What is the contribution of personal information management systems (PIMS) to the Working Model and personal work system of knowledge workers?

Thesis

What is the contribution of personal information management systems (PIMS) to the Working Model and personal work system of knowledge workers?

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Abstract

The thesis reports research into a phenomenon which it calls the personal working model of an individual knowledge worker.

The principal conjecture addressed in this thesis is that each of us has a personal working model which is supported by a personal work system enabled by a personal information management system. For some people, these are well defined; for most they are not even explicit. By means of structured self-reflection aided by conceptual knowledge modelling within the context of a process of action learning they can be improved. That personal working model is predicted by Ashby's law of requisite variety and by the good regulator theorem of Conant and Ashby. The latter theorem states that the only good regulator of a system is a model of that system.

The thesis and the work it reports result from a systemic approach to identifying the personal information management system and personal work system which together contribute to the personal working model. Starting with abductive conjecture, the author has sought to understand what models are and to explore ways in which those models can themselves be expressed. The thesis shows how a new approach to the conceptual modelling of aspects of the personal knowledge of knowledge worker was designed, built and then used. Similarly, the actual data used by a knowledge worker had to be stored, and for this purpose a personal information management system was also designed. Both these artefacts are evaluated in accordance with principles drawn from the literature of design science research. The research methodology adopted in the first phase of the research now ending also included a relatively novel approach in which the PhD student attempted to observe himself over the last five years of his PhD research – this approach is sometimes called autoethnography. This autoethnographic element is one of a number of methods used within an overall framework grounded by the philosophical approach called critical realism.

The work reported in the thesis is initial exploratory research which, it is planned, will continue in empirical action research involving mentored action learning undertaken by professional knowledge workers.

[Abstract 348 words; thesis 104566 words without index but with appendices]

Declaration

No part of this thesis has previously been submitted for a degree or other qualification of the Open University or of any other university or institution.

Acknowledgements and dedication

I am greatly indebted to my supervisors, Prof David Weir and Dr Renaud Macgilchrist, for their long-standing encouragement and knowledgeable contributions to my work. David Weir's contributions have included an initial and ongoing belief that there was something to be gained from researching this area, although for a long time it was very unclear what. David also gave me permission and encouragement to include autoethnography as an element of my research. Renaud has never let me slacken intellectually and always pushed me towards a higher level of thinking and of achievement. His specific contribution includes introducing me to morphogenesis and in particular to semantic morphogenesis – this latter is a concept originated by Renaud, as is made clear later in this thesis. Renaud has inspired me to aim for excellence through team teaching and now through research. He has also generously bought lunch on a quite unreasonable number of occasions! Thank you David and thank you Renaud.

I also wish to thank others who at various times have offered their support, advice and guidance, whether as internal supervisor within the Rennes School of Business or as adviser. I acknowledge the contributions made by the late Dr Wladimir Sachs of Rennes School of Business, Dr. Dirk Schneckenberg of Rennes School of Business, Dr Mario Norbis of Quinnipiac University and Dr Mounir Kehal of the Higher Technical Colleges of the United Arab Emirates. I extend special thanks to former colleagues at Rennes School of Business who have worked with me along the way, encouraged and helped me. In particular, but not exclusively, I thank Dr Mike Ward, Prof Phil Kitchen, Prof Rod McColl, Prof Bouchaïb Bahli, Dr Irena Descubes and Dr Tony Cragg.

This thesis highlights and is based upon practical personal information management PIM which is informed by developments in industry. Practical PIM depends upon effective information management tools. I should like to thank Pierre Paul Landry of NeoTech Systems, Montréal, Canada for creating the InfoQube personal information management tool which forms the basis for the UnIQue PIMS which is one of the contributions of this research work. Pierre has on many occasions - online and in Montréal - helped me better to exploit this tool. He has even enhanced it in order to meet requirements which I have been able to highlight on the product forum. I am also grateful for his inspirational help to Menez Chapleau who consults in InfoQube alongside Pierre. My use of InfoQube is fully reported in this thesis. A third Montrealer who also gave help of a practical kind is Michel Léonard of the LICEF research centre of the *Université de Québec à Montréal UQAM*. Both online and face-to-face, Michel helped me to understand the G-MOT knowledge representation tool, a development of which is at the heart of this thesis.

In similar vein, I would like to thank Randall Minter of Qrimp Inc. and Ismael Ghalimi of STOIC Inc. Both Randall and Ismael have offered lots of assistance at an earlier stage in the project when my research involved shared situational applications. This particular strand of my

research has in large part been omitted from this PhD thesis but continues to have its place in my plans for future work.

I have had a great deal of support from academic, library and administrative support staff of the Open University, for which I thank them all very much.

The template that I have used in the production of this document is based upon one produced by Malcolm Morgan and Kayla Friedman for the Centre for Sustainable Development, University of Cambridge, UK – thank-you.

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Thank you, Alan. Thank you, Caroline. Without the support of Caroline and that of Alan, I would never have been able to submit this thesis and to complete my PhD, which I dedicate to you both.

Copyright acknowledgements

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He thanks the following for specific permissions granted:

Citation and usage	Permission
(Goles and Hirschheim 2000), quoted here in section 2.10	Reprinted from Omega, 28/3, Goles, Tim and Rudy Hirschheim, 'The Paradigm Is Dead, the Paradigm Is Dead… Long Live the Paradigm: The Legacy of Burrell and Morgan', 249-268, Copyright (2000), with permission from Elsevier

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Chapter 0 INTRODUCTION TO A PERSONAL WORKING MODEL

This chapter is firmly in the tradition "tell'em what you're going to tell'em, tell them, then tell'em what you told'em"; it tells a lot of the story in advance and in very condensed form.

0.1 Thesis themes: what are you about to read?

In this thesis, I will present my research into the personal work system and personal working model of knowledge workers. The research question is: What is the contribution of ***personal information management systems PIMS*** to the ***Working Model*** and ***personal work system PWS*** of knowledge workers? I shall discuss the thinking and philosophy behind the highlighted terms as I establish the existence of a governing model and the need for and nature of the PWS and PIMS.

The thesis and the work which it reports results from a ***systemic approach***. In particular it takes as its starting point the work of the cyberneticians W. Ross Ashby and Roger Conant - specifically Ashby's ***Law of Requisite Variety*** (Ashby 1956) and the ***Good Regulator Theorem*** of Conant and Ashby (Conant and Ashby 1970). The latter theorem states that ***the only good regulator of a system is a model of that system***. Clearly therefore we need to understand what models are and we need to explore the ways in which models can be expressed. I will introduce and justify a new approach to the conceptual modelling of personal knowledge. This has been dubbed concept-process reciprocity modelling, abbreviated to ***Conceprocity***.

I shall of course discuss the ***research design***: its objectives, motivation, methodology, techniques and planned dissemination before reporting the ***research findings***: the extent to which I have so far succeeded in identifying a personal working model, a personal work system and personal information management system. The thesis concludes in stressing that this initial exploratory research is only the first part of a planned research programme. This will now move on to mentored action learning - working in conjunction with research volunteers who are themselves knowledge workers.

The thesis title and the principal conjecture

The title of the thesis is:

"What is the contribution of personal information management systems (PIMS) to the working model and personal work system of knowledge workers?"

The principal conjecture is that each of us has a personal **working model** which is supported by a **personal work system enabled by a personal information management system**. For some people, these are well defined; for most they are not even explicit. By means of **structured self-reflection** aided by **conceptual knowledge modelling** within the context of a process of **action learning** they can be improved.

The abductive necessity for, and character of, a working model

The thesis is in part a top-down theory-driven argumentation and justification for the necessary existence of a working model that is vital to the regulation of the individual's personal and working life. Concretely, the thesis takes as its starting point the theory-derived necessity (following Conant and Ashby 1970) for a personal information management system PIMS (whether ICT enabled or not) as a part of the regulatory model essential to an individual's efficient and effective personal and working life. Conant and Ashby (1970), in an article which they entitled **"Every good regulator of a system must be a model of that system"**, showed that:

"The design of a complex regulator often includes the making of a model of the system to be regulated. The making of such a model has hitherto been regarded as optional, as merely one of many possible ways. In this paper a theorem is presented which shows, under very broad conditions, that any regulator that is maximally both successful and simple must be isomorphic with the system being regulated. (The exact assumptions are given.) Making a model is thus necessary. The theorem has the interesting corollary that the living brain, so far as it is to be successful and efficient as a regulator for survival, must proceed, in learning, by the formation of a model (or models) of its environment." (Conant and Ashby 1970, p.89).

The thesis seeks to tease out some of the multiple dimensions and necessarily active nature that such an isomorphic model must requisitely possess if it is to be capable of generating sufficient variety to overcome the variety that exists in its environment, as is required by the same Ross Ashby's earlier law of requisite variety (Ashby 1956). Thus, the model should have both representational and active (actionable) characteristics if the desirable and essential-to-survival goal of effective regulation of the individual's life is to be achieved. To the extent that we all, for a time, do succeed in a degree of self-regulation and viability, the model must exist in some form and the research goal has therefore been to discern and to characterise it initially, with the hope of improving it subsequently.

The thesis is also an investigation of how the affordances and constraints (Maier and Fadel 2009; Volkoff and Strong 2013) offered by information management technology used by the individual influence and limit what the individual can actually achieve in her working life. This aspect of the thesis is informed empirically by multi-methods research (Mingers 2001) which has included the unusual methodological lens of auto-ethnography. Autoethnography, sometimes referred to as confessional writing, is validly subject to considerable criticism in the sociological literature from which it springs. However, it is usually also associated with reflexivity and thus with learning (Wall 2006). I understood at an early stage in what I regard

as a long-term research programme that I myself needed to learn before I could go on to carry out mentored action research into the personal information management of others in planned post-PhD research. My principal existing empirical evidence comes from a 390,000-word five-year auto-ethnographic research journal which I have subjected to textual analysis using ('Leximancer' 2016) (A. E. Smith and Humphreys 2006).

By means of bricolage (Ciborra 1992); (Verjans 2005), of design research (Hevner and Chatterjee 2010a)): (Baskerville, Kaul, and Storey 2015) and of experiential design (Baskerville 2011a) I have also built a personal information management application, based on software called InfoQube (InfoQube 2019) and on the reference management software Zotero (Zotero 2019). This PIM app is a proof-of-concept prototype which encompasses data such as my bibliographic references – and my address book and the repeating elements of my shopping lists! Thus, I have sought to investigate personal information management systems in a multi-method research framework which has included building and using a PIMS in the context of doing a PhD: action learning (Revans 1998) within the context of action design research (Sein et al. 2011). The design and implementation of the PIMS is the first of two pieces of design research in this study.

Modelling the model

My empirical research is buttressed by an innovative and original technique of content analysis based on the conceptual modelling of typed kinds of knowledge. The design of this knowledge modelling method, which is dubbed **Conceprocity - concept <-> process reciprocity**, is a second piece of design research which is shown in this thesis to be based ontologically on an amalgam of the scientific and social ontologies of respectively Mario Bunge (Bunge 1977, 1979) and of John Searle (Searle 2006). The complementarity of these two ontological approaches in the context of information systems was originally suggested by (March and Allen 2014). The use of Conceprocity by a knowledge modeller constitutes in itself a work system supported by an information system.

The thesis also discusses the philosophical justification for the existence and abductive (retroductive) identification of **generative mechanisms** which give rise to **morphogenesis**, terms introduced in the **critical realism** of the philosopher Roy Bhaskar and of the sociologist Margaret Archer (Bhaskar 1975, 1978, 1989; M. S. Archer 1982, 1995). The importance of critical realism in the field of information systems was recognised by (Dobson 2002) and has been discussed inter alia by (Wynn Jr and Williams 2012); (Mingers, Mutch, and Willcocks 2013; Mingers and Willcocks 2014). I argue and begin to demonstrate that morphogenesis is evidenced semantically and semiotically in accordance with work to be reported in a forthcoming paper (Macgilchrist and Gregory 2019). **Semantic morphogenesis** is evidenced by paradigm shifts in language (Macgilchrist 2004) which can be noted empirically across the longitudinal autoethnographic research reported in the thesis. **Semiotic morphogenesis** is evidenced by the emergent requirement for, the introduction, evolving design and use of the Conceprocity knowledge mapping approach.

Generative mechanisms identified

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Two *generative mechanisms* which I have identified in personal information and work management are:

1. Bricolage[1] and *experiential design* (Baskerville 2011a) are evidenced in the necessary and often messy realisation of some kind of personal information management system PIMS - (Baskerville 2011b, 2011a) calls it an individual information system IIS. A proof-of-concept model of a personal work system is represented using Conceprocity. A proof-of-concept PIM application is based on the affordances offered by (inter alia) InfoQube (InfoQube 2019) and Zotero (Zotero 2019). This specific PIM app is currently called UnIQue (pronounced uni-queue - unified information querying or, better, unified IQ usage environment).

2. A second generative mechanism is seen in the *philosophically-informed design science research* employed in the conception, realisation and development of the knowledge modelling mechanism called Conceprocity. I have then gone on to use Conceprocity both to analyse aspects of my auto-ethnography and to model and synthesise the existing research upon which my work is based. Specifically, the proof-of-concept model of a personal work system is represented using Conceprocity. The current implementation of Conceprocity is based on the affordances offered by web-based graphical modelling software, specifically Lucidchart (Lucidchart 2016).

Emergent principles of personal information management

We see that the auto-ethnographic and knowledge-modelling lenses have together been used to explore possible approaches to personal information management as it serves personal work within the context provided by an *integrative personal working model approach*. This combined approach augments the *warrantability* of *principles* which *emerge* from the autoethnography and from *reconsideration of existing theory*. Therefore, the thesis claims to have gained insight into what it calls *morphogenetic stages of learning* and has identified candidate *generative mechanisms* as the individual progressively identifies, assembles and uses ICT-informed control and regulation affordances. The use of affordances as an analytical construct and as a tool in the identification and analysis of generative mechanisms has recently been suggested and exemplified by (Bygstad, Munkvold, and Volkoff 2016). A mechanism is a causal structure that explains an empirical outcome (cf. Bunge 2004). In open systems, these outcomes are not deterministic, but probabilistic and contingent on other mechanisms. In general, mechanisms are abstract and not directly observable. By contrast, affordances – which arise from the relationship between a purposeful actor and an IT artefact – are more concrete and their identification is much more straightforward. The generative mechanisms here identified have included both *abductive bricolage* and *purposeful design* of an analysis and design language and of a specific PIMS.

The suggested *principles* are shown to be grounded in the philosophies both of Peirce's *pragmaticism* (Peirce 1935) but principally of Bhaskar's *critical realism*. The principles are

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[1] Broadly, tinkering or messing about until you achieve a desired result; the French word literally translates as do it yourself.

illustrated by means of the individual case which suggests demonstrable warrantability despite as-yet limited empirical justification.

Warrantability is a measure of the truthfulness or the extent to which we can be certain of a proposition. Warrantability is itself a principle suggested by this research as inspired by the discussion of validity in critical realist research of (Zachariadis, Scott, and Barrett 2013). It is based upon an original idea suggested by (Dewey 1941). See Table 1.

Table 1 Warrantability as viewed by an individual

Level of warrantability	Notes
1: Speculation	A statement for which at the present time there is no evidence and which may give rise to a need for further work.
2: Conjecture / abduction	Provisional assertion which, if proven, would help to explain an observed situation. There is as yet little or no evidence for the conjecture, which nevertheless seems plausible and is not immediately refuted by existing evidence or knowledge. Cf. (Popper 1963) on conjectures and refutations and Peirce on propositions (section 0).
3: Observation	Statement I believe to be true on the basis of initial evidence, for which there is neither strong supporting evidence nor refutation.
4: Emergence	A strong observation which arises and for which a strong warrant can be given. [Less strong observations are simply that: observations.] Statement which I strongly believe to be true on the basis of reasonable proof which has arisen in the situation or can otherwise be asserted. There is no conclusive refuting evidence.
5=: Finding	A very strong observation which has arisen in the context of my own work and for which a proof can be given. [Less strong observations are either emergences or observations.] Statement for which I have evidential proof and against which there is no conclusive refuting evidence. A safe recommendation to other knowledge workers.
5=: Principle	A statement having the same strength and warrantability as finding, but one which is not necessarily based on my own work.
6: Design	Applied to a designed artefact – such as software – or model. Warrantability here is dependent upon conformance to requirement or to what is modelled.
7: Institutional	Axiomatic - widely accepted as true - in accordance with social ontology.
8: Scientific	Axiomatic - widely accepted as true - in accordance with scientific realism.

	An axiom is an established principle, that is, principle which is accepted as having been demonstrated and is not therefore in question, at any rate in a given study. Axioms can instead be assumed as true for the purposes of experimental design. They correspond to Peirce's **assertions** (Yu 1994); Peirce contrasts them with **propositions**.
	~~A theory is an accepted set of axioms having predictive capacity.~~ A theory may be espoused or a theory-in-use; the distinction comes from Chris Argyris and Donald Schön; see for example (Argyris and Schön 1974).

Further justification and evaluation of knowledge production follows in general the principles established in the paper on genres of enquiry (Baskerville, Kaul, and Storey 2015).

A principle applied: designing and building a nugget

A "nugget" is the name I give to an expression of explicit knowledge, often actionable. The process of designing and building a nugget in the Conceprocity approach proceeds as follows. A Conceprocity model of a nugget may include:

- A set of Conceprocity **maps** – these are visual representations of aspects of the model.
- A set of entries in the Conceprocity **dictionary** – this helps to clarify the semantics of the model by naming notions and deciding their notion type.
- A set of supporting **"resources",** that is, files which, together with the maps and the dictionary, constitute this nugget. For example, for a taught class, these might include a PowerPoint presentation and supporting articles.

The steps involved in designing and building a nugget are:

1. Frame the **topic question** and its parameters. Archetypically, this might be: what do we need to learn as we act? (Active.) Or simply, what do we need to know? (Passive.)
2. Give the nugget a **nugget name**. This should normally be a noun phrase if the knowledge to be described is passive and a verb-noun compound if the knowledge is active.
3. Create a resource space in the form of a folder whose name is that of the nugget.
4. Identify the initial **vocabulary** surrounding the nugget in a **nugget dictionary entry**. This is typically based both on existing classifications (**kinds)** and categories **(tags)** and new ones which will be found in and/or stored in the **personal working ontology,** which is represented in the current UnIQue IQBase.
5. Identify and assemble **sources** – using tagged classification in the PIMS and original information searching. These sources will normally include other nuggets – this is nugget reuse; and existing literature references.
6. Create a putative **nugget signature model:** this will always include an **hierarchical outline**[2], and usually **dictionary entry/entries**, a knowledge **map** and tables. The emphasis on outlining is justified by the need to level (hierarchicalise) a nugget model.

[2] The emphasis on **outlining** is justified by the need to level (hierarchicalise) a nugget model. If the number of notions in the model is large, it is essential to split the model up into more manageable chunks. These chunks may be "obvious", that is, correspond to structural distinctions which are evident. Or they may need to be imposed in a more analytical way, distinguishing sub-nuggets of knowledge, possible actionable. There should always be a route map (which is also a root map –

7. Identify and carry out original *research* or initial *problem-solving*.
8. Analyse data and *refine* model and *build nugget resources*.
9. Present or otherwise promulgate *findings*.
10. Use and refine the nugget, typically in an iterative fashion.

This process is applicable both to research and, in modified form, to teaching and to other practice.

Nuggets are originated by individuals but can be developed and shared by groups. This procedure is an example of an emergent principle arrived at by design.

Incidentally, root and route are pronounced the same in British English) which sets out the main chunks and how they are related. We call this the Level 1 map. Each major chunk can then be represented on a specific Level 2 map. There are well established principles to be applied when hierarchicalising (levelling) Conceprocity maps. In particular, we respect the observation of (Miller 1956) concerning "The magical number seven, plus or minus two: some limits on our capacity for processing information". Thus, there should be no more than nine main notions on the route map (or indeed on each level 2 map – this may sometimes require the creation of level 3 maps). The top-level chunks might be identifiable as the themes of the topic which is being modelled.

Modelling the personal working model

Figure 1 A Conceprocity model of a personal working model 2014 – top level only

Figure 2 How the personal working model, work system and information management system interrelate

Contributions made and future research programme

I summarise the contributions of this research in Table 2:

Table 2 Contributions made by this research and their warrantability

Contribution	Warrantability
The identification of the notion of a personal working model and its illustration by means of a specific example, a case based on autoethnographic longitudinal research.	The necessity for this model is demonstrated by reference to the work of Ross Ashby and Roger Conant, in particular (Conant and Ashby 1970). In the classification suggested by (Baskerville, Kaul, and Storey 2015), this is ideographic science.
The identification and exemplification of a personal information management system PIMS; the proof-of-concept PIM application has been dubbed UnIQue. UnIQue encourages classification by kind and categorisation by tag. Thus UnIQue stores both data and metadata.	The regulation of personal work requires appropriate management of personal information and effective feedback mechanisms, as originally identified by (Ashby 1956). The distinction between classification and categorisation is discussed by (Jacob 2004). The evaluation of the example PIMS follows (Volkoff, Strong, and Elmes 2007). In the classification suggested by (Baskerville, Kaul, and Storey 2015), this is primarily ideographic design.
The Conceprocity visual knowledge mapping language and supporting dictionary. Conceprocity is presented as a series of usage profiles, ranging from the highly informal – particularly appropriate	The design of this language is informed by means of cognitive psychology (Paquette 2010), typed notions (Church 1940; Booch et al. 2007), scientific realist ontology (Bunge 1977, 1979) and by the social ontology of John Searle (Searle

for student use in original problem formulation – through to subsets which are sufficiently formal for use in information systems requirements definition. However, its genesis and focus lie in visual knowledge mapping (Paquette 2010) – which I hold to be essential to making the working model explicit and useful in analysing the requirements for PIMS.	2006). In the classification suggested by (Baskerville, Kaul, and Storey 2015), this is in large part ideographic design but with elements of nomothetic design.

The entire thesis therefore reports an exploration of an under-researched area, that of personal information management systems in the service of personal work. This research has employed *multiple research methods* (Mingers 2001) appropriate to the breadth of the topic area. As (Zachariadis, Scott, and Barrett 2013) strongly commend, the research necessarily follows a multi-method approach essential to tease out the various generative mechanisms which can be discerned in accordance with critical realism principles. It is intended to act as prior preparation to a forthcoming, post-PhD, *research programme*.

A one-sentence summary of the thesis

Each knowledge worker should learn continuously to improve both their individual enacted, open and continuously evolving knowledge model and also the system of data organisation which informs and is informed by their daily work.

Associated website

http://markrogergregory.net

0.2 Thesis structure: the classical structure and why I have chosen to depart from it

A common structure for a thesis, as for example discussed by (Crotty 1998), is something like this:

- Problem statement

- Literature review and identification of research gap

- Research themes and conceptual framework

- Research methodology

- Research design

- Results

- Further work

I have followed the alternative approach suggested by the meta-framework provided by Checkland's sensemaking FMA: **Framework – Methodology - Area of concern** (Checkland and Holwell 1998b); (Holwell 2004). In its basic form, this is pictured in Figure 3:
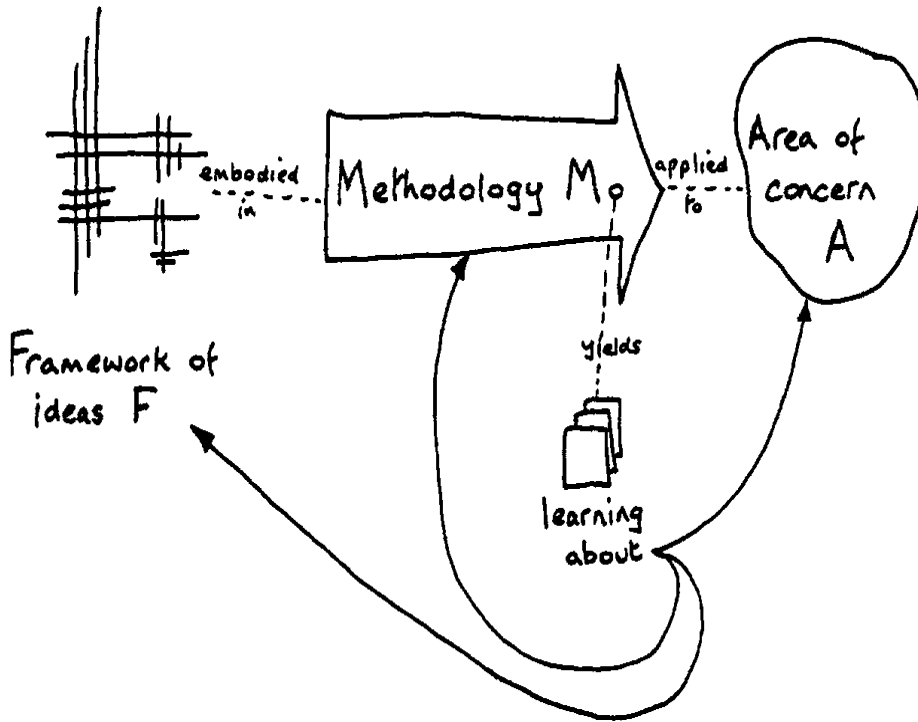
Figure 3 Checkland's FMA skeleton in rich picture form. Source: (Checkland and Holwell 1998b, p.23)

As emphasised by (Ison 2013), systems thinking and practice is fundamental to doing action research. (Ison 2013) notes that (Holwell 2004) proposes three concepts that constitute action research as legitimate research: recoverability, iteration and the purposeful articulation of research themes. Sue Holwell's cycle of action research (Holwell 2004) based on (Checkland and Holwell 1998a) is reproduced here as Figure 4:
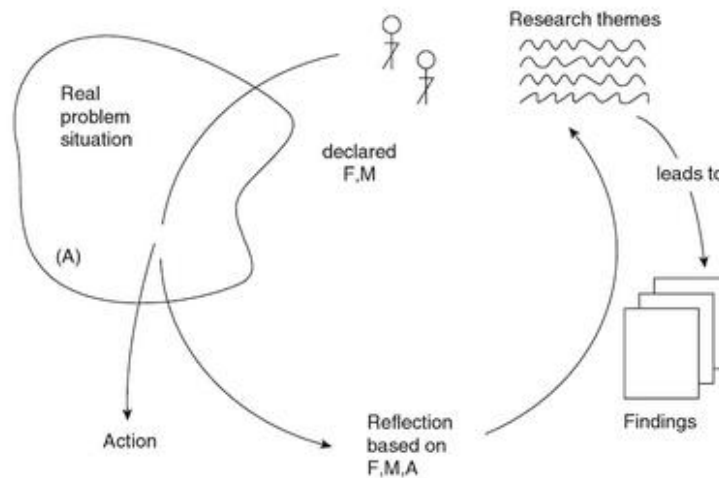
Figure 4 The cycle of action research based on a declared framework of ideas F and methodology M and area of application A together with articulated research themes Source: (Holwell 2004)

I find Sue Holwell's diagram more helpful than Checkland's original in its emphasis on the cyclical nature of action research and in the fact that it doesn't impose a starting point. However, she omits "learning about" as a concept. I have chosen to start from the area of application.

