understanding of sources of uncertainties. Figure 48 demonstrates a summary of these findings. Figure 49 and Figure 51 illustrate strong support from the debriefing and quotes from participants to support the variables as impact factors. Figure 49 repeats the earlier claims that teamwork, participants' feelings and their roles in the simulation are strongly correlated.

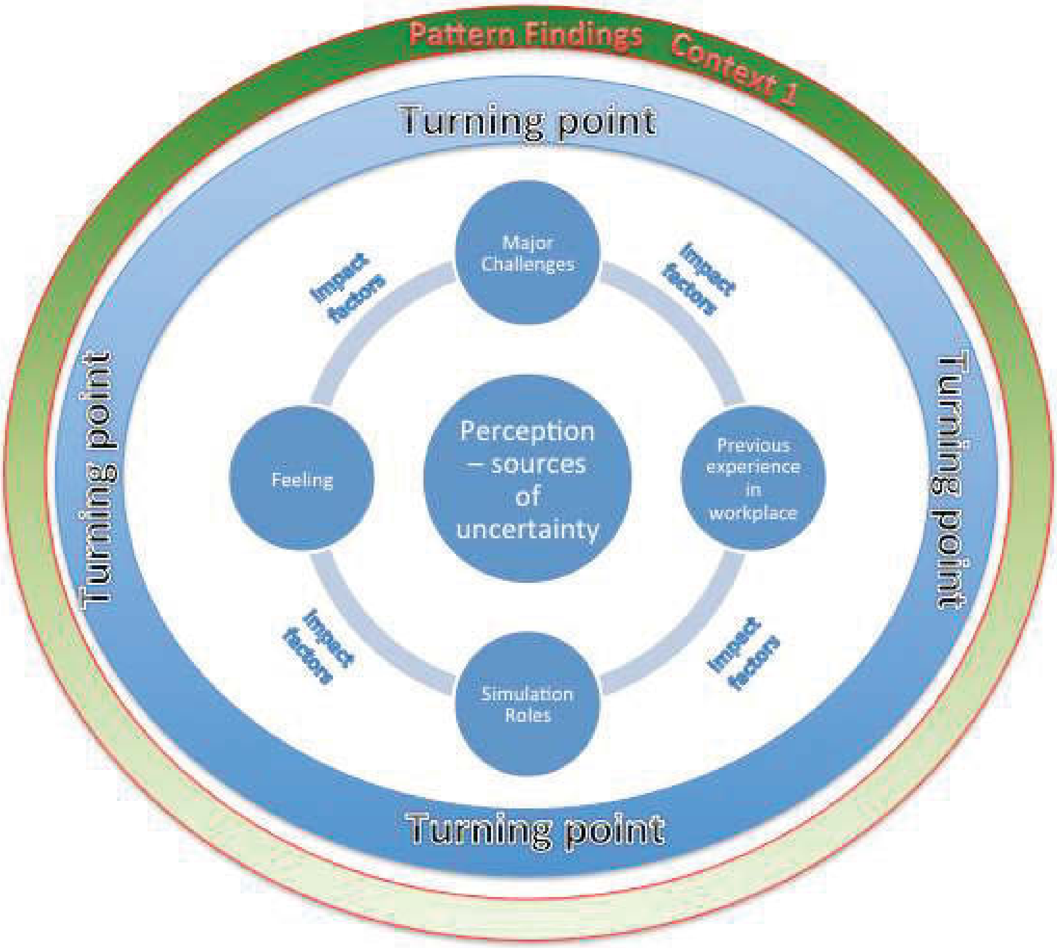


Figure 49– Impact factors on detection of sources of uncertainty

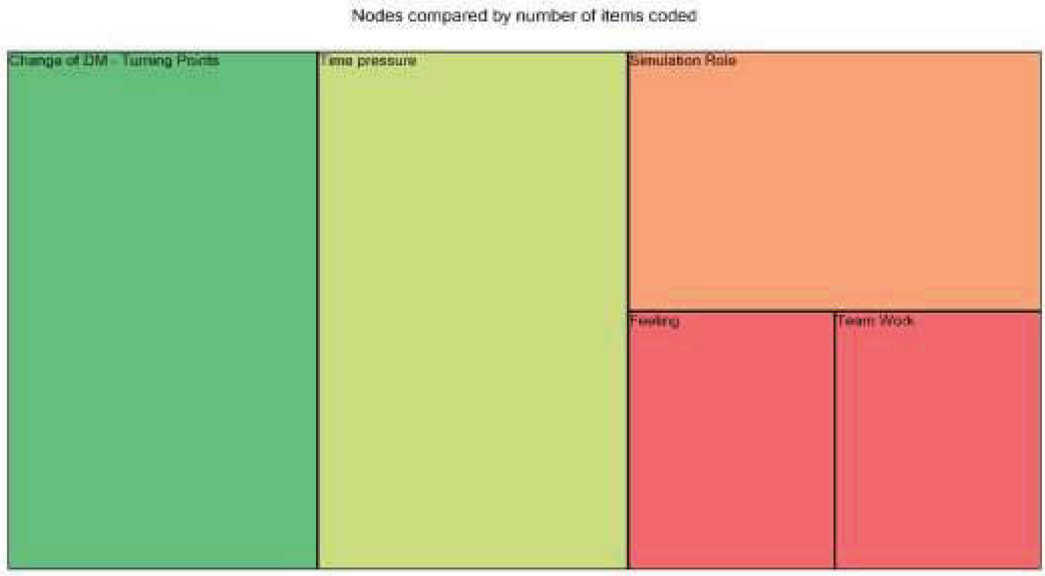


Figure 50 – The debriefings analyses (consistent with others)

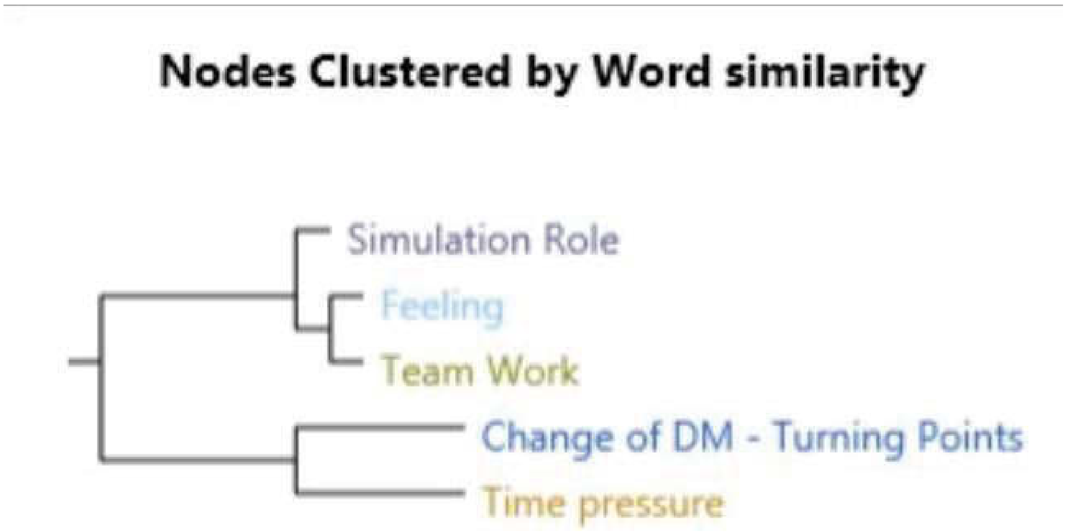


Figure 51 – The debriefings analyses

5.5.2.2 Finding 3 - research question 2

Final group decisions are influenced by turning points in the first context of the simulation. Perception of major challenges and the feelings of participants during decision making are identified as factors which impact on conveying the changes in the environment to the final group decisions. illustrates a summary of the findings from pattern analyses in Context 1.

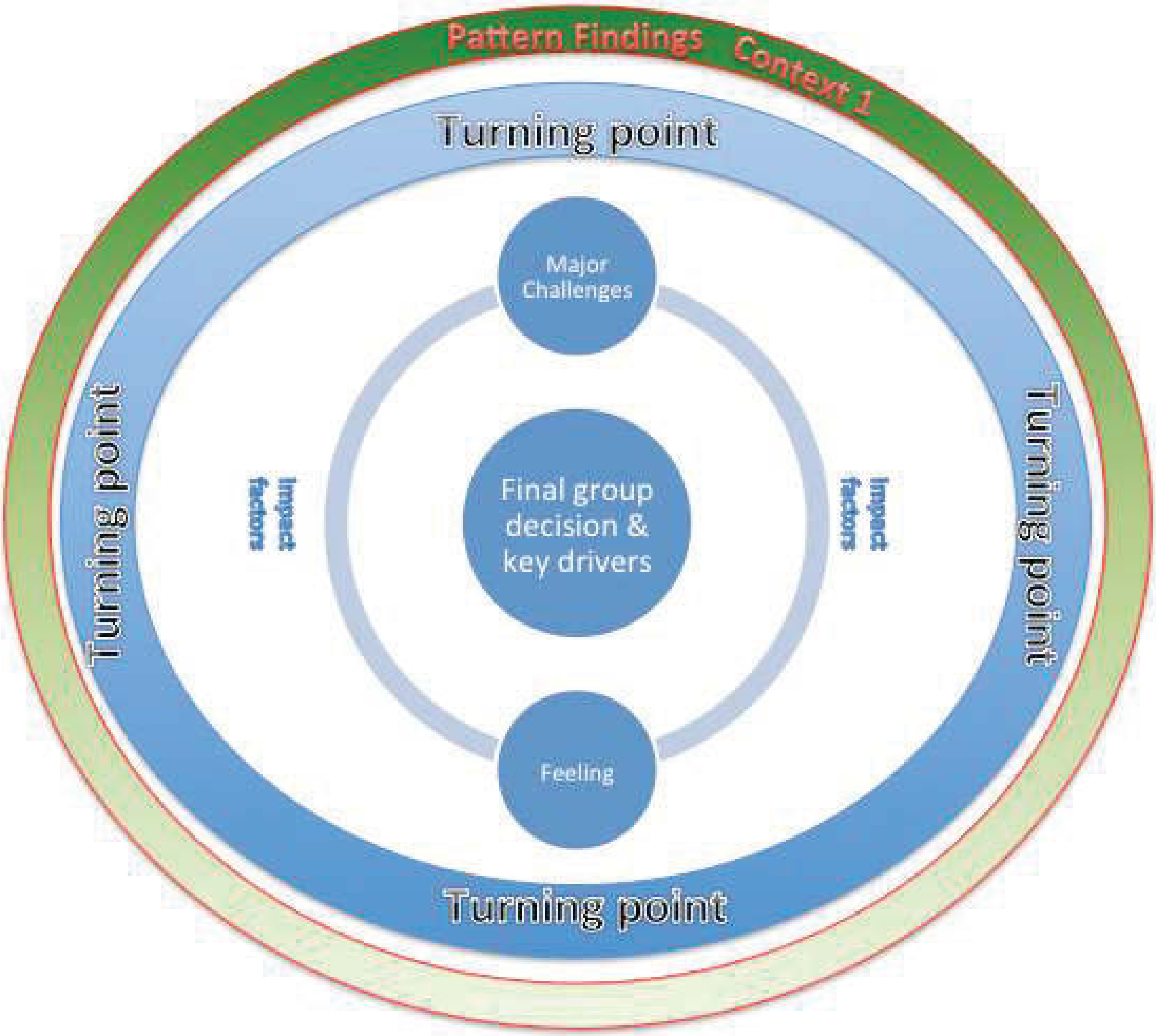
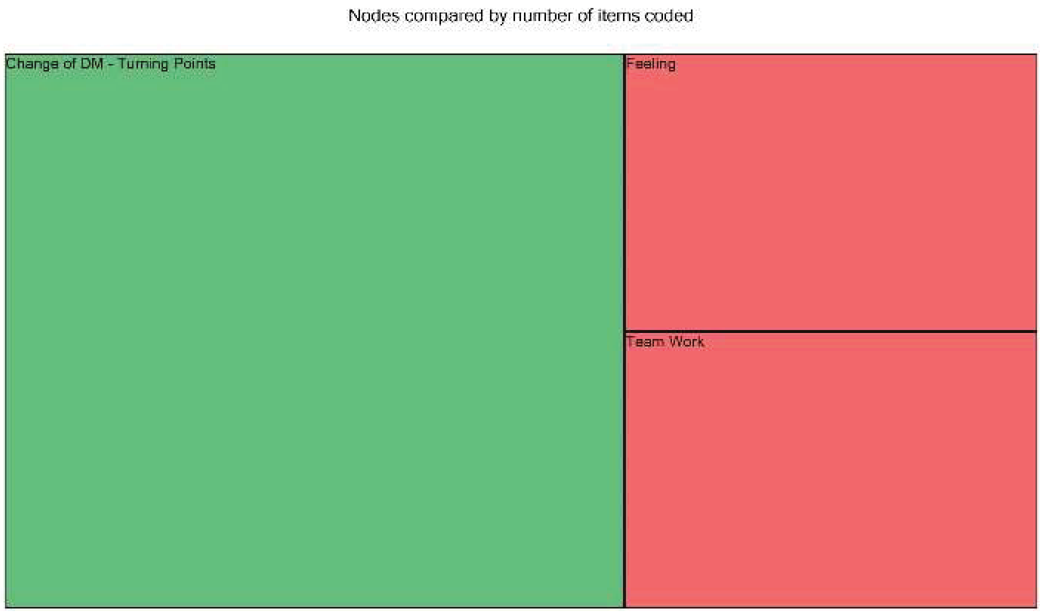


Figure 52 – Impact factors for influence of turning points on final group decision



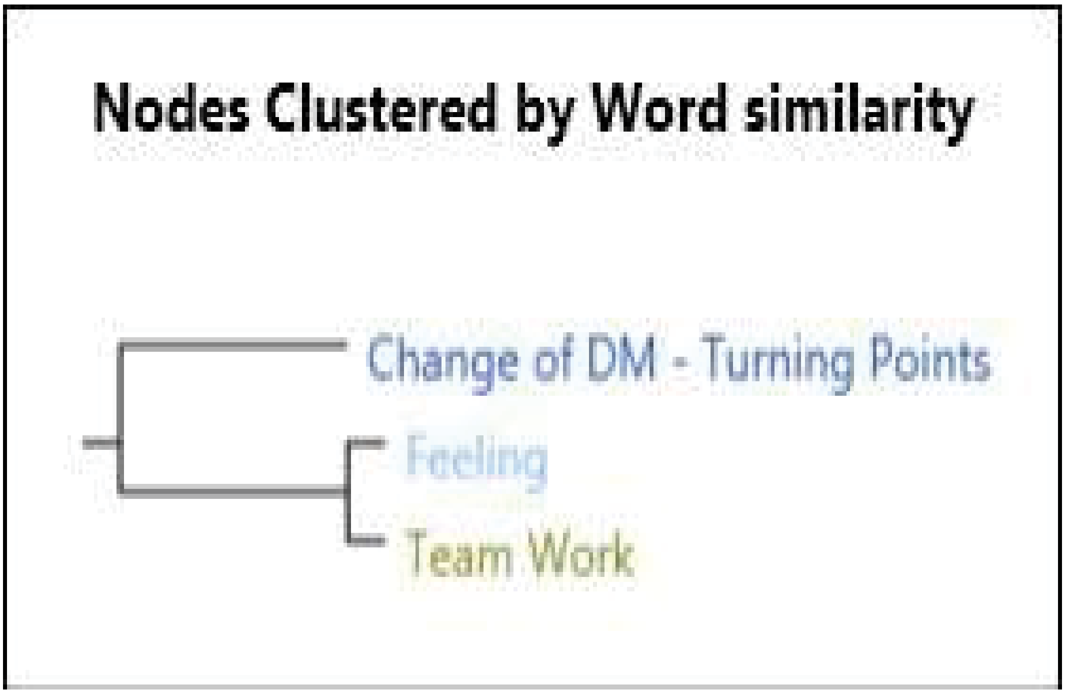


Figure 53 – The debriefings analyses – final group decisions impact factors

Supporting analyses on findings from the debriefing sessions support that teamwork, and feelings of participants as key impact factors for final group decisions. Figure 53 demonstrates supporting findings.

5.5.2.3 Finding 4 - research question 2

Real-time events have impacts on the decision makers' perceptions of sources of uncertainty in the second context of the simulation.
Figure 54 summarises findings from pattern analyses, clusters 4 and 5. The figure demonstrates that real-time events can change the pattern for the perception of participants on sources of uncertainty and major challenges, and that the event—cancellation of a project by a client—are recognised as impact factors.

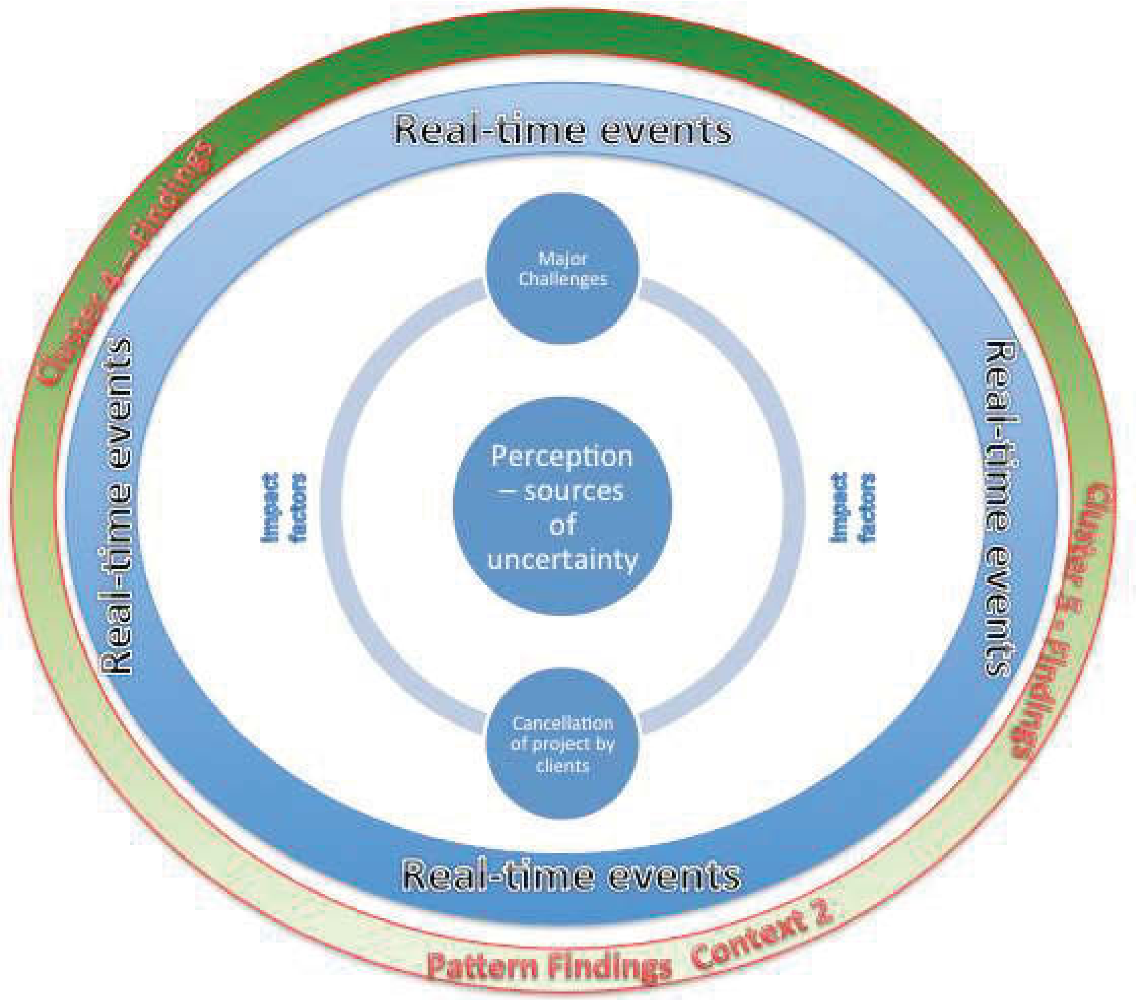


Figure 54 – Impact factors on participants' perceptions of sources of uncertainty

Figure 55 demonstrates the support of comments from participants in the debriefing sessions where they identified time pressure, team work, a change of the decision process and cancellation of a project as relevant to these findings. The cluster analyses also demonstrate strong correlations between changes in the decision-making process and cancellation of the project. Furthermore, teamwork and time pressure are illustrated as impact factors for perceptions on the main challenges.

