Emerging issues in ergonomics: a methodological framework for foresight and sensemaking

A thesis submitted in accordance with assessment requirements for
the Doctor of Philosophy in Environmental Design
Faculty of Arts and Design
University of Canberra, ACT, 2601
By

Wendy D. Elford
M. Sc. (Physiotherapy)

March, 2011

Abstract

Lack of knowledge about emerging issues limits the ability of a discipline to accurately target resources to support effective and sustainable practice. There is evidence to suggest that human factors and ergonomics (HFE) professionals do not have the specific futures thinking skills and methodologies to allow these issues to be identified. This study examined options for the professional not trained in futures studies to explore emerging issues in order to support an interdisciplinary approach to complex problems. The focus of the study was on emerging issues in the ergonomics of office work. The study took an action research/learning and largely phenomenological approach: four narrative methodologies were tested and their strengths and weaknesses compared. These included a literature review/environmental scanning (4 years' duration), expert interviews (19 interviews), a scenarios workshop (16 participants) and a naturalistic sensemaking survey using the software SenseMaker^{TM} (99 participants). The latter two case studies were conducted in a large public sector organisation. Of the four methods, naturalistic sensemaking resulted in the least bias and was the most sustainable. A model– the Sensemaking Spiral– and methodological framework– Context for Action (CA) – were developed through the comparison of the case studies, supporting theory and researcher reflection. The five elements in the CA framework are perspective, momentum, narrative, patterns and meaning. These elements allow a multi-ontology and multi-epistemology approach; a balanced research design should select methodologies which cover all five elements in order to be valid and sustainable. Context for Action allows different methodologies to be 'scaffolded' together without subsuming one into the other. Performance criteria for each element are proposed. These allow the comparison of different research designs to explore emerging issues. This study has argued that meta-data is important and demonstrated the potential for combining meta-data and narrative approaches in ergonomics, allowing quantitative as well as qualitative analysis. Like many problems in HFE, the ergonomics of office work was found to be complex. Evidence that complexity theory contributes to a better understanding of complex problems in ergonomics has been presented. The Sensemaking Spiral allows a research project to be positioned with regards to different frameworks for ignorance and knowledge and with respect to time. An approach using ignorance based learning and narrative was found to be effective for exploring emerging issues. Frameworks for ignorance are suggested as a powerful way to locate and manage a futures focussed project in an interdisciplinary context.

Acknowledgements

A doctorate might be thought of as not one, but two journeys, the first to deliver the product, the second to sustain and develop the person who produces it. These acknowledgements will not try to separate the two, as friends and family have contributed to the academic work and people involved in the 'business' of the doctorate have become friends. From the point of view of the mechanics of this thesis, much is owed to five groups of people– the foresight and ergonomics communities, Cognitive Edge as a business but more importantly as a community of practice, the staff of Centrelink (host organisation for two case studies), staff at the University of Canberra and an eclectic group of free academics whose training, ideas and support have been influential over a period of nearly seven years.

In the foresight community, Luke Naismith and Bronwyn Jones helped start the process of learning about futures studies and later Gary Saliba, Richard Bawden, Marcus Barber, Paul Higgins and Craig Rispin provided many opportunities to explore different specialist areas and answered questions when answers were needed fast. Richard Slaughter provided some welcome early advice and useful resources. Peter Hayward and Joseph Voros of Swinburne University of Technology, Melbourne very graciously advised on the initial development of the methodological framework. In the ergonomics community, thanks must go to Pepe Marlowe, Alan Hedge and Jan Dul but especially to ergonomists who attended a workshop using Cognitive Layered Analysis in November 2005. Dave Snowden, founder and chief scientific officer of Cognitive Edge, provided advice and access to the use of the SenseMaker™ software critical to development of the framework. Viv Reid and Chris Fletcher of Emergent Options assisted in the development of the SenseMaker™ survey. At Cognitive Edge, Steve Bealing and Laurie Webster also deserve a vote of thanks for their support in the technical and analysis phases of this final case study.

Without a real organisation to serve as the field study location this thesis would have much less credibility. More than one hundred staff at Centrelink were involved. Wayne Williams managed the initial application and negotiated the research contract. Tony Vane agreed to host this study within his very active department and managed to keep it going despite changes in staffing and many operational challenges. Karen Baldwin was the initial contact person to set up the study within the agency, Alexandra Seckhold ensured the scenario workshop went ahead and Megan Evans supported the SenseMaker™ survey.