Holwell reiterates what Checkland asserts elsewhere as the principle of recoverability: "the set of ideas and the process in which they are used methodologically must be stated, because these are the means by which researchers and others make sense of the research" (Holwell 2004, p.355). The research process must involve the "articulation of an epistemology in terms of which what will count as knowledge from the research will be expressed" (Checkland and Holwell 1998a, p.9).

(Checkland and Poulter 2006, p20) describe the Learning for a User by a Methodologically-informed Approach to a Situation LUMAS model or meta-framework. They describe it as a generic model for making sense of any real-world application of any methodology, remembering that this word covers a set of principles which need to be embodied in an application tailored to meet the unique features of a particular situation. I reviewed the applicability of LUMAS in the paper (Gregory and Descubes 2011a). I find it to be elegant and the notion that the fundamental output is one of improved learning is attractive. However, I rather think that the authors give the game away in their note that every use of SSM can in principle be described in the language of this model. It is the gradually diminishing activity, over the years, of development occurring along the arrow which links L and M that makes it legitimate to describe SSM as mature. This implies that the authors see L as referring to SSM as a whole and not to the specific situation in which it is being derived. But it is learning about this specific situation that matters to me.

"Checkland stresses that it is not the methodology which leads to improvement. It is the user as (s)he benefits from using the guidelines, as (s)he takes the formally defined methodology M to create or tailor A, the actual, user - and situation - specific approach adopted to the Real –

world problem R that (s)he perceives a concern for. Thus we suggest the existence of problem - focussed or situational learning – using methods in an applied methodology; and higher - level learning – which will manifest itself in a deepening appreciation of methodology and a concern to develop it further in action. We also suggest the possibility that the outer loop corresponds more - or - less directly to the inquiring / learning cycle of Checkland's Soft Systems Methodology SSM." (Gregory and Descubes 2011a)
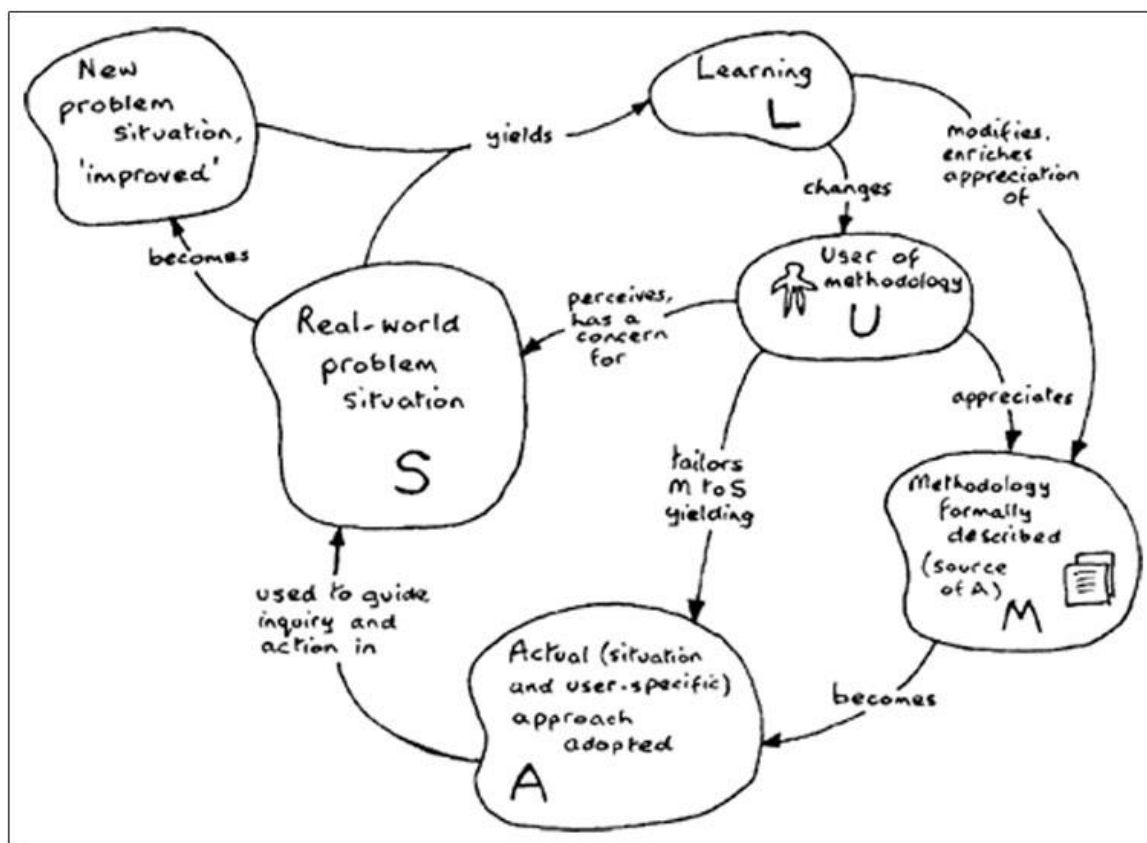
Figure 5 LUMAS Source: (Checkland and Poulter 2006, p20)

It might therefore be valuable to "try" LUMAS – but I had already applied the simpler-to-apply FMA formulation when I was challenged to reconsider LUMAS.

The basic structure of this thesis is therefore as follows:

- Area of concern (Chapter 1)

- The area of concern is that of Personal Information and Knowledge Management by a knowledge worker – initially me as a reflective knowledge worker.

- Studying PIM: literature & knowledge gaps (Chapter 2)

- Framework (Chapter 3)

- Notably:

    o Personal data, information, knowledge and actions

- - Critical realism (Bhaskar 1975, 1978, 1989; Collier 1994)

  - Systems thinking (Mingers 2014) and emergence (Bunge 2003)

  - Knowledge mapping by means of Conceprocity: Concept Process Reciprocity

  - Explicit design and serendipitous bricolage

  - The use of appropriate affordances

- Methodology (Chapter 4)

- Notably:

  - Autoethnography (Rodriguez and Ryave 2002); (Schultze 2000)

  - Design science research and action design research: (Baskerville and Wood-Harper 1998); (Carlsson 2010; Hevner and Chatterjee 2010b); (Hevner et al. 2004); (Sein et al. 2011)

- Findings (Chapter 5)

- Notably: this chapter presents two proof-of-concept prototypes used as learning research vehicles and an analysis of my research journal:

  - Knowledge modelling using Concept $\leftrightarrow$ Process Reciprocity, *Conceprocity*

  - *UnIQue:* a proof-of-concept personal information management system

  - PhD diary; textual analysis by means of Leximancer and categorisation.

- Learning: Morphogenetic Change in The Working Model (Chapter 6)

  - A discussion of the evidence for semantic and semiotic morphogenesis

- Contributions and further work (Chapter 7)

  - Results – principles - and future research programme

0.3 Knowledge work and the management of personal information

Writing about knowledge worker productivity (Drucker 1999) holds that "The most important contribution management needs to make in the 21st century is similarly to increase the productivity of knowledge work and knowledge workers": similarly, that is, to the massive increases in productivity associated with manual work which have been achieved in the hundred years or so since (Taylor 1911) identified "scientific management". This present study has sought to discover how "better" to manage personal information – both in what William

Jones calls KFTF, keeping found things found (W. P. Jones 2007b); and how "better" to get things done GTD (D. Allen 2003).

Sometimes we don't get things done; at best we procrastinate and at worst we fail. Among the myriad reasons for this two may be particularly important.

One is that we don't know how to do what we need to. This may simply be a lack of practical skills, or it may reflect a greater underlying weakness, particularly in abstract thinking. Abstraction skill has been shown to be significant to programming (Kramer 2007) and to structuring data (Ledgard and Taylor 1977). To perhaps a lesser extent, abstraction skills are essential in all scholarship, in learning in general and especially in the recognition and handling of concepts.

The second is, quite simply, that we don't want to do them. We are emotionally disinclined to get started or to complete certain tasks. Emotional barriers (sometimes mis-labelled "psychological" barriers) are perhaps very significant in practice (D. Allen 2003) but are not specifically treated in this study.

When we have a purpose to achieve, we need and decide to take action. In order to act reasonably rationally we marshal the data that we need to inform our proposed action. We apply our knowledge, values and abilities to the data that we have and we decide a course of action which we wish or need to undertake. We catalogue the resources and tools available to us to undertake the action. We identify the process by which we will carry out the action. The action may be individual or it may require the cooperation of others in an ad hoc team brought together to carry out a project including many actions. We then together or alone undertake the actions. As we do so, we update the data we maintain, whether that be in formal organisational information systems (such as student records systems or learning management systems) or in a less-formal personal information management system. What we do may be informed by or evolve in accordance with the changing data.

When we have completed the planned action, we evaluate what we have done and decide to what extent we have achieved our purpose. Frequently we find that corrective or additional action is needed.

This process, which we can characterise as concerning decision making and problem solving, has previously been identified primarily in the organisational context (Simon et al. 1987); (Simon [1970] 1996). Herbert Simon wrote extensively concerning purposeful problem-solving and decision making, and in particular of the necessity for information as a vital component in those two processes.

Sometimes we evaluate what we have attempted and conclude that there is some element of failure: some or all of our purpose has not been achieved. We reflect on that failure; it may be that our purpose was not achievable with the resources available, or it may be that the purpose was in some sense incorrect or inappropriate, or it may be that the knowledge that we applied to the situation was inadequate or defective. We learn from our success, but much more from our failure; see (Ackoff 1987, 1999, 1997). Ackoff's stance became that of a systems thinker and practitioner, no longer so much concerned to identify algorithms but rather to understand heuristics – practical approaches to variably intractable problems – in what he termed

systemic "messes" (Ackoff 1997) and Peter Checkland calls "problematical situations" (Checkland 2000).

Thus, it appears that we are each the principal reflective actor in a goal-oriented (teleological) system that decides, plans, acts, evaluates and learns. We apply knowledge (both theoretical and practical) to carry out informed and decisive action. Our experience causes us to reflect and to learn – our knowledge changes. See for example (Schön 1983)'s discussion of what he calls the reflective practitioner.

Our immediate purpose may be apparently simple, for example, to do the shopping. The data in this case includes a shopping list. Or our purpose may be larger and longer term in its nature, for example, to attempt a PhD in information systems. In both, we apply our existing knowledge (and sometimes we seek to extend that knowledge and then apply it) to relevant data so as to make informed decisions and to solve problems.

0.4 PIM: towards a systemic approach

Approach and limitations

There is a small community of academic researchers that identifies itself by the label **Personal Information Management PIM**. Some of these researchers meet every 18 months or so to exchange and further research in the area of personal information management. Thus, PIM has previously been studied by cognitive scientists or from an HCI or user interface perspective – but almost never from an information systems perspective.

PIM **systems PIMS** have hardly been mentioned in the literature (but we shall highlight as an exception (Baskerville 2011b)) and PIM has never to my knowledge been studied from a systemic perspective. I shall contend that PIMS only make sense within the overall context of personal work systems PWS.

The research which I have been able to undertake into personal information management systems has included a significant element of autoethnography; we might also call it structured self-observation (Rodriguez and Ryave 2002).

This is certainly an unusual research perspective and there are significant dangers associated with its use. Learning from a single case is very unlikely to be generalisable and is obviously subject to significant observer bias. Thus, in the research design, autoethnography is only one of multiple methods of research (Mingers 2001) which together offer insights of varying degrees of warrantability (Dewey 1941). (Schultze 2000) in her own autoethnographic research suggests that autobiographical details should be minimally divulged but that the first person has to be used in expressing the lessons learnt. I concur. I have aimed throughout to make my research a piece of engaged scholarship as suggested by (Van de Ven 2007).

My first degree included cybernetics, the study of control and communications in man, machine and animals (Wiener 1973) – with a strong emphasis on "hard" science and conditions for stability in engineered systems. I have split my working career between information systems **practice** and **teaching**. Much more recently, I have begun to **research** in this area. I aim to take a systemic approach in all my work. I take the word systems in the

phrase information systems very seriously. My understanding of the word system is an evolved emergence arising from my earlier experience but especially from the research and learning reported in this thesis.

0.5 A model of a Personal Working Model

Figure 6 is a diagrammatic, representational, model of a phenomenon which this thesis calls a personal working model. The modelling language used here, called Conceprocity, is itself a contribution of this research. The fundamental notions (object types) of the Conceprocity language will be described later in this thesis, and on the basis of this understanding a fuller description of the model will also be given.
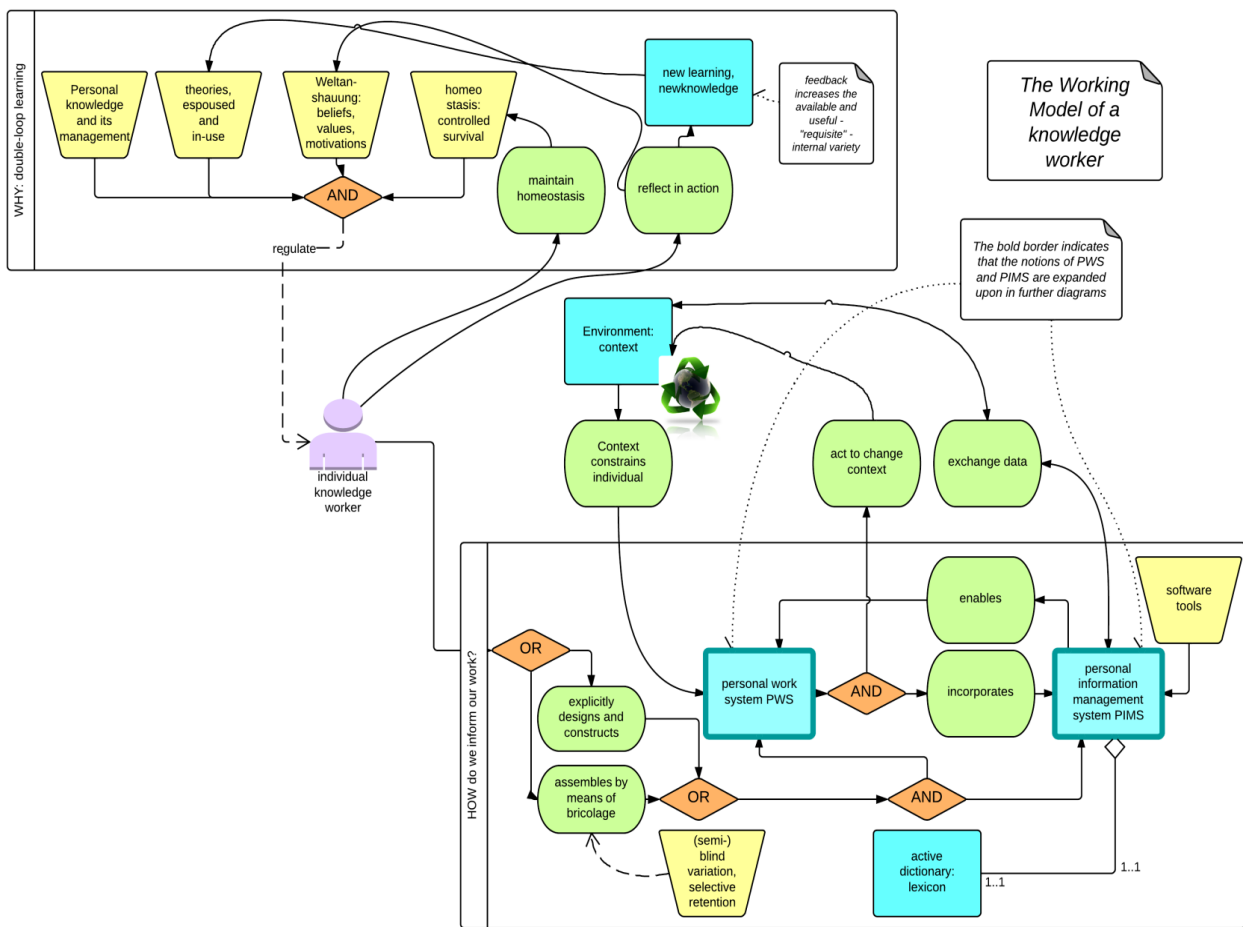
Figure 6 A model of a Personal Working Model (2014)

A deceptively simple example of personal data: doing the shopping

We shall first give consideration to what would appear to be a simpler modelling situation and draw lessons from it.

Doing the shopping requires the creation of a list of things to buy. If that list exceeds a few items – seven or 10 – we need to write it down. This is because of fundamental limitations in

our cognitive capacities first identified by (Miller 1956), who in his article entitled "The magical number seven, plus or minus two: some limits on our capacity for processing information" demonstrated that the unaided observer is severely limited in terms of the amount of information he can receive, process, and remember at a given moment in time

Implicitly or explicitly we attach additional data to our list. Most items might be obtainable from our favourite supermarket, but some might more cost-effectively be obtained from a "hard discounter"[3], and some might better be obtained online. We end up with a shopping list structured as a **table** consisting of **rows** and of **columns**. Its current instantiation is as a table produced in Microsoft Word, although it could equally have been built using a spreadsheet package or as a table in a relational database – or as a list written on the back of an envelope!

Shopping item	Supplier	Quantity
bread	hard discount	2 loaves
pasta	hard discount	1 kg
basic veg	hard discount	enough for 3 days
exotic veg	supermarket	enough for one meal
chicken	farm shop	2.5 kg
Harry Potter DVD	online	2

Figure 7 An example of personal data: a shopping list

We should challenge the apparent simplicity of this table. *A personal information management system* is constituted when someone uses information and communications technology ICT – here a spreadsheet – to store data which is subsequently used to inform decisions or action. The *"systemic"* element – the knowledge-wielding, learning element of the system – is the person who maintains and uses the information. The information is filtered data associated with meaning, here represented linguistically by "simple" column headings. But in fact there is nothing simple about this process of attributing meaning. *How "meaningful" would this data be if the content and headings were in a human language you didn't understand?* By giving structure to the list, by the introduction of columns each with their separate column headings, I have given semantic structure which embodies meaning.[4]

[3] In contemporary French, a "pile-em-high-and-sell-em-cheap" retailer is called *"un hard discount"*.

[4] Formally, I have here created a set of N-tuples in the sense originally identified by Charles Sanders Peirce in a paper published in 1885 and taken up by Edgar Codd when he identified the highly influential relational model of data bases (Codd 1970).We shall find in fact that Charles Sanders Peirce, who died a century ago, makes no fewer than five major intellectual contributions upon which aspects of this present work are deeply dependent. These are (i) the identification of first order logic, which underlies relational databases and also provides the potential for automatic inferencing from

Now consider the life cycle of the list as it is used. Many items recur over time, each with a particular frequency. In effect we can recycle or reuse a list, with the date that an item becomes necessary depending upon when it was last purchased and the replenishment period. Thus, there can be value in storing the list as – say – a spreadsheet table, and then associating the spreadsheet with a calendar app (application program) on the computer or smartphone on which the spreadsheet and calendar reside. If we store the data appropriately, we can see what we need to buy where and present that information when it is needed: "what must I buy where today?" This refined, targeted data informs our repeated action, which is to go to the right shops on the right day and to buy what we need; and then subsequently to revise our shopping list.

Thus, I introduce by way of illustration a phenomenon which is called *personal information management* or *PIM*. An interdisciplinary group of academic researchers and practitioners federated by a website called "Tales of PIM" (Tales of PIM 2016) have collaborated to introduce personal information management in two books, one intended for a more popular audience (W. P. Jones 2007b) and one which consists of a collection of academic papers (W. P. Jones and Teevan 2007b).What is Personal Information Management (PIM)?

(W. P. Jones and Teevan 2007b) state: "**Personal information management** (**PIM**) refers to both the practice and the study of the activities people perform in order to acquire, organize, maintain, retrieve and use information items such as documents (paper-based and digital), web pages and email messages for everyday use to complete tasks (work-related or not) and fulfil a person's various roles (as parent, employee, friend, member of community, etc.)."

PIM is not inherently computer-based. However, computers and computer-like devices such as smartphones are frequently used to assist in more effective personal information management.

There are two key activities[5] which depend upon personal information management. These are:

- ♦ Getting Things Done (GTD)

  - ∗ See for example (D. Allen 2003). The essential: deciding what to do, and when: clearing the decks for action now on tasks deferred earlier and which now properly have priority.

- ♦ Keeping Found Things Found

databases; (ii) what he terms existential graphs, and we shall call conceptual maps, a knowledge representation format; (iii) the philosophy known as pragmatism which I will identify as a foundational aspect of the epistemological stance of this work; (iv) the study of semiotics and semiotic systems; (v) abduction – Peirce sometimes referred to it as retroduction – as a method of reasoning. The University of Helsinki is one of a number of universities to have a research centre focused on Peirce: http://www.helsinki.fi/peirce/ accessed 30

[5] This is a conjecture based on a broad understanding of the practice of PIM. I offer no proof at this stage.

* See for example (W. P. Jones 2007b). The essential here is to store personal information as it arises in a way which permits its easy retrieval and manipulation; which implies searchable and organised or classified

When was PIM invented?

The small existing PIM research community usually identifies Vannevar Bush (Bush 1945) as the first proponent of a device-based approach to personal information management. Bush proposed that science be put to use in organizing the vast record of human knowledge. (Caspi, Shankar, and Wang 2004) summarise Bush's life and work. They introduce his most famous idea thus:

> "Inspired by his previous work in microfilm mass storage, Bush envisioned an information workstation—the memex—capable of storing, navigating, and annotating an entire library's worth of information. His idea of push-button linking between documents is commonly held to be the forefather of modern hypertext."

Who is involved in PIM?

♦ Answer (1): All knowledge workers, since we have all to manage personal information.[6]

♦ Answer (2): A relatively small group of researchers, perhaps 30 or 40 in total, write papers in which the keywords include PIM.

♦ Answer (3): I have been able to identify over 150 PIM tools, that is, software programs whose main or significant emphasis is on personal information management and which are still under active development (Gregory and Norbis 2009b). To that there could be added perhaps a similar number of programs which are now defunct. The earliest such programs appeared nearly 30 years ago. Some programs have developed an active following evidenced in the form of very active forums.

0.6 Is personal information management PIM important?

In terms purely of academic research: there are perhaps 30 or 40 researchers in the world active in this area of 138 on a Yahoo! List (Feb 2016) (Tales of PIM 2016) – *slight significance.* They are largely drawn from cognitive science and human computer interface backgrounds; almost no researchers identify clearly with the Information Systems community with which I most clearly identify.

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[6] Or perhaps more generally everyone everywhere who has ever maintained an agenda and a shopping list!

However, in terms of significance as a business and to businesses and to consumers: the management of personal information is of ***huge significance.*** Thus, one can argue that the businesses of Google, of Microsoft and of Apple are greatly dependent on the use made by consumers of devices and services by means of which they ***store***, ***manipulate*** and ***share*** their personal data.

The phenomenon I am investigating is the personal knowledge management (K. Wright 2005, 2007) ; (Świgoń 2013) of individual knowledge workers as they carry out their data-informed work. I would argue that the emphasis here is on "small data" and personal knowledge management as one pole in a dynamic systemic duality – ***making knowledge work for the individual agent or actor;*** the second pole being the environment within which the agent or actor functions, that of ***business and society.*** Following (Baskerville 2011b), I suggest that there exists a ***personal work system*** in which the primary ***systemic*** element is the knowledge worker, who ***works*** – that is, she ***acts knowledgeably.*** Inter alia, she interacts with her personal data as it is stored on and made available by means of information and communications technology: cf. (Paul 2010)'s definition of an information system as ***"IT in use".***

(Baskerville 2011b) calls the computer-oriented element of the personal work system an ***individual information system.*** I had previously identified this as a ***personal information management system PIMS*** (Gregory and Descubes, 2011b). (Baskerville 2011b) also suggests that such an individual information system interfaces both with the employer work system but also the personal work system of the individual. The concept of the work system was initially introduced by (Alter 1999, 2010).

Is PIM a 'problem'?

(W. P. Jones and Teevan 2007b) quote Benjamin Franklin's autobiography, in which he outlines 13 virtues. The third, order, was the one that gave him the most trouble:

> "Order... with regard to place for things, papers etc., I found extreamly (sic) difficult to acquire".