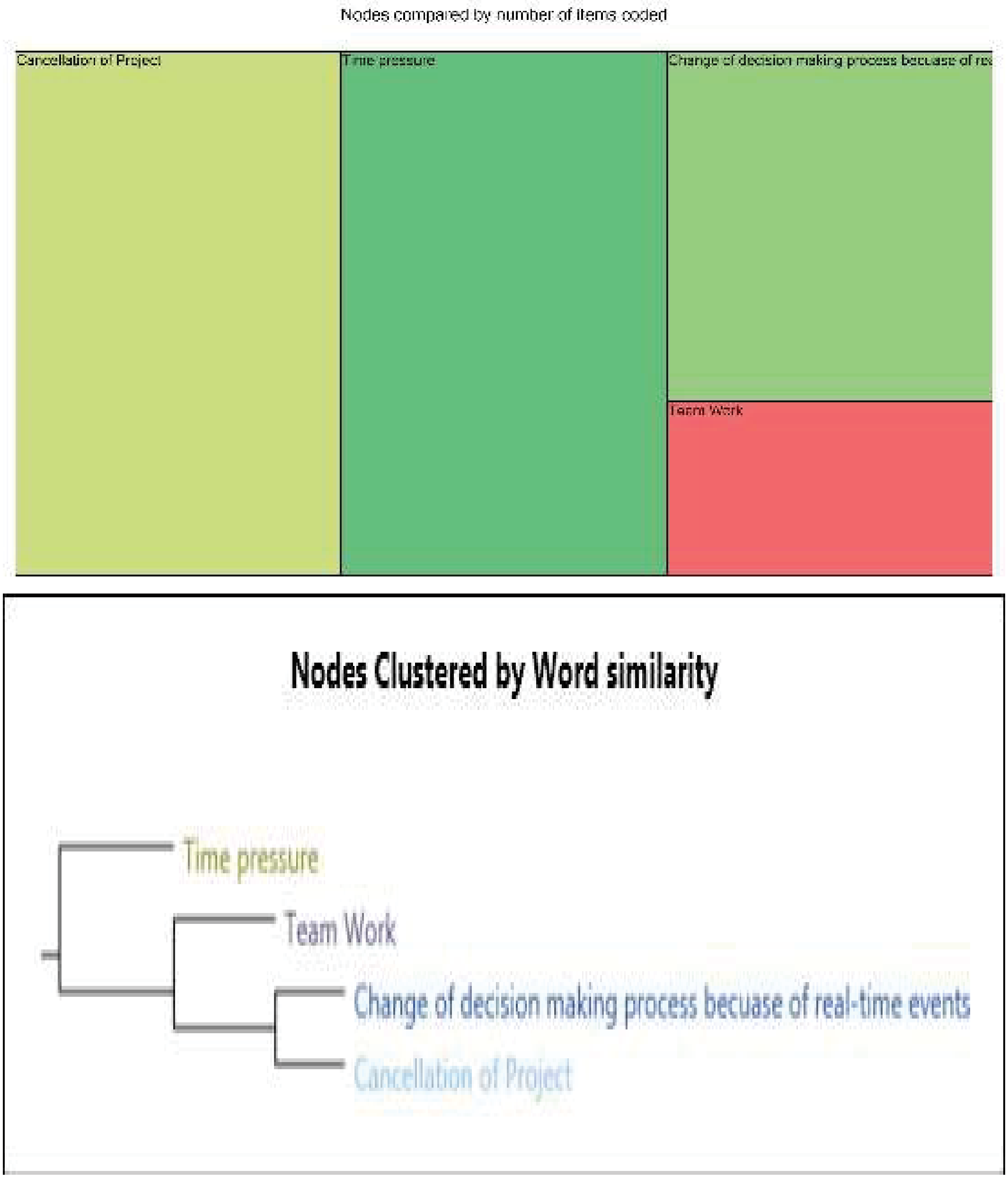


Figure 55 – Supporting evidence from debriefing sessions

5.5.2.4 Finding 5 - research question 2

Figure 56 demonstrates the influence of real-time events on final group decisions in the second context of the simulation. Two key impact factors on people's final decisions are identified as two real-time events: change of organisation and cancellation of projects. Clusters four, five and analyses of patterns created in Context 2 contribute to the Finding 5.

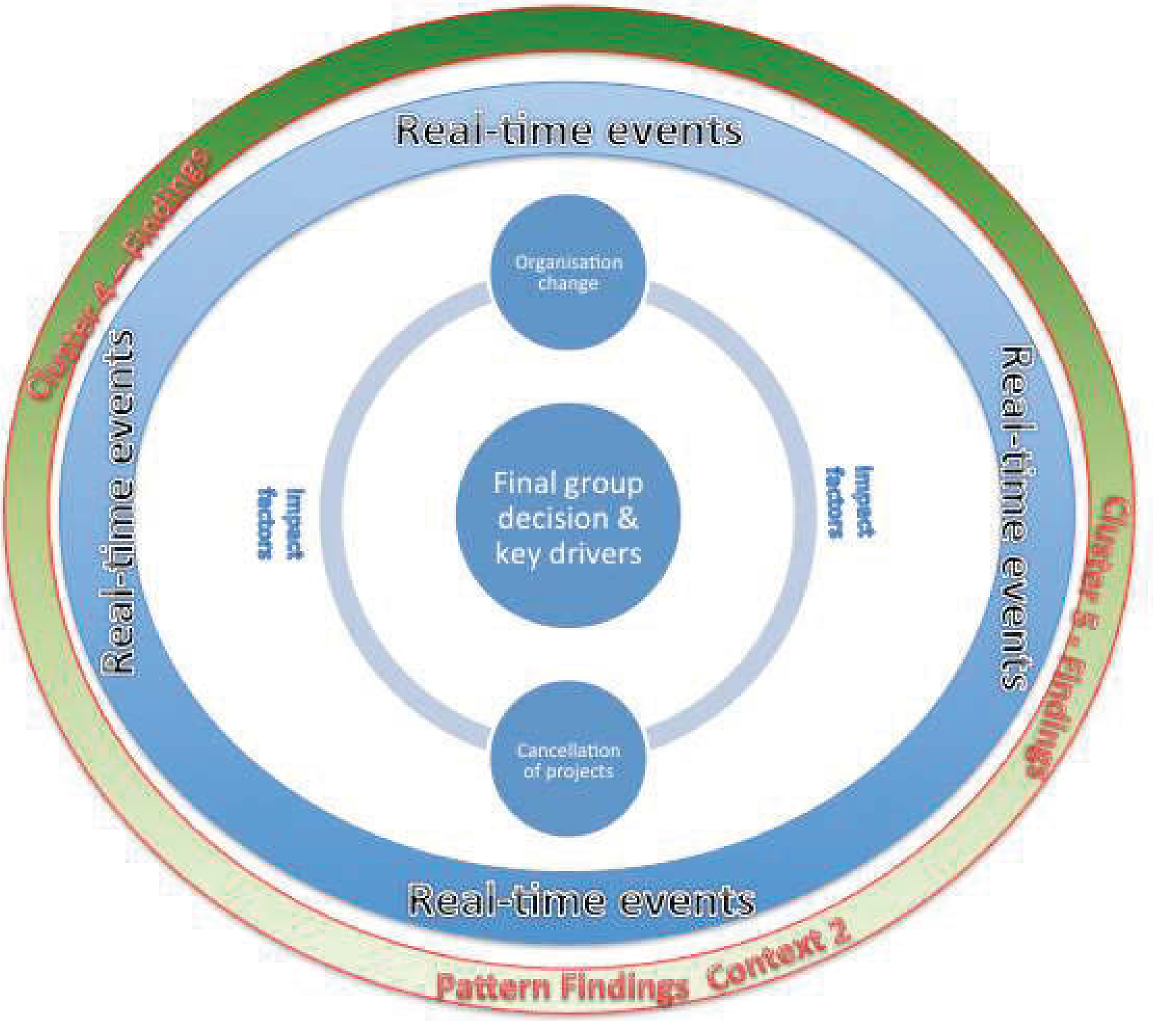


Figure 56 – Influence of real-time events

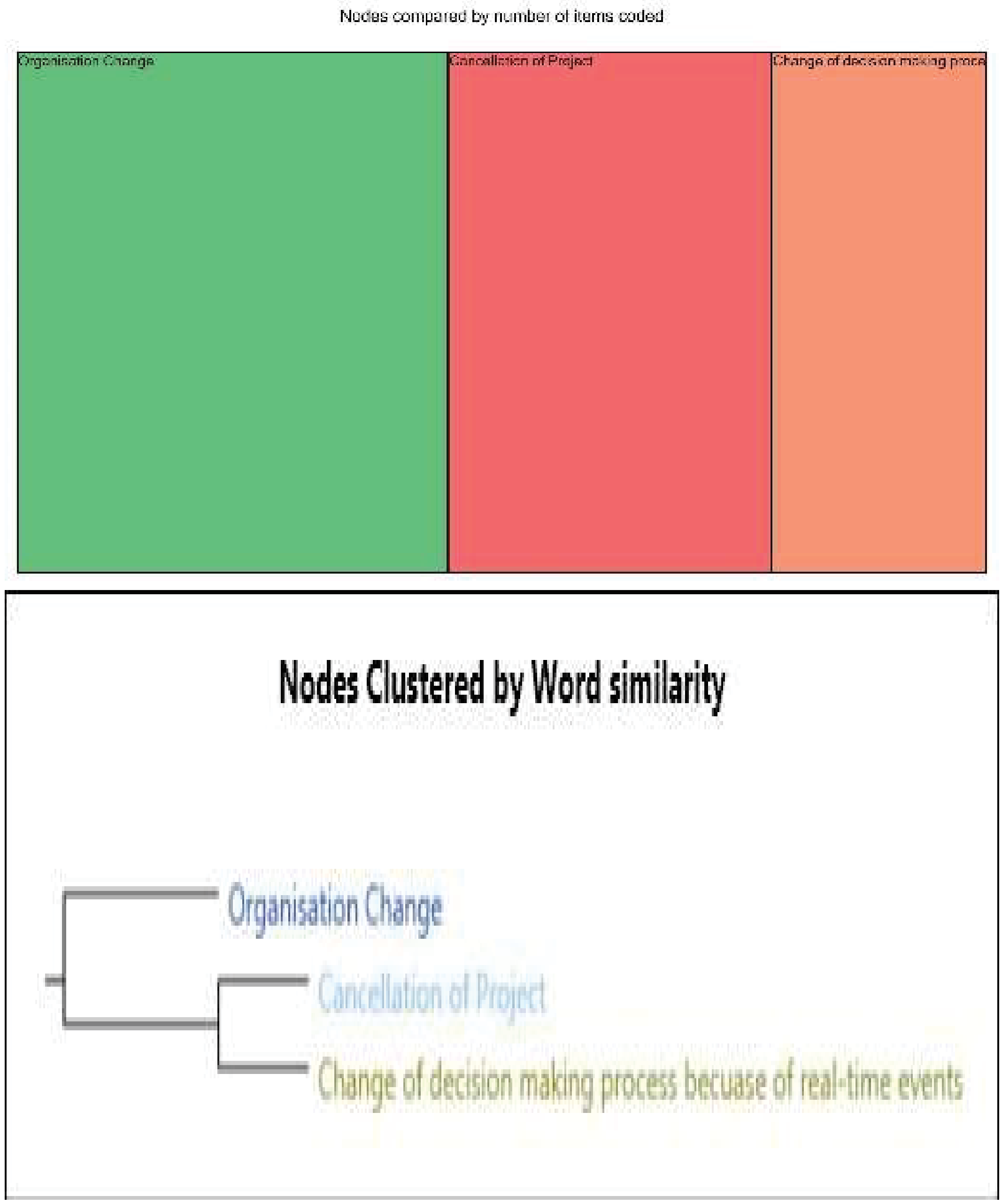


Figure 57 – Supporting evidence from debriefing sessions

Debriefing analyses illustrate (Figure 57) supporting statements from participants to have organisational change, cancellation of projects and change of decision-making process as key variables for Finding 5. Cancellation of a project and decision-making processes are strongly correlated.

5.5.2.5 Finding 6 - research question 2

The collective findings from both simulation contexts support the influence of turning points in Context 1 and the real-time events devised in Context 2 on the decision-making process. Figure 58 demonstrates a summary of findings from earlier analyses.

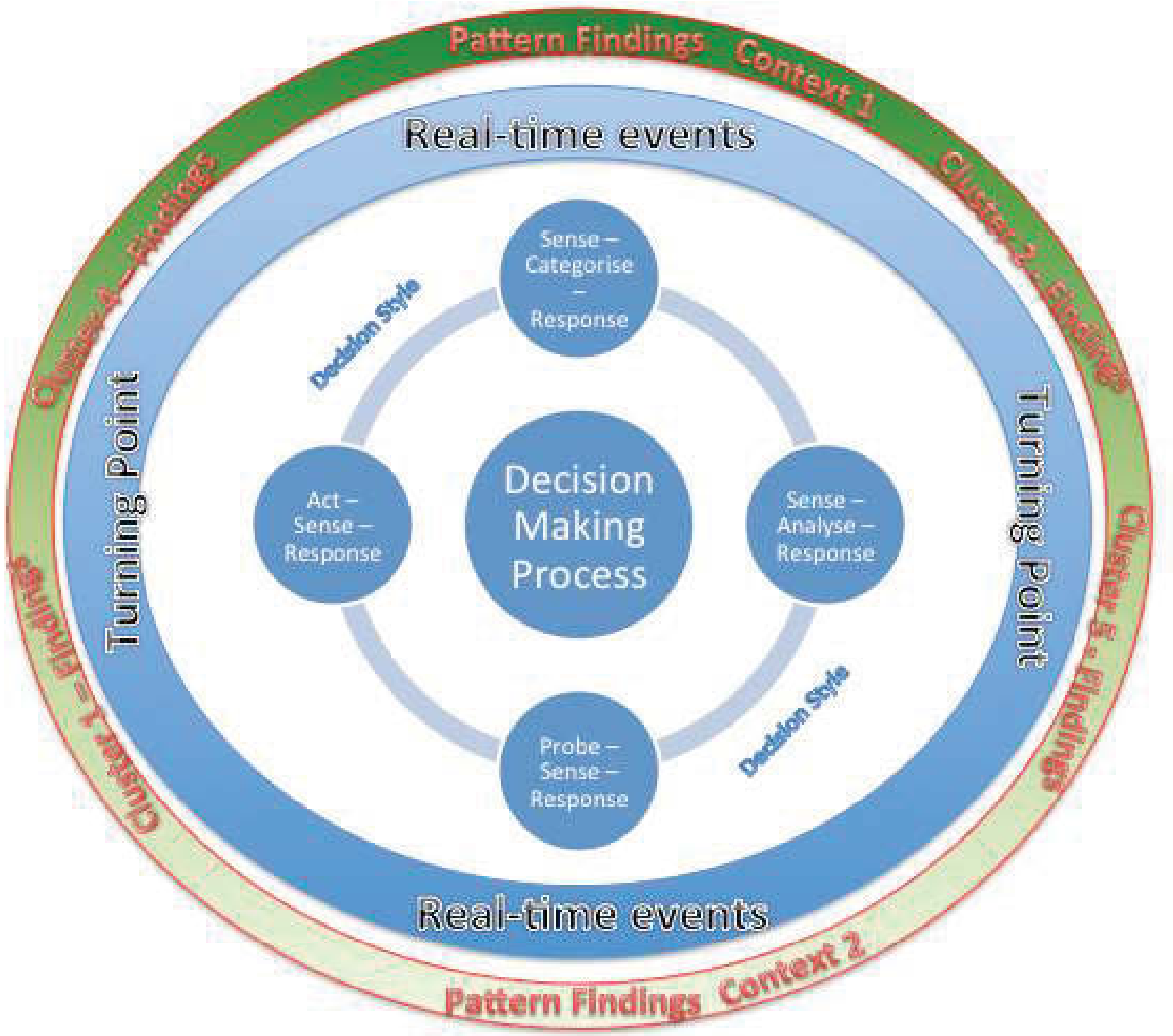


Figure 58 – Influence of real-time events and turning points on decision-making process

A detailed assessment of shifts for decision-making domains in the Cynefin framework in Clusters 1 and 2 are data analyses that support Finding 6.

5.5.3 Finding 7– Research question 3

RQ3—How do decision makers adapt to changes brought about by real-time events and why?

Research Question 3 explores two sets of findings. One concentrates on how, in Triad 11 and Dyads 11 and 17, and the second demonstrates reasons for and actions through Triad 10. Figure 59 demonstrates that real-time events influence the patterns created for these two Triads. The earlier findings emphasise a change of decision-making processes and criteria in response to the real-time events in Clusters 4 and 5. Figure 27 demonstrates the result of Dyads 11 and 17 which indicate a shift from team work to individualism as an approach to respond to real-time events in Context 2.

Triads 10 and 11 demonstrate a scattered pattern where no polarity is identified for the Triads' criteria. However, the majority of participants expressed that they use their work experience to adopt the decision-making process in response to real-time events in Cluster 4. This also discloses the reason for the adaptive actions as accepting the reality and follows the flow.

Nevertheless, data analysis in Cluster 5 supports a different trend from Cluster 4. According to these findings, the majority of participants expressed that they use their knowledge of PPM to adopt decision-making processes in response to real-time events. They also stated adaption to reality and following trends were the key reason for their actions.

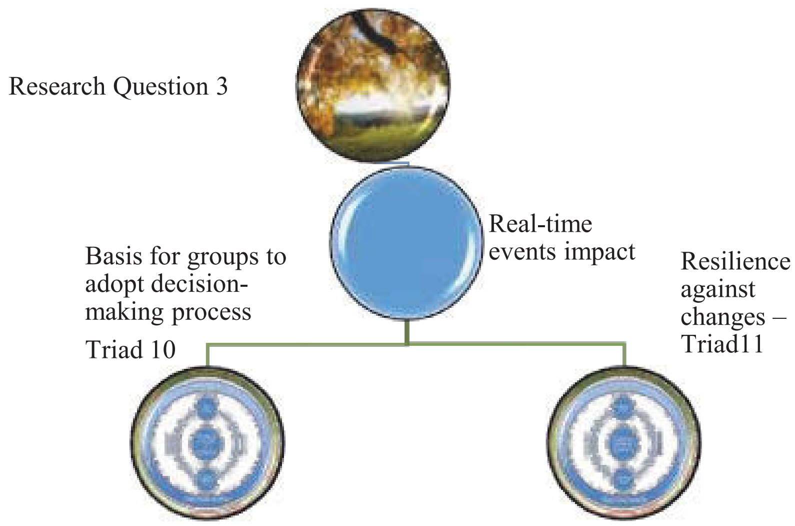


Figure 59 – Influence of real-time events and turning points in decision-making process

Further assessment on debriefing sessions reveals supporting evidence to the Finding 7. Figure 59 demonstrates a summary of the supporting findings. Adaptation, organisation change, cancellation of a project and change in decision-making processes are identified as relevant factors to the RQ3. The cluster analyses in Figure 60 demonstrate the correlation between adaptation and organisational change from one side and the correlation between the cancellation of a project and a change of decision making on the other side.