At the University of Canberra thanks goes to Joelle Vandermensbrugghe, Christine Barnes, Pat Tandy, Jen Webb, Elke Stracke, Stephen Trathen and Bernice Mulcay. Academics and free thinkers working in other locations have also contributed. These are Meg Poore who was then at the Australian National University, Michael Smithson also of the ANU for an influential discussion and for his taxonomy of ignorance, Gabrielle Bammer, also of ANU, for a discussion of her work relevant to the thesis and Pat Bazeley who assisted with training in NVivo. Hugh Pattinson helped out with a brief but very important role on the supervisory panel, contributing to the development of the scenario process and in finalising the structure and conclusions of the thesis. Craig Bremner also contributed to the supervisory panel. Craig's greatest gift was to provide the word 'conversation' as a framing concept. This was hugely valuable to the development of the thesis.

Family and friends are the stalwarts of a doctorate. A huge thanks to Elaine Beale of Safework Australia for being part of many discussions on ideas, models and frameworks, Diane Tanner for help with editing, Jane Mackenzie for assistance with setting up the document and to Nick Elphick and Dominic Mackenzie of Insitec for support with information technology. To my girls Rhiannon and Sarah and my partner, Julian, there are too many ways to count the support you have given. I promise you my best efforts always. The highest praise goes to Leone, my sister whose hard work finalising the script in the final months, weeks and days was unbelievably generous.

Bill Green – Emeritus Professor extraordinaire – a gentleman and a legend. Thanks for all your humour, praise, encouragement, wisdom and patience. It has been a crazy but interesting journey for both of us and worth every moment.

Table of Contents

Table of Figures

Table of Tables

Table of Appendices

Glossary of Terms

Term	Meaning
Abductive reasoning	Reasoning through successive approximation
Action learning	Action learning is a systematic process through which individuals learn by doing. Through the process, people increase their self-awareness and develop new knowledge, attitudes and behaviours as well as skills for making changes and redefining their roles and responsibilities within new or changing workplace contexts. (Skippington, cited in Mitchell and McKenna 2008, p. 4)
Action Research	Action research is a process by which change and understanding can be pursued at the one time. It is usually described as cyclic, with action and critical reflection taking place in turn. The reflection is used to review the previous action and plan the next one. Bob Dick (1997)
All quadrants all levels (AQAL)	A four quadrant model used in Futures Studies based on the work of Ken Wilbur and Richard Slaughter. It presents four general viewpoints(s) of knower(s). The main framework is the Integral Operating System (IOS) which has the intentional (upper/interior individual) perspective, the behavioural (upper right/exterior individual) perspective, the cultural (lower left/interior collective) perspective and the social system (lower right/exterior collective) viewpoints. Further details include waves and lines of development, different states of consciousness and knowing and different perspectives. Slaughter (2004a)
Chaos	An ontological state in which there are no perceivable cause and effect relationships. A system in turbulence.
Complex adaptive systems / complex dynamical system	Systems whose properties change because of the interplay between the generalized adaptive responses of the parts and the emergent properties of the whole. Levin (2008)
discourse	Linguistic units composed of several sentences – in other words, conversations, arguments or speeches'. Ehdlund (2007)
Discourse	A series or exchange of related thoughts by one or more people, which can be described as a conversation.