Blue-collar automation has made enormous strides over the most recent decades. By contrast, there is evidence that white-collar productivity has not increased at anything like the same pace, despite the huge investment in information and communications technology made across the world. Furthermore, the efficiency of individual enterprises and of whole countries in benefiting from these investments is extremely variable. See (Strassmann 1997); (Strassmann 1999).

Market research companies like the Gartner Group suggest that the average investment in information and indications technology (ICT) for a corporate knowledge worker is of the order of US$10,000 per annum[7]. I have found no definitive source which indicates consistent benefits of a similar order. Instead, much ICT investment is of the "me-too" variety, justified in order to

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[7] Gartner Worldwide IT Spending Forecast, http://www.gartner.com/technology/research/it-spending-forecast/, accessed 20/12/2016. Worldwide IT spend is around $3.4 trillion in 2016 and the figure for 2017 will be the same or a little lower.

retain a competitive comparability and to avoid competitive disadvantage. The same market researchers are now reporting that consumer expenditure on ICT-related products and services (including computers and telecommunications) exceeds that made by businesses.

PIM in work and business

Individuals, teams and organisations need to carry out business & personal processes; they have to act, to Get Things Done: GTD, as identified by popular authors such as (D. Allen 2003).

To do this, they need to Keep Found Things Found: KFTF. KFTF, as defined by (W. P. Jones 2007b), means that they must store data, manage information, and act to enhance their knowledge.

They must also share their information with the people with whom they work and play.

We agree with Baskerville's suggested terminology, that of personal work systems. While approving of Alter's very helpful notion of work systems, we suggest a slight revision of his definition. (Alter 2002b) defines a Work System as "a system in which people and/or machines perform a business process using resources (e.g., information, technology, raw materials) to create products/services for internal or external customers".

What is the business significance of effective personal information and knowledge management? The brief answer is that we cannot know until we are clearer concerning what the phenomena are and where they occur. Nevertheless authors such as (Strassmann 1997, 1999) have identified substantial issues concerning the value-for-money of much ICT investment by companies. There may well be an equivalent productivity paradox concerned with investment in individual systems. One of the few discussions of the economics of PKM (and of PIM – the article is much wider in its scope than the title, "Cost-Benefit Analysis for the Design of Personal Knowledge Management Systems", suggests) is provided by (Völkel and Abecker 2008). They provide a cost-benefit analysis (CBA) model, but they have yet to apply it widely.

0.7 Why and how are PIM systems an appropriate focus for doctoral research?

Initial motivation: a focus on tools

Knowledge and information workers work as individuals within virtual team structures. As individuals and as team members, they acquire information, which they store in several complex ways: some paper-based, but increasingly computer-based. There are a number of computer-based tools, sometimes referred to as Personal Information Managers or PIMs (D. Kelly 2006); (Teevan, Jones, and Capra 2008) which can assist in the storage and management of such information. However, it remains the case that little is understood about how people use these tools, how they learn new ones, the ways in which the tools constrain how people work and think, and how best to educate people to make the right choice of the right tools. The original underlying themes of my research work were that

- ♦ Individuals - working alone or in groups - should be encouraged and educated to make better use of the available tools;

- ♦ And that the tools themselves should evolve into better ways of representing information and knowledge.

Is research into personal or individual information systems justified? The story of Jane Doe

"Individual IS may well *be an extremely large, undiscovered, arena for future IS research."* (Baskerville 2011b)

In the March 2011 edition of the European Journal of Information Systems, the editor in chief Richard Baskerville identifies the phenomenon that he calls individual information systems (Baskerville 2011b). He uses a pseudonymous case, that of Jane Doe, whose information system architecture he illustrates thus:
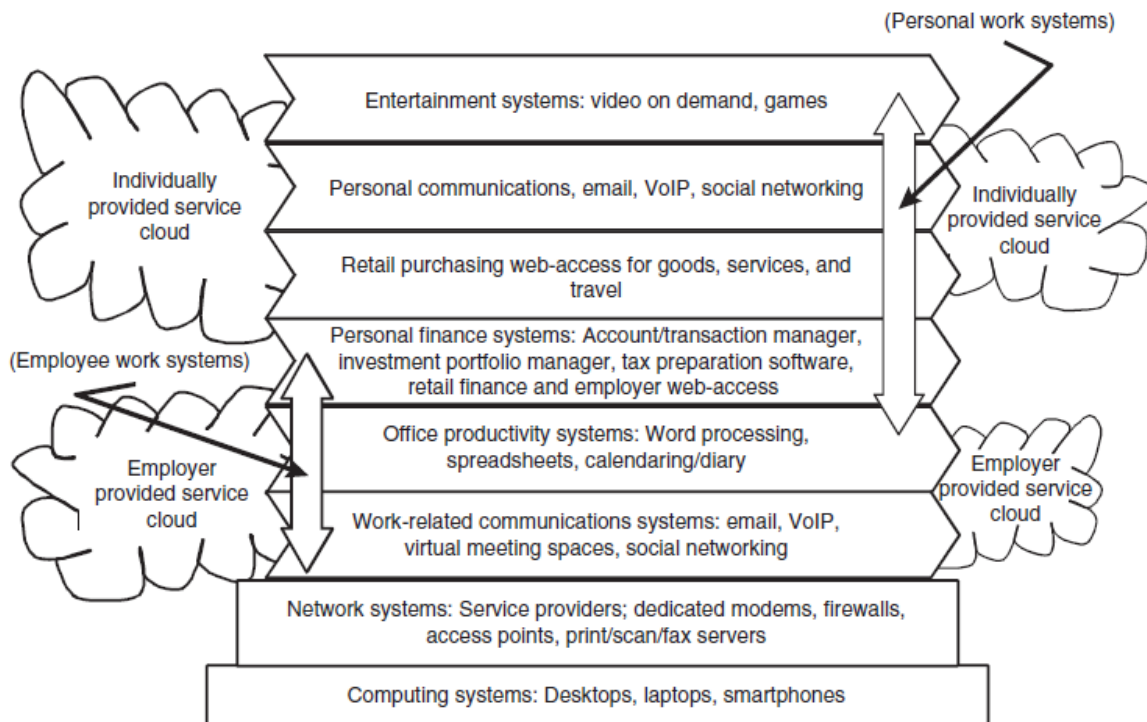
Figure 8 Jane Doe's individual information system architecture

I quote Baskerville at length, because he introduces very well the phenomenon of what he calls individual information systems (and I call personal information management systems). The **emphases** in this extended quote are mine:

"

> Figure 8 delineates the information system architecture of Jane Doe. Such individual IS architectures are unique at this time; many other examples would be more complex, and others simpler. This is a single example. There are two

elements in the architecture that might require slight elaboration. We note with vertical arrow[s] two *'work systems'* within this IS architecture. One is Doe's 'profession[al]' work system as an employee. The other is the work system that serves Doe as a person. While Doe and her family might not regard their involvement with entertainment and personal communications systems as work, it is nevertheless work for the information system that Doe is operating. The other element is the representation of information services consumed and produced as arising from, and sinking into, clouds. The term cloud is used here in its loose, IS perspective because the 'network' is evolving to the 'cloud'. This evolution is because of the increasing availability of not just low-level data services, but ***cloud-based business processes*** (Fingar 2009).

" (Baskerville 2011b, 252–53)

Baskerville reminds us that the field of information systems is about much more than just technologies, information and human factors. He calls in evidence that information systems have been regarded as ***social-technical phenomena*** from the earliest years (Bostrom and Heinen 1977); (Mumford and Weir 1979). But our understanding of the systems has grown. Baskerville recalls that (Alter 2008) details more than 20 different authoritative definitions of IS before himself suggesting that we should '***define [information system] IS as a type of 'work system', 'in which human participants and/or machines perform work (processes and activities) using information, technology, and other resources to produce informational products and/or services for internal or external customers'*** (p.451). But even Alter's definition implies the exclusion of individuals with its reference to internal and external 'customers': information systems is often seen as a sub-discipline of business and management. Baskerville instead suggests that we should study the essential human progress enabled by the ICT now available to individuals. ***A business-centric point of view overlooks the way in which individual IS have evolved into rather a complete and legitimate form of IS.*** Therefore, IS researchers should concern themselves with individual information systems:

"

> As technological evolution has enabled more-and-more complex individual IS, it seems that ***these could easily become the most prevalent of all kinds of such systems.*** Ignoring individual IS within our discipline is an evolutionary oversight that may simply reflect our own assumptions that personal, individual IS are uninteresting: simple; or mostly recreational systems used 'after hours' or outside of real organizational IS (Crowston et al. 2010).
>
> Why should IS researchers have any concern for individual IS? Perhaps we might begin with the recognition that we are fairly benighted about the phenomena. We might also recognize that these systems represent the most recent frontier for the design of computer based IS. These are complicated and unique systems that cross the boundaries between work and home. As such, individual systems still engage social aspects and organizational aspects. Certainly, ***these systems are socially constructed.*** It is not sufficient to regard

individual IS as merely retail consumers of information, entertainment, and technologies. Very few individual systems are purely information sinks. *People* are not merely customers and game-players, but *are actively collecting data and processing it into information for their various purposes, and feeding it outward.*

Thus far, we have yet to seriously introduce our knowledge about complex IS into these individual versions. How has Doe designed her system above? Why has she made the choices, initiatives, and investments apparent in her individual information system? How does she plan and control this complicated architecture? How can our extant body of knowledge improve Doe's individual information system? What are the important relationships between Doe's system and other IS (e.g., individual or otherwise)?

" (Baskerville 2011b, 252–53)

There is, as we shall see, a personal information management PIM literature, and a (smaller) personal knowledge management PKM literature. The PIM literature is mainly influenced by cognitive science and human computer interface considerations. There are no contributions from recognised IS researchers in either the PIM or PKM literatures. Thus, there is almost no discussion of PIM *systems* in the PIM literature, and as Baskerville suggests, IS research has been almost entirely blind to the phenomenon of what he calls individual information systems.

Personal knowledge management

(Apshvalka and Wendorff 2005) draw together definitions of knowledge from the organisational knowledge management literature, notably from (Davenport and Prusak 1998) and (T. D. Wilson 2002); thus knowledge is at least "a combination of facts, experiences and perceptions that are being used to make a decision or to select an action by which a situation is changed into a more valuable situation…. knowledge … is in the mind and only in the mind". They agree with Wilson that it is everybody's personal decision, will and responsibility to manage his/her knowledge.

So, as (Drucker 1994) states:

"In the knowledge society… individuals are central. Knowledge is not impersonal…. does not reside in a book, a databank, a software program; they contain only information. Knowledge is always embodied in a person; carried by a person; created, augmented, or improved by a person; applied by a person; taught and passed on by a person; used or misused by a person. *The shift to the knowledge society… puts the person in the centre.*"

Obtaining a PhD: an illustration of personal knowledge management

Arguably, obtaining a PhD is an exercise in *personal knowledge management PKM* as identified by (Frand and Hixon 1999; Apshvalka and Wendorff 2005), but one which involves much data collection and information management.

A distinctive research approach: using PIMS to study PIMS

Taking up the challenge made by (Baskerville 2011, p.253): ***"Individual IS may well be an extremely large, undiscovered, arena for future IS research"***, we have established the need for an ***information systems perspective*** on personal information management in the papers (Gregory and Descubes 2011b) and (Gregory, Kehal, and Descubes 2012b). This perspective is based critically on necessarily unusual lenses and research approaches because we are here exploring a new area of academic research: therefore, I have chosen to ***use*** individual IS to ***study*** individual IS.

0.8 What has my recent research been demonstrating?

We have previously presented a model of a Personal Working Model (Gregory and Macgilchrist 2014). Initially in that paper, and now in this thesis I show why such a working model perforce exists. I discuss ways in which to identify and to begin to model the Working Model and its components.

My most recent work has consisted in continuing to improve the ways in which to model a working model in Conceprocity. I have also built a proof of concept personal information management system which I have used in the final months of my research and specifically in the planning of this thesis and in the maintenance of the information necessary to its completion.

It would be a mistake to regard these two prototypes as merely garlands, as pretty interpretations. They reify two warrantable principles:

1. Knowledge work requires the construction of representational knowledge models. These might often only be mental models. But there is benefit to be had in making them explicit as knowledge maps (a semiotic representation) and as a knowledge dictionary (a semantic representation).

2. Personal data needs frequently to be made explicit, given semantic structure and tabulated as part of a PIMS.

The Ph.D. research has been largely exploratory in character. However, the research to be described forms part of what I hope will be an ongoing programme which I expect to occupy me for a significant part of the remainder of my career. Thus, subsequent to the PhD, I will undertake more exploration and continue and deepen the explanatory research which I have of necessity only started during the PhD itself.

0.9 My specific perspectives and how they differ from earlier work on personal information management PIM

(Wood and Wood-Harper 1993) distinguish between hard and soft systems viewpoints. I add a design science viewpoint (fairly "hard") to the study of PIMS and a learning or enquiring systems point of view (fairly "soft") to the study of PWS. The thesis will explain and exemplify the language used in this paragraph.

I follow (Conant and Ashby 1970) as I insist on **modelling** in order to **understand** and in order to **regulate**. To support my insistence on modelling to understand, I have also introduced a somewhat novel conceptual modelling approach which I call Conceprocity. This is one of the contributions made by this research.

I have also sought to establish a sound philosophical basis for my work on PIMS and for the new conceptual modelling approach. This philosophical basis draws on critical realism (Bhaskar 1975, 1978, 1989; Collier 1994) and on systemic thought (Herrscher 2006).

The Ph.D. research has largely been exploratory in nature. However, one of the claims made by and for critical realism is that the identification of what it calls generative mechanisms can have explanatory power. It is in the nature of design science research that some at least of these generative mechanisms are explicit and reasonably straightforward to characterise and therefore to apply in an explanatory way.

0.10 Conventions followed in this document

I consider it to be wholly appropriate in a thesis concerning personal work that I should use the personal pronoun much more frequently than is conventional in scientific writing. I hope that you will agree on its utility.

I have included almost no autoethnographic data in the thesis itself. If you wish to examine the contents of my PhD research journal, you will find all entries that I have not tagged as personal via the URL http://markrogergregory.net/2016/03/31/thesis-resources/.

Chapter 1 AREA OF CONCERN

The area of concern is the means by which an individual knowledge worker regulates her life. The terms working model, personal work system and personal information management system are introduced. The role of information is stressed.

1.1 Engaged scholarship

In this chapter, I set out to identify the area of concern. Russell Ackoff suggests that the only way in which we learn is by failure (Ackoff 1999). The causes of failure are usually multiple and compound. As a consequence, and also by deep conviction, the research reported is an example of what Andrew van der Ven calls **engaged scholarship** (Van de Ven 2007). For the starting point for this research was a dissatisfaction with the results which I was achieving by means of the application of PIM tools, hardware and software aids to the management of personal information.

My early career was as a computer programmer and technical support consultant and my later career has been as a teacher of information systems. My university-level education – the French very usefully use the word *formation* – consisted of a systems approach to the social sciences in my first degree in the early 70s and a master's degree in information systems design in the early 80s. Therefore the lenses which I expected to apply to doctoral research included PIM tools or applications, a systems approach to enquiry (Churchman 1971) and designerly conduct (B. Archer 1979).

At the beginning of the 1990s I moved from industry into academia and started to teach at what quickly became the University of Huddersfield. I was employed because of my extensive practical knowledge of databases, database design and conceptual modelling gained in industry. I worked very hard to serve my students. I emphasised practical over theoretical knowledge because that was where my expertise lay. I developed my teaching in the areas of conceptual modelling of information systems, business process modelling and systems integration.

Shortly into the new millennium, I accepted the challenge of moving to France to teach in a business school. Here, I continued to try to teach business students the importance of modelling and of a systems approach. Teaching business students threw up the additional challenge of confronting students - who were often averse to conceptual thinking and unconvinced of the value of theory - with material which they sometimes found frankly difficult and of whose value they needed to be convinced.

I was thus too busy (or too afraid) to take on the challenge of really confronting theory for myself. It was only in 2007 that I agreed to take on the challenge of doctoral research. I registered for this current PhD in the summer of 2008.

(Klein and Rowe 2008) discuss the challenges and the opportunities presented by what they call professionally qualified doctoral students: later-life PhD students who bring applicative knowledge into both research and boundary-spanning engagement with practice. One of the significant ways in which I have remained engaged in practice has been to make very considerable use of information and communications technology in the way that I work – building small information systems to support my own work and in particular to permit effective formative assessment of students working both as individuals and in groups by teachers teaching in teams. Thus, I have had a considerable interest in personal information management and in the development of what are sometimes called situational applications. This chapter introduces the area of concern which I wished to address in my doctoral studies.

1.2 Work systems and information systems

(Alter 1999, 8) holds that a **work system** is 'a system in which human participants and/or machines perform a business process using information, technology, and other resources to produce products and/or services for internal or external customers. Organizations typically contain multiple work systems and operate through them.'

Example work systems include building aircraft and co-authoring textbooks.

(Alter 2008, p.451) defines an **information system** IS as a type of 'work system', 'in which human participants and/or machines perform work (processes and activities) using information, technology, and other resources to produce informational products and/or services for internal or external customers'.

Example information systems include the enterprise resource planning system which often forms a dominant part of the applications portfolio of medium and large enterprises. Whether as part of an enterprise resource planning system or as a stand-alone element, every business possesses some form of accounting information system.

(Alter 2008) summarises and discusses 20 overlapping but distinct definitions of the phrase 'information system'. Amongst which, (Checkland and Holwell 1998b, 451) posit: ''Any and every information system can always be thought of as entailing a pair of systems, one a system which is served (the people taking the action), the other a system that does the serving [i.e., the processing of selected data (capta) relevant to people undertaking purposeful action].''

Elsewhere, Checkland calls these a human activity system and an information system.

We prefer the language of Steven Alter and therefore refer to **work system** and **information system** in this thesis. There are many ways in which an information system and a work system can overlap; see Figure 9.
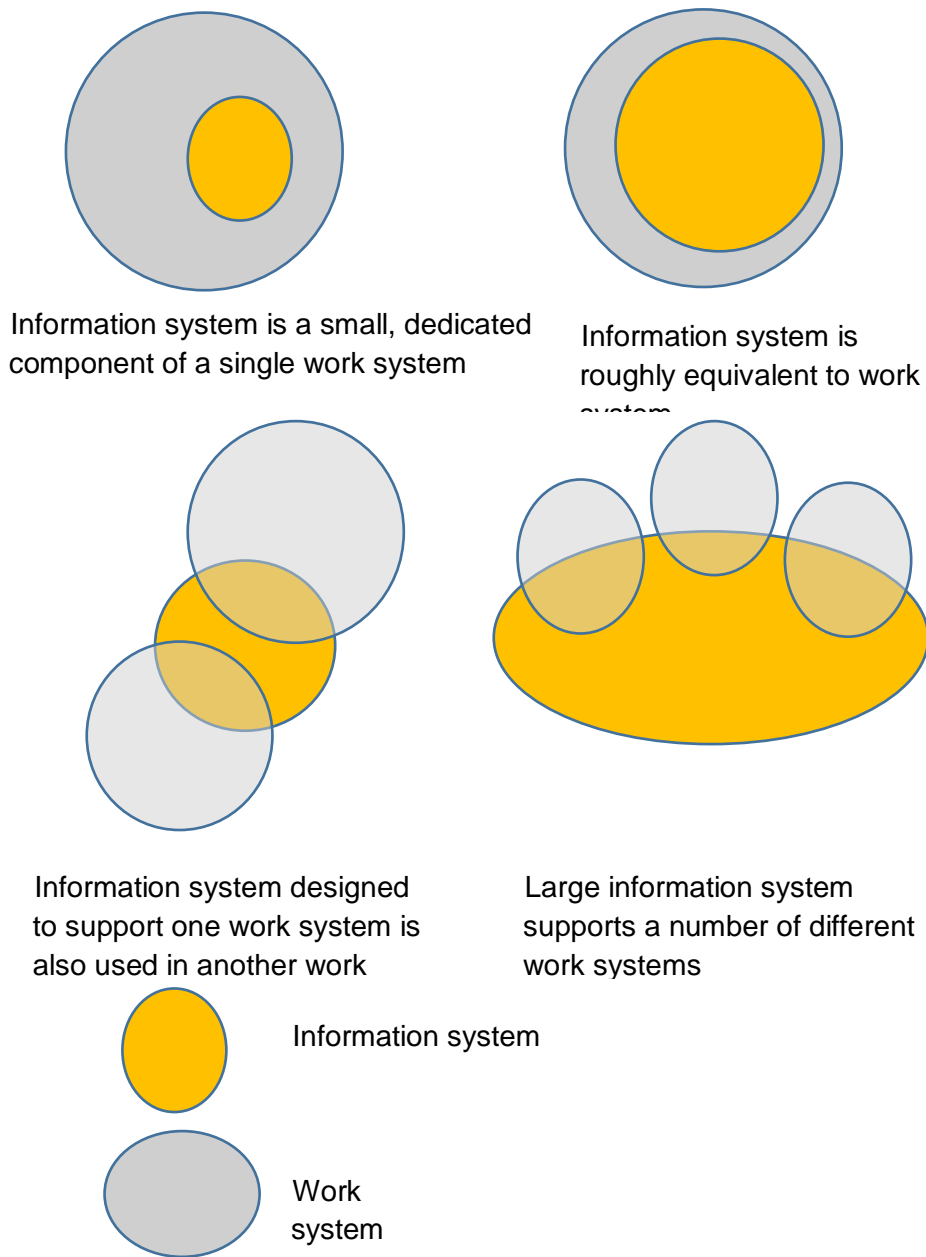
Figure 9 Work systems and information systems. Source: (Alter 2002a)

1.3 Personal work systems and personal information management systems

(Baskerville 2011b) suggests that what he identifies as the individual information system – we had previously called this a personal information management system PIMS (Gregory and Descubes 2011b) – has an interface with both the personal work system of an individual and one or more work systems corresponding to her employer. He attributes to an everywoman knowledge worker that he names Jane Doe an individual information system whose architecture and principal interfaces are shown in Figure 8. Baskerville's posited IIS

architecture incorporates two kinds of system. One is the individual information system itself, largely an artefact made up of computer-based services. Second is two 'work systems' denoted by arrows within this IS architecture diagram. One is Doe's 'profession[al]' work system as an employee. The other is the work system that serves Doe as a person. We note also the representation of information services consumed and produced as arising from, and sinking into, clouds. The term cloud is used here in its loose, IS perspective because the 'network' is evolving to the 'cloud'.

Baskerville reminds us that:

> "IS have been understood as ***social-technical phenomena*** from the earliest years (Bostrom and Heinen 1977); (Mumford and Weir 1979). Steven Alter (Alter 2008) ***defines IS as a type of 'work system', 'in which human participants and/or machines perform work (processes and activities) using information, technology, and other resources to produce informational products and/or services for internal or external customers'"*** (p 451).

Alter's definition can be read as excluding individual work systems with its reference to internal and external 'customers'. Baskerville notes by contrast that individual information systems are evolving into a legitimate and sometimes complicated form of information system supporting the personal work system. Just as expenditure on information and communication technology by individuals has become more quantitatively significant than that by businesses, so the individual information systems which arise when individuals use ICT to collect data, to process it and then feed it outwards to inform others are perhaps beginning to rival in their significance the corporate information systems which until now have been the focus of IS teaching and research.

Creating the personal work system may at least in part be an act of creative design (Cross 2007). Schön in (Schön 1987) points out the significance of design and of synthesis, going beyond analysis:

> "Designing in its broader sense involves complexity and synthesis. In contrast to analysts or critics, designers put things together and bring new things into being, dealing in the process with many variables and constraints, some initially known and some discovered through designing. Almost always, designers' moves have consequences other than those intended for them. Designers juggle variables, reconcile conflicting values, and manoeuvre around constraints – a process in which, although some design products may be superior to others, there are no unique right answers."

1.4 A personal working model and why it has got to exist

My conjecture is based generally upon abductive insight and well-established cybernetic theory and specifically upon the Good Regulator theorem t.he argument for this appears in section 0. I conjecture that the effectiveness of the individual knowledge worker depends to a significant degree upon at least these factors:

1. Each of us has a more or less explicit ***personal working model*** which encapsulates our understanding of how we should organise our personal work and life. Thus, each of us as we work participates in and constructs a personal working model which informs and regulates the personal work system which we as knowledge workers constitute as we work. In most cases, that model is inexplicit. We would expect the extent to which our personal working model is an effective regulator of our personal work system to be determined (inter alia) by the faithfulness, the degree of isomorphism, of that working model with the "reality" with which we have to deal. My ongoing research aims to make empirical evidence available concerning that conjecture. Among the risks are that the "inter alia" – unidentified – will interfere with and perhaps dominate the expected result; or indeed that evidence will contradict the theoretically-based prediction, putting the theory itself in question.

2. My further conjectures are that the effectiveness of personal work can be increased for and by individuals who more explicitly model – and thus understand – their personal work system before seeking to design improvements to aspects of that system (particularly the PIMS element); and that in many cases, individuals will benefit from mentoring as they audit, model and redesign their work system (Gregory, Kehal, and Descubes 2012a).

3. Since a model is an abstraction and simplification, no one model can fully or adequately represent the situation modelled. In this paper, I present and in part justify a modelling (semi-)formalism based on typed concept mapping which I call Conceprocity. Conceprocity has as a characteristic that it supports, enables and encourages multiple models of different kinds of a situation. The different models and kinds of model may together permit richer understanding, all within a reasonably unified representational framework.