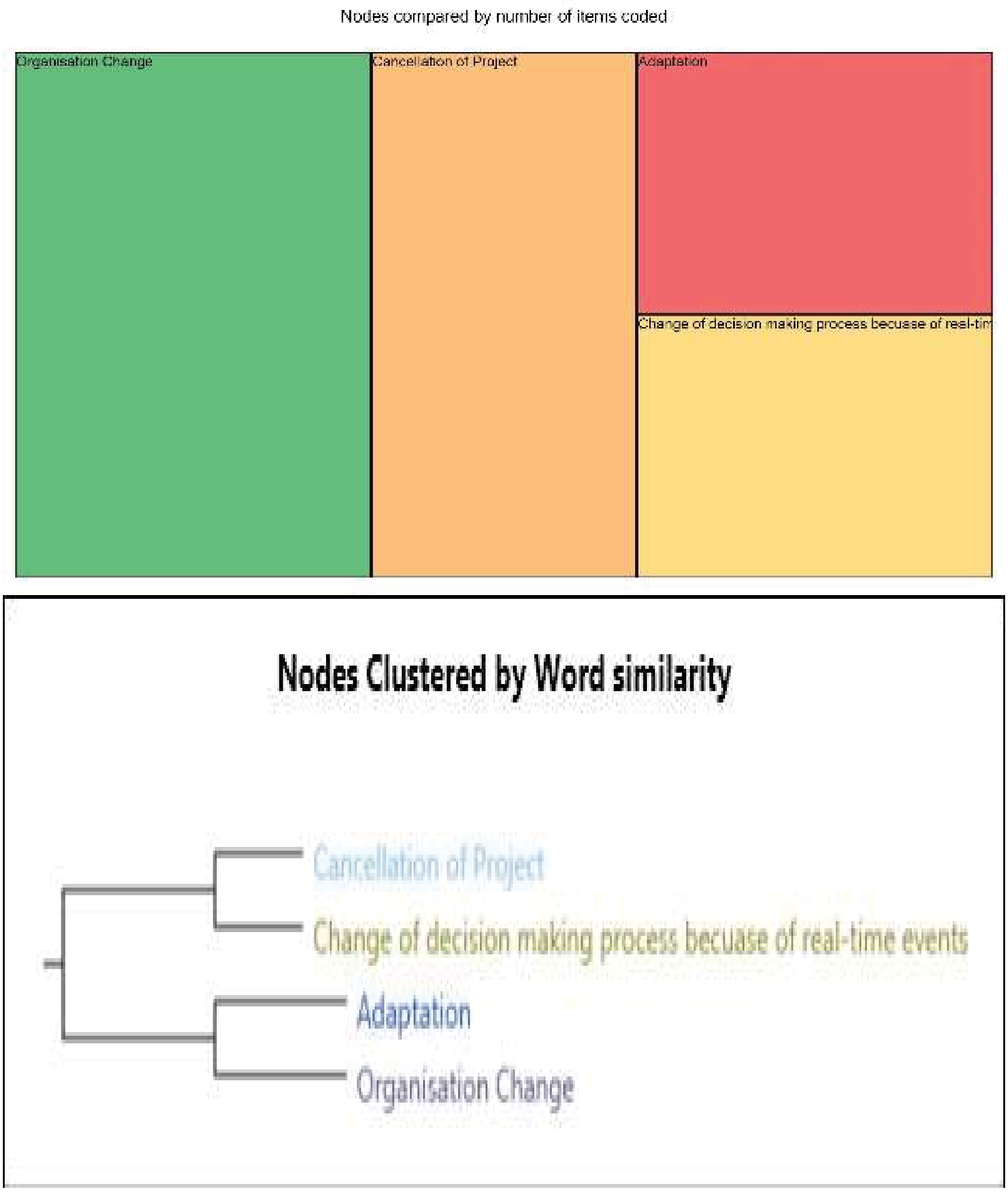


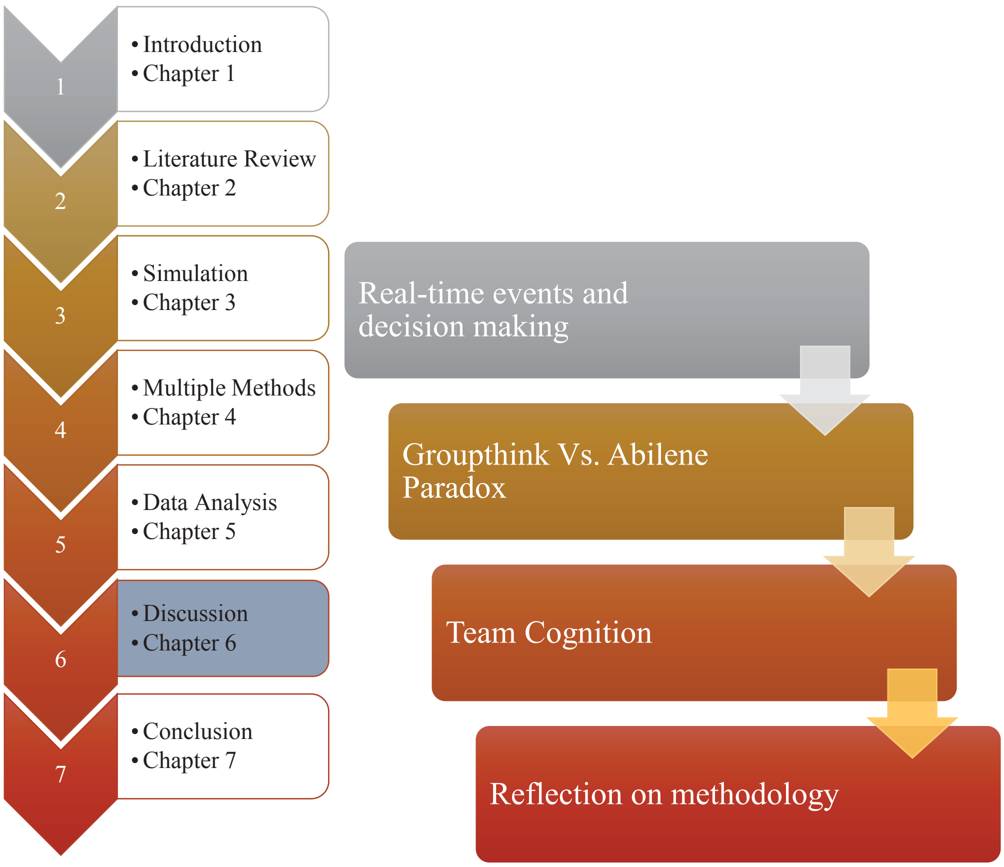
Figure 60 – Influence of real-time events and turning points on decision-making process

Hence, the findings emphasise that participants overall follow the trend of changes and adapt to organisation change. A good example is this extracted transcription from one of the debrief sessions:

"*Because I moved to a different group, I found a significant change from the first thinking; experience in the first team helped me to overcome discussion with the new team. Hence the outcomes did not change a lot."*

In this case, the participant individually demonstrated flexibility to changes and could overcome the challenges after moving to a new group as a leading member.
In summary, six findings addressed three research questions. The finding for first research question indicated that decision makers demonstrated more favour to cost-benefit than resources or business strategy.
The finding for research question 2 indicated that real-time events and turning points are key impact factors to influence decision makers' judgement and decision making processes whilst decision makers 'perception of their roles, understanding of key challenges and perception for sources of uncertainty have contributed to their mental model and judgements.
The finding for research question 3, supported that most participants adapted to reality when the organisation change happen and try to align with change of the leader. However, there have been cases that participants could not stand up to the speed of changes. The evidence also supported that changes by clients such as cancellation of a project were directly changing decision making processes in each group.

Chapter 6: Discussions



This chapter discusses real-time events, Groupthink, Team Cognition and their influence on decision-making processes in PPM. At the end of this chapter a reflection on a novel methodology applied in this research will elaborate lessons learnt for future researchers.

The data analysis chapter provided findings for three research questions as follows:

- Research question 1—How do decision makers change their decision criteria for selection and prioritisation in a project portfolio when conditions are uncertain?

In design of simulation Hooshmand-1, three decision criteria, 1-business strategy, 2-cost-benefit and 3- resources availability were selected (refer to section *3.3.3.3 Action Learning 4 Simulation at the portfolio classroom*). Participants were exposed to two scenarios with different optimisation objectives: cost minimisation and profit maximisation. The participants wrote micr-narratives against prompting questions after each scenario and answered to Triads which were designed in the sensemaking framework, to record their opinions at different times of the simulation before and after real-time events.

- Research question 2—How do real-time events influence decision-making processes for project portfolio management?

The influence of real-time events was argued as a key factor in making decisions for senior managers on project portfolio selection and prioritisation. The first scenario of simulation Hooshmand-1 was designed with the termination decision-making process and cost reduction as strategic directions. Factors of uncertainty were embedded in the Context1 of simulation Hooshmand-1 such as: working with people they did not know before the simulation, being given a new method to assess a project portfolio; and, being given only partial access to information. The second scenario was designed as representing a complex domain because of disruptive real-time events during the decision-making processes. The sensemaking framework provided support to participants to express their opinions regarding sources of uncertainty and the final decisions by their groups in Context1 and Context2 of Hooshmand-1.

- Research question 3—How do decision makers adapt to changes brought about by real-time events and why?

While the simulation creates an artificial environment for decision makers, where changes are introduced, their resilience to change is indicated by their perceptions of adaptation to changes. In addition to the real-time events in Context2, the sensemaking framework encourages the participants to express their opinions as to how their group managed the changes and what eventually helped them to overcome difficulties created by unexpected changes during simulation scenarios.

Table 19 shows the relationship of findings and research questions in summary.

RQ no	Description	Supporting Findings
1	Research question 1	Finding 1 – 5.5.1 Finding1 - Research Question 1
2	Research question 2	Findings 2, 3, 4, 5 and 6 – 5.5.2.2, 5.5.2.3, 5.5.2.4 and 5.5.2.5
3	Research question 3	Finding 7 – 5.5.3 Finding 7– Research question 3

Table 19 – Summary of findings and their relationships to the research questions

Finding 1 emphasises the roles participants play in the simulation, their perception for major challenges to carry on decision making in simulation, and participants' feelings on decision-making processes and their experience to deal with situations in their workplace, which are similar to the simulated scenarios, as four impact factors which influence participants to select their preferred decision criteria in the simulation.

Findings 2 to 5 emphasise that participants' feelings of their performance in Hooshmand-1, their perception of major challenges such as teamwork or communications, and real-time events in Context2, are considered as impact factors on final group decisions. These findings also describe the participants' perceptions of sources of uncertainty relevant to impact factors such as an individual's feelings about their performance in the simulation, their perception of major challenges (as an example teamwork), their assigned roles in the simulation, and their lessons learned from previous experience in their workplace as having relevance in real-time events. Finding 6 elaborates the decision styles for decision-making processes by individuals and their groups, as depending on the domain of knowledge they have entered in a Cynefin framework. Four categories of decision styles are considered relevant to decision-making processes because of exposure to real-time events and turning points (5.5.2.5 Finding 6 - research question 2).

The findings 2 to 5 indicate that people's feelings, their roles and individual capabilities to work in a team, are three impact factors for decision making while dealing with Black Swan events. Individual feelings concern Abilene Paradox which argues that decision-makers' feelings and perceptions may conflict with their final decisions. Furthermore, team cognition versus individual cognition are associated with the ability of decision makers to conduct decision making in a team.

Finding 6 is relevant the Two Model Theory to explain the participants' actions, when they face real-time events. The Two Model Theory explains governing values used by managers related to their espoused values and theory—in practice (Argyris, 1986). The Two Model Theory also helps to understand why the decision processes shift because of the decision-makers' approach to interpreting situations.

Finding 1 and 7 can be discussed further through team cognition and Groupthink. Several factors may contribute to Groupthink in group decision making. The essential factors to group decision making and mechanisms to manage Groupthink in a steering committee for project portfolios shall also be discussed. The discussion of team versus individual cognition supports an understating of how decision makers adapt to changes and make sense of limited information in a short period of time.

6.1 Real-time events: Two Model Theory to explain Black Swan Theory (BST)

Following upon discussion of Black Swan events, and their nature, described in the literature review in Chapter 2, this section discussed how they can affect decision making in project portfolio management (PPM). As defined in Chapter 2, real-time events are proposed as Black Swan events that influence behaviour and orientation of decision makers. Sources of uncertainty in project portfolio decisions have already been discussed in detail in the literature review chapter. Two real-time events were designed as Black Swan events (sudden change due to organisation change and cancellation of a project by the client) in the simulation Hooshmand-1. This was to investigate the effect of such events, the unpredictability of real-time events, and the way that decision makers interpret and adjust to them when making decisions for project portfolios.

The Two Model Theory (Argyris, 1986) provides assumptions deduced from decision makers' actions (theories in use) into two categories. The Two Model Theory helps predictions for decision makers' choices of strategy based on their beliefs and values. The decision makers' governing values are highly dependent on individual backgrounds and their faith and belief in how decision making is approached.

The Two Model Theory categorises decision makers into two groups as model one, (theories in use) which implies the practice and governing values in a majority of decision makers, and model two, 'espoused theory' which describes the ideal situation based on Western values and worldviews (Krupa & Jones, 2013).

Table 20, based on Argyris (1986) summarises the theory underlying the model that helps explain the behaviour of decision makers in organisations.

Table 20 – Two Model Theory, (ActionScience, 2017, p. 2)

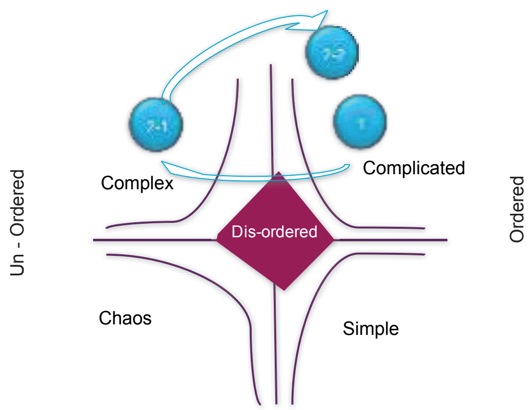
Model one theory in use	**Model two Espoused Theory**
Governing Values Held by Users	**Governing Values Held by Users**
1. Be in unilateral control of situations 2. Strive to win and not to lose 3. Supress negative feelings in self and others 4. Be as rational as possible	1. Utilise valid information 2. Promote free and informed choice 3. Assume personal responsibility to monitor one's effectiveness
Action Strategies	**Action Strategies**
1. Advocate your position 2. Evaluate the thoughts and actions of others (and your own thoughts and actions) 3. Attribute causes for whatever you are trying to understand	1. Design situations or environments where participants can be original and can experience high personal causation (psychological success, conformation, essentiality). 2. Protection of self is a joint enterprise and oriented toward growth (speak in directly observable categories seek to reduce blindness about own inconsistency and incongruity). 3. Protection of others is promoted bilaterally
Learning Outcomes	**Outcomes**
1. Limited or inhibited 2. Consequences that encourage misunderstanding 3. Self-fuelling error processes 4. Single-loop learning	1. Learning is facilitated 2. Persistent reduction of defensive organisational routines is facilitated 3. Double-loop learning is generated

Furthermore, people who fit the governing values in model one theory, set out strategies and actions in such ways that result in single loop learning. People who follow the governing values in model two theory, direct efforts towards double loop learning.

The Two Model Theory helps to understand the behaviour of the participants when they are challenged by the real-time events and turning points when playing their assigned roles in the simulation, particularly in Context2 of Hooshmand-1.

According to Black Swan Theory, most decision makers try to justify their actions as a result of real-time events. However, decision makers rely on their governing values to identify courses of actions as summarised in the Two Model Theory (Argyris, 1986). Further analysis (clusters 1-5) in Chapter 5, has revealed a changing tone and a different course of action among decision makers when they reacted to real-time events.

Participants demonstrated different approaches to the decision-making process, during real-time events. Findings extracted from micronarratives are analysed in Chapter 5 and show participants with similar roles, in different groups, perceived the movements among Cynefin domains differently for the same Black Swan event. For example, participants 3 and 4, who are both in Application Development (AD) management roles showed different movements among Cynefin domains in Figure 30 and Figure 31 in Chapter 5.



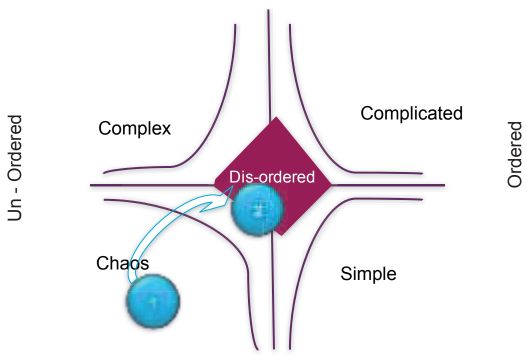


Figure 29 – Transition domains between complicated and complex

Figure 30 – Transition domains from chaos to disorder

Participant 4 demonstrated in Figure 31 that the first real-time event left the group in a chaos domain, while after experiencing the second real-time event, the group moved to dis-order domain until the end of the simulation. The outcome of the decision-making approach points out a governing value that fits in with model 1 theory. The group remained in a passive mode after the second event. This result is highly consistent with previous observations in previously published research results (Argyris, 1986).

However, participant 3 demonstrated a ‘boomerang’ movement among Cynefin domains in Figure 30. This participant perceived the group was in the complicated domain of knowledge after the first real-time event but has shifted to a complex domain (2-1) after the second real-time event. The group returned to the complicated domain (2-2) later on. The observation is aligned to some extent with the assumptions of Two Model Theory where less persistence against the change because of defensive routines is promoted and a double loop learning spirit for group members exists.

Findings in section 5.1.2, in Chapter 5—different patterns for Triads 1, 2, 3 and 4 filtered by major challenges, resulted in taking on simulation roles and informal communications as top impact factors on patterns that emerged. These are evidence that support Triads’ patterns concerning roles as a key challenge for decision making. Some of these conclusions by simulation participants can be understood using Two Model Theory. For example, some participants emphasise the role as a key challenge for decision making. This is in line with the model 1 theory which advocates the position; therefore, the role becomes central to a final decision on the participant’s perception.

Another evidence from Chapter 5 is findings in section 5.1.4 which implies the different view of people who were playing different roles in simulation. They claimed that understanding of their role requirements appeared as one of biggest challenges for them to make final decisions, and filtered patterns of Triads 1, 2, 3 and 4 by roles demonstrated a confirmatory shift in comparison to the base Triad patterns.

Participants who took on the role of PDUs demonstrated different views than people who played in the role of AD and IV in each group. This finding implies that organisations’ roles, its characteristics and nature, influence subjects’ performance and to some extent their governing values.

6.2 Groupthink versus Abilene Paradox in decision making

Decision making in a group may jeopardise anticipated goals because of group biases, and the influence of the group on their individual judgment. Decision making begins with exchanging opinions which are inevitably based on individual decision makers’ biases and Judgement. But other factors then affect the subsequent decision making due to conflicting opinions. Research has identified two frameworks that explain the effect of these conflicts of opinions that are relevant to this research. These are: Abilene Paradox and Groupthink (Harvey et al., 2004, Janis, 1972, Janis, 2016).

The factors identified collectively as ‘Groupthink’ are key sources of failure for policy makers (Snowden & Boone, 2007). According to the theory of Groupthink, a group of cohesive people are more likely to follow or go along with a group consensus to make a decision despite having misgivings about that decision (Kurtz & Snowden, 2003, Slodan, 2010). Furthermore, in a recent research study on Groupthink, the five antecedent conditions that lead to Groupthink are identified as: 1–group cohesiveness; 2–group insulation; 3–lack of tradition of impartial leadership; 4–lack of norms for methodical procedures; and, 5–homogeneity of members’ social background and ideology (Yetive, 2003).

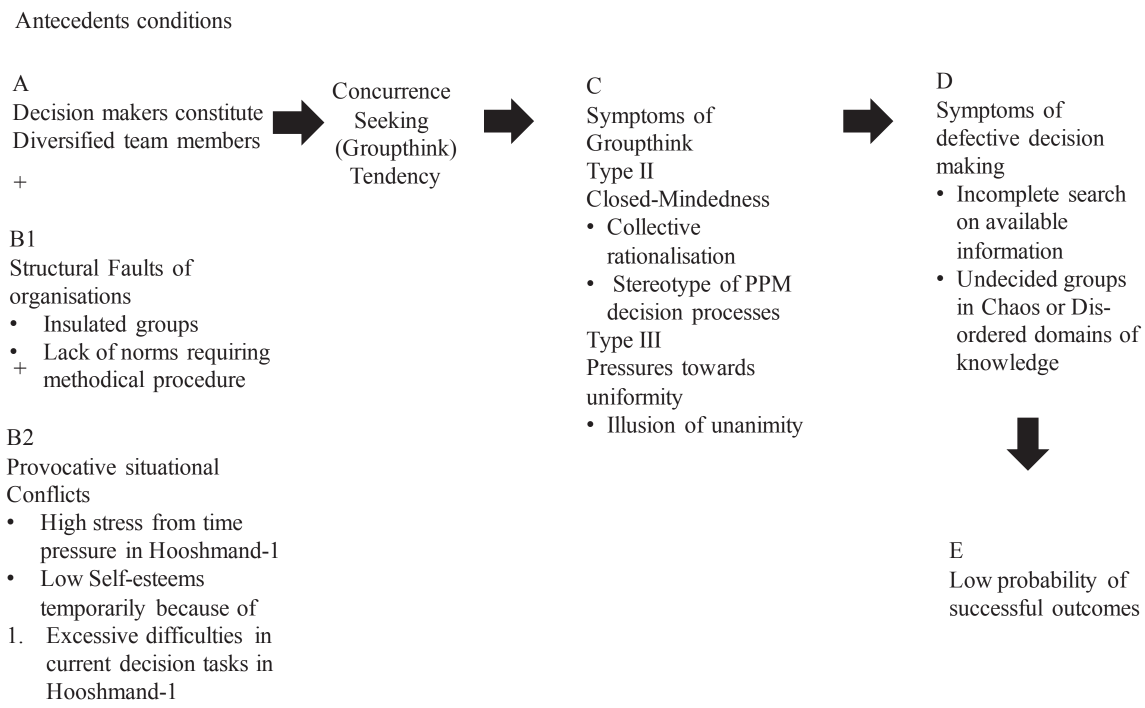


Figure 61 – Theoretical Analysis of Groupthink for results of Hooshmand-1

Figure 61 is a framework for the analysis of Groupthink based on observations during Simulation Hooshmand-1.

Antecedent conditions are listed in parameters, A, B1 and B2. Decision makers were from different groups without any joint experience prior to the simulation. The key organisational issue faced was the insulation of groups from working together, as per rules used in the simulation, and lack of norms that left the decision to a group of participants to decide how to work together and make a decision. Provocative conflicts arose from time pressures and complexity, and the difficulties of working in a simulation Context as many participants were not familiar with the method or the PPM tools that were introduced in Context1 and Context2. All participants tried to progress at the same time.

The symptoms of Groupthink were manifested during the simulation as type II and type III. Symptoms of type II were evident in rationalisation and stereotyping based on the PPM process. There was evidence from the findings that support this type of Groupthink such as Triads 6 and 13 that show the majority of opinions are focused on rational decision making, PPM processes and optimisation. The type III Groupthink symptoms are evident to some extent but less obvious than type II. For example, a few groups demonstrated an illusion of unanimity as they assumed that a consensus materialised from their group discussions. For example, Figure 62 shows that a majority of opinions are concentrated on following the leaders' preferences (5 out of 33 opinions) rather than optimisation (13 out of 33 opinions).