Disintermediation	Removing the layers that separate decision makers from raw data. This allows decision makers to move from an abstract representation of a large data set, spot patterns and anomalies, and focus on the items to which they really need to pay attention. Snowden (2009)
Doxa	Certain classic accepted texts that must be read– that must be adhered to. Inayatullah (2004a, p. 74)
Dynamic Scenario Learning Process (DSLP)	A proprietary systems approach to scenario planning. The decision issue is created in the form of a question and is then used to identify events (variables), the underlying patterns (trends), and structure (causal connections), to develop a system which can be used to model the future context of the issue to be examined.
Dynamic Scenario Generator (DSG)	The system diagram constructed in DSLP that allows researcher to study the potential effect of combinations of significant changes.
Environmental scanning	A futures research tool that allows us to integrate our understanding of various sectors of the external environment and their relationships with systematically collected macro-environmental information to obtain early warning of change. Morrison (1995)
Funnel-based reasoning	A necessary but uncertain narrowing of the project scope over time, a 'waterfall process', as the project moves towards completion
Granularity	The relative size, scale, level of detail, or depth of penetration that characterizes an object or activity
INSPECT	An acronym used in environmental scanning. Letters stand for: Interpretation, Natural, Social, Political, Economic, Cultural, Technological. A perspective tool to look for content in areas apart from those most familiar to researcher. Bawden and Freeman (2007)
Integral Operating System (IOS)	A model with 4 quadrants, representing interior / exterior and individual/collective views. These are the intentional (upper/interior individual) perspective, the behavioural (upper right/exterior individual) perspective, the cultural (lower left/interior collective) perspective and the social system (lower right/exterior collective) perspectives.
Interactive Qualitative Analysis (IQA)	A structured process using a focus group to define the relationship between pairs of affinities

Macrocognition	The mental activities that must be successfully accomplished to perform a task or achieve a goal. Other somewhat related terms have been used in this regard, such as situated cognition and extended cognition. Klein (2003)
Meaning	Signification; the outcome of synthesis and integration involving processes such as reason, perception, imagination, vision and intuition
Microcognition	The 'building blocks' of cognition, more microperspectives (that) carry with them the notion of reductionism, that explanations come from reduction to a set of basic functions or components'. Klein, Moon and Ross (2003)
Momentum	An action or actions taken to assist the exploration of perspective
Narrative	A coherent representation of a story which happens in conversation, is composed of discourse, appears in a sequence, and is interpreted retrospectively
Patterns	A perceptual structure occurring in different forms, that is emergent from the relationship between recurring entities or events and or considered worthy of imitation
Perspective	A vantage point
PINCHASTEM	An acronym used to ensure a systematic search in environmental scanning. Letters stand for: Political/governmental, Information/communication/media, Natural/macro-environmental, conflict, Health, Artistic, Social, Technological, Economic, Moral. A simple basis for categorisation of sources.
Sensemaking	A range of integrated approaches to three broad activities: scanning, (data collection), interpretation (data given meaning) and learning (action taken). Snowden (2007)
Sensemaking item (SMI)	A unit of analysis as it occurs in the context of naturalistic sensemaking.
Spiral Dynamics	A model and theory applied in the area of personal development. The model is in the spiral form, depicting evolution through different stages of personal growth.
STEEP	Acronym to assist environmental scanning: Science, Technology, Economic, Environmental, Political, Ethics, Resources.

Tactics	Summary statements which point to the resources– approaches, activities, methods, tools or principles– that can be used for a specific element in the Context for Action framework
Vinculum	A mathematical symbol denoting an association between two entities
Weak signals	Current oddities, strange issues that are thought to be in key position in anticipating future changes in organizational environments (Hiltunen 2008)

Preface

A thesis is essentially part story, part mosaic. For this thesis, the analogy holds true for the author's experiences in creating the product as well as for the product itself – a methodological framework for exploring emerging issues built on narrative and patterns.

The author maintains that as a thesis in Environmental Design, the thesis can only gain from an element of creativity in its presentation. This creative element is used deliberately to help the readers understand challenging concepts and to tell an interesting story. Strategies for presentation build on the concept that the thesis is really a body of work collected and assembled over the course of the study and not solely a linear text.

Non-textual elements are included to add depth, provide insight and as a navigational feature for the document. Visual data includes a map of the logic of each chapter. These maps build each of the six themes across the chapters to assist the reader to follow the argument of the thesis. A tabular form of these maps is presented at the end of this preface as a single, visual reference point for these themes (Tables 2-4 and in map format in Appendix A). The chapter structure is shown graphically in Figure 2 following these tables. Chapters 1, 4, 7 and 8 build and deliver the methodological framework which is the main work of the project. Chapters 2, 3, 5 and 6 present individual case studies which support the development of that framework.

The intent has been to use different types of text to allow the document to be not only an academic work but also to be seen as a story and a mosaic. Some chapters therefore have a formal and an informal title. Quotations from diverse sources appear intermittently in the margins to highlight insights from the body of the text. Images and even a cartoon are also used to highlight or explain the issues discussed.