Conant and Ashby (1970), in an article which they entitled ***"Every good regulator of a system must be a model of that system"***, showed that:

> "Restated somewhat less rigorously, the theorem says that the best regulator of a system is one which is a model of that system in the sense that the regulator's actions are merely the system's actions as seen through a mapping ***h***. " (Conant and Ashby 1970, p.95).

The thesis seeks to tease out some of the multiple dimensions and necessarily active nature that such an isomorphic model must requisitely possess if it is to be capable of generating sufficient variety to overcome the variety that exists in its environment, as is required by the same Ross Ashby's earlier ***law of requisite variety*** (Ashby 1956). Thus, the model has to have both representational and active (actionable) characteristics if the desirable and essential-to-survival goal of effective regulation of the individual's life is to be achieved. To the extent that we all, for a time, do succeed in a degree of self-regulation and viability, the model must exist in

some form and the research goal has therefore been to discern and to characterise it initially, with the hope of improving it subsequently.

1.5 Regulation: an « age of steam » analogy

Both Figure 10 and Figure 11 are representations and therefore conceptual models of a controlled system. In such a control system, feedback is used to ensure that the output of the principal component – in this case a steam engine – is in accordance with the controller's intentions. The regulator or governor is used to generate a control signal which modifies the input (pressurised steam) to the system as a whole and in this case ensures that the engine will neither overspeed nor underspeed. This is an example of negative feedback. Thus, the principles of control engineering, a concrete instantiation of what later became known as cybernetics, were understood at least in part in earlier centuries.
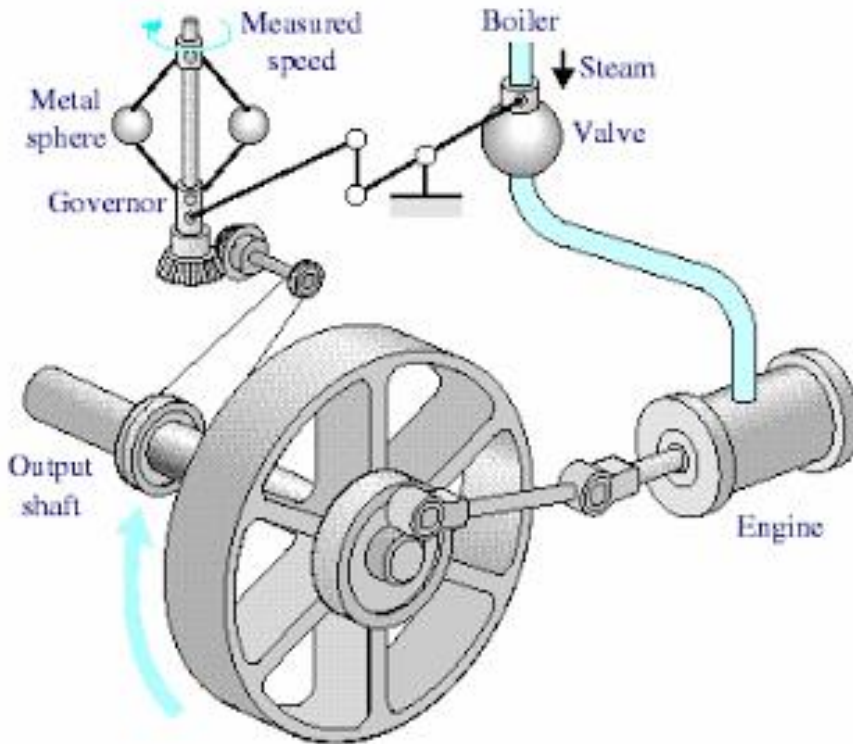
Figure 10 Regulatory active model: the governor Source: Course notes on Otomatik Kontrol Kavramı ve Örnek Devreler. Yrd. / Automatic Control Concept and Sample Circuits, Dr. Aytaç Gören, *http://docplayer.biz.tr/156411-H1-otomatik-kontrol-kavrami-ve-ornek-devreler-yrd-doc-dr-aytac-goren.html*

It is important to notice that we are dealing here with two models. The first, *iconic or conceptual*, model is the representation of the situation. This is what appears in this document. The second, *analogical*, model is in this case the governor. The governor,   part of the machine "in the world", is a *regulatory active model*.

Representation of a regulatory active model: the governor of a static steam engine

Figure 11 Watt's steam engine governor

1.6 Feedback control theory
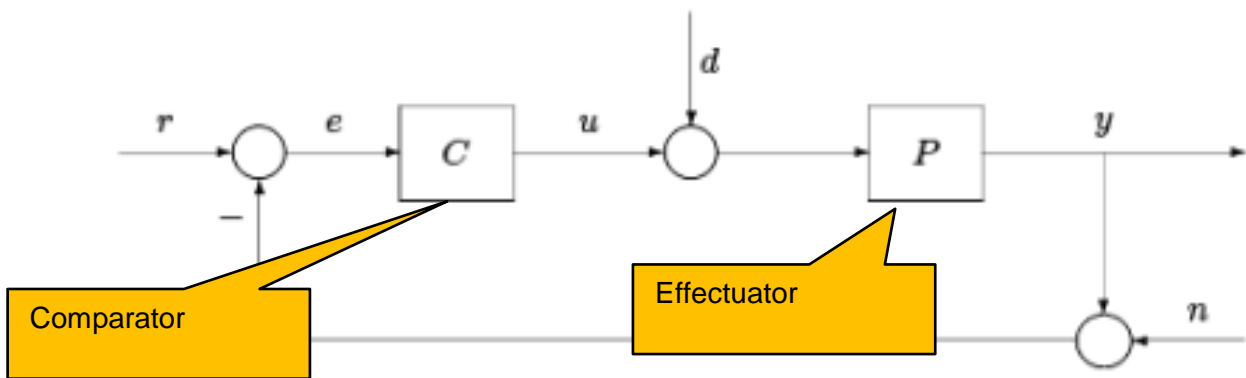
Figure 12 Single-loop feedback system. *Source - (Doyle, Francis and Tannenbaum, 1992, figure 1.3, p.8)*

Figure 12 is drawn from a standard text on control theory; it shows a single-loop feedback system. (Doyle, Francis, and Tannenbaum 1992)

The system under consideration is shown in their Figure 1.3, where P and C are the plant and controller transfer functions.

The signals are as follows:

47 / 343

r reference or command input

e tracking error

u control signal, controller output

d   plant disturbance

y plant output

n sensor noise

This is not a theory which is directly applicable to PIMS.

1.7 A general control system
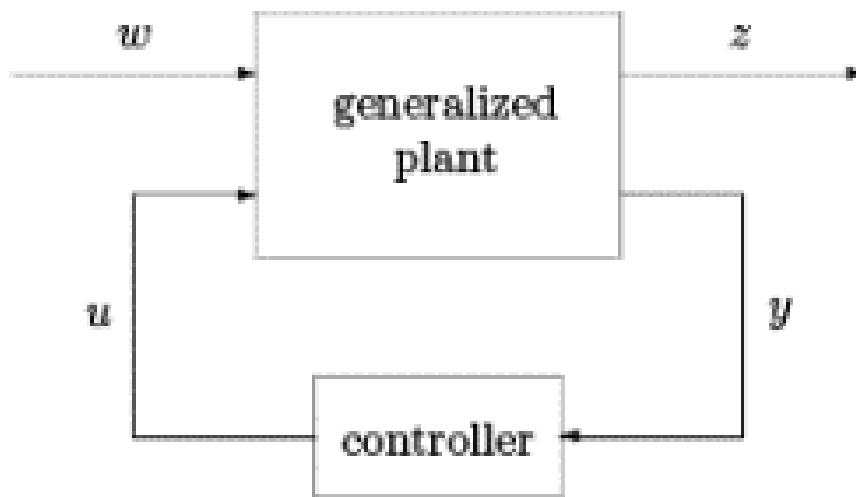
Figure 13 A general control system. *Source - (Doyle, Francis and Tannenbaum, 1992, p.6)*

Figure 13 which is drawn from the same text shows:

1. The "plant" (factory) is the set of production facilities, actuators that generate inputs, signal sensors, etc.
2. The controller must be designed so that the plant creates the desired outputs z from the input w.

This simplified control system is a better analogy for the way in which an individual controls her work.

1.8 Personal Information Management Systems PIMS and Personal Work Systems PWS

The author holds that a very significant component of each such personal work system is an individual and personal information management system (PIMS). That PIMS may from time to time be the consequence of an explicit design act on the part of the individual who constructs and uses it. Perhaps more often it will arise from a process of more-or-less serendipitous bricolage (Ciborra and Jelassi, 1994), (Verjans, 2005) – tinkering until by some happy chance we have a temporarily stable but useful personal information management approach. Thus, we suggest the emergence and (sometimes) design of a personal information management system PIMS, which is an information system specific and personal to an individual knowledge worker.

What a PIMS is

What is the nature of such a personal information management system? One difficulty to be overcome is choosing (and sticking to) the right definition of terms; in this connection see (Holwell 1997, pp. 191-196). According to Holwell, Checkland sees an information system as more-or-less equivalent to a human activity system; he separately identities a data manipulation system (which Checkland points out, as does his Lancaster colleague Brian Wilson (B. Wilson 1984), is only a component of an information system).

(Checkland and Holwell 2005) state that:

"The act of creating information is a human act, not one which a machine can accomplish. It is the human being who can attribute meaning to the selected data which have been highlighted for attention, this being done in a context which may well be shared by many people but may also be unique to an individual. Of course the designer of a system which processes focussed-on data (i.e. capta) into a more useful form will have the aim of making the processed capta correspond to some obvious categories of information which will be meaningful to many different people. But attributing meaning to the processed data is a human ability and a particular attribution may be unique to one individual. No designer can guarantee that his or her intended attributions of meaning will be universally accepted." (Checkland & Holwell 2005, p. 54).

The PIMS as part of a personal work system PWS

A personal information management system PIMS is posited as an information system in which an individual structures and stores data so as subsequently to yield information which she requires (inter alia) in order to be able to control her own activities. Her aim is to get work done more efficiently or effectively by more closely achieving desirable goals or outcomes. The achievement of this aim is embodied in a personal work system (where work is to be understood very generally so as to embrace play rather than to contrast with it). Thus:

- ❑ An engineer designs and constructs a "better future", that is she looks at an existing messy situation and identifies problems and problem owners - the latter may be or become the clients for possible solutions – realisable improvements to the messy situation (Ackoff 1997). In such a way an engineer might construct improved personal information management tools.

- ❑ A do-it-yourselfer, what the French call *un bricoleur*, makes something that is useful but typically in a less systematic manner than the engineer.

- ❑ The motivations for *bricolage*, a French word meaning do-it-yourself or "muddling through" (Lévi-Strauss 1966), include inadequate access to expertise or cost saving. As (DesAutels 2011) suggests, individuals have frequently to mash together various components so as to address their personal information management needs by means of what he calls user generated information systems UGIS. When the scope of the required system extends beyond the individual to groups, we suggest that a UGIS becomes a situational application (Gregory and Norbis 2009b). Situational applications are used primarily by groups and as such fall outside the immediate scope of this present paper.

- ❑ A worker progressively assembles together, more or less consciously, a "mashup" of components – often in the form of apps and/or office software – which are together useful as her personal information management system. Knowledge workers work within (a) work system(s) (Alter 2008, 2002b, 2006).

- ❑ A player is similar to a worker, since we here treat play as work much as some people treat work as play. For both worker and player the emphasis is on creatively finding a solution to an immediate problem while always seeking to learn how to solve that problem or others like it better next time.

What do the engineer, the bricoleur and the knowledge worker / player have in common?

- ❑ They are all involved in everyday task identification and management, and in problem-solving.

- ❑ They are all part of a work system and have some limited or constrained ability to improve the system of which they are a part.

- ❑ They all understand something of the systemic nature of the situation, which is that any improvement will change the problem situation but will rarely completely "solve" it, since unanticipated systemic effects – sometimes positive, often negative – will emerge and then in their turn need to be addressed.

- ❑ They work best, that is, they get more done more quickly, if they have:

  - o a good problem-solving framework

  - o competences, perhaps including modelling and design skills

- they learn by doing and from doing (the latter being the fruit of reflection).

❑ They sometimes see the need for, and either acquire or make, a new tool in order to amplify their competences.

What the PIMS consists of

Information systems researchers have not as yet contributed much to the study and practice of personal information management. Thus, Baskerville (Baskerville 2011b) as editor of a leading information systems journal has recently identified what he calls "individual information systems IIS" as a new subject of enquiry. PIM is not a new field of enquiry. Studying PIM systems or individual information systems as information systems is arguably novel.

What are the essential characteristics of the PIMS that supports the PWM? Here are just sketches of an answer:

1. Conceptual data structures which are adapted to the data to be stored and the information to be derived. These structure the specks and nuggets which are the data. Nuggets will take concrete form as for example data tables, data views and multimedia documents; specks are either specific items (e.g. rows) in tables, or standalone information items such as contact details or bibliographic references. It is convenient to distinguish between so-called structured and unstructured data, although these may not be as distinct as some seem to think. In any given PIMS, multiple conceptual data structures will almost invariably be required. In many cases, multiple software packages will be needed to manage those structures.

2. Some individuals will wish to go right back to the philosophical roots of personal knowledge as they seek to understand their work. We cite here (Polanyi 1958) and (Polanyi 1962), but also (Popper 1972). Thus, ontological issues may also need to be addressed. We suggest that it is necessary to support a personal ontology (Katifori et al. 2008) -- specific, that is, to each personal information management system. This may sound very grand; in practice, it might take the form of a hierarchical classification scheme – a taxonomy – and a parallel categorisation or tagging scheme. The difference between categorisation and classification is made by (Jacob 2004) and further discussed by (J. Sinclair 2008; J. R. Sinclair 2007). They see categorisation as "the process of dividing the world into groups of entities whose members are in some way similar to each other". Classification, by contrast, is the process of dividing a set of entities into mutually exclusive classes related according to formally defined rules. "A classification scheme is a set of mutually exclusive and non-overlapping classes arranged within a hierarchical structure and reflecting a predetermined ordering of reality." (Jacob 2004)

3. In so far as the Working Model is a model of a way of working, it is as much a set of activities, sometimes repeated in accordance with a template and thus

distinguishable as processes; as it is a set of concepts, data tables and data views. However, those processes are likely to be extremely specific to the individual and very difficult to discern, let alone to model. Probably the best that can be hoped for is to explicate certain of the lower-level data-oriented processes surrounding the use of a PIMS while at the same time recognising the necessity for higher-level "processes" such as planning and delivering a new course, writing a paper or book.

4. It then becomes desirable or necessary to model a PIMS. We have devised Conceprocity for this purpose and for others. Conceprocity permits the construction of visual concept-process knowledge models – the significance of the visual component being that it resonates with a large part of the brain's variety-absorbing and learning capacity.

5. We suggest the use of a dictionary / lexicon to store the metadata / semantics associated with named things; that dictionary should be an active component (Zahran 1981) which can also support the taxonomic classification and / or tagging of target information items in an integrated lexicon.

6. An implication is that the model of a personal information management system, the meta information about that system, may itself be a part of the personal information management system. Here we can draw a parallel to those data management systems which incorporate a data dictionary as an active component of the database management system itself. Just as an active data dictionary is a vital component of a really effective data management system (Zahran 1981), so an active working model dictionary is a vital component of a well-defined personal information management system. By active, we mean that the model not only describes the system but is a vital (living and growing) component of the system.

1.9 An initial model of how a knowledge worker uses information to regulate her work

Figure 14 is a Conceprocity model of a conjectured use by a knowledge worker of information which she stores in some personal information management system PIMS. It is also intended for use by the reader as a Conceprocity tutorial example.
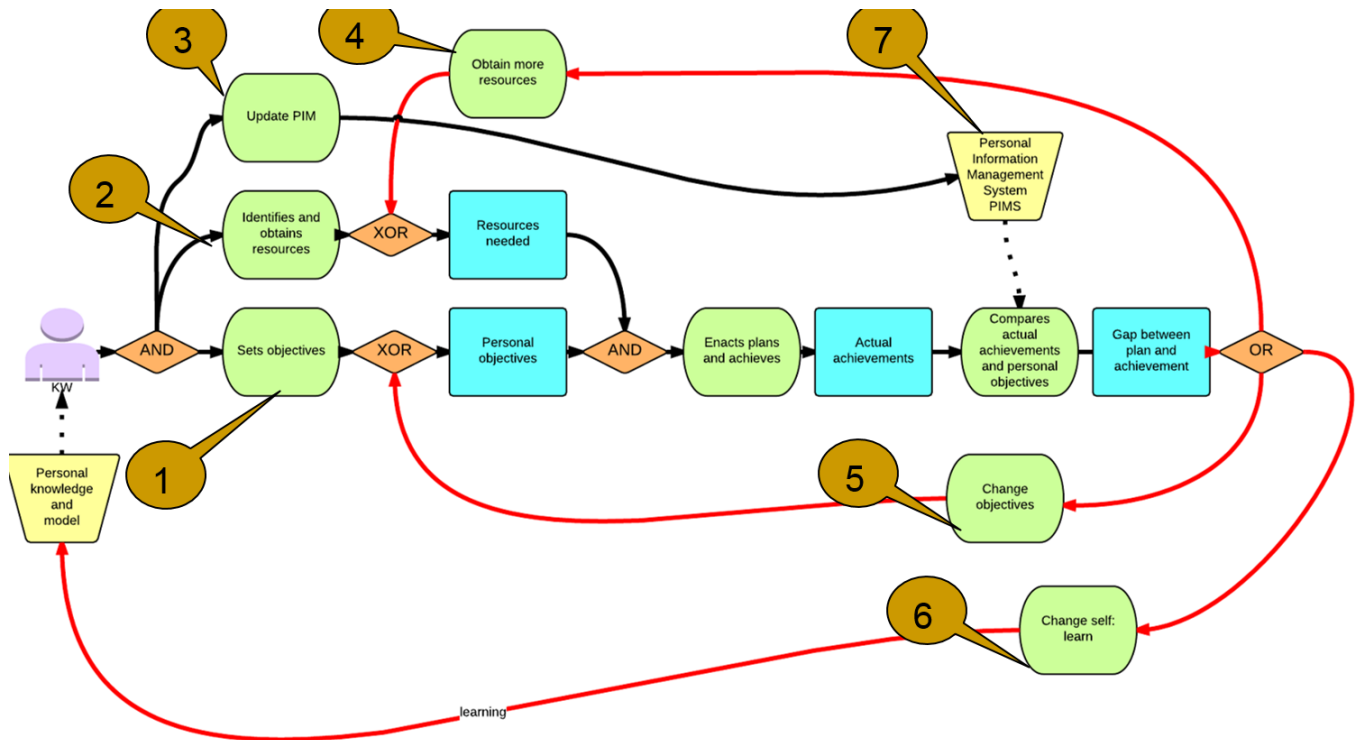
Figure 14 How a knowledge worker uses information to regulate her work

In Conceprocity, **concepts** are normally represented as light blue rectangles and **procedures** – actions, repeated activities or formalised processes – as light green rounded rectangles. **Principles** are shown as light yellow trapezoids and logical decisions or **logical connectors** are represented by light orange trapezoids. **Actors** are represented by a stylised person icon in mauve. Conceprocity users are recommended to follow certain grammar rules, only some of which are enforced by the software currently used to construct a Conceprocity diagram. Further information concerning Conceprocity is provided in chapter 3 and in appendices.

In Figure 14 the numbered callouts have the following significance:

- ♦ At 1, the knowledge worker sets objectives.

- ♦ At 2, she identifies and obtains necessary resources.

- ♦ At 3, she updates the information in her personal information management system. This information is then used at 7 to influence her actions.

- ♦ The black arrows indicate the forward path; the red arrows represent the feedback path. The AND connector between the knowledge worker and the first three procedures indicates that she does all the procedures in some indeterminate order. It has one arrow coming in and three coming out – it is a splitting connector; it *splits* a process into three parts carried out in parallel or at any rate in an indeterminate order.

- ♦ Once she has the necessary resources and has set her personal objectives, she goes on to enact her plans and achieves some part of them. Notice that the 2nd AND logical connector has two arrows going into it and one coming out – this connector *joins together* previous paths. The AND connector indicates that all previous paths must have terminated before the procedure which follows the connector can be enacted. She needs both resources and objectives before she can carry out meaningful action.

- ♦ She now has some actual achievements. A procedure (which she carries out) compares the actual achievements with the objectives which are assumed to be stored in the personal information management system labelled as 7. This comparison may indicate a gap between the plan and the actual achievement. It will therefore be necessary to carry out one or more corrective

actions, introduced by the inclusive OR at the right-hand end of the diagram.

♦ At 4, she obtains more resources.

♦ At 5, she changes her objectives.

♦ At 6, she changes herself – she learns. The output of this process is shown going into a principle, labelled personal knowledge and model, which is shown to regulate or influence the knowledge worker – whereas flows that prompt an action are shown as solid arrows, control or influence is shown as a dotted arrow.

Thus, the conjecture which is being modelled here is that in a way analogous to the way in which a controller or governor is used in a physical system such as a steam engine, so personal information is used by the knowledge worker in what we stress to be *an open, self-organising system demonstrating continuous evolution and learning. This premise is basic to the entire thesis.*

There are two senses here in which a model is an active regulator. The first is that data stored in the personal information management system may influence or even direct the actions of the knowledge worker. Thus, for example a diary entry might "make" a person take action – for example, to send a birthday card. This is because the data in the information system, perhaps stored in a relational table, models the real-world situation in which someone was born on a particular date, that that date was recorded in a birth certificate, reproduced in the personal information management system and presented by software in the personal information management system as an alert. The second way in which a model may be an active regulator is that a knowledgeable person may produce or have presented to her a conceptual model such as the one in Figure 14. Taking cognizance of the situation represented in the model, the knowledgeable person may decide to examine her existing personal information management system and find ways in which to improve it. The modelling process has enabled her to achieve improved understanding on the basis of which she changes her action. She has both learned and changed.

1.10 Summarising the area of concern

In this chapter, I have set out to illustrate the area of concern which is that of the regulation by the individual knowledge worker of her personal work. I have suggested, but not as yet justified, a conjecture which is that in some way she maintains a personal information management system in which, in this example, she holds details of her objectives.

Among the questions which therefore arise are these:

- o Do the conjectured mechanisms exist in reality?

- o What is the scope and nature of the "reality" to which we can apply this kind of modelling approach?

- o How should we best model or represent a situation into which we wish to enquire or which we seek to control?

It is hardly likely that I am the first person to ask questions of this nature. They have perhaps already been answered adequately in the past. In the next chapter, I review literature relevant to this area of concern.

Chapter 2 STUDYING PIM: LITERATURE & KNOWLEDGE GAPS

This chapter reviews the literature of PIM. Philosophical considerations are introduced. It discusses data, information, knowledge and the distinctions and co-dependencies between these concepts. Design science research is discussed. The chapter concludes with notes on the diverse evaluations required for the different approaches introduced.

(Boyne 2009) examines the PhD literature review and makes recommendations concerning how to produce a literature review which assists in the generation of original, and defensible, research questions which correspond to gaps in existing research. Literature review is both a process and a product. However, (Alvesson and Sandberg 2011) object that such "research gap spotting" makes it less likely that academic work will challenge our assumptions in some significant way. They prefer what they call problematisation. An alternative approach based on abductive logic and reflexivity suggested by (Alvesson and Sköldberg 2009) is discussed later in this review. It is this last view which has most informed my approach.

The literature review reported in this chapter contains a much higher proportion of material that can be labelled philosophy than would be normal in a PhD thesis in information systems. I believe this both to be justified and essential given that:

1. One of the contributions of the doctoral work is a demonstration by case study of a ***critical realist*** approach to principled and experiential design.

2. A second major contribution is the modelling approach which I call Conceprocity. This is strongly based in scientific realist and social ontology, both of which I have therefore to have understood before applying them to the design of that modelling approach.

3. The personal working model of a researcher must to some degree embody her belief system, her Weltanshauuang (Checkland and Davies 1986).

(Checkland and Holwell 1998b) review the nature and validity of action research, arguing that "***its claim to validity requires a recoverable research process based upon a prior declaration of the epistemology in terms of which findings which count as knowledge will be expressed.***" This thesis reports on the first part of a planned long-term research programme. The principal research methods reported in this thesis include design science research and autoethnography. It is only in the second part of the programme that significant use of mentored action research will be made. Nevertheless, I have chosen to apply the injunction to the entire programme.

2.1 Personal information management PIM

PIM systems and techniques

* PIM

(a) Origins

Vannevar Bush identified the Memex as a theoretical concept 70 years ago: (Bush 1945); see also (Caspi, Shankar, and Wang 2004); (S. Davies, Velez-Morales, and King 2005).

The first modern reference to personal information management (which was also the last for many years) was by the psychologist (Lansdale 1988).

Deborah Barreau, a library scientist, was probably the first author to discuss personal information management ***systems***: (Barreau 1995). She also identified the vital need to preserve the ***context*** in which personal information is first encountered. The only other author of whom I am aware who seeks to tackle personal information management systems qua systems is Ofer Bergman; see for example (Bergman et al. 2008).

Popular authors such as Dave Allen have written about various aspects of what is commonly known as "time management": and what he dubs "getting things done GTD" (D. Allen 2003).