Triad 13 – Final decision in your group is focused on…?

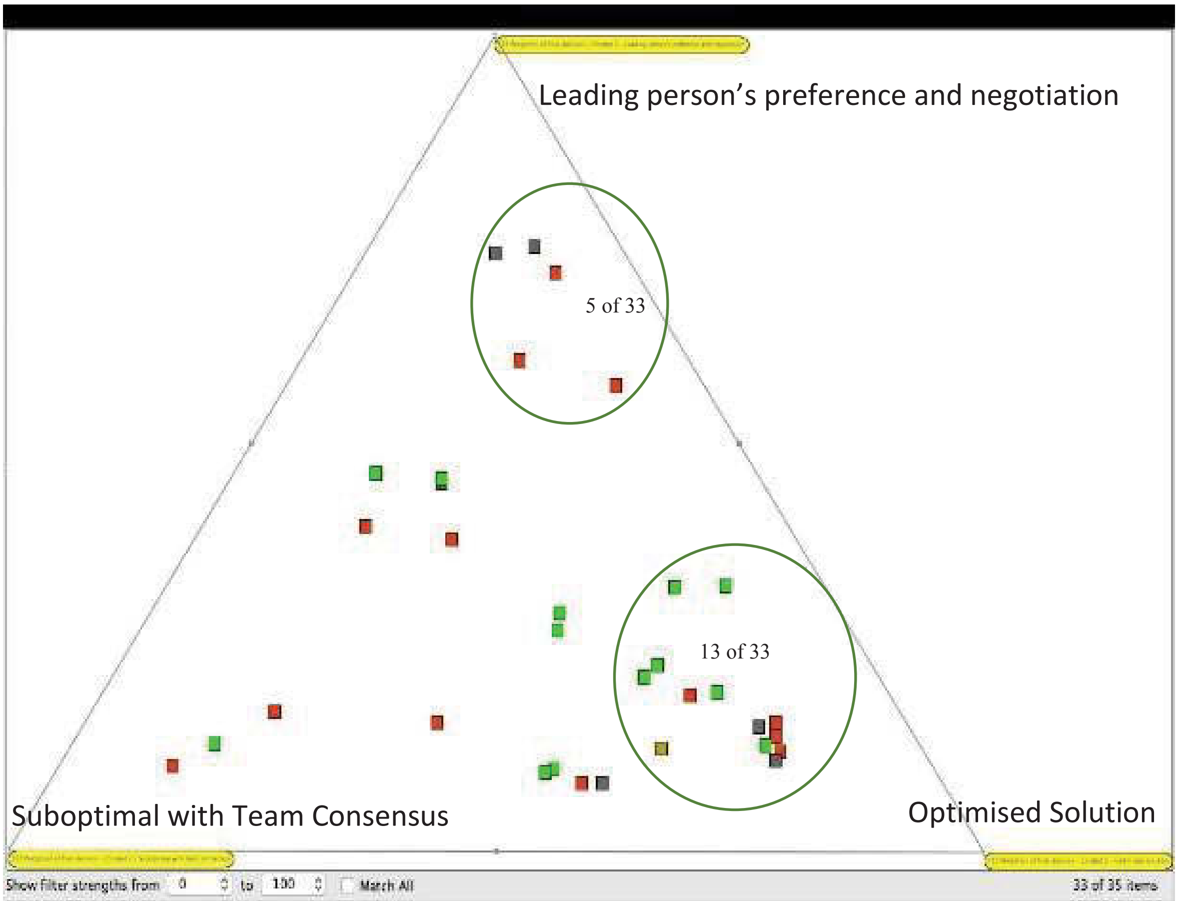


Figure 62 – The nature of final group decisions from individuals' perspectives

Decision defects are expressed as the incomplete search on available information and lack of a conclusion for final decisions demonstrated in some groups. This is evident from using the Cynefin analysis that resulted in finishing the simulation in Chaos or Dis-order domains such as Figure 28 – Transition of domains from simple to chaos and Figure 31 – Transition domains from chaos to dis-order or those comments in micronarratives show that the participants did not comprehend the available information. Appendix 5.2 Themes and micronarrative analysis provides details of all micronarratives and a few supporting fragments are selected and presented here:

Workshop no 2/

Member: Group Green / Role Application Development Manager

Name of Micronarrative: Corporate fit

Turning points were identified in Context1:

1- we were applying budget cuts based on strategic fit

2- Only considering the A&D project and not the I&V projects

Key Fragments for each turning point and nominated domain of knowledge:

"1-2 we did not look at the total picture" – Chaos

"2-1 also did not consider the I&V projects for budget cuts and relevance to other projects "– Chaos

"2-2 lack of focus on our specific roles and KPIs that we were being measured on "– Chaos

Abilene Paradox is also relevant to data analysis results and to interpret the conflict between decisions and decision makers' feelings. "Harvey describes Abilene Paradox as follows: organisations frequently take actions in contradiction to what they really want to do and therefore defeat the very purposes they are trying to achieve" (Kim, 2001, p. 170). There are common factors that lead to the Groupthink and Abilene Paradox and nine points of differences between them;

> 1- group cohesiveness, 2 - leadership style, 3 - stress from external threats, 4 - private views vs. group illusion, 5 - coerced vs. voluntary, 6 - dissatisfaction vs. satisfaction, 7- passive vs. active attitudes, 8 - blamers vs. mind guards and 9 - fear of separation vs. cohesiveness (Kim, 2001, p. 168).

The relevant elements of these factors to findings of the simulation are described further.

Group cohesiveness is a common factor for Groupthink and Abilene Paradox. While this factor supports group members to come closer in their final decision in Groupthink, the group cohesiveness can diverge after making a wrong decision collectively in Abilene Paradox (Kim, 2001, p.170). Mechanisms and controls could be deployed in organisations to set the group cohesiveness through the diversity of decision makers (Kim, 2001). Diversity of group members may arise due to personal and work related attributes. While personal attributes include gender, age and ethnicity, work-related attributes identified as work experience, relevancy to the current role, and industrial background should be considered (Kim, 2001). Diversification of participants in a decision-making exercise is usually focused on bringing a mixed combination of people who have the knowledge of projects but who are coming from a different organisation to minimise bias in making decisions.

The role of diversity was assessed in relation to group cohesiveness and its performance and disclosed a positive relationship between any increase of diversity and group performance (Harvey et al., 2004). For example, people with external positions in a group, group members who have not worked directly in a field, or people with different field background, are examples of diversity for a participant's selection process in the simulation Hooshmand-1. Despite these precautious, data collected during the simulation, surprisingly, point to the prevalence of Groupthink and Abilene Paradox. In one case during the third workshop, a participant, who was working with other colleagues from the same organisation, stated in the micronarrative that the group reached a seamless decision because of his leadership. Usually these participants' views of the decision-making domains focus on moving from un-ordered to ordered domains in the Cynefin framework. To some extent this finding supports the group cohesiveness view in a Groupthink context.

Nonetheless, other evidence supports the participants' view that specifically because team leaders changed in the second context, the group cohesiveness diverged and the group could not come to a conclusion. These groups of participants likely perceived the change of decision domains to be un-ordered and usually resulted in the dis-ordered or chaos domain, with no final group decision. Lack of expressing different opinions because of conflicts seems to support Abilene Paradox assumptions.

Group insulation occurs when a group of policy makers are totally excluded because of the restricted structure and confidentiality of discussions and exchanges of opinion (Slodan, 2010). The project portfolio steering committee concerns group insulation antecedent because of the rule in Hooshmand-1 which stops the communication among different steering communities in the same simulation workshop. These decisions usually are categorised as confidential and can be survival factors for the business and its strategic objectives. The rules of Hooshmand-1 mandates participants to contain their discussions within their allocated groups and tables. In Context1, this rule could meet the criterion for group insulation. But there is no evidence that group insulation caused a group think, after critical analysis of the micronarratives from the participants. To some extent, mitigation measures, such as role rotations among the groups, and the change of

PDU as events, supported group members to overcome group insulation. Evidence from data analysis suggests that rotating key members of a decision-making committee have transferred knowledge from one group to another. This means that other opinions were considered in their final decisions in Context2 because of rotating PDUs. This seems to be an effective mechanism to counter Groupthink.

Literature on impartial leadership points to mechanisms that could influence the leader's decision through independent expertise (Slodan, 2010). Simulation Hooshmand-1 has, unintendedly, addressed this element in its design through role rotation and introducing new leaders to each group at the final stage of decision making in Context2. As an example in practice, the New South Wales (NSW) Government in Australia has set up Infrastructure NSW (INSW) as a governing entity to monitor decision making on complex capital projects for construction of infrastructure across the state (Yetive, 2003). INSW uses a gateway review and an independent expert panel review to ensure that all aspects of a project's feasibility study are met before the business case is presented to the Cabinet for funding approval (Yetive, 2003). This resembles closely the mechanism of the rotation of key decision makers in Hooshmand -1 as the project team exposes their knowledge to a new panel of experts and receive their independent feedback and comments.

On the other hand, the Abilene Paradox views the leadership style differently from Groupthink. According to Kim (INSW, 2016), non-existent or incompetent leadership could result in an Abilene Paradox situation. As assignment of roles was intentionally random in the simulation, there were a few instances during the simulation when the participants blamed leaders for lack of knowledge or competencies. This supports Abilene Paradox's assumptions of the influence of a leadership style that leads to poor decision making due to incompetence.

Norms for methodical procedures are often used in setting decision criteria and options assessment processes. Lack of methodical procedures opens up the room for individual bargaining with the team leaders and reaching a group consensus without a holistic assessment of alternatives (INSW, 2016). The simulation Hooshmand–1 provided expected outcomes, and information for decision making, but assessment procedures were intentionally left to each group's discretion. Hence, to some extent there was mixed evidence that people tried to follow the leader's view or sometimes their final decision was somewhat based on group consensus. However, a majority of the participants emphasised the use of rational and optimisation approaches to make their final decisions.

Despite the fact that Groupthink has attracted significant attention, the amount of empirical evidence to support the theory is not significant (Kim (2001). For example, disruptions such as non-voluntary role rotations, diversified members in each group and facilitation processes were made to avoid Groupthink, although there was evidence of its presence in the simulation Hooshmand-1.

Homogeneity of group members and their ideological backgrounds can enhance Groupthink in decision making. According to Yetiv (Yetive, 2003), advisors with common world views created a group consensus on policy making resulting in the first war in the Persian Gulf. This has been countered in the design of the simulation through the selection process, as a majority of participants have been volunteers from different organisations, without any direct work relationships. This supports the importance of considering experts' opinions who have no direct interest in the final decision and its outcomes.

6.3 Team versus individual cognition

The concept of individual and team cognition was discussed in the literature review—section 2.5.1. Team cognition depends on the process of information integration through a group of decision makers, over time. The application of team cognition as a science is a growing field for future study of decision making among a group of stakeholders. Unlike other applications of research studies which aim at a well-developed theory, the application of team cognition has received more attention from a practical perspective (Turner, 1998). Simulation has been one of the key drivers to assist the understanding of team cognition. For example, development of dynamic team environments is referred to as TANDEM, DDD and UAV (Yetive, 2003). All three simulations tried to create a team dynamic environment to facilitate a study of team cognition in military matters. All of them have considered the adaptability to change as a key factor for team performance in complex problem solving.

Despite technological advancements for team cognition, its measurement is not well advanced. Team cognition measurement is important as the measures are indicators for development and training planning for professional groups (Cooke & Shope, 2002, Johnson et al., 1998, Kleinman et al., 1996).

Table 21 summarises some of the challenges and solutions for measuring team cognition.

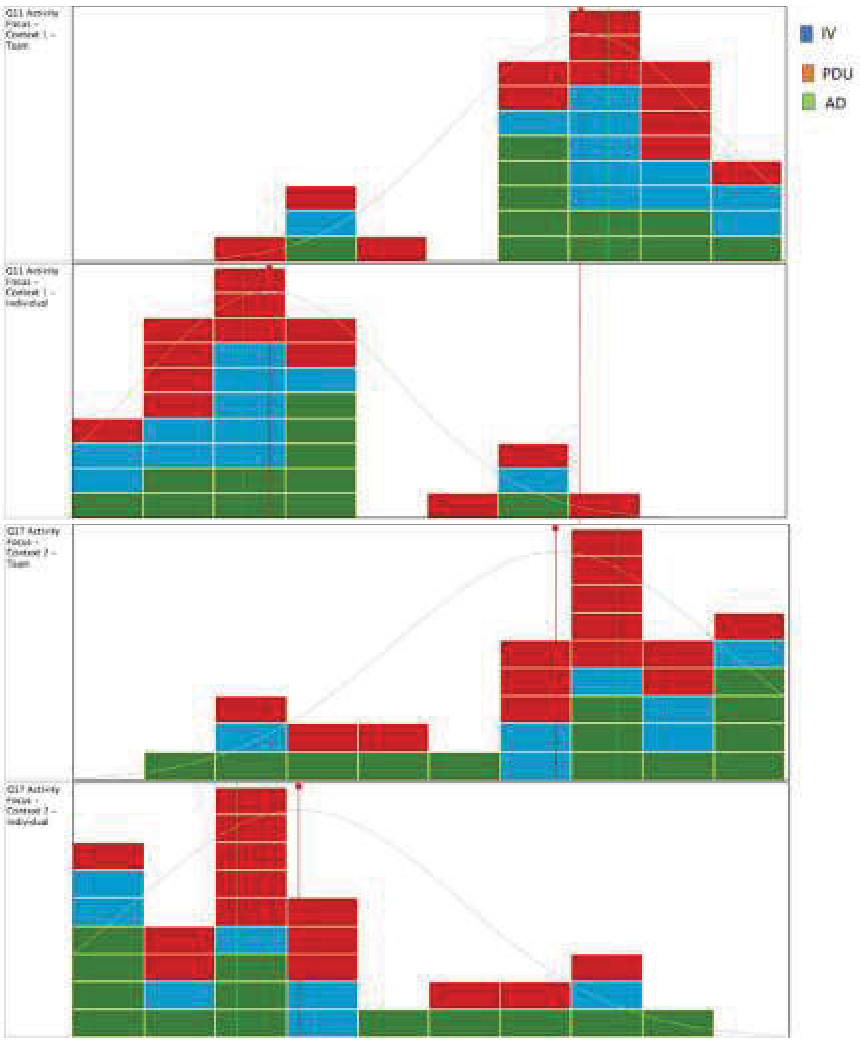
Table 21 – Adapted from (Durso et al., 2007, p. 246)

Some challenges to measuring team cognition and some solutions

Challenges	Solutions
Measures applicable to heterogeneous teams	Heterogeneous knowledge metrics (e.g. role-specific referents)
Measures that capture emergent cognition	Holistic measures taken at the team level (e.g. consensus ratings)
Holistic, embedded, real-time metrics	Communication pattern analysis (Hooshmand-1) Cynefin Domains Movements (Hooshmand-1)
Measures of emergent team situation awareness	CAST: coordinated perception and action of team members in the face of change

The simulation Hooshmand-1 has clearly tested challenges with emergent cognition, and real-time metrics, such as the future backward method (details in Appendix 2.1), to describe events in a chronology from the end to the start, where the researcher could trace the flow of decision processes and the change's alignment with real-time events. As mentioned in Table 21, Cynefin domain movements through theming in micronarratives has proven to be a powerful tool to respond to needs for real-time metrics. The details are available in section 5.3 Micronarratives and fragments of the data analysis chapter.

Additionally, the individual's perceptions were investigated using the sensemaking framework to understand patterns of focus on teams or individuals in Context1 and 2 of Hooshmand-1. Section 5.2.6 Dyad - 2 Distributions, explains some of the findings from Dyads as indicators that were used to measure the shift between individualism and team work as a result of Black Swan events during decision making. Figure 27 recaps earlier discussion in the data analysis chapter that summarised how the real-time events such as changing the group leaders, or role rotation, indicated a shift to a weaker team centred approach and growing individualism to make final decisions.



Blue : Role of leader for IV department
Red: Leader of each steering committee
Green: Role of leader for AD department

Figure 27 – Focus of team vs individuals in Context1 and Context2

Time pressure and real-time events are key perceived factors that could increase individualism and reliance on individual participants' knowledge and experience to find a resolution. This theory is supported by the evidence from the simulation to some extent. The nature of integrative and intuitive firms was discussed (Kester et al., 2009) in the literature review—section 2.4.2 Uncertainty, impacts on decision makers—and the approach of integrative firms was designed in Hooshmand-1 scenarios which outline a hybrid approach to decision making by applying qualitative and quantitative methods (Kester et al., 2009). The participants in each group of simulation Hooshmand-1 were representing a corporation's steering committee for PPM and they were supposed to take a hybrid approach. However, after exposure to real-time events in Context2 of the simulation, quick changes negatively impacted teams to direct collective decisions. For example, the group leader lost control of the decision process in some cases, which resulted in finishing the decision making in the dis-order domain. This result supports that the hybrid approach of decision making was downgraded and intuitive decision making became dominant when exposed to real-time events. Therefore, expertise-based, intuitive, decision making (Salas et al., 2009) manifested as one way to adapt to changes in Context2 and the indicator above shows a shift to individualism in the second Context of simulation Hooshmand-1. This shows the value of Dyads as an effective tool for measuring CAST as mentioned earlier in the Table 21.

Participant 2 shows how his team experienced a mental block as a result of team cognition. While the Figure 28 shows the shift from complicated domain to Chaos, the participant asserted in his micronarrative that his team could not conclude any decision at the end of Context2. He also rated individualism of 82% in Dyad 17 which indicates weak team work among group members in this particular group.

Those Cynefin movements which have resulted in Chaos or dis-order without any decision, can be seen as one of key factors for failure in team work to share implicit knowledge among themselves in a short time of decision making. This emphasises the importance of senior managers' need for awareness of the role of team cognition in PPM decision making. It would be useful for senior managers to evaluate team cognition during the early stages of portfolio planning to prepare for dealing with an unexpected Black Swan event during decision making.

6.4 Reflection on methods

The methodology used to find responses to the research questions is a novel approach to study PPM decision making in uncertain conditions. The process of evolving the methodology was discussed in literature review, and simulation chapters. As the methodology has been presented, this was the first time that it has been applied for research on decision making in a changing environment. The results from the first trial of the method were found to be better than earlier expectations.

I wanted to combine an exploration of applying Hooshmand-1 and Sense-Maker with how decision makers deal with unexpected situations and identify meaningful resolutions in a short period of time.

Evaluating the use of a multiple methodology showed there are lessons learnt that will be outlined in two categories. One is a positive aspect with how it was applied, and the second one is considerations of improving this methodology for further use based on the feedback received after using the simulation several times.

6.4.1 Current multiple methodology

The current methodology as demonstrated in Figure 14, used a combination of Simulation, the SenseMaker and Nvivo providing an opportunity for me to investigate relatively lesser known or complex problems to enable a deeper understanding of the problem. This combination of multiple methodologies demonstrates a novel way of carrying out research in a business Context to address the demands of being able to improve practice on a just-in-time needs basis in a fast changing world. Stienstra & van der Noort (2008) support the view that traditional research approaches such as deduction or induction belong to past times, and new narrative research (Snowden, 2010a) based on emergent complexity as the rules of law, is guiding future research. The use of SenseMaker as an advanced tool for micronarrative research has supported the need for a novel approach.

The simulation exercise provides a unique case for each group of participants and it is used as a facilitated environment where indirect investigation can be applied to answer the research question/s. It also provided an opportunity to simulate real-time events and reactions to these events from participants. All four case studies which were facilitated with four different groups of people went smoothly for engaging them realistically with their problem-solving challenge. Indirect investigation on research questions through using SenseMaker tools such as Triads, Dyads and Multiple Choices not only gave participants a opportunity to reflect on their micronarrative stories after each context, but also encouraged them to cross check their way of making sense from their experience using a sensemaking process.