The reader will note the extensive use of appendices in this thesis. This thesis is essentially about the methodology for looking at emerging issues in the ergonomics of office work, not about delivery of content on that subject. Empirical content arising from each element of the work is therefore presented in the appendices. For example, Appendix B contains ethics documents relating to the case study chapters, Appendix C to conference papers, Appendix D to Chapter 2 and Appendix E relates to Chapter 3. This strategy allows only the exemplars necessary to the argument, such as quotations and summaries to appear, in the main text of the thesis. The mapping of content to appendices is shown in Table 1.

Except for some grammatical changes, papers in the appendices appear largely in their original form at the time of writing. While the author would dearly like to change content to suit her current understanding, the original output needs to be included with all its conceptual flaws.

A diagram showing the development of the thesis as a body of work is shown in Figure 1. This is presented as a timeline. The timeline shows that not all of the analysis of the content was done in the order of presentation of material in the thesis. The material for Chapter 3 (expert interviews) was, for example, analysed after the material for Chapters 2 and 5 (environmental scanning and the scenario workshop respectively). The order of presentation of the material in this thesis does, however, mirror that of data collection. The timeline also shows the mechanics of the project and highlights some of the significant challenges of a thesis of this type.

Thesis element	Appendix	Nature of Appendix content
Introductory Parts	A	Maps of themes of chapters, thesis
Ch 2,3,5,6	B	Ethics documents
Chapter 1	C	Conference papers IEA and HFESA
Chapter 2	D	Draft ssues paper environmental scanning
Chapter 3	E	Selected interview transcripts and summaries
Ch 2,3,5,6	F	Transcripts of reflections on process
Chapter 4	G	List of methods and tools in futures studies
Chapter 5	H	Scenario Workshop documents
Chapter 6	I	Sensemaker paper and survey
Chapter 7	J	Summary of results Ch 2,3 5,6 relating to development and use of methodological framework

Table 1 Mapping of appendices to individual chapters

Figure 1 shows the significant time input that was required to drive the administrative and technical phases of the project. It took thirteen months from October 2006 to November 2007 to obtain a contract relationship with a government entity to carry out the scenario workshop and survey using naturalistic sensemaking. Organisational activity, staff changes and technical issues saw the timeline for the survey extend from three months to thirteen months

from February 2008 to March 2010. The survey then coincided with a period of significant change for the government entity at which time it had the potential to fail altogether due to concerns on the impact to human resources. The recursive nature of the project suggested by the timeline provides evidence of the choice of action research for the research design as being appropriate.

The author would like to thank the reader in advance for putting in the effort needed to work with what is often rather densely written prose. An additional challenge is the use of terms which hail from sociology and the philosophy of knowledge which may be unfamiliar to some readers. The scope of the thesis demanded many disparate ideas to be brought successfully together in the one thesis. Whole chapters could have been written on many of these ideas to explore them in greater depth. If this had been done, the work would never have been completed and the central themes in the narrative lost. The strategy taken has been to actively use literature to support each step taken as necessary, not to explore every alternative at each step. The intent has always to be to cover an idea well enough to build a sufficient case, to provide a stepping stone to the next idea and so on until it became possible to build the methodological framework that was the aim of the study.

The thesis aims to act as a guide for the single researcher, academic or professional seeking new ways to explore emerging issues that can shape research and practice now and in the future.

A guiding inspiration for this thesis has been the quote by Samuel Butler:

'Life is the art of drawing sufficient conclusions from insufficient premises.'