(b) PIM community of practice

The current, fairly active if small, PIM research community dates its origins to work by (Barreau and Nardi 1995), (Bergman, Beyth-Marom, and Nachmias 2003) and (Bergman et al. 2004). Richard Boardman completed Ph.D. research in PIM, largely from a tool-usage, HCI point of view: (Boardman and Sasse 2004); (Boardman 2004). Perhaps the most prolific current author on PIM is William Jones, of the University of Washington. Dr. Jones received an NSF award to kick-start serious PIM research, (W. P. Jones and Bruce 2006). Jones' three most recent books on personal information management are (W. P. Jones 2013, 2012, 2015).

A general blog, but a closed-entry community of practice, centres on (Tales of PIM 2016), http://talesofpim.org/. Jones instigated a small group of PIM researchers which first met as a special interest group in the summer of 2006, and this has become the primary cross-disciplinary PIM-focussed research group. Subsequent meetings have occurred in 2008, 2012, 2014 and 2016.

(c)   PIM: Core references

Following the 2006 symposium, William Jones wrote a popularising, but scholarly, text in 2007 - (W. P. Jones 2007b). The title, "*Keeping found things found: The study and practice of personal information management* ", suggests the bias – which is to the study of human activities that require personal information to be managed. Dr. Jones' own background is in cognitive psychology.

(d)   Review articles

(Teevan, Jones, and Bederson 2006) introduced PIM in a special edition of the Communications of the ACM devoted to PIM. This was updated in (Teevan and Jones 2008) and again for (Teevan, Jones, and Capra 2008).

Conference papers that I wrote with Dr. Mario Norbis are a good general introduction, although they place too heavy an emphasis on PIM tools: (Gregory and Norbis 2008a), (Gregory and Norbis 2008b).

(e)   Initial definitions of PIM

Dr. Jones also collaborated, notably with Jaime Teevan, now a Microsoft researcher, on a book which is a collection of scholarly articles: (W. P. Jones and Teevan 2007b). Many of the authors are associated with the PIM community of practice instantiated in the Tales of PIM website and in the various special interest group meetings.

What the PIM community defines PIM to be can be seen from the brief analysis of the articles that appear in Jones and Teevan's 2007 book which follows in Table 3. The analytical technique is very simple; it is to classify the book chapters by main disciplinary influence:

Table 3 An analysis of (W. P. Jones and Teevan 2007b)

Authors	Title	Main disciplinary influence
(W. P. Jones and Teevan 2007a)	Personal Information Management: Introduction	Cognitive psychology

Authors	Title	Main disciplinary influence
(Teevan, Capra, and Perez-Quiñones 2007)	How people find personal information	Cognitive psychology
(W. P. Jones 2007a)	How people keep and organize personal information	Cognitive psychology
(Marshall 2007)	How people manage information over a lifetime	Cognitive psychology
(Naumer and Fisher 2007)	Naturalistic approaches for understanding PIM	Philosophy
(Tan et al. 2007)	Save everything: Supporting human memory with a personal digital lifetime store	Human activity systems
(Catarci et al. 2007)	Structure everything	Computer science
(Karger 2007)	Unify everything: It's all the same to me	Human activity systems
(Russell and Lawrence 2007)	Search everything	Human activity systems
(Whittaker, Bellotti, and Gwizdka 2007)	Everything through email	Information retrieval
(Diane Kelly and Teevan 2007)	Understanding what works: Evaluating PIM tools	Clinical psychology
(Gwizdka and Chignell 2007)	PIM: Individual differences	Human activity systems
(Moen 2007)	Personal health information management	Health care
(Lutters and Ackerman 2007)	Group information management	Human activity systems
(Karat, Karat, and Brodie 2007)	Management of Personal Information Disclosure: The Interdependence of Privacy, Security and Trust	Information security
(Shamos 2007)	Privacy and public records	Records management
(W. P. Jones and Teevan 2007c)	Personal Information Management: Conclusion	Cognitive psychology

This rather superficial analysis is however sufficient to indicate that some disciplines are over represented and that some (notably information systems) are hardly represented at all.

Also notable by its absence is sufficient discussion of "psychological" (or emotional) barriers to action. However, (E. Jones et al. 2009) does contribute a discussion on why people give up on PIM efforts.

There are remarkably few references in the established literature to PIM systems PIMS. Some that appear to refer to PIMS are simply making the common error of considering a tool or a collection of components to be a system: typical of this kind of error is the paper (Al Nasar, Mohd, and Ali 2011).

(Hwang, Kettinger, and Yi 2015) is the first quantitatively informed study that I have so far encountered in the field of PIM. The article focuses on the construct "personal information management effectiveness" of knowledge workers and its antecedents.

(f)   Specific issues: organising personal information

(W. P. Jones et al. 2005) discusses the crucial significance of folders (directories) as a mechanism for organising personal information. This requirement is complemented by (Catarci et al. 2007) in their more general discussion of the need to structure personal information.

Otherwise, the relatively clear distinctions made in library science between classification and categorisation – as for example in (Jacob 2004) – are not sufficiently emphasised in the PIM literature (nor in the practical sphere). This is at least in part the result of differences of vocabulary. Here and elsewhere in the literature of PIM, authors prefer to talk about folders rather than classifications and tags rather than categories.

(g)   Specific issues: organising personal information

(Whittaker and Bergman 2016) continue the development of what (Bergman, Beyth-Marom, and Nachmias 2003) originally termed the user-subjective approach. Bergman and Whittaker argue that both information theories and technologies that work well in other areas of information management do not do so in the sphere of personal information management. They propose a three-stage model for curation, keeping, management and exploitation. They note that PIM differs from other information management approaches in that the hierarchical folder method which dominates practical PIM usage is preferred by PIM users over the search-everything and tag-everything information management approaches which are otherwise becoming ubiquitous. Their suggestion is that what they term PIM systems should exploit the fact that in PIM the person who organises the information is the same person who later retrieves it. They suggest a user-subjective approach and related design principles consistent with their three-stage model for curation.

(h)   Specific issues: supporting cognitive processes

The strong influence of cognitive psychology on PIM research is emphasised by, for example, (W. P. Jones and Ross 2006). Part of the value of this synergy appears in the use

of evaluative techniques inspired by measurement approaches borrowed from cognitive psychology. This approach is exemplified by (Elsweiler and Ruthven 2007) and by (Elsweiler 2008) – the latter extending the memex metaphor of in a discussion of supporting human memory in personal information management.

(i) Specific issues: learning how to improve personal information management

The PIM research community has commented favourably on my suggested "how to learn PIM more effectively" research emphasis. Thus Sauermann, in a forum communication, commented that he thought the approach was novel and likely to prove valuable. One of my proposals – that of individual self-auditing of PIM effectiveness – is discussed in the conference paper (Gregory and Norbis 2009a).

(j) Specific issues: end user PIM system development

This has been discussed in (Gregory 2010), concerning collaboration and end-user information management tools.

(k) Evaluating PIM

This is discussed in (D. Kelly 2006).

∗ Personal knowledge management PKM

The literature on personal knowledge management seems to be closer to that on organisational knowledge management than to PIM. See (Apshvalka and Wendorff 2005), (Frand and Hixon 1999), (Grundspenkis 2007), (Snowden and Pauleen 2008), (Pauleen 2009), (Pollard 2008), (Sauermann 2005b), (Schwarz 2006), (Smedley 2009), (Snowden and Pauleen 2008)

Kirby Wright takes an interesting perspective. Convinced of the value of organisational knowledge management, he nevertheless contends that that knowledge is situated in individuals. Thus he makes a very clear link between organisational and personal knowledge management in (K. Wright 2005) and (K. Wright 2007). Similar synergistic thinking informs (Zhang 2009).

♦ PIM and personal knowledge management PKM

We accept as axiomatic for this study that knowledge is personal (Polanyi 1958) and that even to share knowledge requires that that knowledge first be made explicit as communicable data structured to permit meaningful information to be extracted from it.

PIM can be done using computers; PKM can (at this stage) only be assisted by ICT, e.g. by so-called "E-learning" and by the creative use of social networks.

True knowledge representation (KR) using computers is perhaps a near-reality, but as yet of little practical significance in most personal information management systems. I would identify John Sowa's work (John F. Sowa 1992b; Shapiro 2001; John F. Sowa 2000a) as an accessible and influential summary of the insights of computer science and artificial intelligence concerning knowledge representation. (Schubert 2005) is an example in the literature of artificial intelligence AI of the definition of a notion of explicit self-awareness.

This also needs an explicit internal representation which the author claims might enable general inference methods and overt communication about the self. To achieve this requires particular forms of knowledge representation and reasoning including natural language expressiveness, autoepistemic inference grounded in a computable notion of knowing and / or believing, meta-syntactic devices and an ability to abstract and summarised stories. This technology is not as yet widely available to, and readily applicable by, the ordinary PIM user who is addressed by this thesis. (Schwarz 2006) discusses a context-sensitive support system which aids the user with her knowledge work, defined as searching, reading, creating and archiving of documents. The context model it incorporates necessarily restricts the information items with which it concerns itself to things already known to the user – links to home documents, folders et cetera. It depends upon shared ontologies and the use of knowledge representation mechanisms such as RDF. In a prototype, data is retrieved from the user's own computer via XML and remote procedure call technologies. This present thesis refers to such technologies but holds that they are not yet in a form which is mature enough to be usable by the ordinary computer user. Indeed, a rash of research was reported in this general area – sometimes referred to as the semantic desktop – about 10 years ago, but has largely fallen into abeyance since. The most prolific author who attempted to bridge the gap between PIM and what he identifies as the semantic desktop is the Austrian researcher and entrepreneur Leo Sauermann: see (Sauermann and Schwarz 2004), (Sauermann 2005b), (Sauermann 2005a), (Sauermann, Bernardi, and Dengel 2005), (Sauermann, Cyganiak, and Völkel 2008).

♦ An evaluation of the PIM / PKM literature and an initial identification of knowledge gaps

Currently, the published literature on PIM only rarely refers to the PKM literature. The converse is also true. A rare exception is provided by (Świgoń 2013). Her work is notable for her clear enunciation of the necessity of personal information management to effective personal knowledge management. Although guilty in my mind of insufficient precision in distinguishing information and knowledge, she has an excellent literature review on personal information management and personal knowledge management. (Agnihotri and Troutt 2009) usefully considers the more technological aspects of personal knowledge management.

One initially-promising area of research which I nevertheless largely ignore in my current research is in the cross-over between personal information management and the semantic web. The semantic web, should it appear, will depend upon formal knowledge representation mechanisms: see (Sauermann and Schwarz 2004), (Sauermann 2005b), (Sauermann 2005a), (Sauermann, Bernardi, and Dengel 2005), (Sauermann, Cyganiak, and Völkel 2008).

This leaves very significant knowledge gaps. I would highlight the following disciplines and fields whose literature ought greatly to influence PIM practice, but where the current influence is restricted to one or two articles or to none:

∗ Computer science (but note the work of Leo Sauermann and his collaborators)

∗   Information systems

∗   Logic, artificial intelligence and knowledge representation

∗   Knowledge management (in the organisational sense)

∗   Semiotics and semantics

∗   Linguistics

∗   Neuroscience

∗   Education

∗   Educational psychology

∗   Learning

∗   Organisational learning

Only in the areas below is there much cross-pollination:

∗   Information and library science

∗   Sociology

∗   Cognitive psychology

∗   Human computer interfaces, HCI

♦   Knowledge gaps

Elaborating, I now go on to suggest the existence of specific knowledge gaps.

The literature of PIM makes very little reference to philosophy. And yet: if for a moment we exclude the work of the artificial intelligence community, we live in a world in which all knowledge is personal to human beings. A somewhat more profound consideration of epistemological issues is essential. Ontological issues surface very practically in considerations of information item classification and of categorisation ("tagging" by multiple criteria). See section 2.2 for further discussion of this gap.

The productivity impact of poor PIM is not known – for example, how much time is lost every day because people search again for information that they ought already to have readily-available to them under a managed form? We know neither how many people habitually manage personal information, nor to what extent in their working days. A very recent article is the first in a major journal to tackle this issue: (Hwang, Kettinger, and Yi 2015). However, I think it is too early to assert the existence of clearly-identified and quantifiable PIM constructs in the way that they seek to do.

How much productivity is lost, and how many opportunities are never realised, because one person files information under a category or a classification which is not the same as

that used by another member of the same team or community of practice? Again, the literature is largely silent on this issue; however, see (Catarci et al. 2007).

The academic literature seems to emphasise tool usability and not to study the structure and usefulness of PIM tools (and very little, the huge investment in so-called "office" productivity software used to permit PIM). For example, (Boardman 2004); (Boardman and Sasse 2004) view tools from the perspective of an HCI researcher. HCI (human computer interaction) is a cross-disciplinary area of study usually regarded as being at the intersection of computer science, behavioural sciences (particularly cognitive science) and design. Thus, Boardman is chiefly concerned to identify ways in which to improve the user experience of PIM tool users.

The literature on personal information management generally takes an uncritical view of what data, information and knowledge are. Further, there is no systematic consideration of the contexts within which personal information is used and managed.

As yet, there is little in the way of well-founded "how to" guides to people who wish to improve their PIM practice.

Group aspects remain underdiscussed. Mechanisms for sharing information exist. For synchronising and rationalising data, some tool support is available. For synchronising and rationalising ontologies, there is little support available. Nor is much written on teaching, learning and mentoring to improve PIM. There is nothing yet on explicitly reflective approaches to improving PIM / PKM.

The PIM literature makes almost no mention of systems and apparently knows nothing of the systems approach and of systems thinking.

In summary, among the questions insufficiently addressed in the literature of PIM are these:

1. Can people be helped to improve their PIM? How?

2. Are existing methods, tools and techniques appropriate? How could they be improved?

3. What are the barriers to effective PIM?

4. When should people simply use existing tools, when should they integrate them, and when should they resort to creating or sponsoring new tools?

5. What can PIM practice learn from epistemology and from ontology?

6. What can PIM learn from systems thinking?

PIM conceptual data structures

Much practical personal information management is carried out using the facilities of so-called office-productivity software, such as for example Microsoft Office. The effective use of such software depends upon practical skills possessed by the user, particularly the key issue of choosing the appropriate data structure for the problem at hand.

Data is more or less organised. It can take many forms, including texts, lists, graphs, tables, related tables and objects. Dictionaries – metadata which ascribes meaning to data - are essential to organising data and information. The better the organisation the easier it is to exploit the underlying data.

There are many ways of organising the same data. We often need to change the organisation of data according to the needs. Reorganisation or conversion is a common need of institutions such as business organisations.

Information is derived from data by means of processes summarised in Figure 15:
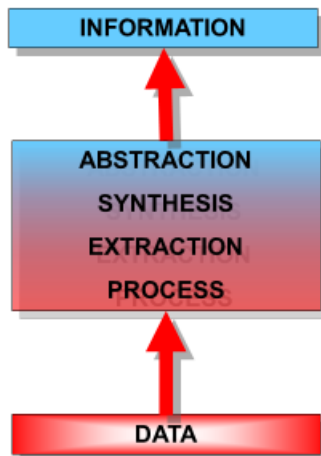
Figure 15 How information is obtained from data *Source: Renaud Macgilchrist, personal communication.*

Table 4 suggests types of data. The table is ordered by increasing degree of structure. This initial classification is partially corroborated by (Völkel and Haller 2009).

Table 4 Types of data ordered by degree of structure

Some forms of data
Text: Natural language that follows the rules of grammar
Bullet points with text
Structured Lists (e.g. <Names and telephone numbers>)
Sequences: (like structured lists but richer)
Outlines
Tables

Tables include 2-dimensional structures that have columns and rows In MS Office terms: Word tables (also PowerPoint) Excel worksheets Access tables (collection of rows)
Spreadsheets and functional spreadsheets
Graphs (can be represented as partially filled in tables)
Concepts linked by relations (e.g. mind map, concept map)

Clarifying some of the items in Table 4:

* Text

Natural language and text is in fact characterised by a very high degree of structure, that of natural language. Much software engineering expertise has been applied to text processing, giving rise to practically useful software such as voice recognition. However, it is not yet the case that office productivity software can accurately classify, categorise or otherwise "make sense" of textual data. It has to treat text as being without structure.

* Hierarchic outlines and multiple hierarchy

An outline is a hierarchical way to display related items of text to graphically depict their relationships. Outlining is a technique which may be implemented in general office programs or in specific computer programs known as "outliners". An outliner is a program which stores and depicts outlines: a special text editor that allows text to be structured as an outline. Outliners are typically used for computer programming, collecting or organizing ideas, tasks or even project management. Outlining is the technique widely used in programs such as Microsoft Office PowerPoint, in which the main headings of a presentation appear as separate slides and on each slide appear points and sub-points. The same technique is available in a more powerful but perhaps less widely-used form in word processing packages such as Microsoft Office Word, which supports a very useful and underused Outline mode.

In an outline, a data item is given meaning by being shown in its owning hierarchy. Thus, a person's surname may be presented as a component of a composite contact object. The relative positioning of an item conveys meaning in that the label of the owner classifies or otherwise gives contextual information concerning the owned item; and the depth in the hierarchy gives some idea of the relative importance or significance of the item.

Some programs allow a data item to participate in more than one hierarchy. Thus, for example an appointment for a meeting can appear in an overall agenda or calendar, but also be linked to the name of each participant in the meeting. Effectively, the same datum is classified in more than one way. To the extent that knowledge is a product of the recognition by intelligent agents of connections between information otherwise not

explicitly linked, tools that permit the representation of multiple hierarchy can be used as a mechanism for storing and representing relatively unsophisticated knowledge.

∗ Relational databases

The most widely accepted, implemented and used type of database is the so-called "relational" database (Date 2003). In a relational database all data is stored as relations or sets, as originally suggested by (Codd 1970). Date suggests as an informal initial definition that

> "A relational system is one in which the data is perceived by the user as tables (and nothing but tables); and the operators at the user's disposal (e.g. for data retrieval) are operators that generate new tables from old. For example, there will be one operator to extract a subset of the rows of a table, and another to extract a subset of the columns – and of course a row subset and a column subset of a table can both be regarded as tables themselves. The reason such systems are called 'relational' is that the term 'relation' is essentially just a mathematical term for a table."

∗ Semantic web and web science

(Shadbolt, Hall, and Berners-Lee 2006) introduces the notion of the semantic web and of what has become known as web science. Most practical work in this area emphasises XML documents, RDF and OWL. See (J. Davies, Studier, and Warren 2006).

Two possibilities exist when applying semantic web approaches to personal information: either (1) specialist PIM software or services which incorporate semantic web techniques; or (2) systems which apply semantic web techniques to pre-existing data stored on a specific computer. The latter approach is referred to as the semantic desktop (Sauermann 2005b; Sauermann, Bernardi, and Dengel 2005).

♦ PIM processes

I suggest the following initial classification of processes which commonly involve PIM techniques:

∗ Decision making and control in the presence of constraints and with incomplete information

∗ Problem solving

(a) Algorithms

(b) Heuristics

PIM packages and tools

♦ Basic data management tools exist in proliferation: such as spreadsheets and databases

Spreadsheets are a very powerful combination of the nearest approach to widely available end-user computer programming so far invented; and ways of storing (more or less) structured data in which the relationship between items of data is imposed using formulae and by physical organisation.

Databases generally have a more limited remit which they fulfil with greater semantic precision than do spreadsheets. The most widely accepted, implemented and used type of database is the so-called "relational" database (Date 2003).

It is possible and common to use spreadsheets and database management systems as the means by which personal data is stored, in other words, as the means by which a given individual carries out personal information management.

♦   PIM tools and packages

However, effectively using spreadsheets (or even more so, databases) involves a level of planning and organisation which not every professional can do well together with technical skills which not every such worker possesses. Consequently, over the years, a plethora of application programs (frequently based on an underlying relational database) have been devised to ease the task of storing and retrieving personal information such as contacts (addresses), appointments, tasks and the like. The most widely used such tool has been Microsoft Outlook, which additionally provides access to the facilities of an email system by means notably of the user's email inbox.

Many more focussed commercial PIM packages have been proposed over the years, but none has achieved ubiquity.

In the open-source world, the Thunderbird and Lightning developments have provided an effective email capability (but little more in the way of PIM functionality at this stage). LibreOffice is widely used but has not threatened to replace Microsoft Office thus far.

♦   PIM tools: specific personal information managers

Various so-called "PIM" (Personal Information Manager) tools have been developed and marketed with varying degrees of success.

A personal information manager (PIM) is a type of application software that functions as a personal organizer. As an information management tool, a PIM's purpose is to facilitate the recording, tracking, and management of certain types of "personal information".

Personal information can include any of the following:

* Personal notes/journal
* Address books
* Lists (including task lists)
* Significant calendar dates
* Birthdays
* Anniversaries
* Appointments and meetings
* Archives of email and instant messages

* Fax communications, voicemail
* Project management features
* Recorded music, films and similar media
* RSS/Atom feeds

♦ In some domains, specialised information management tools have become established

* E.g. bibliographic citation and referencing tools such as EndNote and Zotero

User-generated information systems (UGIS)

Baskerville (op. cit.) identifies "individual information systems". I suggest that this is the same phenomenon that I have chosen previously to name "personal information management system", abbreviated to "PIM system" or even PIMS. Further, I believe that this is much the same phenomenon recently identified as a ***"user-generated information system" UGIS*** by (DesAutels 2011).

Philip DesAutels suggests as a formal definition:

"A user-generated information system is defined as a set of component services, integrated by the user into a novel configuration such that the resulting information service is (1) qualitatively different from its components and (2) offers unique value to the user over and above the value of its inputs" (DesAutels 2011, 187).

More generally, the individual may find herself in a situation where a gap exists between capability or individual competence on the one hand and need on the other. Bridging that gap requires both tools and general knowledge specifically applied. It is the fundamental contention of this present research that no general mechanism exists to build these bridges and that therefore "all" that can be done is to help people to learn "enough" to be able to construct the necessary bridges at appropriate cost. The components of such bridges may be general in their form and application even if each specific bridge has to be crafted for the particular circumstances of its use.

♦ PIM system acquisition

I suggest the following initial categorisation:

* The Make or Buy? Decision (Coase 1937) – that is, do I buy PIM software or do I craft my own PIM approach? To what extent do I combine the approaches?

* Procurement / Acquisition

* Systems development of tools of specific or general applicability

(a) End user development

(b)   Conventional software engineering

(c)   Object-oriented approach

(d)   Logic databases

(e)   Functional programming

2.2 Philosophical considerations

∗   Introduction: determining the epistemological and ontological influences on this research

In principle, every piece of research needs to demonstrate its epistemology: how we claim to know what we know. In this research, it has additionally been necessary to think about and develop (an) ontology: a classification of what we know. Ontology is "that branch of philosophy which deals with the order and structure of reality in the broadest sense possible" – quoted by (Wand, Storey, and Weber 1999, 496).

Epistemology

Epistemology addresses the questions:

• What is knowledge?

• How is knowledge acquired?

• How do we know what we know?

• What warrant exists for our knowledge claims?

Ontology in philosophy and ontology in computer and information science

Ontology in the philosophical sense is the philosophical study of the nature of being, existence or reality as such, as well as the basic categories of being and their relations. Ontology deals with questions concerning what entities exist or can be said to exist, and how such entities can be grouped, related within a hierarchy, and subdivided according to similarities and differences.

In both computer science and information science, *an* ontology is a data model that represents a set of concepts within a domain and the relationships between those concepts. It is used to reason about the objects within that domain.

Ontologies are used in artificial intelligence, the semantic web, software engineering and information architecture as a form of knowledge representation about the world or some part of it.

♦   Ontologies, formal and personal

A formal *ontology* (or upper-level ontology) is defined by axioms in a formal language and aims to provide a domain- and application-independent view of reality. The notion of a personal ontology is not well-developed but we demonstrate by example that it is

fundamental to more exact personal information management and more explicit personal knowledge management.

(Chandrasekaran, Josephson, and Benjamins 1999) introduce ontology thus:

> "In philosophy, ontology is the study of the kinds of things that exist... [An] ontology is a representation vocabulary, often specialized to some domain or subject matter. More precisely, it is not the vocabulary as such that qualifies as an ontology, but the conceptualizations that the terms in the vocabulary are intended to capture... The representation vocabulary provides a set of terms with which to describe the facts in some domain, while the body of knowledge using that vocabulary is a collection of facts about a domain."

(Gruber 1993) suggests that an ontology is a specification of a conceptualization. "A specification of a representational vocabulary for a shared domain of discourse — definitions of classes, relations, functions, and other objects — is called an ontology." (Gruber 1993, p.11)

A ***filing system*** (paper or on a computer) can be viewed as an embodiment of such a personal ontology or at least taxonomy. The expression of the personal ontology may be less rich than the ontological stance of its owner; thus a student's filing system may distinguish only Home and School folders, but her mental categorisations and classifications (Jacob 2004) are very much richer. Further discussion of the distinction between ***classification*** – as exemplified by physical or computer-based ***folders***; and ***categorisation*** – as exemplified by ***tagging***; is held over until section 0.

Pragmatism

Pragmatism – its founder Peirce preferred to call it pragmaticism – is one of a small number of philosophical approaches which have overtly influenced the present study.

(Hartshorne, Weiss, and Burks 1931) – just one volume of several which together make up the collected papers of Charles Peirce – epitomises the vast intellectual outpourings of the American philosopher and polymath Charles Sanders Peirce.

Abduction and the abductive logic of enquiry

My initial approach has been abductive and it is pragmatic: I have followed Charles Sanders Peirce as interpreted by (Yu 1994, p.1):

> "In [the] Peirceian logical system, the logic of abduction and deduction contribute to our conceptual understanding of a phenomenon, while the logic of induction adds quantitative details to our conceptual knowledge. Although Peirce justified the validity of induction as a self-corrective process, he asserted that ***neither induction nor deduction can help us to unveil the internal structure of meaning***. As exploratory data analysis performs the function as a model builder for confirmatory data analysis, ***abduction plays a role of explorer of viable paths to further inquiry***. Thus, the logic of abduction fits well into exploratory data analysis. At the

stage of abduction, the goal is to explore the data, find a pattern, and suggest a plausible hypothesis; deduction is to refine the hypothesis based upon other plausible premises; and induction is the empirical substantiation."