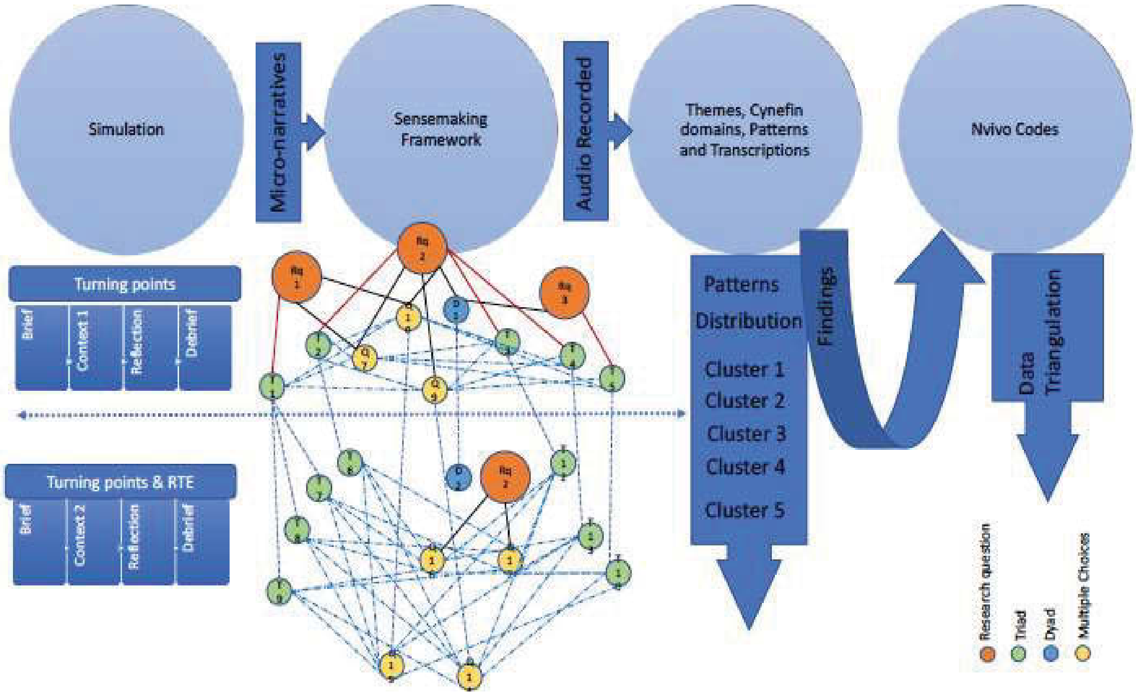


Figure 14- Research methodology process chart

The combination of SenseMaker and Simulation also provided an opportunity for the researcher to cross check findings from micronarratives, Triads, Dyads and Multiple choices through creating combined filters in the data analysis. This has provided a deeper understanding of patterns in sections 5.1 Patterns – 1ST Scenario of the Simulation **Hooshmand-1** and 5.2 Patterns - 2nd Scenario of Simulation Hooshmand-1. This adds rigor to this research. The design of simulation Hooshmand-1 was based on two sets of scenarios for PPM decision making with Context1 in the complicated domain of knowledge and Context2 in the complex domain of knowledge. This design created an opportunity to investigate decision making using the Cynefin framework.

In addition, use of findings in clusters to inform the coding of Nvivo assisted in the implementation of data triangulation based on facilitated dialogue. The role of facilitator in using creative prompting questions based on the Contextof research and observation during implementation of the simulation, is crucial. A highly skilled facilitator can rejuvenate the sensemaking process for participants during a debriefing session at the end of a simulation and it can become a coaching exercise for participants to understand the meanings of the process in which they are engaged, with a clear approach (Toit, 2006). The research process has resulted in creating transcriptions that are easily linked to a sensemaking framework, as the Node analysis using Nvivo could verify the findings in clusters of data analysis from SenseMaker.

6.4.2 Improvements to multiple methodology

Recommended improvements of the multiple methodology applied for this research relate to design and implementation. While the framework of this form of multiple methodology is known, using a community of experts to prioritise and select the most relevant criteria for using a sensemaking framework was useful in setting up this research. In the current research, an adaptation process was taken using examples of similar research conducted using SenseMaker and enhanced using an Action Learning approach, guided by experts. The first questionnaires and criteria for Triads and Dyads was discussed with a community of Australian experts during the SenseMaker workshop at UTS in 2014. However, the criteria could have been created with more engagement during the preparation phase for signifiers. Combining the field of expertise and a community of practice for use of SenseMaker could generate a more innovative design for SenseMaker questionnaires and improve utilization of its tools for data collection and data analysis.

The second design improvement is focused on simulation. As the simulation with the sensemaking framework presented to a community of management practice is fairly new, the time allowed for participants to understand the procedure they need to follow during and after simulation is essential. This could improve the consistency of results from participants. As an indicator, discussed in the data analysis chapter, 21 out of 33 participants produced quality micronarratives that were consistent with requirements they received during simulation briefings. This could have produced a stronger case for data analysis if the number of informative micronarratives had been higher. Hence, if more time was set aside for the 'cold run', briefing could have helped the facilitator to identify participants who did not know what they did not know! This approach may have reduced loss of opportunities for utilising outputs of participation in each simulation such as the correct use of future backwards reflection, or understanding the differences between turning points and real-time events in the case of Hooshmand-1.

The last improvement to the simulation's design could be the addition of a consultation workshop with a focus group of field experts, perhaps by applying a four tables technique (see Appendix 2.1) which could informally facilitate a problem-solving workshop in four domains of Cynefin (Cognitive-Edge, 2013) to validate the interpretation of the researcher on fragments for each group of participants. This would help to further support the validity of findings.

The experiment could have resulted in more data if the number of participants was increased to beyond 100. An increase in the number of participants would support the case for statistical analysis of megadata, based either by using SenseMaker's statistical tools or by applying a statistical analysis in Nvivo.

6.5 Reflection on my learning from this research

I outline key learning outcomes over my research project. I have developed skills in identifying opportunities to design and implement role play simulation for education and practice, knowledge and skill of using SenseMaker and Nvivo as key research tools. I have also learned about body of knowledge to implement project portfolio management and analytical skills to make sense of complex situations.

6.5.1 Knowledge of Project Portfolio Management

I have developed my understanding with body of knowledge for PPM practice through comparison between PMI standard of Portfolio Management and OGC guidelines for implementation of PPM across organizations. I have also developed my understanding about application of PPM in different industries such as IT, Infrastructures, Research and Development. I understood from previous research works that the governance of PPM can be tailored per industry, however, all industries have proved benefits and gained competitive advantages after successful implementation. Lastly, I learned about tools and techniques such as decision criteria (financial and non-financial) , Portfolio roadmap and mathematical models which support the successful delivery of PPM for clients.

6.5.2 Critical Skills Development for leading decision making in complexity

I have learned through observing actions and analyzing reflections of simulation participants. As participants in four simulations were coming from diversified background, I received a very rich perspective on the way decision makers deal with uncertainty. I believe that the way senior managers handle the uncertainty and complex issues in the process of making decision will become a useful asset for future practice across executive decision boards, PPM committees and Project and program practitioners.

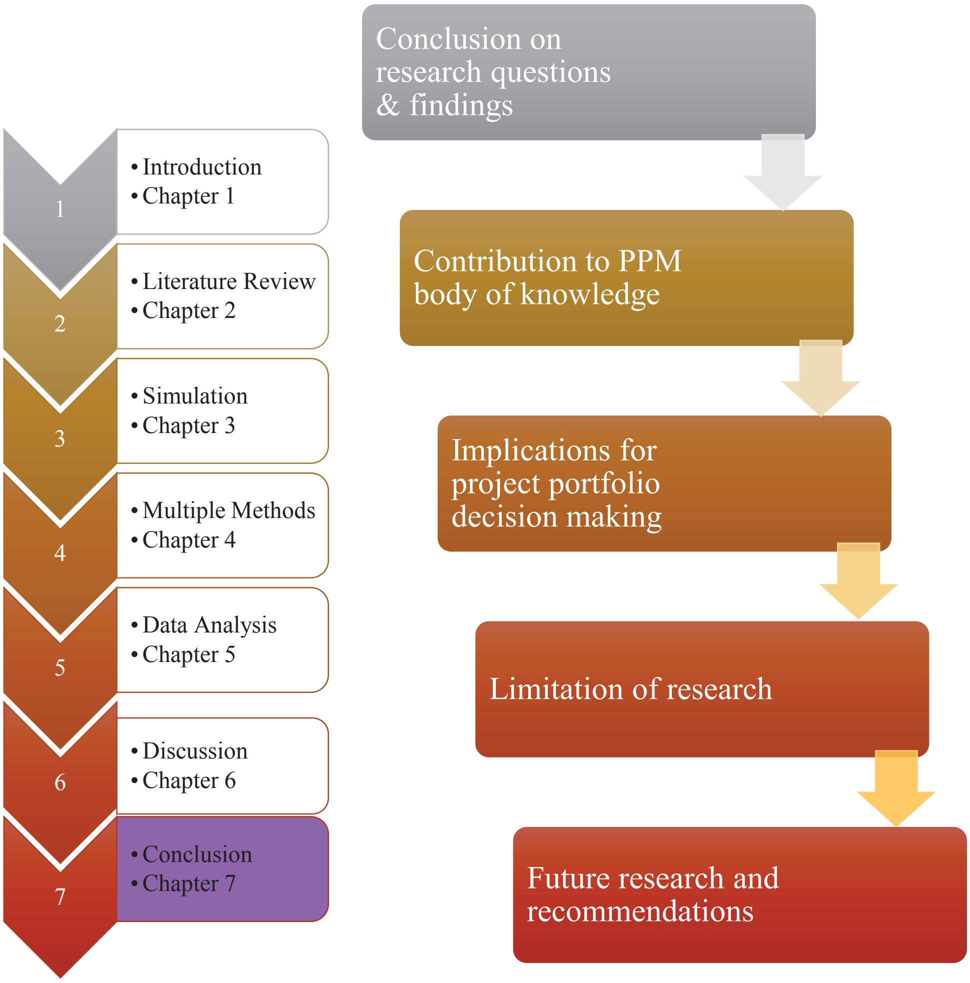
Furthermore, I have developed skills to design and facilitate role play simulations for complex domains. This is a capability to advise on similar situations as an independent member of advisory boards, or to provide support to universities and research centres to improve decision making under uncertainty for post graduate students, executive researchers and senior managers who might deal with complex problems such as R&D projects.

6.5.3 Research and Analysis Tools

I have learned how to design the sensemaking items in SenseMaker software. The software has special tools which enable the user for research analysis, mega data collection, strategy integration and identifying early warning signals. It has the theoretical support of Cynefin framework to further make sense of its data analysis results.

I have also learned how to use Nvivo cluster analysis tool on word themes in debriefing transcriptions. I believe Nvivo enables me with interrogating expressions of participants in research projects. It is a well-established qualitative tool for both academic and practice led research.

Chapter 7: Conclusion and Implications



Chapter 7 presents a summary and conclusion of this dissertation. After comparing the findings of data analysis with existing theories, Chapter 6 discussed key findings from the study including the effect of Groupthink, Abilene Paradox, Two Model Theory and applications of the Cynefin framework to an analysis of decision processes fused in PPM. The conclusion revisits the research questions, multiple methods research, data analyses, findings and the discussion. It then explains the implications for theory, practice and methodology from this research, limitations of the research and points to some directions for this research.

The research problem set out in this thesis arose from my observations and concerns about decision making at my workplace. Therefore, I believe that the finding from this research would provide some useful guidelines for practicing PPM in a real context.

Three key implications for decision makers in project portfolio management (PPM) identified in this research are: a) complexity of dealing with un-predicted changes; b) the capacity to handle changes during implementation; and, c) individual decision makers' abilities to manage decisions under uncertainty.

As the world becomes more complex, decision making about project portfolios comes under more strain. Real-time events can upset outcomes from rational and information-based decision making which are the conventional tools used to decide on major projects and strategic initiatives. The impacts of such unexpected events can be compounded by a lack of appreciation for risk management in project portfolios. Furthermore, poor establishment of information systems, and inadequate communications in organisations, threaten the success of decision making for project portfolios if the effect of sudden changes are neglected during the process.

Groupthink and Abilene Paradox are two concepts relevant to the possible vulnerability of PPM contexts. Use of the simulation Hooshmand-1 was designed to control some of the influence of these effects on decision making. However, this influence continued to affect decision making during the simulation.

Individual decision makers' actions to tackle uncertainty are informed by their governing values explained by the Two Model Theory outlined in the discussion chapter. The Two Model Theory explains how governing values of decision makers influence the approach they select in complex situations. This has an effect on the final outcomes from a decision-making exercise.

7.1 Responses to research questions

The literature review and a carefully designed research methodology were used to find the responses to the key research question which was set out as:

"What is the impact of real-time events on managers during the decision-making process for PPM?"

As a result of gaps identified in literature review, the main research question was divided into three specific research questions which emerged as key focus areas where little attention has been paid in the existing theory on decsion making in PPM in a fast changing and dynamic world.

Using an Action Learning process to develop an effective simulation as a research tool, with a novel methodology for analysis of the data collected from four runs of simulation Hooshmand-1, seven findings were presented and their relationship with the research questions was discussed in Chapter 4. The findings are summarised below.

7.1.1 Research question—How do decision makers change their decision criteria for selection and prioritisation in a project portfolio when conditions are uncertain?

Changes to decision criteria for a multi-objective process such as project portfolio selection is a critical area when projects are facing uncertain conditions. RQ 1 examined three sources of uncertainty. These are a) time, b) individual skills and c) information likely to be available to participants when facing crucial decisions. The key findings from data analysis show that the key factors on individual's judgement to select decision criteria for project portfolio selection or prioritisation as *feeling*, *previous experience* and *simulation roles*.

7.1.2 Research question 2—How do real-time events influence decision-making processes for project portfolio management?

Research question 2 examined the influence of real-time events on the emergent processes of decision making in PPM. The Cynefin framework that was used to analyse the results of simulation Hooshmand-1 provided some key insight on how research participants' perception of decision-making style changes due to turning points experienced during the simulation. The findings emphasise that factors such as *individual feelin*g, *personal experience*, *their understandings on own roles* and *their perceptions of major challenges* can influence their understanding of sources of uncertainties in both complicated and complex situations. The research results provide evidence that real-time events influence the individual perceptions on the key driving factors for final group decisions for project portfolio selection and prioritisation in simulation Hooshmand-1. Finally, *decision-making processes and styles* are linked to individuals' perceptions of knowledge domains in which they make decisions as they cope with real-time events.

7.1.3 Research question 3—How do decision makers adapt to changes brought about by real-time events and why?

Research question 3 discussed adaptability and the range of emergent patterns for decision makers' perception in dynamic environments. Participants' acceptance of changes and their perceptions about the adaptations were assessed. The results of the simulations show that the majority of participants expressed that they use their *knowledge of PPM* to adopt a decision-making process in response to real-time events. They also stated that *adaption to reality* and *following the trend*s influenced their actions.

7.2 Conclusion on data analysis and findings

From data analyses on the results of four runs of simulation Hooshmand-1, seven findings were presented and their relationship with the research questions were explored in Chapter 4.

Real-time events and turning points were two key drivers for data analyses. Real-time events were designed as intentional changes in the simulation to observe the reaction of participants and their influence on participants' perceptions. Turning points were the key momentums from a participants' perspective. The participants presented different ways of group decision processes even within the same group when faced with real time events. For instance, Figure 32 and Figure 33 show how two members of the same group presented their views on movements among Cynefin domains.

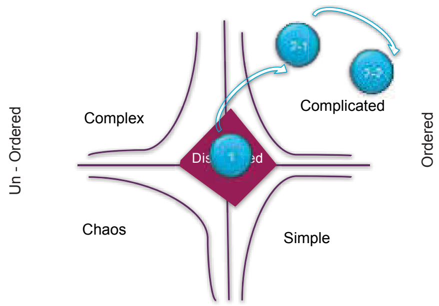


Figure 32 – Shift domains from dis-order to complicated

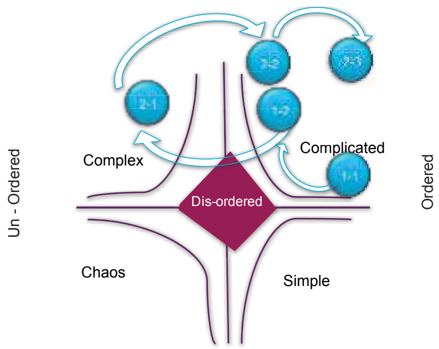


Figure 33 – Shift domains between Complicated and Complex

The findings about the effect of the real-time events and turning points is discussed briefly in this section:

Finding 1 – Feelings, previous experience, roles, and perception of major challenges were **four** factors that influenced **individual judgement** when making decisions on project portfolios. The factors are also influenced by real-time events or turning points in the simulation as perceived by participants.

Finding 2 – Feelings, previous experience, roles, and perception of major challenges were **four** factors that impacted individual judgement to identify **sources of uncertainty** for decision making of project portfolios. These factors are further influenced by turning points as perceived by participants in Context1 of the simulation.

Finding 3 – Feelings, and perception of major challenges were **two** factors that impacted individual judgement to identify **key drivers for final group decisions** on project portfolios. The factors are also influenced by turning points as perceived by participants in Context1 of the simulation.

Finding 4 – Feelings, and instructions received from the client to cancel a project were **two** factors that impacted individual judgement to identify **sources of uncertainty** for decision making of project portfolios. The factors are influenced by real-time events as perceived by participants in Context2 of the simulation.

Finding 5 – Organisational changes and instruction from the client to cancel a project were **two** factors that impacted individual judgement to identify **key drivers for final group decision** of project portfolios. The factors are also influenced by real-time events as perceived by participants in Context2 of the simulation.

Finding 6 – Decision-making processes are influenced by real-time events, turning points and decision style of participants in the simulation.

Finding 7 – Participants adapted to the change to adjust decision-making processes after being subjected to turning points or real-time events.

This thesis makes contributions to the body of knowledge for PPM, research methodology and improvement of decision making in practice.

Table 22 – Summary of findings and impact factors

	Finding 1	Finding 2	Finding 3	Finding 4	Finding 5	Finding 6	Finding 7
Feeling	☑	☑	☑	☑			
Experience	☑	☑					
Roles	☑	☑					
Major Challenges	☑	☑	☑				
Cancellation of Project				☑	☑		
Organisation Change					☑		
Real-Time Events						☑	☑
Turning Points						☑	☑

7.3 Conclusion on discussion

The discussion chapter elaborated on the most significant findings with a focus on real-time events and mechanisms to manage them during decision making, group decision making, its defects and mechanisms to manage the relevant symptoms, team cognition measurement and the reflection on research methodology. The real-time events were defined as Black Swan events for decision making in PPM. The impact of these events on decision makers was assessed through the lens of Two Model Theory. The assessment explains some earlier observations for simulation participants, their actions and their micronarratives.

Group decision making, Groupthink antecedent, symptoms, decision defects and mechanisms to manage Groupthink in group decision making were discussed. Abilene

Paradox was used to discuss some conflicting findings between participants' actions and their feelings and statements in their micronarratives.

Team cognition and individual cognition and their roles in information comprehension were discussed and new measures for team cognition based on Cynefin framework were identified.

Key improvements from the current research methodology provided some guidelines for researchers to apply this multiple methodology in other related fields of study.

7.4 Contributions from this research

This study's contributions are manifested in three areas: theory of PPM; practice of decision making for senior managers; and, research methodology.

7.4.1 Contribution to theory

The research's key contributions to theory include: the use of Cynefin for decision making in PPM; application of GDM and assessment of its defects; and the impact of team cognition on GDM in PPM. A summary of these contributions to the theory of decision making and PPM is elaborated in the following sections.

7.4.1.1 Application of Cynefin framework to analyse decision-making processes

The Cynefin framework has been used to study decision making and categorising leadership styles and strategies in different situations in the past but this is its first known use in PPM research. The leadership framework (Table 9 , Chapter 5) helped to understand actions of decision makers depending on the domain of knowledge with which they are dealing in a Cynefin framework as applied to PPM.

7.4.1.2 Group Decision Making, Managing the Groupthink

PPM steering committees as discussed in Chapter 2 can use group decision making as a mechanism to manage uncertainty for strategic decisions such as the Selection, Prioritisation and Balance processes in PPM. A group decision-making exercise has its implications such as Groupthink, Abilene Paradox and team cognition and each can contribute to the theory of group decision making (Cooke et al., 2004, Harvey et al., 2004, Huey-Wen et al., 2012, Kim, 2001, Yetive, 2003).

The discussion chapter elaborated Groupthink and how its effects may highjack the decision-making process. It also discussed smart mechanisms to make the fine line between Groupthink and a fair group decision manageable. This is a clear contribution to the theories of community of practice on how the effects of Groupthink can paralyse the decision-making process in a fast-changing world.

7.4.1.3 Group Decision Making, Managing the Abilene Paradox

Abilene Paradox is another deficiency in Group Decision Making which identifies conflicts between decision makers' feeling and their final decisions thus acting as a negative factor on good decision making. The Abilene Paradox can lead to failure where a group collectively makes a wrong decision, mainly due to individuals failing to disclose their feelings due to a belief that they should take into consideration the needs of others during a group decision exercise. This can have serious consequences to a business if the group of decision makers cannot communicate honestly about their feelings and their beliefs about a pending decision. The rules of simulation, in selecting people from different organisations with no direct work relationship, attempted to combat the impact of an Abilene Paradox effect. However, this did not work as there were instances of the Paradox, as reported in the findings in Chapter 4, which indicate that the Abilene Paradox still manifested to some extent.

7.4.1.4 Decision making in PPM and team cognition

The individual cognition and its role in information comprehension for complex decision making has been discussed in previous research. However, this thesis has extended the view on team cognition and its roles in the decision-making process by showing how uncertainty encourages decision makers to develop an effective sensemaking strategy that uses team cognition as a means to accrue the knowledge and intuition of all the individuals in the team to cope with the changing situations. Furthermore, the thesis has identified the use of team cognition as an important factor by which to understand the most appropriate course of action in PPM under uncertain conditions.

Measurement of team cognition based on the Cynefin framework for project portfolios in complex situations is an original contribution to the body of knowledge for PPM.