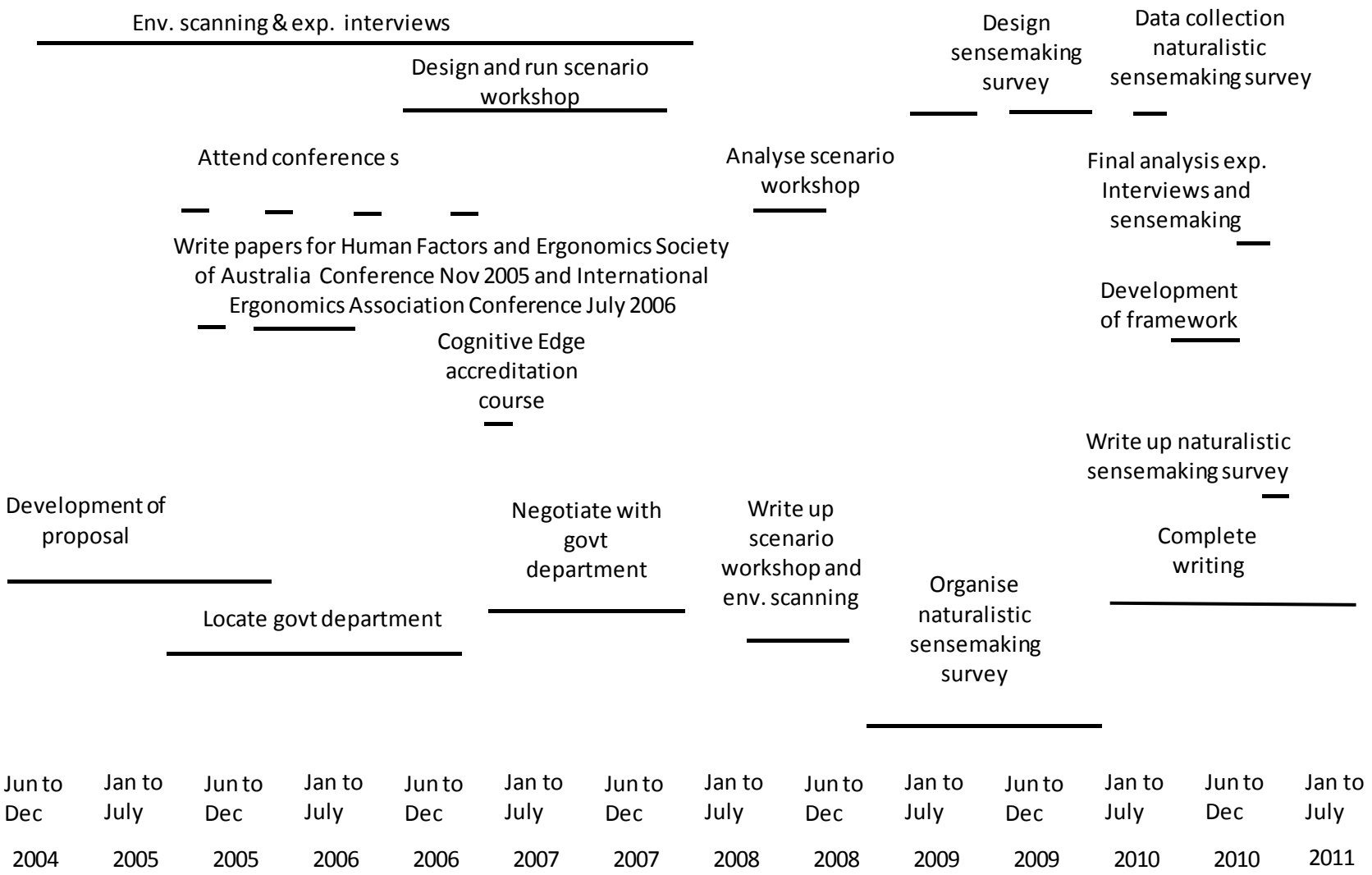

Figure 1 Timeline for development of thesis

	Chapter 1	Chapter 2	Chapter 3
Ignorance based learning	Exploring emerging issues can be seen as reducing ignorance rather than pursuing knowledge	Ignorance perspective demands validity via scope/fine granularity. Uncertainty of too much information forces other ways to make sense such as experts	Experts also becomes wiser with time and may admit ignorance; suggests experts need motivation and structure to explore role of ignorance in their work
Perspective	Authentic exploration of future includes multiple perspectives which is basis for validity	Pluralism - multiple epistemologies, gives authentic exploration but volume of information challenges ability to make information coherent so try trust in expert perspective	Interviews allow a promising shift to story as method - but lack the ability to ensure both deep and broad perspectives so best to try a formal way to ensure multiple perspecives
Momentum	Research about future is a 'learning journey' so action research / learning is appropriate	To plan route for research journey, need a vantage point and to manage scope by understanding relationship between quantity and quality	Interviews are resource intensive / useful guide but the opinions of others are no subsitute for the struggle to find own answers
Narrative	Conversations on way as a guide HFE and FS	Narrative of academic literature not in accessible or agile form. Env scanning picks up conversations but is costly so try co-creation with experts	Understanding expert narrative is limited by perspective of those creating and interpretting it
Patterns	Research design a mosaic with interactions defining how the pieces fit together	Need to see interactions of agents and events but environmental scanning has no inbuilt means to do this so conclude expert can integrate knowledge from many sources	Interaction in interviews creates part of pattern of information (the mosaic) but patterns between interviews is still the work of researcher.
Meaning	Need a way to integrate conversations for meaning and action	Environmental Scanning lacks an embedded way to proceed to meaning except through hands on interpretation by researcher or another person	Expert gives sense of coherence through believable story - narrative - but opinon is fallible, need more structure
Summary	**Journey is metaphor for exploring future. Need a methodological framework to guide ergonomist exploring emerging issues. Try standard approach of literature search.**	**Validity is important in ergonomics; seen as a postnormal science, validity demands scope but too broad a scope leads to overload so choose experts to deal with uncertainty about future.**	**Experts provide valuable insights but limited by options for perspective and interpretation. Try futures studies methods to improve validity.**