Thus, before any possibility of hypothesis testing in the Popperian sense, hypotheses (or at least, initial questions) should be generated by means of critical thinking applied to pattern recognition. Yu continues:

"Exploratory data analysis, as an application of abduction, is not a permit for the analyst to be naive to other research related to the investigated phenomena. Peirce strongly criticized his contemporaries' confusion of propositions and assertions. Propositions can be affirmed or denied while assertions are final judgments. The objective of abduction is to determine which hypothesis or proposition to test, not which one to adopt or assert…

"Peirce stated that classification plays a major role in making hypotheses; that is the characters of phenomenon are placed into certain categories. In short, abduction by intuition can be interpreted as observing the world with appropriate categories which arise from the internal structure of meanings. The implication of abduction for researchers is that the use of exploratory data analysis is neither exhausting all possibilities nor making hasty decisions. Researchers must be well-equipped with proper categories in order to sort out the invariant features and patterns of phenomena."

In parallel, we also draw a very strong analogy to the method of inference called abduction, initially by Charles Sanders Peirce. We do this both for what we believe to be sound philosophical reasons but also because abduction has been suggested as a mechanism of situated cognition (Clancey 1997). We are therefore not alone in our speculation that abduction is not only a mode of inference, but also fundamental to human cognition. This stance is notably associated with the work of Lorenzo Magnani. Specifically, see: (Magnani 2009, ch.8), where he discusses what he calls morphodynamical abduction. He makes specific reference to catastrophe theory (Thom [1980] 1993, [1972] 1989):

"A cognitive process (and thus abduction) is described [by some] by the manipulation of internal semiotic representations of the external world. This view assumes a discrete set of representations fixed in discrete time jumps and, because of its functionalist character, cannot render the embodied dimension of cognition and the issue of anticipation and causation of a new hypothesis adequately. An integration of the traditional computational view with some ideas developed within the so-called dynamical approach and catastrophe theory can lead to important insights."

Critical realism (CR)

♦ Origins of CR

The seminal publications quoted in almost all work on CR are (Bhaskar 1975); (Bhaskar 1978); (Bhaskar [1986] 2009); (Bhaskar 1989); (Collier 1994).

♦ Reality exists independently of our observation of it: (Dobson 2002)

This section is informed by the work of the information systems scholar Philip Dobson, specifically (Dobson 2002). Dobson poses the question: Why bother with philosophy? Dobson sees the emancipatory power of a researcher's understanding of different philosophical positions as a powerful argument for "bothering with philosophy".

Thus, Dobson agrees with the critical realist Roy Bhaskar as they argue for a recognition of the intimate relationship between philosophy and methodology; the continued success of a philosophy is considered by (Bhaskar 1975) to be dependent on its effectiveness as "underlabourer and occasional midwife" to the research process: (Dobson 2002, 199).

Dobson suggests that "the adoption of the 'critical' foreword [in the name 'critical realism'] is unfortunate in that it misleadingly suggests that the philosophy is aligned with "Habermas' 'critical theory', with its close links to phenomenology".

Dobson follows a classification of different conceptions of social structure that he ascribes to (M. S. Archer 1995) and concentrates his discussion on Giddens' Structuration Theory (Giddens 1986). This Dobson restates by positing a 'system' between structure and agency, creating an interdependent duality. Further he emphasises a realist interpretation which sees structures as referring to actual forms of social organizations, following Archer's "real entities with their own powers, tendencies and potentials" (M. S. Archer 1995, 106).

Thus for Dobson "Giddens' structuration theory and Bhaskar's critical realism provide an opportunity for the recognition of both structure and agency although both representations provide little real practical guidance".

From a more systems theoretical perspective, (Mingers 2004) also shows appreciation of Bhaskar's re-appropriation of the real.

♦ Reality exists independently of our observation of it – following (Mingers, Mutch, and Willcocks 2013)

Reality exists independently of human knowledge of that reality.

Our imperfect – corrigible and provisional – knowledge of that reality can only come through our fallible conceptual apparatus.

CR defends a strong realist ontology. There is an existing, causally-efficacious world which is independent of our knowledge of that world. This realism contrasts with positivism (which reduces the world to that which can be empirically observed and measured) and constructivism which seeks to ignore that part of the world of which we are ignorant.

CR can be characterised as holding to an objective ontology, even while accepting epistemic relativity. This corresponds to Kantian critical thinking.

CR accepts the existence of different kinds of objects of knowledge, physical, social and conceptual. Because these have different ontological and epistemological characteristics it is appropriate to use a range of different research methods to enquire into them. Thus, CR supports and arguably encourages multi-method research.

- ♦ Object of scientific investigation: real internal mechanisms – following (Mingers, Mutch, and Willcocks 2013) as based on (Bhaskar 1975)

Causality cannot be reduced to empirical constant conjunction as argued by David Hume – such conjunction is neither sufficient nor even necessary to establish a causal relationship.

Science is understood as an ongoing process in which scientists improve the concepts they use to understand the mechanisms that they are studying. It is not about the identification of a coincidence between a postulated independent variable and dependent variable; nor is causality located in events but rather it depends on mechanisms.

Popper's falsification is not adequate to reject a hypothesis because a mechanism may exist but either (i) not be activated or (ii) not be perceived or (iii) be activated but counteracted by other mechanisms which result in unpredictable effects.

The fact that a posited mechanism is not realised does not necessarily signify its nonexistence.

- ♦ Object of investigation: human world; critical naturalism: special philosophy of the human sciences – following (Mingers, Mutch, and Willcocks 2013) as based on (Bhaskar 1978)

CR is fundamentally realist in its outlook and, if one follows the later thinking of its founder Roy Bhaskar, takes a dialectical perspective. CR opposes the view of David Hume and his successors that science concerns itself with recording constant conjunctions of observable events so as to posit laws that correspond to those regularities. Instead, it seeks to concentrate on the objects, entities and structures that exist – whether observable or not. Philosophically, CR stands against the Humean and positivist idea that empirical regularities are genuinely explanatory. Instead, there must be some intransitive domain of objects and events which exists independently of our perceptions of them. Thus, CR stands against the epistemic fallacy, that of reducing the ontological domain of existence simply to the epistemological domain of what we know.

CR is based on an abduction, the necessary explanation of surprising facts. There must exist enduring entities – physical, social or conceptual – that have powers or tendencies to act in particular ways. "It is the continual operation and interaction of these mechanisms that generates the flux of events.… The heart of this argument is that of a causal criterion for existence rather than a perceptual one" (Mingers 2006, p.21). Further, the cause may not in a specific circumstance be perceived – but may nonetheless be real. Margaret Archer, following Roy Bhaskar, emphasises that reality is both intransitive and stratified. Thus, CR distinguishes, then stratifies: mechanisms, the events they give rise to, and the subset of events that are actually experienced. These are identified as the domains of respectively the real, the actual and the empirical.

- ♦ Stratification and emergences – following (Mingers, Mutch, and Willcocks 2013)

The existence of strata or of levels gives rise to emergences at higher level from the lower level – Bhaskar calls this "emergent powers materialism". Thus, these "generative mechanisms", each of which has certain causal powers, tendencies or ways of acting, then

interact to generate the observable, the actual. Since some of these mechanisms work in opposition to others, specific events may or may not occur.

The basic methodology of science as conducted in a critical realist framework is also abductive or retroductive. (Peirce tended to use the word retroductive when arguing after the historical fact for which an explanation is sought, but methodologically abduction and retroduction are largely indistinguishable.) In logical terms, a surprising fact, a phenomenon for which we seek an explanation, causes us to seek hypothetical mechanisms which – were they to exist – would explain the surprising phenomenon. The latter part of the process is sometimes called inference to the best explanation. So the essential methodological step is to move from descriptions of empirical events or regularities to potential causal mechanisms, the interaction of which could potentially have generated the events. This abductive process gives no proof that the mechanisms which are posited actually exist. We need to move on from the abductive phase to deductive and inductive reasoning. Even then, CR accepts that knowledge is always fallible and that the hypothesised mechanisms, even where there are strong indications that they really do exist, may not in fact explain the observed reality. In summary, we describe events of interest, retroduce explanatory mechanisms, eliminate false hypotheses, aim to identify correct mechanisms. CR tends to be eclectic in its research methods because different kinds of mechanism require different kinds of investigation. Thus, what we might call quantitative and qualitative approaches may be indicated in a study of a single phenomenon. There is no prescription of the right way to advance scientific knowledge. Instead, strong principles can be put forward and have already been so in areas such as case study research (Wynn Jr and Williams 2012).

Bhaskar argues strongly against methodological individualists and what he sees as the conceit of constructivism. So much of what we know and of what we experience comes to us quite independently of how we think about reality. Thus, for example, we use language which is essentially social in its character.

Archer in sociology and Tony Lawson in economics (M. S. Archer et al. 1998) have exploited critical realism in its role as a philosophical "under-labourer" to give strength to their respective critical engagements. (D. K. Allen et al. 2013) use critical realism both to require and to facilitate engagement with other traditions, in their case that of the application of activity theory (Nardi 1996) in information systems case studies.

♦   Generative mechanisms - (Wynn Jr et al. 2013)

There is currently more literature concerning what critical realism is than there is about using or applying it. Usefully, Wynn and Williams set forth methodological principles for evaluating CR-based explanatory case study research in information systems. They then apply them to existing case studies.

♦   Morphogenesis - (M. S. Archer 1995); (M. S. Archer et al. 1998); (M. S. Archer 2007); (M. S. Archer 2010)

Margaret Archer does not follow the specific model of transformative social action which Bhaskar put forward. Instead, in seeking to address the fundamental issue in sociology of the respective roles of structure and agency, Archer has developed a distinctive

morphogenetic approach as she insists on the necessity for studying both agency and structure – avoiding all temptations to conflate the two. Specifically, Archer accuses Anthony Giddens of such conflation in his notion of structuration.[8]

- ♦ Analytical dualism and the morphogenetic approach - (M. S. Archer 2014)

This extract from her recent presentation of ideas which she originally introduced in (M. S. Archer 1982) and developed in (M.S. Archer 1995) usefully summarises what Archer means by morphogenesis and specifically the mechanisms that give rise to it.

"

Analytical Dualism & the Morphogenetic Approach

Through analytical dualism we can separate 'structure' and 'agency' and examine their interplay to account for the structuring and re-structuring of the social order.

Possible because 'structure' and 'agency' are *different kinds of emergent entities,* with different properties and powers, *despite* the fact that they are crucial for each other's formation, continuation and development.

Secondly, 'structure' and 'agency' operate diachronically over different time periods because:-

(i) structure necessarily pre-dates the action(s) that transform it and,

(ii) structural elaboration necessarily post-dates those actions. [See Figure 16.]

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[8] In a parallel way, (Mingers and Willcocks 2014) argue against the conflation implicit in Orlikowski's notion of "sociomateriality" (Orlikowski and Scott 2008).

The basic Morphogenetic sequence

Structural Conditioning

T ^{1}

Social Interaction

T ^{2} T ^{3}

Structural Elaboration

T ^{4}
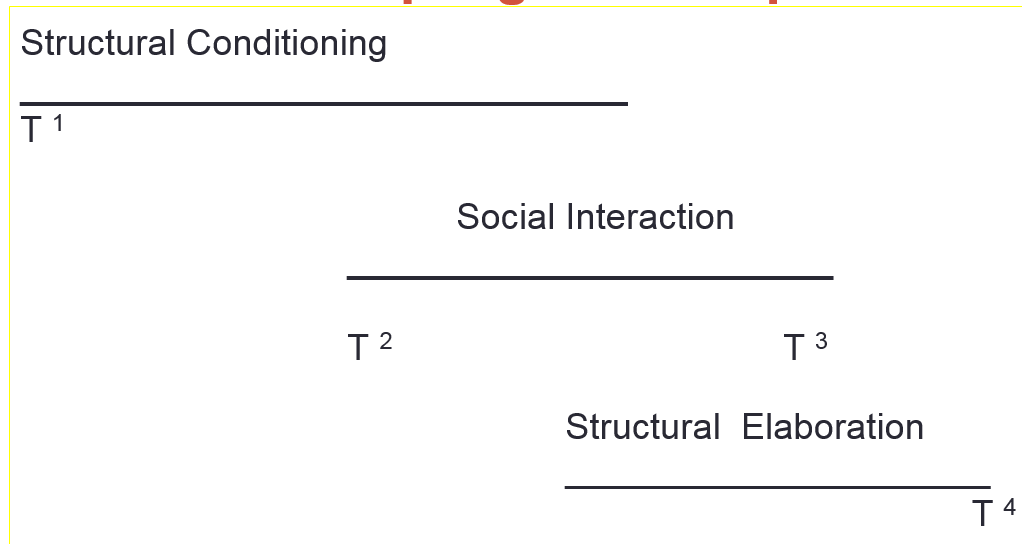
Figure 16 The basic morphogenetic sequence according to Margaret Archer (source: (M. S. Archer 2014))

...

Interaction T2 – T3

Motives for interaction shaped by prior context (where groups are 'beneficiaries' OR 'obstructed' OR 'indifferent')

...

At T4:

Morphogenesis/stasis at T4 is not just the eradication/modification of previous structural/cultural properties and powers

But also the elaboration of:-.

- a new 'relational organization' with powers of downward causation
- of new constraints and enablements for different groups/ new opportunity costs
- new 'generative mechanisms' governing how things work

"

All of this is consistent with what Archer said in her early article: (M. S. Archer 1982) and in her book (M. S. Archer 1995, chap. 5).

More recently, Archer has extended the scope of her work to give considerable consideration to reflexivity. (M. S. Archer 2010) holds that all human beings are reflexive in the sense that they monitor their central concerns in an ongoing way. However, we are not all reflexive in the same way and the mode of reflexivity is significantly influenced by the combination of structural and cultural moments that we experience in life.

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(Mingers, Mutch, and Willcocks 2013), while agreeing on the importance of reflexivity, contend that Archer's emphasis on reflexivity may tend to downplay both routine action and tacit forms of knowing.

♦ Morphogenesis and technology (Mutch 2010)

Mutch suggests certain dimensions of a morphogenetic approach to technology. Structure always forms an objective context for the exercise of agency. Technology renders some of those structures more durable in both time and space.

Why philosophy matters in this study

♦ The importance of a strong epistemological and ontological stance in researching individual information systems: an introduction

How we know what we know is the subject of epistemology. What we know and how it is classified is the subject of ontology. When a researcher seeks to enhance their personal knowledge by undertaking research, they are carrying out a learning process – they are an actor. The data they collect and its analysis are carried out using information management tools. Together, these elements constitute a personal knowledge management system.

I have therefore needed to reflect a great deal on the concepts of data, information, knowledge and how they are used: on enacted knowledge. For me, these are not just abstract philosophical conceptions – they drive the process of research and they are its substance. In a very real sense, the process of doing this PhD is a use of (and a participation in) a personal knowledge expression or representation system based on a concrete personal information management system made up of multiple more-or-less integrated components.

2.3 Systems thinking and models

Systems thinking, systems theory and PIMS

(a) Systems Thinking: General

There exist tools of thought and enquiry that take a systemic and systematic approach to problem identification, analysis and solution. Among these is the so-called Systems Approach (Georgiou 2007), the underlying science of which is called cybernetics. Norbert Wiener and Arturo Rosenblueth are generally regarded as the fathers of what Wiener named cybernetics, which he defined as the science of control and communication in man, machine and animals (Wiener 1973). Cybernetics deals with complexity by seeking to control it, where control is to be understood as steering a course towards a better solution – from kybernetes, κυβερνετες, the steersman or helmsman. The helmsman applies her intelligence and experience, as amplified by the machine, the ship, which she controls, to create sufficient and appropriate variety to deal with and overcome the variety and complexity she is encountering in her turbulent environment. Wiener and the other early cyberneticians identified as fundamental to control the notion of feedback. Feedback exists

when the effect of a process (or the things that come out of it) has a connection to its cause (or things that go in to it). Feedback can be negative, which tends in general to increase the stability of a system but may reduce its responsiveness; or positive, which amplifies the possibility of change but may also result in system instability. The effects of feedback can be positive in terms of greater controllability or negative in terms of a loss of effective control.

Walonick (Walonick 1993) provides a useful introduction to the general systems theory of the biologist Ludwig von Bertalanffy. GST is a complementary approach to the issues of control and complexity which initially developed independently of the engineering-focussed cybernetic tradition. Walonick observes that:

> "A *closed system* is one where interactions occur only among the system components and not with the environment. An *open system* is one that receives input from the environment and/or releases output to the environment. The basic characteristic of an open system is the dynamic interaction of its components, while the basis of a cybernetic model is the feedback cycle. Open systems can tend toward higher levels of organization (negative entropy), while closed systems can only maintain or decrease in organization." (Walonick 1993)

This observation suggests the necessity that a system be open if it is not over time to decay. Specifically, a tool alone cannot improve the controllability of a system; only its use as part of an open system holds this potential.

The British cybernetician W. Ross Ashby first enunciated his Law of Requisite Variety in 1956 (Ashby 1956): ***"Variety absorbs*** variety, defines the minimum number of states necessary for a controller to control a system of a given number of states" (albeit in a discrete state controller).

The contributions of the original cyberneticians include (Rapaport 1970), (Rosenblueth, Wiener, and Bigelow 1943), (Wiener 1965), (Buckley 1968); and those of of the originators of the systems approach, (Churchman 1968), (Churchman 1971), (Churchman 1979). The great apostate of Operations Research is (Ackoff 1971); he moved instead to embrace more general systems thinking, a System of Systems Concepts. He works this out further in, for example, (Ackoff 1994).

The originator of General Systems Theory is (Von Bertalanffy 1968); (Von Bertalanffy 1972). Also present at the original Macy conferences in which the early cyberneticians discussed their new insights was (Von Foerster 2003) who was subsequently linked to the development of second-order cybernetics.

(Ison 2013) presents a concept map which models the various different influences that have shaped historical and contemporary systems approaches. He suggests that many well-known systems thinkers had particular experiences which led them to devote their lives to their particular forms of systems practice. He distinguishes between soft systems and hard systems approaches and between the words systemic and systematic. He does not do this in the somewhat polemical way in which some authors seek to force binary choices between these terms. Instead, he argues for duality against unhelpful dualism. An epistemological awareness can be made apparent in what he calls the 'as if' attitude, "e.g.

the choice can be made to act 'as if' it were possible to be 'objective' or to see 'systems' as real". He suggests also that systemicity is associated particularly with interconnectedness and process-awareness. (Salner 1986) has found that many people are not able fully to grasp relatively simple systemic concepts such as self-reflective structures. As a consequence they will not be able to rethink organisational dynamics in terms of managing complexity without substantial alteration in their applied epistemology, their worldview. This involves the deliberate breaking down and restructuring of mental models that support worldviews. (Prigogine and Stengers 1985) discuss dissipative structures, a theory of the dynamics of epistemic learning. Ray Ison suggests that their theory provides a model of the dynamics of epistemic learning. Each learner goes through a period of chaos, confusion and being overwhelmed by complexity before new conceptual information brings about a spontaneous restructuring of mental models at a higher level of complexity, thereby allowing a learner to understand concepts that were formerly opaque. He notes our need to "live in" language as we reflect on what is happening as we create an object of what is happening and name it experience.

A simplistic definition of a system would be a set of interacting or interdependent components which together form an integrated whole. However, some argue that what makes a system viable is its capacity to adapt, that is, to develop increased order (negentropy). Thus, Francis Heylighen (Heylighen 1992) identifies a number of cybernetic principles. One among these is what he calls blind-variation-and-selective-retention (BVSR). Accepting as another principle that a stable system is to be preferred to one that decays towards higher entropy (disorder), Heylighen goes on to suggest:

> "BVSR processes recursively construct stable systems by the recombination of stable building blocks. The stable configurations resulting from BVSR processes can be seen as primitive elements: their stability distinguishes them from their variable background, and this distinction, defining a "boundary", is itself stable. The relations between these elements, extending outside the boundaries, will initially still undergo variation. A change of these relations can be interpreted as a recombination of the elements. Of all the different combinations of elements, some will be more stable, and hence will be selectively retained.

> Such a higher-order configuration might now be called a system. The lower-level elements in this process play the role of building blocks: their stability provides the firmness needed to support the construction, while their variable connections allow several configurations to be tried out. The principle of "the whole is more than the sum of its parts" is implied by this systemic construction principle, since the system in the present conception is more than a mere configuration of parts, it is a stable configuration, and this entails a number of emergent constraints and properties. A stable system can now again function as a building block, and combine with other building blocks to a form an assembly of an even higher order, in a recursive way." (Heylighen 1992, p.3)

In living systems the selection process is evolutionary. In a work system, the selection mechanism is no longer blind but can itself be purposeful, what Bruce Archer quoted in

(Hevner and Chatterjee 2010c) identifies as "designerly enquiry": 'there exists a designerly way of thinking and communicating that is … as powerful as scientific and scholarly methods of enquiry'. Similarly (Schwaninger 2004) identifies evolutionary design or evolution by design. In the context of PIM I would identify categorisation, classification, ontology and "programming" (broadly understood so as to include spreadsheet formulae, as well as "traditional" computer programming) as among the intelligent behaviours which cause the order of a system to increase.

(b)   Critical Systems Thinking and Total Systems Intervention

This is represented by (Flood 1996), (Flood and Romm 1996), (Flood and Ulrich 1990) based on origins identified by (Jackson 1991). The literature of critical systems thinking has not greatly influenced this thesis.

Problem solving and heuristics and decision science

Herbert Simon - (Simon [1970] 1996); compare (Simon et al. 1987) - saw the work of managers, of scientists, of engineers, of lawyers – the people whom he saw as steering the course of society and of its economic and governmental organisations - as largely the work of making decisions and solving problems.

Problems can be solved using algorithms or by using heuristics. Problems that can be solved algorithmically are now usually the province of computers. But the descriptive theory of problem solving and decision making is centrally concerned with how people cut problems down to size: how they apply approximate, heuristic techniques to handle complexity that cannot be handled exactly. Thus, heuristics are ways of solving (or at any rate of addressing) problems where there is not just one possible desirable outcome. Problem solving enters the domain of many disciplines, but is particularly associated with what Herbert Simon has described as the sciences of the artificial and are today more commonly called the decision sciences. The decision sciences include management science, operations management and management information systems.

Models, mental and conceptual

Models are necessary; the IS community with which I identify has a duty to help people understand that. The alternative to models is not no models, but bad models because they remain inexplicit mental models.

(Leonard 2009) discusses the viable system model VSM originated by her partner Stafford Beer.

"Models flow from distinctions; selections of characteristics important to the question at hand. Stafford said models are not 'true' or false; they are more or less useful, depending on the purpose of the person using it… A good model, for the purpose, has requisite variety and captures the salient relationships. An inadequate one lacks requisite variety and misses important aspects of the situation, leading to unintended consequences." (Leonard 2009, p.225)

"Cybernetic models differ from others in that they focus on relationships that are dynamic. Ross Ashby showed that only a few simple decision rules in a model could lead to complex interactions. Often they centered [on] the maintenance of equilibria called homeostasis with the 'mechanisms' referred to as homeostats. A complex organism, like the human body sustains itself through the operation of a great many homeostats. Body temperature, electrolyte balance, blood sugar and many others operate for the most part out of our conscious awareness although if they fail, they do intrude on consciousness and the consequences can be serious. Stafford was especially interested in the operation of homeostasis in human organizations. He postulated that the first consideration of an organism or an organization, such as a business or a city, was to survive. To do so required that the variables on which its survival depended be maintained within acceptable limits. Often he was able to point to a single homeostat as a bellwether measure—if this aspect was in equilibrium, the rest of the situation would remain stable. He defined viability as able to maintain an independent existence." (Leonard 2009, p.226)

Modelling an organisation in order better to control it involves discovering what the organization's critical variables are and finding or installing the homeostats that will show that they are maintaining equilibrium. Within that context, the model will help you ascertain that the principle functions and communications channels are in place and can function effectively. Leonard explicitly links Ross Ashby's law of requisite variety to the later Conant-Ashby Theorem as she states that the good regulator of a system needs to have as much variety at its disposal as does the system being regulated.

According to Leonard, Stafford Beer also used modelling in the representational or analogical manner. She refers to his yo-yo model (Beer 1966) as she describes how he would draw a metaphor between an organisational situation and a scientific one. If it was sufficiently logically consistent, it could then be regarded as a simile. If the simile were to be effective, the next step is homomorphic and perhaps isomorphic mapping and sometimes mathematical description.

Although (Conant and Ashby 1970) themselves do not explicitly suggest that their "good regulator" is to be equated with the notion of a mental model, (Rouse and Morris 1985) start their discussion and review of mental models by equating the regulator as suggested by Conant and Ashby with a mental model. Rouse and Morris then go on to discuss the notion of mental models at length, demonstrating the pervasiveness of the concept particularly in the fields of manual / supervisory control and of cognitive science. They state:

> "The notion that humans have "mental models" of the systems with which they interact is a ubiquitous construct in many domains of study. This paper reviews the ways in which different domains define mental models, characterize the purposes of such models and attempt to identify the forms, structures, and parameters of models. The resulting distinctions among domains are described in terms of two dimensions: 1) nature of model manipulation, and 2) level of behavioural discretion. A variety of salient issues emerge, including accessibility of mental models, forms and content of representation, nature of expertise, cue utilization, and, of most importance, instructional issues. Prospects for dealing with these issues are

considered, as well as fundamental limits to identifying or capturing humans' "true" mental models." (Rouse and Morris 1985, abstract)

They note also the necessity and difficulty of distinguishing the notion of mental model from knowledge.