This is the first time that the concept of team cognition measurement has been applied to a PPM Context

7.4.2 Contribution to practice

The use of simulation to replicate decision making under time pressure with limited information provides an action-based Contextin which senior managers can develop PPM skills. Recognition of this outcome for senior managers has been a valuable but an unintended outcome of developing the simulation. The project management practitioners who participated in the simulation acknowledged learning about different tools of PPM in PMI, and appreciated the use of the Cynefin framework to reflect on their decision-making experience for PPM. The experience of using the simulation in the PPM Contexthas made me confident that the Cynefin framework can be used to improve decision making in other contexts.

> Although an examination of project portfolio management (PPM) as a function of corporate strategic decision making was a core goal in developing Hooshmand-1, the activity can be applied to many kinds of decision-making situations in which there are high level (sic) of uncertainty and persistent complexity. Such contexts include urban planning, sustainable energy strategies, capital transport and infrastructure projects, and macro-economic strategies. All these areas have things in common with the environment created in Hooshmand-1 - including i) the impact of social factors linked to decision makers' emotions, ii) unintended consequences of inadequate decisions arising from poor use of limited information, iii) confusion about how to handle unknown factors, and iv) variations in technical knowledge occurring during the early stages of planning for mega projects (Shalbafan & Leigh, 2017, p. 8).

Participants also appreciated the importance of practising skills such as team building, communications and awareness of diversity to achieve a stable and desirable condition for decision making. The importance of relevant experience for leadership for guiding the team through uncertain conditions was explicitly mentioned in participants' feedback.

7.4.3 Contribution to methodology

This study has introduced a novel approach in the design of tailored research methods for data collection and data analysis in response to the research questions. Simulation with role-play, the use of the Cynefin framework and SenseMaker software contributed to development of a novel approach to multiple methodology. In the following sections, a brief description of these contributions to research methods are further elaborated

7.4.3.1 Development of simulation Hooshmand-1 using Action Learning

Action Learning was used to develop the research methodology on decision making in PPM. A Black Swan events is a rare and very hard concept to grasp in the real-world and one cannot predict when one might happen. This study extended the use of Action Learning cycles to develop a new simulation in the Context of PPM decision making. Application of this Action Learning method to discover a new research method for study and practice of decision making in PPM Context is considered one of the major contributions of this research to research methodology.

In this research, after exploring existing simulations, and games to study decision making in similar contexts such as project management, operations management and communications, several Action Learning cycles as shown in Figure 63, were used to transform the knowledge about a simulation to full development of a simulation named Hooshmand-1.

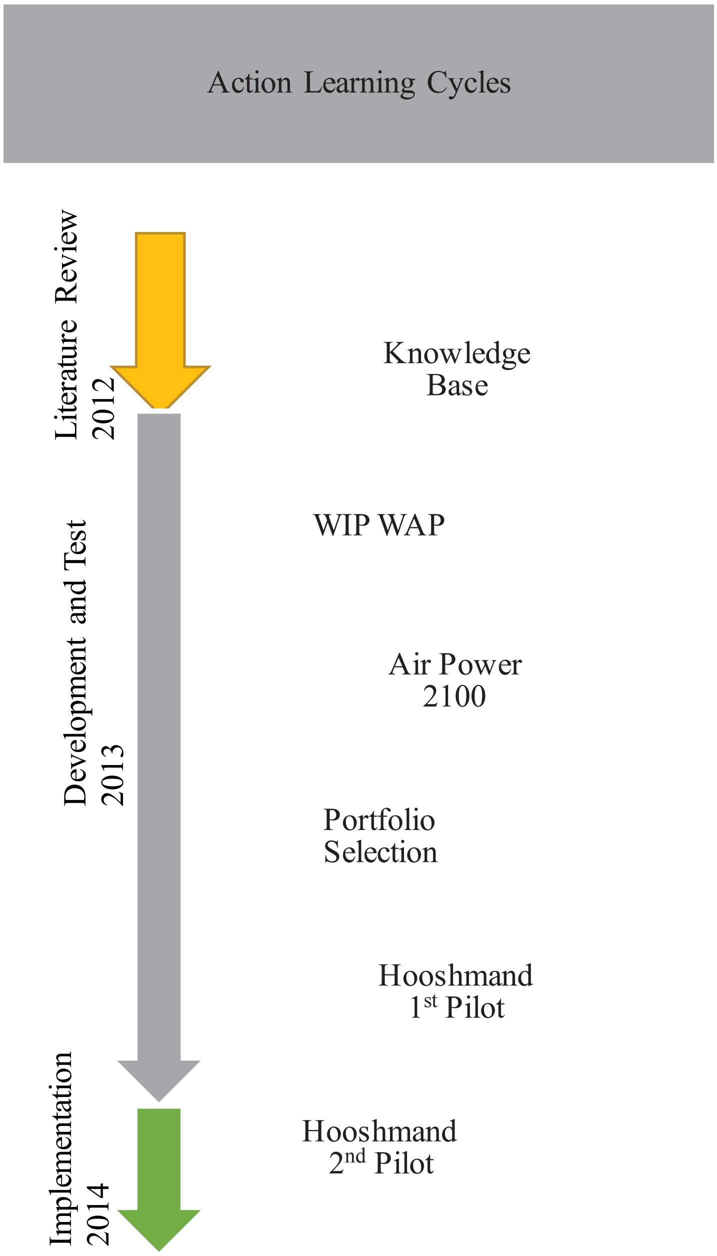


Figure 63 – Summary of Action Learning cycles to develop Simulation Hooshmand-1

7.4.3.2 Hooshmand-1, a role-play simulation for PPM decision making

The use of role-play simulation, based on Cynefin principles, is also a unique research tool. This tool has proved to facilitate observation and data collection on decision-makers' perceptions and actions while they try to deal with decision making under uncertain conditions. Hooshmand-1 is an appropriate tool as its use helps to uncover rich insight from the flow of thinking of decision makers while they are exposed to uncertainty. Figure 64 shows Hooshmand-1 as an original research instrument to create a relatively safe environment in which subjects and researchers can study decision making.

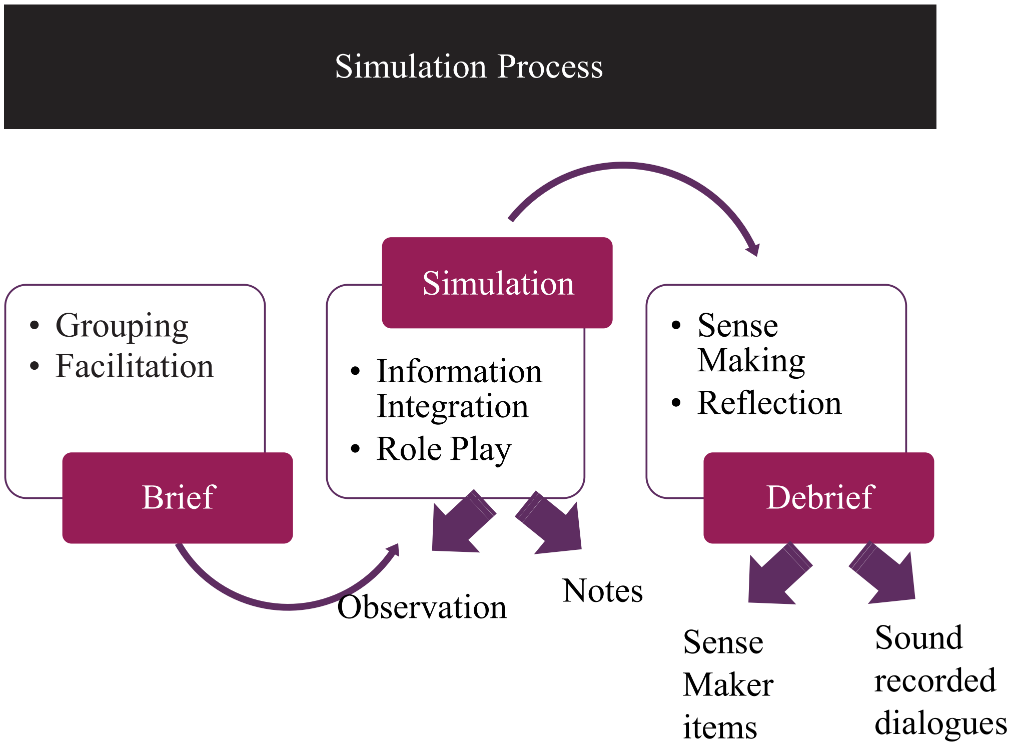


Figure 64 – Process of simulation Hooshmand - 1

Hooshmand-1 has proved successful for research purposes and has been further developed for educational institutions and companies intending to use it for training. As the complexity of the world is growing, education of students should include consideration of their competencies and move a situation from chaos Context to a complex context.

7.4.3.3 Application of SenseMaker (SM) as an analyses tool

SM was used as an analytic tool for reflection on and recording of micronarratives after experiencing the phases in the simulations. This is first time that SM was used with a community of practice for PPM. The use of SM, its tools such as Triads and Dyads to analyse subjects' reflections on their experience in Simulation Hooshmand-1 were a useful contribution, as they have provided a new method for research, and strategic decision making in practice.

This research has used the concept of three dimensions as a decision-making tool via the use of Triads. Most managers and engineers are familiar with using two polarities for decision-aiding tools. The use of three dimensional scales via the Triads was a learning challenge for the research participants as it was used for collecting and analysing the data that drew on research subjects' Judgement rather than the researcher's biases.

7.5 Limitations of research

This research has overcome a number of tough limitations. There were problems with attracting sufficient research participants, new technology in the form of the SenseMaker software had to be mastered, although it became central to this research with a less that effective understanding of how individuals think - especially in times of crisis, and the formal time constraints of the research plan provided limited time to play. Participants' replies produced limited data, so that while SenseMaker has the capacity to provide statistical analyses where a greater amount of data is available, it was not possible to use all its functions in this work.

The multiple methods used for data collection were novel and research participants were not familiar with approaches and tools used during simulation. Concepts, central to the research, including a portfolio roadmap, future backward as an analysis method and use of micronarratives, were difficult for some participants to grasp. A careful briefing at the beginning of each simulation helped to raise awareness among participants of the special tools they were using in the scenarios. Nevertheless, evidence showed that participants did not always comprehend the tools in use.

Another limitation on the research was the use of video recording. It was planned from an early stage to record all group activities using video cameras in order to collect data for further analysis. As there were not sufficient resources to support three to four video cameras during the simulation, the quality of recorded video was poor and they were not used for data analyses. Finally, the results of the data analyses were based on participants' actions, Judgement and perceptions in a simulated world which does not guarantee exactly the same results would occur in similar situations in workplace. Thus, generalisability of results is limited.

Despite all this the research has achieved its goals and provides a number of important contributions to or understanding of what happens when real time events collide with planned implementation of projects.

Table 23 shows a summary of contributions from this research to theory, practice and methodology.

Table 23 – Summary of research contributions to theory, practice and methodology

Theory	Practice	Methodology
Use of Cynefin in PPM	Diversity of decision makers	Action Learning
Groupthink and Abilene Paradox in PPM	Team building for PPM steering committees	Role-play simulation
Use of team cognition in PPM decision making	Leadership styles in decision making under uncertainty	SenseMaker software

7.6 Recommendations for further research

Several original contributions listed in this section can be tested in further research to examine the replicability of results. In summary, two key approaches are suggested for investigation.

Two recommended propositions can be tested in decision making for capital projects such as PPP infrastructure projects by the governments. This approach will result in an increase of awareness among high profile decision makers about the application of PPM tools and management of uncertainties in their decision-making processes. A combination of Simulation Hooshmand-1, followed by a development and implementation of decision-making frameworks in SenseMaker is proposed for a multiple project-based organisational study.

Proposition 1: A successful model for decision making of project portfolios in uncertain situations shall consider team work, decision makers' feelings and emotions, and the organisational roles as the three key impact factors.

Proposition 2: Diversity of decision makers shall be encouraged for project portfolio decisions across organisations. This diversity counters the unconscious bias of policy makers when selecting decision-making criteria and, assessing the final quality of decisions.

7.7 Recommendations for practical applications

The findings of the study provide specific recommendations for senior managers in practice. Organisations which deal with investment decisions at the early stage of planning could be beneficiaries of the study. At a broader perspective, state and federal departments dealing with planning for growth and infrastructure could also use these findings.

The findings of the research show decision making in PPM can be flawed and become error prone for similar reasons that Janis (1972) stated in the concept of group decision making and Groupthink. As the use of simulation Hooshmand-1 proves effective in identifying syndromes of Groupthink, it could be used as a preventive measure to identify sources of decision deficiencies before a final decision is made for allocating capital to portfolios of projects. Hooshmand-1 is also useful for identifying shifts in decision-makers' emotions as they cope with Black Swan events.

The simulation scenarios could be tailored for industries to assess the maturity of team cognition and the impact of emotions into final decisions. It can be used as a preparation or warning tool for decision makers to seek alternatives for tackling the Black Swan events at the level of single projects. One example as such is Sydney Light Rail project. It would seem that the project has gone through all the processes of gates and decision making, but there have been, for example, several incidents of exposure of unknown utilities under the main streets of Sydney which have resulted in significant delays in the final delivery of the project (ABC, 2016). Such a scenario could be embedded in the simulation to engage project decision makers in a real decision-making process and provide insight and early warnings from the available evidence.

Lastly, Hooshmand-1 can be extended as a commercial game for training and research. Commercial games can be used as training, or even as a decision aiding tool in corporate executive committees. The games also are common for education of students in universities. This approach would create an opportunity for a broader range of participants and the creation of megadata for analysis. The key objectives for this approach are a breakthrough for the standard of PPM and improvement of decision makers' awareness. For example, PMI standard may develop competencies matrixes with a focus on managing decision making in uncertain cases.

References

ABC. 2016, *Sydney light rail construction delayed after disused underground utilities found*, viewed 24 March 2017, http://www.abc.net.au/news/2016-08-09/light-rail-construction-to-cause-sydney-cbd-delays/7704766.

Abe, N., Akkiraju, R., Buckley, S., Ettl, M., Huang, P., Subramanian, D. & Tipu, F. 2007, 'On optimizing the selection of business transformation projects', *IBM Systems Journal,* vol. 46, no. 4**,** pp. 777-795.

Abt, C. 1971, 'Serious games', *Policy Sciences*, vol. 2,no. 3, pp. 332-334.

ActionScience. 2017, *Organisational Development for the 21st Century Manager,* viewed 26 Jan 2017, http://www.actionscience.com/actinq.htm.

Ahrens, D. 2015, 'Serious Games – A New Perspective on Workbased Learning', *Procedia - Social and Behavioral Sciences,* vol. 204**,** pp. 277-281.

Aldrich, C. 2005, *Learning by doing : a comprehensive guide to simulations, computer games, and pedagogy in e-learning and other educational experiences,* Pfeiffer San Francisco, CA.

Allal-Chérif, O. & Makhlouf, M. 2016, 'Using serious games to manage knowledge: The SECI model perspective', *Journal of Business Research,* vol. 69**,** pp. 1539-1543.

Andrews, K. 1971, *The Concept of Corporate Strategy,* Irwin, Homeward Il.

Archer, N. P. & Ghasemzadeh, F. 1999, 'An integrated framework for project portfolio selection', *International Journal of Project Management,* vol. 17**,** pp. 207-216.

Argyris, C. 1986, 'Reinforcing organizational defensive routines: An unintended human resources activity', *Human Resource Management,* vol. 25**,** pp. 541-555.

Arlt, M. 2010, *Advancing the Maturity of Project Portfolio Management Through Methodology and Metrics Refinements,* DPM, RMIT, Melbourn.

Banks, J., Carson, J. S. & Nelson, B. L. 1996, *Discrete-Event System Simulation,* Prentice-Hall, Englewood Cliffs.

Bardhan, I., Bagchi, S. & Sougstad, R. 2004, 'Prioritizing a portfolio of information technology investment projects', *Journal of Management Information Systems,* vol. 21**,** pp. 33-60.

Bateson, G. 1972, *Steps to an Ecology of Mind,* Jason Aronson Inc, Northvale.

Beattie, M., Smith, A. & Kyle, R. G. 2014, 'Sadness, socialisation and shifted perceptions: school pupils' stories of a pre-nursing scholarship', *Nurse Educ Today,* vol. 34**,** pp. 894-898.

Beck, J. & Wade, M. 2004, *Got Game - How the Gamer Generation is Reshaping Business Forever*, Harvard Business School Press, Boston.

Belaid, A. 2009, 'Multi-Attribute Portfolio Selection: New Perspectives', *INFOR,* vol. 47**,** pp. 1-4.

Belaid, F. 2011, 'Decision-making process for project portfolio management', *International Journal of Services Operations and Informatics,* vol. 6, no. 1, pp. 160-181.

Berry, G. R. 2001, 'Telling stories: making sense of the environmental behavior of chemical firms', *Journal of Management Inquiry,* 10**,** pp. 58-73.

Biedenbach, T. & Müller, R. 2012, Absorptive, 'innovative and adaptive capabilities and their impact on project and project portfolio performance', *International Journal of Project Management,* vol. 30, pp. 621-635.

Biggs, W. 1975, 'Some impacts of varying amounts of information on frustrations and attitudes in a finance game', *Simulation Games and Experiential Learning in Action,* vol. 2, pp. 103-110.

Blaikie, N. & Priest, J. 2017, *Social Research Paradigms in Action*, Polity Press, Cambridge.

Blichfeldt, B. S. & Eskerod, P. 2008, 'Project portfolio management: there's more to it than what management enacts', *International Journal of Project Management,* vol. 24, pp. 357-365.

Blomquist, T. & Muller, R. 2006, 'Practices, Roles, and Responsibilities of Middle Managers in Program and Portfolio Management', *Project Management Journal*, vol. 37, no. 1, pp. 52-66.

Boudes, T. & Laroche, H. 2009, 'Taking off the heat: narrative sensemaking in post-crisis reports', *Organization Studies,* vol. 30, pp. 377-396.

Bragge, J., Thavikulwat, P. & Töyli, J. 2010, 'Profiling 40 Years of Research in Simulation & Gaming, *Simulation & Gaming',* vol. 41, no. 6, pp. 869-897.

Brown, A. D. 2004, 'Authoritative sensemaking in a public inquiry report', *Organization Studies,* vol. 25, no. 1, pp.95-112.

Brown, A. D. & Jones, M. 1998, 'Doomed to failure: narratives of inevitability and conspiracy in a failed IS project', *Organization Studies,* vol. 9, no. 1, pp. 73-88.

Brown, A. D. & Jones, M. 2000, 'Honourable members and dishonourable deeds: sensemaking, impression management and legitimation in the 'Arms to Iraq' affair', *Human Relations,* vol. 53, no. 5, pp. 655-689.

Brown, S. & Eisenhardt, K. 1998, *Competing on the Edge: Strategy as Structured Chaos*, Harvard Business School, Boston.

Browning, L. & Boudès, T. 2005, 'The use of narrative to understand and respond to complexity: A comparative analysis of the Cynefin and Weickian models', *Emergence: Complexity & Organization,* vol.7, no. 3-4, pp. 35-42.

Bryman, A. & Bell, E. 2007, *Business research methods,* Oxford University Press, Oxford.

Cano, J. L. & Saenz, M. J. 2003, 'Project management simulation laboratory: Experimental learning and knowledge acquisition', *Production Planning and Control,* vol. 14, no. 2, pp. 166-173.

Chen, C. T. & Cheng, H. L. 2009, 'A comprehensive model for selecting information system project under fuzzy environment', *International Journal of Project Management,* vol. 27, no.4, pp. 389-399.

Christiansen, J. K. & Varnes, C. 2008, 'From models to practice: decision making at portfolio meetings', *The International Journal of Quality & Reliability Management,* vol. 25, no.1, pp.87-101.

Clapper, T. C. 2010, 'Role Play and Simulation Returning to Teaching for Understanding', *The Education Digest*, vol. 75, no. 8, pp. 39-43.

Clemens, R. 2009, 'Environmental Scanning and Scenario Planning: A 12 month Perspective on Applying the Viable Systems Model to Developing Public Sector Foresight', *Systemic Practice and Action Research,* vol. 22, no. 4, pp. 249-274.

Cognitive-Edge, 2013, *Four Tables Contextualisation Workflow*, viewed 31 Jan 2014, http://cognitive-edge.com.

Cognitive-Edge. & Cognia. 2011, Dental Services Signification Framework, presented at UTS Workshop for application of SenseMaker software Jan 2014.

Coldrick, S., Longhurst, P., Ivey, P. & Hannis, J. 2005, 'An R&D options selection model for investment decisions', *Technovation,* vol. 25**,** no. 3, pp. 185-93.

Collis, J. & Hussey, R. 2009, *Business research: a practical guide for undergraduate & postgraduate students*, Palgrave Macmillan, UK.

Collyer, S. & Warren, C. M. J. 2009, 'Project management approaches for dynamic environments', *International Journal of Project Management,* vol. 27**,** no. 4, pp. 355-364.

Collyer, S. C. & Mallecki, G. S. 1998, *Tactical decision making under stress: history and overview,* American Psychology Association, USA.