Table 2 Summary of themes in thesis: Chapters 1-3

	Chapter 4	Chapter 5	Chapter 6
Ignorance based learning	Knowing fallibly - humble ignorance - is important in practical sense to support decisions	Scenarios must preserve uncertainty to be effective (Shoemaker 2002 p. 5)	Naturalistic sensemaking consistent with ignorance based learning but comes from knowledge management
Perspective	Epistemic pluralism requires questioning approach to future; Strength of futures studies is breaking and making perspectives, in particular about assumptions and worldview	Achieves multiple perspectives; scenarios may fail if not matched to needs of client and expected outcomes (Barber 2009 4-5).	Multi-ontology approach: complex adaptive systems co-exist with the simple, chaotic and complicated. Features scalability, co-evolution, autopoesis, non-linear interactions
Momentum	Self awareness and action learning and research support idea of strategic navigation. Futures methodologies support agile enquiry.	Scenarios are an imagined journey to the future; participants need skilled guidance to move between past, present and future.	Allows multiple epistemologies; idea of safe fail rather than fail safe allows intervention to co-occur with research
Narrative	Consciousness about the future and futures thinking skills are important to support effective conversations about the future.	Scenarios are a category of techniques - story building with future focus	Micro-narrative provides finely granulated data; distributed cognition with signification at source eliminating researcher bias.
Patterns	Some futures studies methods use systems approach and group processes and include ways to integrate multiple perspectives through patterns eg scenarios	Scenarios model complexity but highly structured scenarios are resource instensive so integration may be in hands of researcher, not group.	Relationships/interaction of agents define the system and emerge in metadata. Disintermediation allows multiple people to see patterns in the data;
Meaning	Diffult to engage with futures studies as non-expert; try simple narrative approach that with history of extensive use in futures studies to make meaning	Scenarios are a search for understanding (Barber 2009 p. 4-5); meaning comes from participation	Narrative is a scientific discipline capable of statistical analysis: Pers. comm. D Snowden 19 Jan 2007
Summary	**If not an expert in futures studies, try scenarios: method has common history in business and futures fields, is story based, accessible to target audience and uses social construction of knowledge.**	**Narrative/multi perspective focus of scenarios models complexity but interpretation creates bias; try naturalistic sensemaking approach**	**Sensemaker is sustainable way of collecting and using narrative to find patterns in the narrative. This supports both integration and implementation in the long term.**