(Moray 1990) also refers back to the work of Ashby and of Conant as he proposes lattice theory to provide a formalism for the knowledge base used as a mental model by the operator of a complex system. The ordering relation '$\geq$' is interpreted as `is caused by', and the lattice becomes a representation of the operator's causal hypotheses about the system. A given system can be thought of causally in different ways (purposes, mechanics, physical form, etc.). Each gives rise to a separate lattice. These are related to each other and to an objective description of the structure and function of the physical system by homomorphic mappings. Errors arise when nodes on the mental lattices are not connected in the same way as the physical system lattice; when the latter changes so that the mental lattice no longer provides an accurate map, even as a homomorphism; or when inverse one-to-many mapping gives rise to ambiguities. Moray makes suggestions about ways of reducing error.

(Nersessian 2002) discusses the cognitive basis of what she calls model-based reasoning. She puts forward a mental modelling framework and discusses the various kinds of representation that it might encompass. She sees mental modelling and in particular thought experiments as the basis of creative reasoning.

(Scholten 2010b) in his discussion of the good regulator theorem of (Conant and Ashby 1970) suggests but does not prove that "Of course, the preceding sort of analysis does not constitute a proof that 'every good solution must be a model of the problem it solves.' It is a plausibility argument only." But he does provide a long list of everyday problem-solving situations where we create models as the genesis of solutions. "What must we always do? Make a model of the problem. How do we know we have to do that? Because we know that every good solution must be a model of the problem it solves. Whatever else we do, we must do at least that. Of course, most of the time this approach will fail, at least on the first attempt, but only because there are many, many ways to model any given problem, and only a relatively few will make the solution transparent. But if after modelling the problem the solution is not transparent, then we also know that we have to come up with a different model. How do we know this? Again, because every good solution must be a model of the problem it solves. If the model we currently have doesn't solve the problem, then we must find some other way to model the problem… the C&A theorem shows us that the process of problem solving is equivalent to the process of problem modelling, and especially, the process of problem re-modelling."

In a later publication (Moray 1997), Neville Moray distinguishes between several distinct usages of the notion of "mental model" and goes on to suggest a single unifying formalism. He first distinguishes between the tradition of mental models associated with the psychological community, most notably (Johnson-Laird 1983); and that associated with the control engineering and cybernetics community. Moray notes the occasionally loose usage of the term mental model – which then becomes indistinguishable from the basic knowledge of the person to whom a mental model is being ascribed. But he then goes on to demonstrate that there is a particular and quite precise reason for using the term mental

model because that captures an important aspect of human functioning. This can only properly be applied to long-term representation of system knowledge. There is commonality between researchers in identifying as the significant concepts those of human, task and environment. Moray goes on to suggest that there is a single canonical form of a mental model which is a homomorphic mapping from one domain to another, resulting in an imperfect representation of the thing modelled. The person building a model has to have had a prolonged period of experience of the task and the environment. "That experience results in a mapping of features and properties (relations, dynamics, entities) from the task and environment into the long-term memory of the person. It is a reducing, many to 1 mapping, which results in memory containing a simplified version of reality (the properties of the task and its environment)." (Moray 1997)

Moray suggests that as the complexity of the situation to be controlled increases, a skills-based pattern recognition approach has necessarily to give way to rule-based and ultimately the knowledge-based paradigm of the "logical reasoning tasks" suggested by Johnson-Laird – where there is nothing but knowledge of and no overt action on, the world.

In the paper (Moray 1997), Neville Moray surveys the literature concerning the notion of "mental model". His context is largely that of the operation of complex machines or systems. He surveys the literature then existing and seeks to create a single unifying formalism. He identifies as the pioneering notion of a mental model the work of the philosopher and physiological psychologist Kenneth Craik (Craik 1967). Moray notes that Craik suggested that knowledge consists of a model of the world formed by humans in their nervous systems. Thus for Craik, to talk of a mental model is to talk of the way in which our knowledge of the world is represented in the head. That mental model is necessarily a part of long-term memory. Craik was also interested in human-machine systems and closed-loop skills, so his notions come not only from psychology but are consistent with those of the control engineering community and more broadly of cybernetics in general. This control engineering view of the mental model as regulator contrasts strongly with the more general notion of mental model put forward by, for example, (Johnson-Laird 1983). Moray restricts his discussion of mental model to what he terms "the more or less imperfect knowledge that a person has of his or her functional environment – the environment, in a broad sense of that word, with which moment-to-moment interaction is occurring, from which information is being received, with respect to which decisions are being made, and upon which the person is acting." (Moray 1997). Moray agrees with Craik that the more typical use of the term mental model refers to certain contents of long-term memory, and that the contents of working memory are constructed from moment to moment from the interaction of the contents of long-term memory, including mental models among other such contents, together with information obtained anew from the environment. This view is consistent with the notions of cybernetic levels, traverses and of practopoiesis introduced by (Nikolić 2015) discussed in section 0 below. Moray identifies five main uses in the literature of mental model which can be characterised by the nature of the task and the form of interaction with the environment. The one which superficially comes closest to our notion of model-based regulation is probably that termed "logical reasoning" introduced by (Johnson-Laird 1983).

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However, Moray bases his own canonical mental model on a series of homomorphic mappings from one domain to another, resulting in an "imperfect" representation of the thing modelled. By means of these homomorphic mappings, both models of knowledge (hypotheses, facts and expectancies about the task in the world), and also plans for action – models for what to do - emerge. Long-term models wait to be activated in accordance with specific task demands – Moray calls them schemata. They give rise to frames or to scripts in short-term memory. Moray insists that these models are usually only homomorphic and only rarely isomorphic. Moray identifies as the appropriate formalisms for discussing both models and relations those of lattice theory and of mapping theory. These mappings can account for the fact that two pieces of knowledge that are quite disparate can interact. Thus, a single semantic network can cover both knowledge and action and is a lattice which orders the relations between things that a person knows. The models in use are highly dynamic and can be modified in real time in accordance with incoming information. However, because the model is not isomorphic in the sense required by (Conant and Ashby 1970) and because it depends on internal remappings which may further distort the representation, people make errors. Moray concludes that it is engineering models – in particular of the performance of human operators – which are central to understanding the nature of mental models. Thus, he holds that a synthetic view deriving from control engineering and from psychology is appropriate to conceptualisation of mental models.

(Greca and Moreira 2000) discuss mental models, conceptual models and modelling. The context within which they write is that of educational theory and specifically the study of mental representations constructed by students in their interactions with the world, its phenomena and artefacts. Starting from the representational nature of knowledge, they ask whether processes and representations can be understood as either innate or acquired? Is it in fact possible to change the mental representations held by students? The notion of representational models is particularly attractive in the context of the teaching of science, where it is common to present conceptual models to students in order that they can "learn" them. This is to neglect the facts that:

> Firstly, students hold mental models which are imperfect copies of conceptual models;

> Secondly, the process of modelling is far from being evident to the students concerned.

(Greca and Moreira 2000) go on to note that mental models exist to allow their builder to explain and make predictions about a physical system represented by that model – the model must be functional to the person who constructs it. The models are not computational in nature although they may include production rules of the If... Then type. The models are also active in the sense that they may be used to simulate or to "run" aspects of the real world in order to improve the qualities of prediction made. Thus, a child may initially know that it is impossible to ride a bicycle, then conceive of the possibility by observation, then learn how to do it in practice. They say that (Johnson-Laird 1983) characterised mental models as analogical representations of reality. In the face of a given situation, the individual chooses models to interpret the situation together with perceived or imagined relations between them. The resulting substitute model is internally manipulated in order to make possible a "reading" by the individual of the situation which

she is facing. The models might rarely be propositional or symbolic; they are more likely to be mental models – structural analogues of the world, or they might be images. Mental models are dynamically reconstructed as new information is incorporated or taken into account in a recursive process.

(Greca and Moreira 2000) consider (Nersessian 1992)'s conception of mental models as intermediate levels of analysis between the phenomenon and the resulting final mathematical or conceptual model. Generally, a conceptual model is an external representation created by researchers, teachers, engineers et cetera that facilitates the comprehension or the teaching of systems or states of affairs in the world. Conceptual models are or should be precise and complete representations that are coherent with scientifically accepted knowledge. Thus, whereas mental models are internal, idiosyncratic and essentially exist for functional reasons, conceptual models are external representations shared by a given community which are coherent with the scientific knowledge of that community. (Greca and Moreira 2000) suggest that teachers commonly assume that students have acquired or constructed mental models that are copies of the conceptual models that have been presented to them. However, this does not happen. There is no simple and direct relation between a conceptual model and a mental model. Indeed, students frequently do not have the necessary knowledge to interpret any representation as a conceptual model. This is true also of trained scientists – who also neglect to seek to share the mental model by which they achieved a conceptual model. This is significant because it may well be the mental model which governs their actual actions as scientists.

(Greca and Moreira 2000) see the challenge of seeking to align the internal representations held by students (and practitioners) with knowledge that is scientifically accepted as best being addressed by means of modelling. Just as scientists have already learned to play the modelling game, so must students. They need to learn an integrated reasoning process which

> "uses an analogical and visual modelling as well as thought experiments in the creation and transformation of the internal representation of a problem" (Nersessian 1995, p.204)

This modelling process is a semantic one, so that they produce models which are:

> "interpretations that should satisfy the restrictions derived from the text, equations, diagrams, and other salient information sources in the external medium and in the mental representations of those who solve the problems" (Nersessian 1995, p.204).

Thus, the learning process of modelling should be explicit; the students should be explicitly taught the procedures by means of which they can construct mental models that in turn will enable them to understand the taught conceptual models. It is not an easy task to teach the modelling process, even more so when the intention is to help to build useful mental models behind that modelling process. Meaningful learning could be improved if students were taught the construction process – modelling – of the internal representation rather than simply being presented with the complete scientific model.

Learning, enquiry and cognition

∗   Learning

Learning can be viewed as adaptation - see (Ackoff 1999). Learning can also be regarded as conversion of explicit information to personal tacit knowledge - see (Nonaka and Konno 1999).

In order to improve learning - individual, team, wider – we need to see that:

- o The human agent, working with his or her information and knowledge base, is but one agent in a complex network of interacting intelligent agents

- o She has her own memory, augmented by her personal information management system

- o She works in a local network: her team, her community of practice

- o The global network of semantic agents (human, and nascent artificial intelligence) also has access to a memory system: this is the social web (now – Web 2.0) and will be the augmented or extended semantic Web (soon – Web 3.0)

- o Learning itself can occur via planning: (De Geus 1988)

- o Teaching / mentoring can be viewed as agency (Giddens 1986) in effective learning

One source of external information and indeed knowledge is mentoring. Mentoring is more than information or even knowledge exchange. (Bozeman and Feeney 2007, 732) give as their definition:

"Mentoring: a process for the informal transmission of knowledge, social capital, and psychosocial support perceived by the recipient as relevant to work, career, or professional development; mentoring entails informal communication, usually face-to-face and during a sustained period of time, between a person who is perceived to have greater relevant knowledge, wisdom, or experience (the mentor) and a person who is perceived to have less (the protégé)."

∗   Barriers to effective personal information management: capacity for abstraction

(Kramer 2007, p.37) has suggested that

"All these courses require that students are able to perform problem solving, conceptualization, modelling, and analysis. My experience is that the better students are clearly able to handle complexity and to produce elegant models and designs... What is it that makes the good students so able? What is lacking in the weaker ones? Is it some aspect of intelligence? I believe the key lies in abstraction: The ability to perform abstract thinking and to exhibit abstraction skills."

Kramer goes on to discuss the findings of Jean Piaget (Piaget [1955] 1999); see also, (Inhelder and Piaget 1955) on the foundations of an understanding of the cognitive

development of children from infants to adulthood. Only in the fourth and final operational stage of that development does a strong capacity for abstraction emerge:

> "The fourth is the formal operational stage, from around 12 to adulthood, where individuals indicate an ability to think abstractly, systematically, and hypothetically, and to use symbols related to abstract concepts. This is the crucial stage at which individuals are capable of thinking abstractly and scientifically…. Tests conducted on adolescent and adult populations indicate that only 30% to 35% of adolescents achieve the formal operations stage; some adults never do." (Kramer 2007, p.40)

Kramer reports his own experience that teaching model building and analysis gives very encouraging results, particularly when students are given existing models with which to work. However, some students still find it extremely difficult to create their own models ab initio. Although such students are capable of abstract thinking and reasoning, these students seem to lack the skills to apply abstraction… therefore "efforts must be made to measure student's abstraction abilities annually while at college".

However, universal to all effective personal information management is a capacity to categorise and classify data and information. (Ledgard and Taylor 1977) considered an abstraction capacity in the context of the structuring and organisation of data. They suggested the need for the design of data and abstractions analogous to the design of algorithms as operational abstractions. I suggest as axiomatic for this study a clear distinction between *data* and *process*. Almost happily, as we shall see, most personal information management tools concentrate very much on the structuring of data and offer limited or no support for process as such. Pragmatically, it is sensible to teach processes and data initially as separate if orthogonal concerns.

Further, there is some evidence that Kramer is too pessimistic in his contentions. (Bennedsen and Caspersen 2008) reported on a three-year longitudinal study to confirm the hypothesis that general abstraction ability has a positive impact on performance in computing science. Abstraction ability was operationalized as stages of cognitive development for which validated tests exist. Performance in computing science was operationalized as grade in the final assessment of ten courses of a bachelor's degree programme in computing science. To their surprise, they showed that there is hardly any correlation between stage of cognitive development (abstraction ability) and final grades in standard computer science courses, neither for the various groupings, nor for the individual courses.

Reflection, reflexivity and autoethnography

∗ Reflection and reflexivity as an essential part of the research process

(Schön 1983) powerfully argued for *reflection* in and on practice a generation ago. A similar but distinct concept is that of *reflexivity* (Van de Ven 2007). In using the word reflexivity I am consciously referring to a concept which is well understood in the sociological literature (Denzin and Lincoln 2000), (Denzin and Lincoln 2005) and which is closely related to autoethnography. The associated community of practice (Wenger 1998)

ranges in its expression from the frankly autobiographical (Ellis 2002) - as self-justified in (Ellis 1997) in (Tierney and Lincoln 1997) - through the merely personal (Boje and Tyler 2009), (Holbrook 2005) to the more objectively reflective (Humphreys 2005). (McIlveen 2008) explicitly links autoethnography and reflexivity in arguing for their admissibility in the context of vocational psychology research. Reflection on reflection is discussed by (Wall 2006).

There has been a recent backlash against the validity and verifiability of scientific conclusions drawn from autoethnography alone and a consequent attempt to reposition it: e.g. (Tsekeris and Katrivesis 2009).

2.4 My discipline: Information Systems

Information Systems as an academic field

The academic field with which I identify myself is known in the American speaking world as **Management Information Systems (MIS)** and in Europe as **business information systems.** In both North America and Europe it is frequently more simply referred to just as **information systems IS**.

The United Kingdom Academy for Information Systems (UKAIS), of which I am a member, defines information systems thus:

Definition: Information systems are the means by which people and organisations, utilising technologies, gather, process, store, use and disseminate information.

Domain of Study: The domain involves the study of theories and practices related to the social and technological phenomena, which determine the development, use and effects of information systems in organisations and society.

Disciplines

(Biehl, Kim, and Wade 2006) is an empirical study based on the extent of referencing between business journals. They build a spatial representation of these links which shows the centrality of IS and management science MS journals to business research. However, they also show that it is IS and MS journals that quote extensively from other business disciplines rather than the converse.

2.5 What are data, information, and knowledge?

As knowledge workers (Drucker 1999), we engage daily in meta-cognitive processes through which we build our own personal knowledge concerning our own cognitive processes and learning-relevant properties of knowledge, information or data. As a former practitioner and current academic teacher and researcher engaged in doctoral studies, I consider myself to be a knowledge worker who analyses existing knowledge and seeks to create new. As I do so, I also engage in metacognitive processes, i.e. I build personal knowledge concerning my own cognitive processes and learning-relevant properties of knowledge, information or data.

Knowledge defined

Philosophical debates in general start with Plato's formulation of knowledge as "justified true belief". There is however no agreed definition of knowledge, nor any prospect of one, and there remain numerous competing theories.

Knowledge acquisition involves complex cognitive processes: perception, learning, communication, association, and reasoning. The term knowledge is also used to mean the confident understanding of a subject, potentially with the ability to use it for a specific purpose.

We are concerned both with etymology (which deals with the history and development of language and linguistic meaning) and also epistemology (which refers to the philosophy of knowledge).

Knowledge creation

We firstly introduce a working definition of knowledge. This definition is *operational*, based on how we create knowledge.

Tsuchiya (Tsuchiya 1993) suggests an approach built around knowledge creation ability. He states that "Although terms 'datum', 'information', and 'knowledge' are often used interchangeably, there exists a clear distinction among them. When datum is *sense-given* through (an) interpretative framework, it becomes information, and when information is *sense-read* through an interpretative framework, it becomes knowledge" (p.88; italics mine). He emphases how organizational knowledge is created through dialogue, and highlights how "commensurability" of the interpretative frameworks of the organization's members is indispensable for an organization to create organizational knowledge for decision and action. Here, commensurability must be understood as the common space of the interpretative frameworks (e.g. cognitive models or mental models) of each member. Tsuchiya states that "It is important to clearly distinguish between sharing information and sharing knowledge. Information becomes knowledge only when it is sense-read through the interpretative framework of the receiver. Any information inconsistent with his interpretative framework is not perceived in most cases. Therefore, commensurability of interpretative frameworks of members is indispensable for individual knowledge to be shared."

Epistemology

Epistemology or the theory of knowledge is the branch of philosophy that studies the nature and scope of knowledge and belief. The term "epistemology" is based on the Greek words "ἐπιστήμη or episteme" (knowledge or science) and "λόγος or logos" (account/explanation); it was introduced into English by the Scottish philosopher James Frederick Ferrier (1808-1864).

Much of the debate in this field has focused on analyzing the nature of knowledge and how it relates to similar notions such as truth, belief, and justification. It also deals with the means of production of knowledge, as well as scepticism about different knowledge claims.

In other words, epistemology primarily addresses the following questions: "What is knowledge?", "How is knowledge acquired?", and "What do people know?".

There are many different topics, stances, and arguments in the field of epistemology. Recent studies have dramatically challenged centuries-old assumptions, and the discipline therefore continues to be vibrant and dynamic.

A more populist rendition of epistemology (Mark Gregory, after Roger White, University of Leeds; personal conversation) is "how we know what we know".

Language and Classification

Simplistically, language concerns specific instances of general classes of things: occurrences of entity types; or proper and collective nouns. The codification and the management of knowledge start with these insights: we need to group specific instances into entity types (or classes) and to recognise rules (which generalise the relationships between things).

Classification and categorisation

The work of Barsalou, notably (Barsalou 1989), on categories and categorisation, is discussed by (Jacob 2004). Jacob notes that because different features or properties are used to represent the same category at different times and in different contexts, the information associated with a particular category varies across individuals and across contexts. Thus, the set of features associated with a category on any given occasion is composed of both context-dependent and context-independent information. Context-dependent information is relevant only within a particular context. The apparent instability of categories is therefore a reflection of the flexibility and the plasticity that are the power of the cognitive process of categorisation and of the individual's ability to create and modify the informational content of a category as a function of immediate context, personal goals, or past experience.

Barsalou also demonstrated that subjects could rank a robin, a pigeon, an ostrich, a butterfly, and a chair on a single continuum of representativeness for the category "bird"— a continuum extending from the most typical member of the category (robin) to the most atypical member (chair). The evidence for graded structure of categories points to the lack of fixed and determinate boundaries separating members of a category from non-members.

Thus, concepts are frequently, and sometime of necessity, fuzzy. However, there are many contexts in which strict classification is necessary. (Jacob 2004) discusses and distinguishes classification and categorisation.

Data, information and knowledge

It is a long established common understanding that data is transformed into information, and information then feeds or becomes knowledge or even translates into further levels, these being understood and praised as wisdom (Ackoff 1999). Russell Ackoff focuses on

learning from experience in an organizational context. He suggests an extended KID hierarchy:

- Data

- Information – data processed for some purpose

- Knowledge – cognitively processed information

- Understanding

- Wisdom

He sees adaptation as a special situational case of learning.

For a diagrammatic summary of Ackoff's formulation, we suggest Figure 17 below.

In the paper (Gregory, Descubes, and Makovsky 2010) we argued that that sequence – data -> information -> knowledge – is limited and does not encompass the reality of systematic and pragmatic approaches to personal information management (PIM) and personal knowledge management (PKM) systems. We also pointed to an insufficient level of understanding of how to make the best use of personal information management systems to extend the power of knowledge workers to think and to create. In a subsequent paper (Gregory and Descubes 2011d) we firstly summarised and then extended the discussion of the 2010 paper.

The relationship between data and information was initially established in the seminal work of Shannon and Weaver reported in the 1940s (Shannon 1948), (Shannon and Weaver 1949). (Floridi 2005) largely confirms what he identifies as the Dretske-Grice approach, that meaningful and well-formed data constitute semantic information, even as he adds as a qualification that they be contingently truthful. This is despite Claude Shannon's own later observation that "It is hardly to be expected that a single concept of information would satisfactorily account for the numerous possible applications of this general field" (originally written in 1953; see (Shannon 1953)). See also (Capurro and Hjørland 2003).
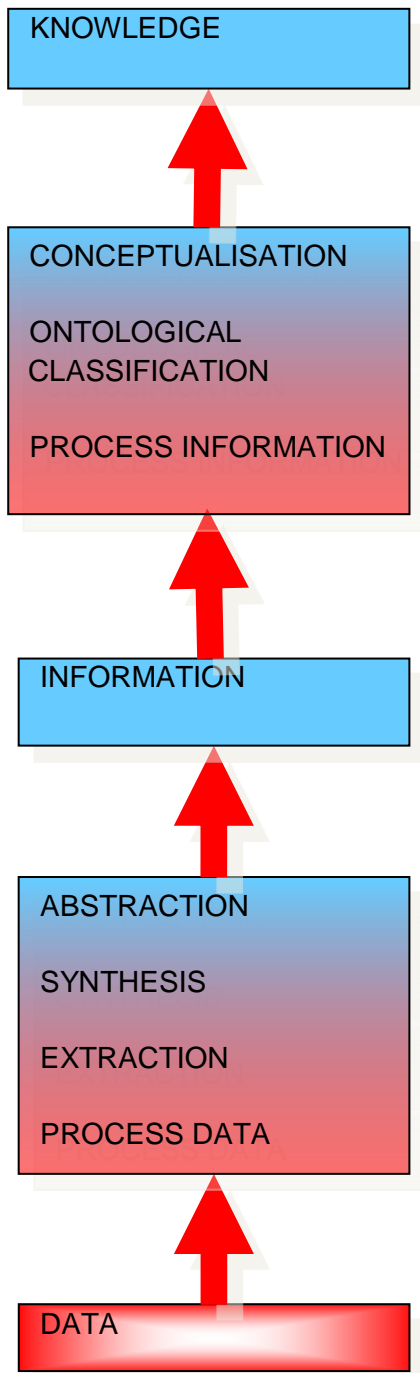
Figure 17 Simple hierarchical data, information and knowledge sequence & "pyramid" *Source: Renaud Macgilchrist, personal communication*
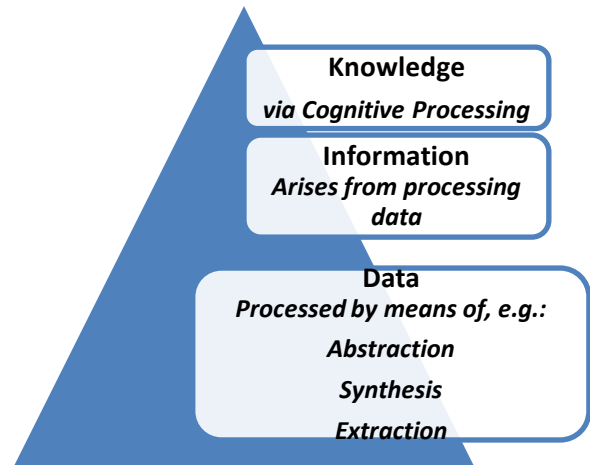
Figure 17 illustrates the commonly-posited data, information, knowledge hierarchy. The diagram is ours, and is illustrative only, being obviously incomplete – for example in its failure fully to elaborate what it means by "process data".

Knowledge, information and data revisited

This section reuses argument previously published in the paper (Gregory and Descubes 2011a).

(K. Wright 2005) views knowledge as an organisational resource or asset, but one that is always vested in the individual. Early organisational knowledge management (KM) initiatives adopted a knowledge-leverage model, based on a view that computers could capture and disseminate information and knowledge throughout the organization leading to increased productivity, cost savings and innovative capacity (Davenport and Prusak 1998). We follow Wright in suggesting that, at least at this stage in the development of artificial intelligence (AI), all knowledge is intrinsically personal.

The very idea that knowledge can be managed is cogently criticised by (T. D. Wilson 2002), who reports that he cannot distinguish much KM from re-engineered information management. Both Wright and Wilson agree that what is manageable by computer is information; for them, knowledge is intrinsically human.