Cooke, N. J., Dejoode, J. A. & Pedersen, H. K. 2004, *The role of individual and team cognition in Uninhabited Air Vehicle Command-and- Control*, viewed 21 March 2013, http://www.dtic.mil/docs/citations/ADA422050 .

Cooke, N. J. & Shope, S. M. 2002, 'The CERTT-UAV task: a synthetic task environment to facilitate team research', *Advanced technologies conference : military, governance and aerospace simulation symposium, 2002, San Diego*, The society for modelling and simulation international, pp. 25-30.

Cooper, R. G. 1994, 'Perspective third-generation new product processes', *Journal of Product Innovation Management,* vol. 11, no. 1**,** pp. 3-14.

Cooper, R. G., Edgett, S. J. & Kleinschmidt, E. J. 1997a, 'Portfolio management in new product development: Lessons from the leaders-I'. *Research technology management,* vol. 40**,** no. 5, pp. 16-28.

Cooper, R. G., Edgett, S. J. & Kleinschmidt, E. J. 1997b, 'Portfolio management in new product development: Lessons from the leaders-II', *Research technology management,* vol. 40, no. 5, pp. 43 - 52.

Cooper, R. G., Edgett, S. J. & Kleinschmidt, E. J. 2000, 'New Problems, New Solutions: Making Portfolio Management More Effective', *Research technology management,* vol. 43, no. 2, p.18.

Cooper, R. G., Edgett, S. J. & Kleinschmidt, E. J. 2001, *Portfolio management for new products,* Cambridge, MA, Perseus.

Cooper, R. G., Edgett, S. J. & Kleinschmidt, E. J. 2004, 'Benchmarking best NPD practices-II', *Research Technology Management,* vol. 47**,** no. 3, pp. 50-59.

Cooper, R. G. & Kleinschmidt, E. J. 1995, 'Benchmarking the firm's critical success factors in new product development', *Journal of Product Innovation Management,* vol. 12**,** no. 5, pp. 374-391.

Costantino, F., Di Gravio, G. & Nonino, F. 2015, 'Project selection in project portfolio management - An artificial neural network model based on critical success factors', *International Journal of Project Management*, vol. 33, no. 8, pp. 1744-1754.

Crisisconsultant. 2017, *The Institute for Crisis Management,* viewed 31 Jan 2017, http://crisisconsultant.com/crisis-management-firm/history-overview/.

Csíkszentmihályi, M. 1990, *The Psychology of Optimal Experience,* Harper & Row, New York.

Culpin, V. & Scott, H. 2012, ‘The effectiveness of a live case study approach: Increasing knowledge and understanding of ‘hard’ versus ‘soft’ skills in executive education’, *Management Learning,* vol. 43, no. 5, pp. 565-577.

Daft, R. L. 1992, *Organization Theory and Design*, West Publishing*,* St. Paul.

de Caluwé, L., Geurts, J. & Kleinlugtenbelt, W. J. 2012, ‘Gaming Research in Policy and Organization: An Assessment From the Netherlands’, *Simulation & Gaming,* vol. 43**,** no. 5, pp. 600-626.

Dickinson, M. W., Thornton, A. C. & Graves, S. 2001, ‘Technology portfolio management: optimizing interdependent projects over multiple time periods’, *IEEE Transactions on Engineering Management,* vol. 48**,** no. 4, pp. 518-527.

Dietrich, P. H. 2007, *Coordination strategies in organizational development programs.*, Helsinki University of Technology, Helsinki.

Dooley, K. J. & van de Ven, A. H. 1999, ‘Explaining complex organizational dynamics’, *Organization Science,* vol. 10, no. 3, pp. 358-372.

Driman, J. 2000, ‘What is intentionality, and why is it important? (ch.1); Perception of a cube as a paradigm of conscious experience’, *Introduction to Phenomenology,* viewed 13/09/2015.

Dubois, A. & Gadde, L. 2002, ‘Systematic combining: an abductive approach to case research’, *Journal of Business Research,* vol. 55**,** no. 7, pp. 553-560.

Duffy, T. M. & Cunningham, D. J. 1996, Constructivism: Implications for the design and delivery of instructions, *Handbook of research for educational communications and technology*, pp. 1-31.

Duke, R. D. 1974, *Gaming: The future's language*, SAGE, Beverly Hills, CA.

Duncan, R. B. 1972. Charateristics of organisational environments and perceived environmental uncertainty. *Aministrative Science Quarterly,* vol. 17**,** no. 3, pp. 313-327.

Durbach, I. N. & Stewart, T. J. 2012. Modeling uncertainty in multi-criteria decision analysis. *European Journal of Operational Research,* vol. 223, no. 1**,** pp. 1-14.

Durso, F. T., Nickerson, R. S., Dumais, S. T., Lewandowsky, S. & Perfect, T. J. 2007, *Handbook of Applied Cognition* , Second Edition. John Wiley & Sons, Ltd., viewed 22 Feb 2015, http://onlinelibrary.wiley.com/doi/10.1002/9780470713181.ch7/summary.

Dzeng, R.-J. & Wang, P.-R. 2017, ‘C-Negotiation Game: An educational game model for construction procurement and negotiation’, *Automation in Construction,* vol. 75**,** pp. 10-21.

Easterby-Smith, M. & Prieto, I. M. 2007a, ‘Dynamic Capabilities and Knowledge Management: An integrative role for learning?’ *British Journal of Management,* vol. 19**,** no. 3, pp. 235-249.

Easterby-Smith, M. & Prieto, I. M. 2007b, ‘Dynamic Capabilities and Knowledge Management: An integrative role for learning?’, *British Journal of Management,* vol.19**,** no. 3, pp. 235-249.

Elgood, C. 1993, *Handbook of management games,* Gower, USA.

Elgood, C. 1997, *Handbook of management games and simulations,* Gower, Aldershot.

Engwall, M. & Jerbrant, A. 2003, ‘The resource allocation syndrome: the prime challenge of multiproject management’, *International Journal of Project Management,* vol. 21, no. 6, pp. 403-409.

Faria, A. J. 2001, 'The changing nature of business simulation/gaming research: A brief history', *Simulation & Gaming,* vol. 32**,** no.1, pp. 97-110.

Faria, A. J., Hutchinson, D., Wellington, W. J. & Gold, S. 2009, 'Developments in Business Gaming: A Review of the Past 40 Years', *Simulation & Gaming,* vol. 40**,** no. 4, pp. 464-487.

Faria, A. J. & Wellington, W. 2004, 'A survey of simulation game users, former-users, and never-users'. *Simulation & Gaming,* vol. 35**,** pp. 178-207.

Faria, A. J. & Wellington, W. J. 2005, 'Validating business gaming: Business game conformity with PIMS findings', *Simulation & Gaming,* vol. 36, no. 2, pp. 259-273.

Flanagan, J. C. 1954. The critical incident technique. *Psychol Bull,* vol. 51, no. 4, pp. 327-358.

Gemünden, H. G., Kock, A., Kopmann, J. & Schulz, B. 2015, The Influence of Project Portfolio Management Information Systems (PPMIS) on Project Portfolio Success, *Apros Egos 2015,* UTS, Sydney.

Ghapanchi, A., Tavana, M., Khakbaz, M. & Low, G. 2012, 'A methodology for selecting portfolios of projects with interactions and under uncertainty', *International Journal of Project Management,* vol. 30**,** pp. 791-803.

Ghasemzadeh, F., Archer, N. & Iyogun, P. 1999, 'A zero-one model for project portfolio selection and scheduling', *The Journal of the Operational Research Society,* vol. 50**,** no. 7, pp.745-755.

Ghasemzadeh, F. & Archer, N. P. 2000, 'Project portfolio selection through decision support', *Decision Support Systems,* vol. 29**,** no. 1, pp. 73-88.

Goosen, K., Jensen, R. & Wells, R. 2001, 'Purpose and learning benefits of simulations: A design and development perspective', *Simulation & Gaming: An Interdisciplinary Journal,* vol. 32, no. 1, pp. 21-39.

Gorzen-Mitka, I. & Okreglicka, M. 2014, Improve Management By Suitable Approach To Complexity– Cynefin Framework Example, *MEKON*, 2014 Czeck Republic.

Gray, D. E. 2014, *Doing Research in the real world,* SAGE, London.

Greenwood, J. 1983, 'The role of reflection in single and double loop learning', *Journal of Advanced Nursing,* vol. 27**,** no. 5, pp. 1048-1053.

Hall, J. 2004, 'Computer simulation: A design architectronic', *Developments in Business Simulation and Experiential Learning,* vol. 31**,** pp. 166-175.

Hancock, D. R. & Algozzine, B. 2011, *Doing case study research: A practical guide for beginning researchers*, Teachers College, New york.

Hansen, P. K., Mabogunje, A. & Haase, L. M. 2009, 'Get a grip on sensemaking and exploration dealing with complexity through serious play'*, 2009, IEEE International Conference on Industrial Engineering and Engineering Management 8-11 Dec. 2009*, pp. 1593-1597.

Hart, P. 1991, *Irving L. Janis' Victims of Groupthink, viewed* 20 October 2016, http://www.ftms.edu.my/images/Document/MOD003554 - Effective Team and Performance Management/Seminar 9-Janis - group think.

Harvey, M., Novicevic, M. M., Buckley, M. R. & Halbesleben, J. R. B. 2004, 'The Abilene Paradox After Thirty Years', *Organizational Dynamics,* vol. 33**,** no. 2, pp. 215-226.

Hassanzadeha, F., Modarresb, M., Nematia, H. & Amoako-Gyampaha, K. 2014, 'A robust R&D project portfolio optimization model for pharmaceutical contract research organizations', *International Journal of Production Economics,* vol. 158, pp. 18-27.

Helfat, C. E. 2007, *Dynamic Capabilities: Understanding Strategic Change in Organisations,* Blackwell Publishing, Malden, MA.

Henderson, S. & Blackman, D. 2015, 'My organisation is in an unhappy space ? Is that a strategy?', *Apros Egos 9-11 Dec. 2015,* UTS, Sydney.

Hengst, M. d., Vreede, G.-J. d. & Maghnouji, R. 2007, 'Using soft OR principles for collaborative simulation: a case study in the Dutch airline industry', *Journal of operational research society,* vol. 58, no. 5, pp. 669-682.

Hodgetts, R. & Kreitner, R. 1975, 'Motivating simulation game performance and satisfaction with performance-contingent consequences', *Simulation Games and Experiential Learning in Action,* vol. 2, pp. 151-156.

Hofstede, G. J., de Caluwe, L. & Peters, V. 2010, 'Why Simulation Games Work-In Search of the Active Substance: A Synthesis', *Simulation & Gaming,* vol. 41, no. 6, pp. 824-843.

Hoover, D. 1976, 'An experimental examination of group size effects', *Computer Simulation and Learning Theory,* vol. 3, pp.426-432.

Hosseini, S. M. 2010, 'The application of SECI model as a framework of knowledge creation in virtual learning', *Asia Pacific Education Review,* vol. 12, no. 4, pp. 263-270.

Huang, C. C., Chu, P. Y. & Chiang, Y. H. 2008, 'A fuzzy AHP application in government-sponsored R&D project selection'. *Omega,* vol. 36, no. 6, pp. 1038-1052.

Huebscher, J. & Lendner, C. 2010, 'Effects of Enterpreneurship Simulation Game Seminars on Entrepreneurs' and Students' Learning', *Journal of Small Business and Entrepreneurship,* vol. 23, no. 4, pp. 543-554.

Huey-Wen, C., Yu-Hsun, L. & Shyan-Bin, C. 2012, 'Team cognition, collective efficacy and performance in strategic decision-making team', *Social behaviour and personality,* vol. 40, no. 3, pp. 381-393.

Hussein, B. A. 2007, 'On using simulation games as a research tool in project management', *organizing and learning through gaming and simulation (ISAGA) 9-13 Jul 2007,* Trondheim, pp. 131-138.

Huyakorn, P., Denpaiboon, C. & Kanegae, H. 2012, 'Role-play Gaming Simulation for Flood Management on Cultural Heritage - A Case Study of Ayutthaya Historic City', *World Academy of Science, Engineering and Technology,* vol. 6, no. 3, pp. 111-116.

Ilmola, L. & Kuusi, O. 2006, 'Filters of weak signals hinder foresight: Monitoring weak signals efficiently in corporate decision-making', *Futures,* vol. 38, no. 8, pp. 908-924.

INSW. 2016, *Overview of the Gateway Review System,* viewed 26 Jan 2017, https://www.procurepoint.nsw.gov.au/policy-and-reform/gateway-review-system/overview-gateway-review-system.

J.C., F. 1954, 'The critical incident technique', *Psychol Bull,* vol. 51, no. 4, pp. 327-58.

Jang, Y. & Lee, J. 1998, ‘Factors influencing the success of management consulting projects’, *International Journal of Project Management,* vol. 16, no. 2, pp. 67-72.

Janis, I. L. 1972, *Victims of groupthink*, Houghton Mifflin*,* Boston.

Janis, I. L. 2016, *Groupthink-Psychological-Studies-of-Policy-Decisions-and-Fiascoes,* viewed 31 Jan 2017.

Järvensivu, T. & Törnroos, J. 2010, ‘Case study research with moderate constructionism: Conceptualization and practical illustration’, *Industrial Marketing Management,* vol. 39, no. 1, pp. 100-108.

Johnson, J. H., Poirier, J. & Smith-Jentsch, K. A. 1998, *Decision making under stress: creating a research methodology*, American Psychology Association, Washington DC.

Joldersma, C. & Geurts, J. L. A. 1998, ‘Simulation/Gaming for Policy Development and Organizational Change’, *Simulation & Gaming,* vol. 29, no. 4, pp. 391-399.

Jonas, D. 2010, ‘Empowering project portfolio managers: How management involvement impacts project portfolio management performance’, *International Journal of Project Management,* vol. 28, no. 8, pp.818-831.

Jones-Evans, D., Williams, W. & Deacon, F. 2000, ‘Developing entrepreneurial graduates: an action learning approach’, *Education and Training,* vol. 42, no. 4/5, pp. 282-288.

Jugend, D. & da Silva, S. L. 2013, ‘Product-portfolio management: A framework based on Methods, Organization, and Strategy’, *Concurrent Engineering,* vol. 22, no. 1, pp. 17-28.

Juite, W. & Hwang, W. L. 2007, ‘A fuzzy set approach for R&D portfolio selection using a real options valuation model’, *Omega,* vol. 35, no. 3, pp. 247-257.

Kaiser, M. G., El Arbi, F. & Ahlemann, F. 2015, ‘Successful project portfolio management beyond project selection techniques: Understanding the role of structural alignment’, *International Journal of Project Management,* vol. 33, no. 1, pp. 126-139.

Kearney, J. W., Heffernan, M. & McLuckie, J. 2013, *Fleet Doctor to AIRPOWER 2100 From Tailored Solution to Learning Environment.*

Kester, L., Hultink, E. J. & Lauche, K. 2009, ‘Portfolio decision-making genres: A case study’, *Journal of Engineering and Technology Management,* vol. 26, no. 4, pp. 327-341.

Keys, B. & Wolfe, J. 1990, The Role of Management Games and Simulations in Education and Research, *Journal of Management,* vol. 16, no. 2, pp. 307- 336.

Khalili-Damghani, K. & Sadi-Nezhad, S. 2013, ‘A hybrid fuzzy multiple criteria group decision making approach for sustainable project selection’, *Applied Soft Computing,* vol. 13, no. 1, pp. 339-352.

Khurana, A. & Rosenthal, S. R. 1997, Integrating the fuzzy front end of new product development, *Sloan Management Review,* vol. 38, no. 2, pp. 103-120.

Killen, C. P. 2013, ‘Evaluation of project interdependency visualizations through decision scenario experimentation’, *International Journal of Project Management*, vol. 31, no. 6, pp. 804-816.

Killen, C. P. & Hunt, R. A. 2010, ‘Dynamic capability through project portfolio management in service and manufacturing industries’, *International Journal of Managing Projects in Business,* vol. 3**,** no. 1, pp. 157-169.

Killen, C. P., Hunt, R. A. & Kleinschmidt, E. J. 2008a, ‘Learning investments and organizational capabilities Case studies on the development of project portfolio management capabilities’, *International Journal of Managing Projects in Business,* vol. 1**,** no. 1, pp. 334-351.

Killen, C. P., Hunt, R. A. & Kleinschmidt, E. J. 2008b, ‘Project portfolio management for product innovation’, *The International Journal of Quality & Reliability Management,* vol. 25, no. 1, pp. 24-38.

Killen, C. P., Jugdev, K., Drouin, N. & Petit, Y. 2012, ‘Advancing project and portfolio management research: Applying strategic management theories’, *International journal of project management,* vol. 30**,** no. 5, pp. 525-538.

Kim, Y. 2001, ‘A Comparative Study of The "ABILENE PARADOX" and "GROUPTHINK"’, *Public Administration Quarterly,* vol. 25**,** pp. 168-191.

King, T. 2002, *Development of student skills in reflective writing*, viewed 4 April 2016, http://www.osds.uwa.edu.au.

Klabbers, J. 2007, *The magic circle: Principles of gaming & simulation*, SensePublishers, Rotterdam.

Klein, G. 2008, ‘Naturalistic Decision Making’, *Human Factors,* vol. 50**,** pp. 456-460.

Kleinman, D. L., Young, P. W. & Higgings, G. 1996, ‘The DDD-III : a tool for emprical research in adaptive organisations’, *command and control research and technology symposium 1996 Monterey*, NPS.

Kodukula S., P. 2014, *Organizational Project Portfolio Management*, J. Ross, Plantation, USA.

Koh, A. & Crawford, L. 2012, Portfolio Management: The Australian Experience. *Project Management Journal,* vol. 43**,** no. 6, pp. 33-42.

Korhonen, T., Laine, T. & Martinsuo, M. 2013, ‘Varying Perfections of uncertainty among managerial actors in project portfolio management’, (*EURAM) European Academy of Management Istanbul 26 – 29 June 2013,* Tampere University of Technology.

Korhonen, T., Laine, T. & Martinsuo, M. 2014, Management Control of Project Portfolio Uncertainty: A Managerial Role Perspective, *Project Management Journal,* vol. 45**,** no. 1, pp. 21-37.

Krems, J. F. 1995, ‘Complex Problem Solving: The European Perspective’, In: French, P. A. & Funke, J. (eds.), *Cognitive Flexibility and Complex Problem Solving,* Psychology Press, New York, pp. 201-218.

Krupa, J. & Jones, C. 2013, Black Swan Theory: Applications to energy market histories and technologies, *Energy Strategy Reviews,* vol. 1**,** no. 4, pp. 286-290.

Kuit, M., Mayer, I. S. & de Jong, M. 2005, The INFRASTRATEGO game: An evaluation of strategic behavior and regulatory regimes in a liberalizing electricity market, *Simulation & Gaming,* vol. 36**,** no. 1, pp. 58-74.

Kurtz, C. F. & Snowden, D. J. 2003, The new dynamics of strategy: Sensemaking in a complex and complicated world, *IBM Systems Journal,* vol. 42**,** no. 3, pp. 462-462.

Lechler, T. G. & Thomas, J. L. 2015, Examining new product development project termination decision quality at the portfolio level: Consequences of dysfunctional executive advocacy, *International Journal of Project Management,* vol. 33, no. 7, pp. 1452-1463.

Leigh, E. 2013, 'Simulation in project management research', *In:* Drouin, N., Muller, R. & Sankaran, S. (eds.) *Novel Approaches to organizational project management research: Translational and Transformational,* Copenhagen Business School Press, Denmark, pp. 199-219.

Leigh, E. & Kinder, J. (eds.) 2001, *Fun & Games for Workplace Learning,* McGraw Hill, Sydney.

Lenhard, J. 2015, Simulation, Representation, and Cartography: Compiling a Virtual Atlas, *Perspectives on Science,* vol. 23, no. 4, pp. 386-404.

Lesca 2011, *Environmental Scanning and Sustainable Development*, John Wiley & Son, London, viewed 22 May 2015, https://ebookcentral.proquest.com/lib/uts/reader.action?docID=1117283&ppg=1.

Lester, S. 1999, *An introduction to phenomenological research,* viewed 10 Feb 2017, https://www.researchgate.net/profile/Stan_Lester/publication/255647619_An_introduction_to_phenomenological_research/links/545a05e30cf2cf5164840df6.

Levinthal, D. A. & Warglien, M. 1999, Landscape design: designing for local action in complex worlds, *Organization Science,* vol. 10, pp. 342-353.

Lewis, J. 2009, Redefining Qualitative Methods: Believability in the fifth moment. *International Journal of Qualitative Methods*.

Lin, C. H. & Hsieh, P. J. 2004, A fuzzy decision support system for strategic portfolio management, *Decision Support Systems,* vol. 38, pp. 383-398.

Lipshitz, R., KLEIN, G., ORASANU, J. & SALAS, E. 2001, Focus Article: Taking Stock of Naturalistic Decision Making, *Journal of Behavioural Decision Making,* vol. 14, pp. 331-352.