Table 3 Summary of themes in thesis: Chapters 4-6

	Chapter 6	Chapter 7	Chapter 8
Ignorance based learning	Naturalistic sensemaking consistent with ignorance based learning but comes from knowledge management	Sensemaking spiral is about exploring unknown, reducing ignorance in all its forms: ignorance based learning	Knowledge is about expectations; ignorance based learning about surprise; both needed for complex research context
Perspective	Multi-ontology approach: complex adaptive systems co-exist with the simple, chaotic and complicated. Features scalability, co-evolution, autopoesis, non-linear interactions	Multiple ontologies and epistemologies; need an open framework which locates not subsumes different methods	Use multiple ontologies and epistemologies, a methodological framework with perspective being dominant; regard complex adaptive systems as common
Momentum	Allows multiple epistemologies; idea of safe fail rather than fail safe allows intervention to co-occur with research	Sensemaking Spiral shows spatial / temporal qualities of action learning/research.; the framework acts as a topology	Action learning / research is common to futures studies, HFE and knowledge management; sensemaking is action focussed
Narrative	Micro-narrative provides finely granulated data; distributed cognition with signification at source eliminating researcher bias	Narrative (stories, conversation, dialogue) is central to human function; valid to analyse patterns in narrative for emerging issues.	Narrative is accessible and valid; self signification improves its usefulness in research into emerging issues
Patterns	Relationships/interaction of agents define the system and emerge in metadata. Disintermediation allows multiple people to see patterns in the data	Patterns are essential to humans to perception and to create meaning; position individuals /groups to make own patterns	Metadata allows new patterns to be seen; it is the interactions, best represented with verbs and relationships, that keep patterns agile
Meaning	Narrative is a scientific discipline capable of statistical analysis: Pers. comm. D Snowden 19 Jan 2007	Sensemaking is thought essential to making meaning in uncertain environment	Meaning is always emergent, never 'known'; ignorance is a useful frame from which to look for emerging issues
Summary	**Sensemaker is sustainable way of collecting and using narrative to find patterns in the narrative. This supports both integration and implementation in the long term.**	**Methodological framework supports sensemaking to explore emerging issues through use of five elements and multi epistemology / multi ontology approach.**	**Reducing ignorance is important; Sensemaking spiral and CA Framework support foresight and sensemaking for exploring emerging issues**

Table 4 Summary of themes in thesis: Chapters 6-8

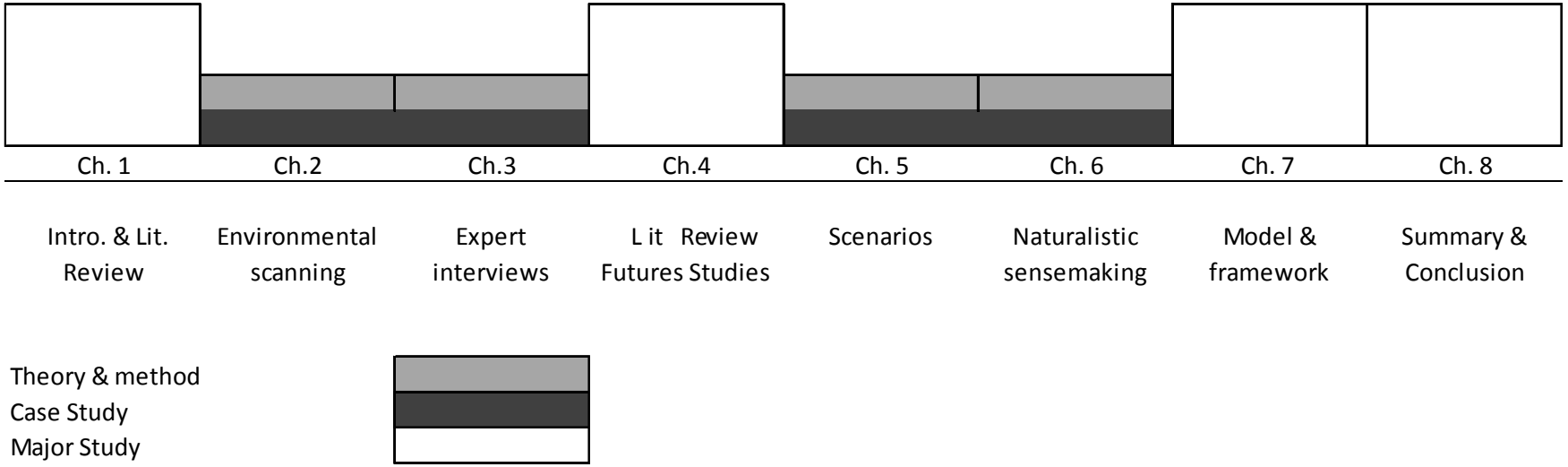

Figure 2 Structure and content of chapters