Lis, A. 2014, Knowledge Creation and Conversion in Military Organizations: How the SECI Model is Applied Within Armed Forces, *Journal of Enterprenureship,* vol. 10, no. 1, pp. 57-78.

Lundberg, C. G. 2000, Made sense and remembered sense: Sensemaking through abduction, *Journal of Economic Psychology,* vol. 21, no. 6, pp. 691-709.

Maged, S. M. 2008, Modelling resource allocation of R&D project portfolios using a multi-criteria decision-making methodology, *The International Journal of Quality & Reliability Management,* vol. 25, no. 1, pp. 72-86.

Markowitz, H. M. 1952, Portfolio selection, *Journal of Finance,* vol. 7, no. 1, pp. 77-91.

Martinsuo, M. 2013, Project portfolio management in practice and in context, *International Journal of Project Management,* vol. 31, no. 6, pp. 794-803.

Martinsuo, M., Korhonen, T. & Laine, T. 2014, Uncertainty in the practice of project portfolio management *The Routledge Companion to Strategic Project Management,* Routledge: Tampere University of Technology, Department of Industrial Management, Finland.

Martinsuo, M. & Lehtonen, P. 2007, Role of single-project management in achieving portfolio management efficiency, *International Journal of Project Management,* vol. 25, no. 1, pp. 56-65.

Mayer, I. & Martin, D. J. 2004, Combining GDSS and Gaming for Decision Support, *Group Decision and Negotiation,* vol. 13,no. 3, pp. 223-241.

Meijer, S. A., Mayer, I. S., van Luipen, J. & Weitenberg, N. 2012, Gaming Rail Cargo Management: Exploring and Validating Alternative Modes of Organization, *Simulation & Gaming,* vol. 43**,** no. 1, pp. 85-101.

Miller, C. C. & Ireland, R. D. 2005, Intuition in strategic decision making: Friend or foe in the fast-paced 21st century? *Academy of Management Perspectives,* vol. 19**,** no. 1, pp. 19-30.

Mills, J. H., Thurlow, A. & Mills, A. J. 2010, Making sense of sensemaking: the critical sensemaking approach, *Qualitative Research in Organizations and Management: An International Journal of Business Research,* vol. 5, no. 2, pp. 182-195.

Mooij, A. 2010, Intentionality, Desire, Responsibility, *A Study in Phenomenology, Psychoanalysis and Law,* Brill, Boston.

Morse, J. M., Barrett, M., Mayan, M., Olson, K. & Spiers, J. 2002, Verifications Strategies for Establishing Reliability and Validity in Qualitative Research *International Journal of Qualitative Methods,* vol. 1, no. 2, pp. 13-22.

Müller, R., Martinsuo, M. & Blomquist, T. 2008, Project Portfolio Control and Portfolio Management Performance in Different Contexts, *Project Management Journal,* vol. 39**,** no. 3, pp. 28-42.

Naber, T. & van Oort, M. 2005, Master Thesis, University of Tilburg, Tilburg.

Nikander, I. O. & Eloranta, E. 2001, Project management by early warnings, *International Journal of Project Management,* vol. 19**,** no. 7, pp. 385-399.

Nixon, B. 1998, Creating the futures we desire - getting the whole system into the room: part I, *Industrial and Commercial Training,* vol. 30**,** no. 1, pp. 4-11.

Nobel, H. & Smith, J. 2015, Issues of validity and reliability in qualitative research *Evid Based Nurs,* vol. 18**,** no. 2, pp. 34-35.

Nonaka, I. & Konno, N. 1998, The concept of "ba": Building a foundation for knowledge creation, *California Management Review,* vol. 40**,** no. 3, pp. 40-54.

Nonaka, I., Toyama, R. & Konno, N. 2000, SECI, Ba and Leadership: a United Model of Dynamic Knowledge Creation, *Long Range Planning,* vol. 33, no. 1, pp. 5-34.

Nonaka, I. & von Krogh, G. 2009, Tacit Knowledge and Knowledge Conversion: Controversy and Advancement in Organizational Knowledge Creation Theory, *Organization Science,* vol. 20**,** no. 3, pp. 635-652.

O., K. 1994, Abduktion. In. *In:* H., A. (ed.) *Videnskabsteori og metodelaere,* Samfundslitteratur, Frederiksberg.

OGC 2011, *Management of Portfolios MOP,* TSO, Belfast.

Oh, J., Yang, J. & Lee, S. 2012, Managing uncertainty to improve decision-making in NPD portfolio management with a fuzzy expert system. *Expert Systems with Applications,* vol. 39**,** no. 10, pp. 9868-9885.

Okuda, Y., et al 2009, The Utility of Simulation in Medical Education:What Is the Evidence? *Mount Sinai Journal of Medicine: A Journal of Translational and Personalized Medicine,* vol. 76**,** no. 4, pp. 330-343.

Orod, T. G. 2017, *Sokhananhakim,* viewed 25 March 2017, http://sokhananhakim.blogfa.com/tag/Great-Orod-The-greatest-philosopher-of-the-world: Blogfa. Available: http://sokhananhakim.blogfa.com/tag/Great-Orod-The-greatest-philosopher-of-the-world.

Papert, S. 1996, *The Connected Family*, Longstreet Press, Atlanta.

Parish, L. 1975, Business simulations: Competition or learning, *Simulation Games and Experiential Learning in Action,* vol. 2**,** pp. 284-288.

Pendharkar, P. 2014, A decision-making framework for justifying a portfolio of IT projects. *International Journal of Project Management,* vol. 32**,** no. 1, pp. 625-639.

Perry, P. M. 2011, *Business Driven Project Portfolio Management ; Conquering the top ten risks that threathen success,* J. Ross Publishing, USA.

Petit, Y. 2012, Project portfolios in dynamic environments: Organizing for uncertainty, *International Journal of Project Management,* vol. 30**,** no. 5, pp. 539-553.

Petit, Y. & Hobbs, B. 2010, Project portfolios in dynamic environments: Sources of uncertainty and sensing mechanisms, *Project Management Journal,* vol. 41**,** no. 4, pp. 46-58.

Petit, Y. & Hobbs, B. 2012, *Project portfolios in dynamic environment: organizing for uncertainty.* PhD, Montreal.

PMI 2013a, *A guide to the project management body of knowledge*, Fifth ed, PMI Publications, Newtown Square, PA.

PMI 2013b, *The standard for Portfolio Management*, Third Edition*,* PMI Publications, Newtown Square, PA.

Pollack, J. 2009, Multimethodology in series and parallel: strategic planning using hard and soft OR, *The Journal of the Operational Research Society,* vol. 60**,** no. 2, pp. 156-167.

Porter, M. 1980, *Competitive Strategy. Techniques for Analysing Industries and Competitors,* New York, The free press.

Project Management Institute, P. 2012, *The standard for project portfolio management*, Third Edition, PMI Publications, Newtown Square, PA.

Quade, E. S. 1989, *Analysis for public decisions,* Amsterdam, Elsevier Science Publishers.

Quarantelli, E. L. 1988, Disaster crisis management: a summary of research findings, *Journal Of Management Study,* vol. 25, no. 4, pp. 373-385.

Radke, S., Gu¨ rog˘ lu, B. & de Bruijn, E. R. A. 2012, There's Something about a Fair Split: Intentionality Moderates Context-Based Fairness Considerations in Social Decision-Making, *Plos One*, vol. 7, no. 2, pp. 1-6, viewed 20 Dec 2016, www.plosone.org.

Remington, K. & Pollack, J. 2008a, *Tools for complex projects*, Gower, Hampshire.

Remington, K. & Pollack, J. 2008b, *Tools for complex projects*, Gower, Burlington, Aldershot.

Revans, R. 1998. *The origin and growth of action learning,* Chartwell-Bratt, Brickley.

Revans, R. W. 1982, *The origing and growth of action learning*, Chatwell Bratt, London.

Ribbers, P. M. A. & Schoo, K.-C. 2002, Program management and complexity of ERP implementations, *Engineering Management Journal,* vol. 14**,** no. 2, pp. 45-52.

Rogério Tadeu de Oliveira, L., Ensslin, L. & Sandra Rolim, E. 2011, A performance measurement framework in portfolio management, *Management Decision,* vol. 49**,** no. 4, pp. 648-668.

Rollings, A., Adams, E. 2003, *Andrew Rollings and Ernest Adams on Game Design*, New Riders, Boston.

Rosen, K. R. 2008, The history of medical simulation, *Journal of Critical Care,* vol. 23**,** no. 2, pp. 157-166.

Rungi, M. 2010, Foundation of interdependency management in project portfolio management: A strategic view, *Management of Innovation and Technology (ICMIT), 2010 IEEE International Conference on, 2-5 June 2010*, pp. 117-122.

Silva, P.S., Pedrosa, D., Trigo, A. & Varajao, J. 2011, *Simulation, Games and Challenges: From Schools to Enterprises*, *In:* Barjis, J., Eldabi, T. & Gupta, A. (eds.), Springer, Berlin, pp. 63-73.

Salas, E., Rosen, M. A. & DiazGranados, D. 2009, Expertise-Based Intuition and Decision Making in Organizations. *Journal of Management,* vol. 36**,** no. 4, pp. 941-973.

Sardon, G. & Wong, S. W. 2010, making Sense of Safety: A Complexity-Based Approach to Safety Intervention, Association of Canadian Ergonomists 41st Annual Conference, 2010 Kelowna, BC.

Schon, D. A. 1983. *The Reflective Practitioner,* Basic Books*,* New York.

Shalbafan, S. & Leigh, E. 2017, Design thinking: Project Portfolio Management and Simulation – a creative mix for research, *ISAGA 10-14 July 2017,* ISAGA, Netherlands.

Shalbafan, S., Leigh, E., Pollack, J. & Sankaran, S. Application of Cyenfin framework to facilitate decision-making in complex conditions in project portfolio management, *IRNOP 11-14 June 2017*, Boston University, Boston.

Shalbafan, S., Leigh, E., Pollack, J. & Sankaran, S. 2015, Using simulation to create a time-bound, space-constrained context for studying decision-making in project portfolio management using the Cynefin framework, *Apros - Egos 9-11 Dec 2015,* Sydney.

Shalbafan, S., Leigh, E., Pollack, J. & Sankaran, S. 2016, Using simulation to study decisionmaking in project portfolio management, *Second Danish Project Management Research Conference 8-9 Jun 2016,* Denmark.

Sharoff, L. 2007, Critical incident technique utilisation in research on holistic nurses. *Holist Nurs Pract,* vol. 21**,** pp. 254-62.

Shepherd, N. G. & Rudd, J. M. 2014, The Influence of Context on the Strategic Decision-Making Process: A Review of the Literature. *International Journal of Management Reviews,* vol. 16**,** no. 3, pp. 340-364.

Shrivastava, P. 1987, *Bhopal: Anatomy of a Crisis*, Ballinger*,* Cambridge.

Shubik, M. 1989, Gaming: Theory and Practice, Past and Future, *Simulation & Gaming,* vol. 20**,** no. 2, pp. 184-189.

Shute, V. J. & Ke, F. 2012, 'Games, Learning, and Assessment, in Assessment in Game-Based Learning', *Foundations, Innovations, and Perspectives***,** Springer, New York, pp. 43-58.

Silver, D. 2014, *Managing corporate communications in the age of restructuring, crisis, and litigation : revisiting groupthink in the boardroom*, Ross Publishing, Plantation, FL.

Sinclair, M. 2005, Intuition: Myth or a Decision-making Tool? *Management Learning,* vol. 36, no. 3, pp. 353-370.

Slodan, Z. 2010, Group Cohesiveness and Performance - The Moderating Effect of Diversity, *International Journal of Interdisciplinary Social Sciences,* vol. 5, no. 4, pp. 155-168.

Snowden, D. 2002, Complex acts of knowing: Paradox and descriptive self-awareness. *Journal of Knowledge Management,* vol. 6, no. 2, pp. 100-111.

Snowden, D. 2010a, Narrative Research, *Naturaising Decision making,* viewed 21 March 2017*,* http://www.cognitive-edge.com/.

Snowden, D. 2010b, Naturalizing Sensemaking. *In:* Mosier, K. & Fischer, U. (eds.) *Informed by Knowledge: Expert Performance in Complex Situations, pp.* 223-243.

Snowden, D. J. 2005, Multi-ontology sensemaking: a new simplicity in decision making, *Informatics In Primary Care,* vol. 13, no. 1, pp. 45-54.

Snowden, D. J. & Boone, M. E. 2007, A Leader's Framework for Decision Making, (cover story), *Harvard Business Review,* vol. 85, no. 11, pp. 68-76.

Sommer, A. & Pearson, C. M. 2007, Antecedents of creative decision making in organizational crisis: A team-based simulation, *Technological Forecasting and Social Change,* vol. 74, no. 8, pp. 1234-1251.

Sontag, S. 2001, *Against Interpretation, and other Essays,* New York, Picador USA.

Stainton, A. J., Johnson, J. E. & Borodzicz, E. P. 2010, Educational Validity of Business Gaming Simulation: A Research Methodology Framework, *Simulation & Gaming,* vol. 41, no. 5, pp. 705-723.

Stienstra, J. & van der Noort, W. 2008, Loser, Hero or Human Being; Are You Ready For Emergent Truth?, ESOMAR World Research Paper*, Annual Congress ESOMAR Sept. 2008 Montreal,* Netherlands.

Suter, G. 2009, The black swan theory. *Integrated Environmental Assessment and Management,* vol. 5, p. 357.

Taleb, N. N. 2007, *The Black Swan,* Random House, New York.

Taleb, N. N. 2010, *The Black Swan: The Impact of the Highly Improbable,* viewed 20 October 2016, http://www.goodreads.com/book/show/242472.The_Black_Swan.

Teller, J., Kock, A. & Gemünden, H. G. 2014, Risk Management in Project Portfolios Is More Than Managing Project Risks: A Contingency Perspective on Risk Management, *Project Management Journal,* vol. 45, no. 6, pp. 67-80.

Teller, J., Unger, B. N., Kock, A. & Gemünden, H. G. 2012, Formalization of project portfolio management: The moderating role of project portfolio complexity, *International Journal of Project Management,* vol. 30, no. 5, pp. 596-607.

Tiryaki, F. & Ahlatcioglu, B. 2005, Fuzzy stock selection using a new fuzzy ranking and weighting algorithm, *Applied Mathematics and Computation,* vol. 170, no. 1, pp. 144-157.

Tiryaki, F. & Ahlatcioglu, B. 2009, Fuzzy portfolio selection using fuzzy analytic hierarchy process, *Information Sciences,* vol. 179, no. 1-2, pp. 53-69.

Toit, A. D. 2006, Making sense through coaching, *Journal of Management Development,* vol. 26, no. 26, pp. 282-291.

Tomasini, A. 2011, Cynefin Lego Game, *Agile 42 blog*, Weblog, viewed 06 Mar 2013, pp. 1-7.

Trrip, D. 1993, *Critical Incidents in Teaching: Developing Professional Judgement,* Routledge, London.

Tsoukiàs, A. 2008, From decision theory to decision aiding methodology, *European Journal of Operational Research,* vol. 187, no. 1, pp. 138-161.

Turan, F. K., Scala, N. M., Besterfield-Sacre, M. & LaScola Needy, K. 2009, An Analytic Network Process (ANP) Approach to the Project Portfolio Management for Organizational Sustainability, *Industrial Engineering Research Conference 18-22 May 2009*, Minneapolis.

Turner, M. E. 1998, Twenty-Five Years of Groupthink Theory and Research- Lessons from the Evaluation of a Theory, *Organisational Behaviour and Human Decision Processes,* vol. 73, no. 2-3, pp. 105-115.

Unger, B. N., Gemünden, H. G. & Aubry, M. 2012a, The three roles of a project portfolio management office: Their impact on portfolio management execution and success, *International Journal of Project Management,* vol. 30, pp. 608-620.

Unger, B. N., Kock, A., Gemünden, H. G. & Jonas, D. 2012b, Enforcing strategic fit of project portfolios by project termination: An empirical study on senior management involvement, *International Journal of Project Management,* vol. 30, no. 6, pp. 675-685.

Vachon, B. & LeBlank, J. 2011, effectiveness of past and current critical incident analysis on reflective learning and practice change *Medical Education,* vol. 45, no. 9, pp. 894-904.

van den Heuvel, C., Alison, L. & Power, N. 2012, Coping with uncertainty: police strategies for resilient decision-making and action implementation, *Cognition, Technology & Work,* vol. 16, no. 1, pp. 25-45.

van den Hoogen, J. & Meijer, S. 2014, Gaming and Simulation for Railway Innovation: A Case Study of the Dutch Railway System, *Simulation & Gaming,* vol. 46, no. 5, pp. 489-511.

Van Houten, S. P. & Verbraek, A. 2006, Controlling Simulation Games Through Rule-Based Scenarios, *In:* Perrone, L. F. e. a., ed. *Winter Simulation Conference 3-6 Dec 2006*, IEEEE, Netherlands.

Vygotsky, L. S. 1978, Mind in Society: The development of higher psychological processes, Harvard University Press, Cambridge.

Walker, W. E., GIddings, J. & Armstrong, S. 2011. Training and learning for crisis management using a virtual simulation / gaming environment, *Cogn Tech Work,* vol. 13, no. 3, pp. 163-173.

Walls, M. R. 2004, Combining decision analysis and portfolio management to improve project selection in the exploration and production firm, *Journal of Petroleum Science and Engineering,* vol. 44, no. 1, pp. 55-65.

Weick, K. E. 1995, *Sensemaking in Organizations,* SAGE,Thousand Oaks CA.

Weick, K. E. 2001, *Making Sense of the Organization*, Blackwell Publishers, Oxford.

White, I. 2002, Size matters: large group methods and the process of operational research, *Journal of the Operational Research Society,* vol. 53, no. 2, pp. 149-160.

Williams, T. M., Klakegg, O. J., Walker, D. H. T., Andersen, B. & Magnussen, O. M. 2012, Identifying and Acting on Early Warning Signs in Complex Projects, *Project Management Journal,* vol. 43, no. 2, pp. 37-53.

Williams, T. M., Samset, K. & Sunnevag, K. J. 2009, *Making essential choices with scant information*, Palgrave Macmillan.

Winter, M. & Szczepanek, T. 2008, Projects and programmes as value creation processes: A new perspective and some practical implications, *International Journal of Project Management,* vol. 26, no. 1, pp. 95-103.

Wolfe, J. 1997, The Effectiveness of Business Game in Strategic Management Course Work, *Simulation & Gaming,* vol. 28, no. 4, pp. 360-376.

Yahaya, S.-Y. & Abu-Bakar, N. 2007, New Product development management issues and decision making approaches, *Management Decision,* vol. 45, no. 7, pp. 1123-1142.

Yetive, S. A. 2003, Groupthink and the gulf crisis, *British Journal of Political Science,* 33.

Young, L. & Saxe, R. 2011, When ignorance is no excuse: Different roles for intent across moral domains, *Cognition,* vol. 120, no. 2, pp. 202-214.

Yuming, Z., Quan, P. & Peng, G. 2007, Research on the Application of Project Portfolio Management (PPM), Program Management (PM) and Project Management in Enterprise Strategic Management, Wireless Communications, Networking and Mobile Computing, *WiCom 2007 International Conference on, 21-25 Sept. 2007*, pp. 5266-5269.

Zarghami, M., Szidarovszky, F. & Ardakanian, R. 2008, A fuzzy-stochastic OWA model for robust multi-criteria decision making, *Fuzzy Optimization and Decision Making,* vol. 7, no. 1, pp. 1-15.

Zee, D.-J. V. d. & Slomp, J. 2009, Simulation as a tool for gaming and training in operations management - a case study, *Journal of Simulation,* vol. 3, no. 1, pp. 17-28.

Zheng, G. 2009, *A multidimensional and visual exploration approach to project portfolio management,* Georgia State University Ph.D.

Zuber-Skerrit, O. 2002, The concept of action learning, *The Learning Organization,* vol. 9, no. 3, pp. 114-124.

Appendix 2.1 SenseMaker tools

[Production Note:
This appendix is currently embargoed and not included in this digital copy.]

Appendix 3.1 Material of Joint Workshop – UTS & Cognitive Edge - SenseMaker

[Production Note:
This appendix is currently embargoed and not included in this digital copy.]

Appendix 4.1 SenseMaker, the designer guidelines

[Production Note:
This appendix is currently embargoed and not included in this digital copy.]

Appendix 4.2 Sensemaking Framework

[Production Note:
This appendix is currently embargoed and not included in this digital copy.]

Appendix 4.3 Simulation Protocol

[Production Note:
This appendix is currently embargoed and not included in this digital copy.]

Appendix 5.1 Cross Checks between Multiple Choices Queries and Triads

[Production Note:
This appendix is currently embargoed and not included in this digital copy.]

Appendix 5.2 Themes and micronarrative analysis

[Production Note:
This appendix is currently embargoed and not included in this digital copy.]

Appendix 5.3 Transcriptions of audio recorded files

Workshop 1 – Transcription

Workshop 2 – Transcriptions

Workshop 3 – Transcription

Workshop 4 – Transcription

[Production Note:
This appendix is currently embargoed and not included in this digital copy.]