(Tuomi 1999) suggests that it is necessary to reverse the pyramid and create a seemingly illogical sequence "Knowledge -> Information -> Data". Tuomi emphasises the dependence on knowledge for the interpretation of information, and of information to situate the processing of data. The contrasting points-of-view are well summarised by (Alavi and Leidner 2001). We have conceptualised these two views in Figure 17, which shows the forward DIK and reverse KID pyramids in a concept map.
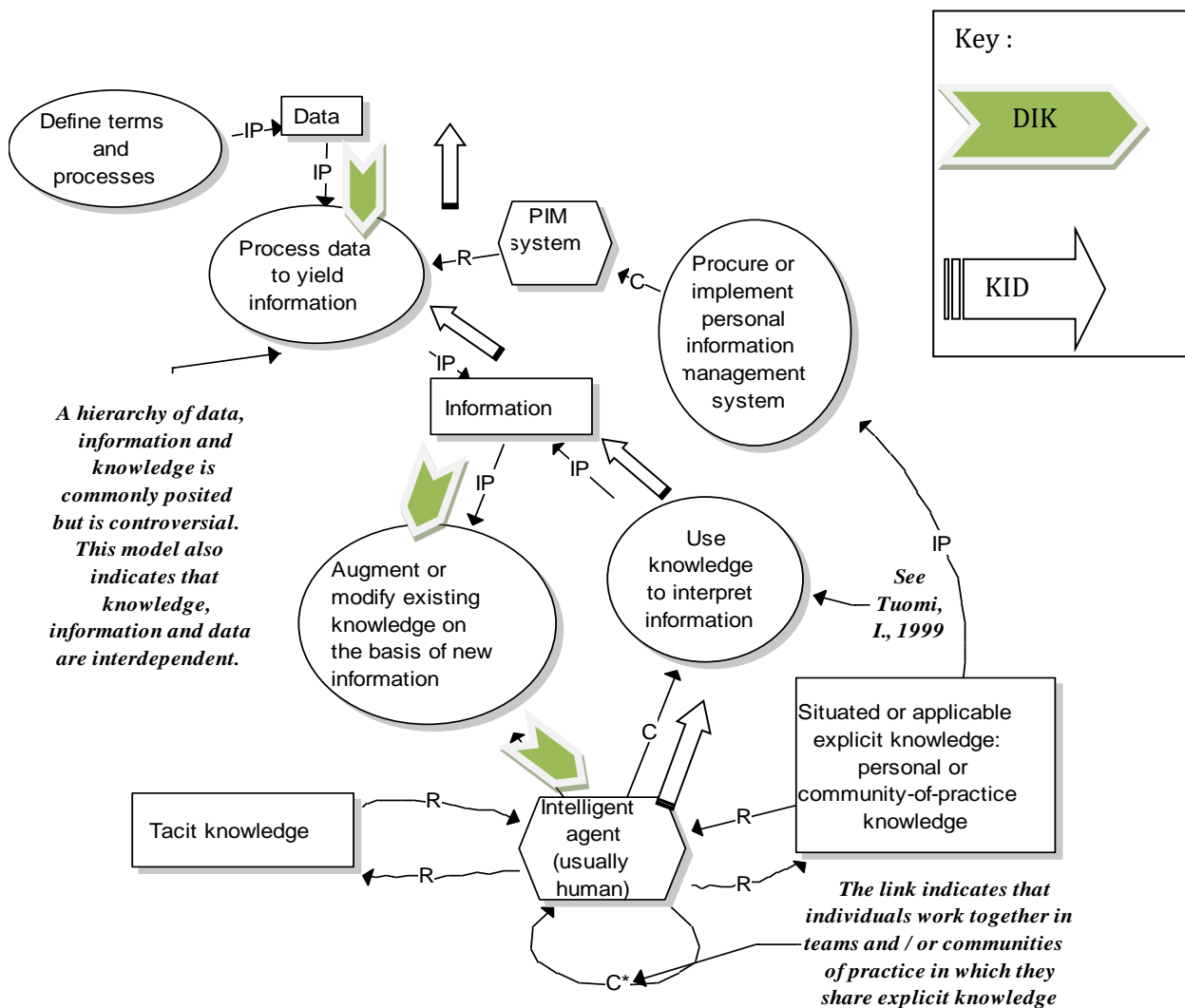
Figure 18 "Data -> Information -> Knowledge" Pyramid revisited: an initial interpretation of the concepts and processes involved

This reversed hierarchy has itself been criticised in an approach developed by (Kettinger and Li 2010). Kettinger and Li have extended (Langefors 1980)' infological equation, suggesting that information is the joint function of data and knowledge. They name their approach the KBI theory, the knowledge-based information theory. They put forward the following initial definitions:

- Data are the measure or description of states of objects or events, usually referred to as a set of interrelated data items that measure the attributes of the objects or events.

- Knowledge is justified true belief of the relationship between concepts underlying these states.
- Information is the meaning produced from data based on a knowledge framework that is associated with the selection of the state of conditional readiness for goal-directed activities.

Information, representing a status of conditional readiness for an action, is generated from the interaction between the states measured in data and their relationship with future states predicted in knowledge. They view data, information, and knowledge as being core to the Information System (IS) field. In response to limitations in existing models, they propose a knowledge-based theory of information. This is extended from (Langefors 1980)' infological equation, suggesting that information is the joint function of data and knowledge. Different forms of IS are conceptualized as the embodiments of knowledge domains capable of transforming specific categories of data into information for business operations and decision-making.

They conclude that the production of information from data needs knowledge, and when knowledge varies, so does information.

Similar concerns had been raised earlier by (Alavi and Leidner 2001), who see knowledge as information possessed in the mind of individuals: it is personalized information (which may or may not be new, unique, useful, or accurate) related to facts, procedures, concepts, interpretations, ideas, observations, and judgments. They posit that information is converted to knowledge once it is processed in the mind of individuals and knowledge becomes information once it is articulated and presented in the form of text, graphics, words, or other symbolic forms. A significant implication of this view of knowledge is that for individuals to arrive at the same understanding of data or information, they must share a certain knowledge base.
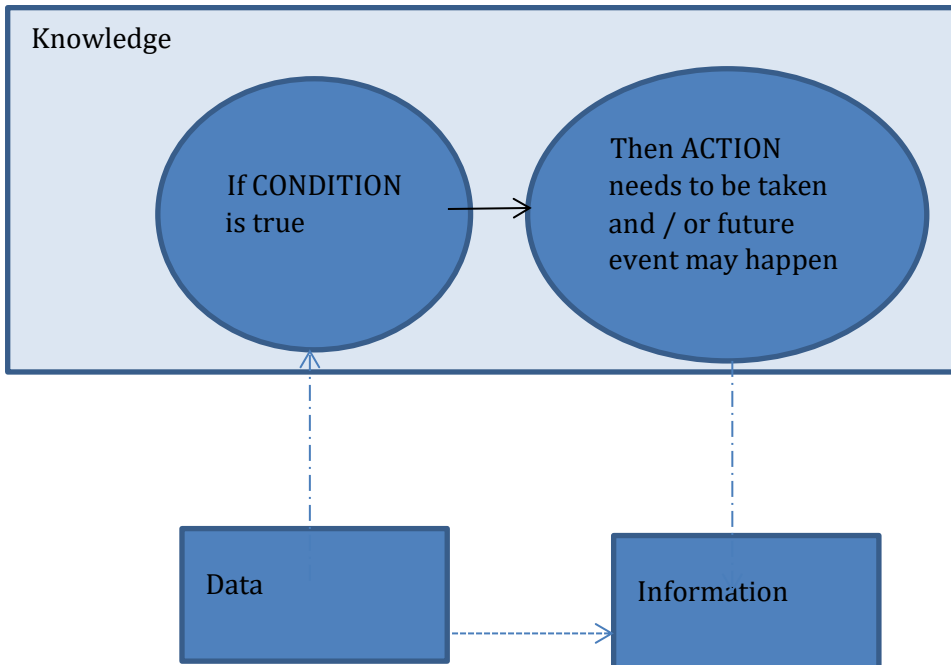
Figure 19 General depiction of the relationship between data, knowledge and information - (Kettinger & Li, 2010)

We would comment that (Kettinger and Li 2010):

1. Emphasise *meaning* as an integral element of information; they do this by reference to (Mingers 1995). [Mingers views information not as processed data but rather as 'data plus meaning'. Mingers distinguishes four levels of information: symbolic empirics, syntactics, semantics and pragmatics. Meaning is generated from the information carried by signs. Information is objective, but inaccessible to humans, who exist exclusively in a world of meaning. Meaning is inter-subjective — that is, based on shared agreement and understanding — rather than purely subjective. Information and information processing systems exist within the wider context of meaning or sense-making (cf. Weick, Sutcliffe, and Obstfeld 2005).]

2. Implicitly reintroduce a crucial element inevitably omitted in any view of data, information and knowledge as static concepts. The missing element is that of *process*.

Extending their discussion, we suggest that a more or less knowledgeable agent transforms data to create meaningful information. The transformation may be represented as a function, or more generally it may be a process carried out by a more or less intelligent agent within a socio-technical information system.

(Johnson 2007) in his review of John Mingers' book (Mingers, 2006) on critical realism in management science suggests that:

> "The fundamental question that Mingers poses is to what extent can a 'critical agent'… stand outside the thing they intervene in, and what is the driving force for them to intervene in the first place?"

For Mingers, motivation for intervention can only come from the individual, who must act either to remove constraints or fulfil absences. A praxis-based conception of knowledge does not separate mind and body: the difference between knowing and doing is dissolved.

Because management information systems MIS is (with management science) one of Herbert Simon's "sciences of the artificial" (Simon [1970] 1996), we would similarly hold that knowing and doing are almost inextricably interlinked and that they meet in individual knowledge and action. (Ågerfalk et al. 2006) argue the generality of this proposition.

2.6 Knowledge

Popper's characterisation of subjective and objective knowledge

(Popper 1978) distinguishes three worlds as he seeks what he terms **objective knowledge** (Popper 1972).World 1 is the physical universe. It consists of the actual truth and reality that we try to represent, as in energy, physics, and chemistry. We exist in this world. However, we do not always perceive it or then represent it correctly.

World 2 is the world of our subjective personal perceptions, experiences, and cognition. The theory of personal knowledge of (Polanyi 1958) is based entirely within this world.

World 3 is the totality of the abstract products of the human mind – such as booksand similar artefacts. While knowledge may be created and produced by World 2 activities, its artefacts are stored in this world. There are various relationships between these three worlds:
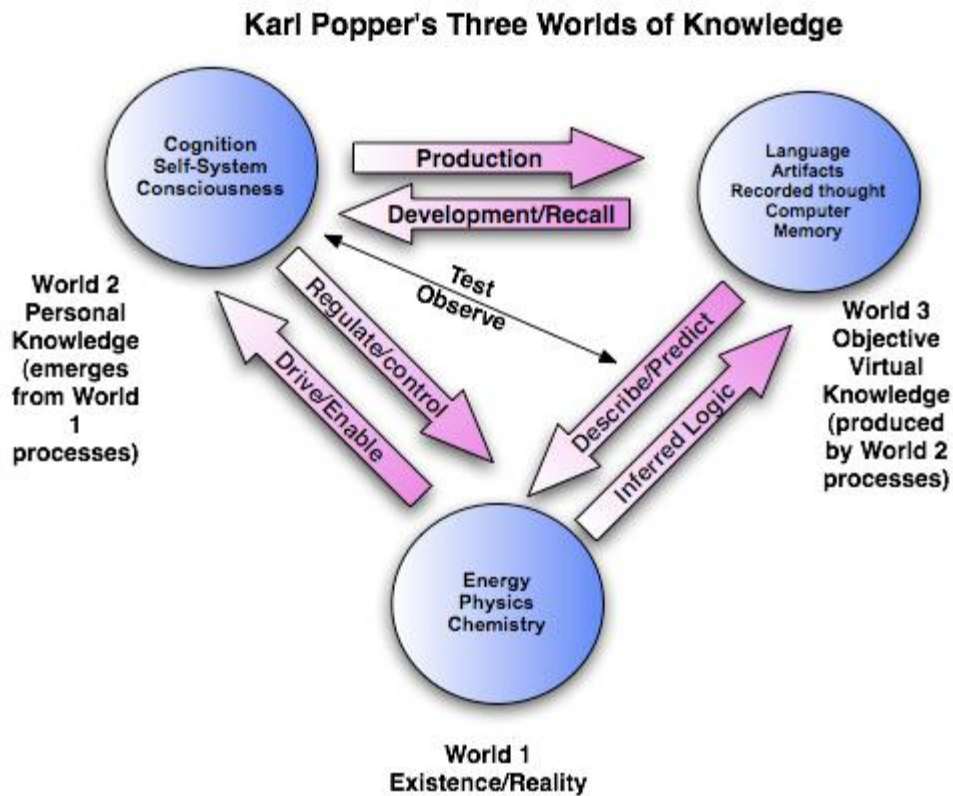
Karl Popper's Three Worlds of Knowledge

Figure 20 Popper's Three Worlds

(Source: http://www.knowledgejump.com/knowledge/popper.html accessed 20/12/2016)

We can summarise Popper's thinking here (text adapted from http://www.knowledgejump.com/knowledge/popper.html accessed 20/12/2016) as a framework yielding two different senses of knowledge or thought:

"Knowledge in the subjective sense, consisting of a state of mind with *a disposition to behave or to react or to act.*

Knowledge in an objective sense, consisting of the expression of problems, theories, and arguments.

While the first is personal, the second is totally independent of anybody's claim to know — it is knowledge without a knowing subject."

See also Table 6 below.

Data, information, knowledge and the economic agent

(Boisot and Canals 2004) consider the issue primarily from an economic point of view. In doing so, they introduce two useful perspectives.

One is to make a clear distinction between data and information by discussing cryptography. Without a key to an encrypted message, we have only a flow of data. With a key, we have information in the sense discussed by Claude Shannon and his collaborators (Shannon 1948), (Shannon 2001), (Shannon and Weaver 1949): "Thus

while the data itself can be made "public" and hence freely available, only those in possession of the "key" are in a position to extract information from it".[9]

A second useful perspective which is implicit in the work of many other writers but is made explicit by (Boisot and Canals 2004) is that knowledge exists in the head of an agent. They criticise the notion of information and knowledge as "things". They define information as "an extraction from data that, by modifying the relevant probability distributions, has a capacity to perform useful work on an agent's knowledge base."
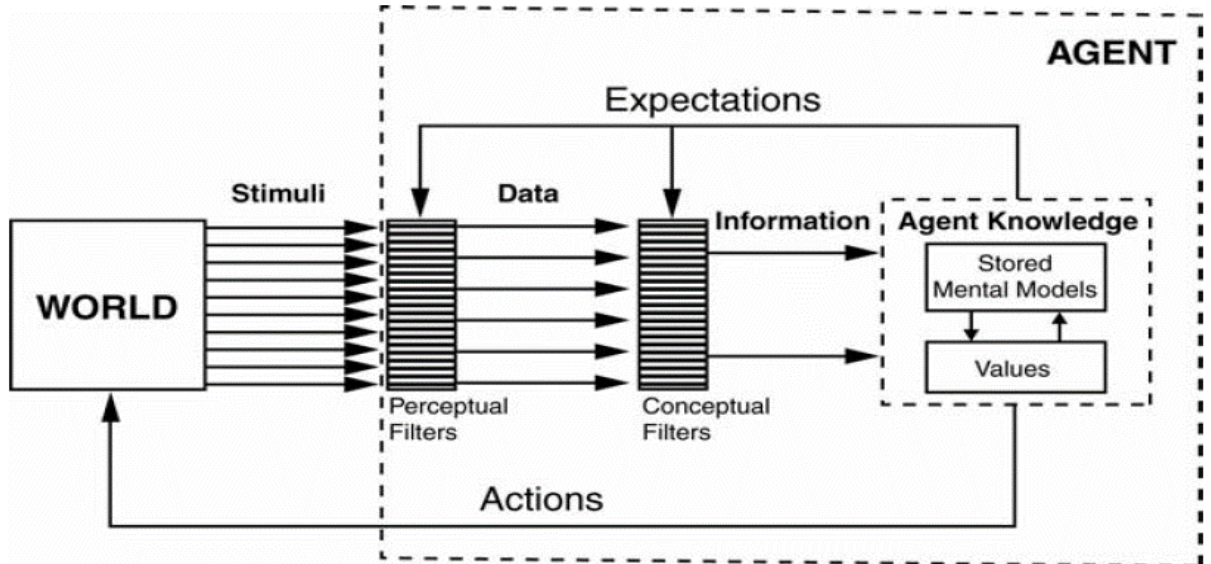
They posit Figure 21:

Figure 21 The agent-in-the-world (Boisot & Canals 2004)

(Boisot and Canals 2004) state:

> "Building on the concept of entropy that information theory shares with thermodynamics, we would like to suggest that information-bearing data may be likened to free energy in a physical system. That is to say, data that carries information retains a capacity to do work – i.e., it can act on an agent's prior state of expectations and modify it"...

> "The act of extracting information from data constitutes an interpretation of the data. It involves an assignment of the data to existing categories according to some set of pre-established schemas or models that shape expectations. For this to be possible, such schema or models must already exist in some form or other. But how do such schemas and models come into existence in the first place?

> "They do so primarily through explicit or tacit rules of inference. Explicit rules will for the most part be applied to codes; implicit rules will be applied primarily to context. Expectations and categories co-

[9] See below in section 0 for a discussion of the basis for this result in the original work of (Shannon 1948), (Shannon 2001), (Shannon and Weaver 1949)

evolve, with expectations shaping the categories that we create, and these, once created, in turn shape the evolution of subsequent expectations. Our categories condition the dispositions that we adopt towards the world – i.e., our knowledge, taken here in the Popperian sense of a disposition towards action (Popper 1972). Thus, data can only constitute information for an agent who is already knowledgeable."

Knowledge, information and process

A single synthetic view of data, information and knowledge is elusive and likely to remain so. However, an emergent theme is that of action through agent, activity and process. Information and knowledge have value only insofar as they are actually used (because usable and useful), that is, use is enacted.

Organisational knowledge

♦ Views of knowledge: (K. Wright 2005) - organisational resource, asset

Kirby Wright (K. Wright 2005) summarises this approach as "Early KM initiatives adopted a knowledge-leverage model, based on a view that computers could capture and disseminate information and knowledge throughout the organization leading to increased productivity, cost savings and innovative capacity e.g. (Davenport and Prusak 1998)".

Kirby Wright argues here and elsewhere (see also, Wright 2007) that, at least at this stage in the history of AI (artificial intelligence), all knowledge is intrinsically personal.

2.7 Knowledge representation

Back to basics: Organising data

Data and information is more or less organised. It can take the form of texts, lists, graphs, tables, related tables, objects, etc.

Dictionaries are essential to organising data and information; they are an example of metadata, that is, data about data.

The better the organisation the easier it is to exploit the underlying data.

There are many ways of organising the same data. We often need to change the organisation of data according to the needs.

Reorganisation or conversion is a common need of individuals and organisations. (For example we convert an Excel table to an Access table).

Knowledge and data representation

Existing KR techniques vary in their:

* Expressiveness

* Precision

* Ease of comprehension

* Degree of abstraction (Hoare 1972)

The more abstract, the more precise we can be in expression and manipulation (potentially even by machine); but less generally applicable, and more difficult to learn.

* Knowledge workers cannot really survive only with one data and knowledge representation approach

Especially if that is "just" natural language (which is in fact extremely rich semantically), but is "only" the expression of a single individual in a specific context.

A justification for visual modelling: graphical analysis (GA) and representation (GR)

This section borrows heavily from (Shiu and Sin 2006).

* Why are both GA and GR useful?

Both qualitative and quantitative analyses play important roles in information and knowledge management.

Unfortunately, people who prefer qualitative analysis may consider quantitative analysis "tedious mathematics", while people who prefer quantitative analysis may consider qualitative analysis "imprecise, if not empty."

They argue that GR and GA can bridge the gap between qualitative and quantitative analyses by quantifying the concepts and conceptualizing the quantities.

* Top-down, Middle-out, and Bottom-up Processes

In cognitive psychology and cognitive science, top-down and bottom-up processes refer to processes that flow from either the top or the bottom of the information processing hierarchy, respectively (Lindsay and Norman 1977).

The top of the hierarchy is assumed to contain high-level, abstract, and encompassing knowledge representations such as concepts, mental models, and schemata.

The bottom of the hierarchy is assumed to contain low-level, concrete, and specific knowledge representations such as visual features, lexicons, and propositions (e.g., (Bruning, Schraw, and Ronning 1999); (Kintsch 1998)).

Bottom-up processing draws from some particular examples, instances, cases, or events to a generalization, rule, or law to capture the commonality between the examples, instances, cases or events - e.g., (Brown, Collins, and Duguid 1989).

Top-down processing infers from a generalization, rule or law to conclude something about a particular example, instance, case, or event.

Induction is an example of bottom-up processing and deduction is an example of top-down processing.

    *   Graphical approaches to Top-down, Middle-out, and Bottom-up Processes

(Shiu and Sin 2006) suggest that graphical representations and analyses could be very useful devices that bridge the gap between top-down and bottom-up processes; bridging theories and facts:

- GR are not as abstract as theories or concepts - they may portray the important features of abstract theoretical concepts in a concrete form

- GR are not as concrete as empirical facts or events - they may delineate theoretical explanations in a sequence of discrete steps

Using concept maps to make knowledge representation more visual

In the processes of teaching and of research, we frequently resort to creating simple diagrams or sketch maps of the topics we are seeking to illustrate. One largely-informal representation mechanism which has seen widespread use is that of mind mapping (T. Buzan & B. Buzan 1996). Mind maps can be criticised for giving primacy to a single central concept or question.

A related technique, also widely used, is that of *concept maps.* Concept maps may give primacy to a single question but do ṇot make one single concept central to the whole diagram.

Concept maps were identified by Joseph Novak (Cañas and Novak 2006); (Novak and Cañas 2008). Their use in information systems teaching and assessment contexts is discussed by (Croasdell, Freeman, and Urbaczewski 2003). They are a very useful way of summarising the model-maker's understanding of knowledge and, as such, highly complementary to the use of natural language, specifically as represented textually. I have been making use of a particular kind of concept map as described by Gilbert Paquette and his co-workers at the LICEF research centre of the *Télé Université de Québec de Montréal* (Paquette 2010). Paquette and his co-workers distinguish *processes, concepts and principles* – see Figure 22. Their approach, *la modélisation par objets typés* - typed object modelling - is implemented by means of software called Mot+ (subsequently, G-MOT).
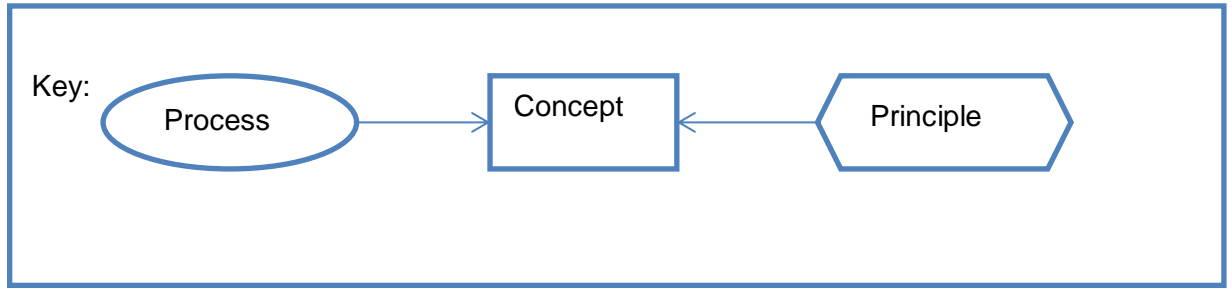
Figure 22 Objects (and links) have type (Paquette 2010)

Paquette notes that process and procedure are near-synonyms in this context.

The approach also cclassifies the links (relationships) between objects:

C	Composition
S	Specialisation
R	Regulation
P	Precedence
I	Instantiation
IP	Intrant-Product
A	Application
C*	multiple Composition
NT	Non-typed (untyped)

Table 5 Link types in Mot+

Mot+ modelling can be seen to be heavily influenced by object-oriented analysis and design, as described by (Deacon 2005), (Bennett, Farmer, and McRobb 2010). The Mot+ approach thus introduces greater semantic precision by means of typed concepts and relationships.

Criticism of the LICEF approach

Distinguishing process, concept and principle is useful. It might even make it possible to carry out more-or-less formal quantitative analyses of the contents of concept maps, which is potentially valuable as the basis of metrics for assessment. However, Mot+ does not allow a relationship to be labelled in the same simple way that does, for example, Novak's Cmap software. Instead, in Mot+, each relationship has a type. Theoretically useful because it increases the expressive power and semantic precision of the concept map, it necessitates the use of an additional concept to express even a simple proposition. Thus, John loves Mary is modelled using two concepts-as-facts John and Mary and one process, loves. This makes the diagram more complex and somewhat more difficult to read. Deciding how to type (classify) the relationships between John and loves and between loves and Mary is not straightforward and requires a good understanding of the Mot+ modelling technique. Thus, increased precision can only be achieved at the expense of greater

complexity and an increased possibility that the modeller, the reader or both will make mistakes.

An application of the LICEF approach

In Figure 23 we present an example of a concept map with forward and feedback loops highlighted; the application is to research on personal knowledge management PKM. The diagram is of historical interest in the current research. It represents an early stage in a process elsewhere identified in this thesis as semiotic morphogenesis. A consideration of knowledge creation by researchers and knowledge synthesis by teachers suggests the need for an inner-loop and an outer-loop. The inner loop depends on the practice of structured self-observation SSO to generate concepts and the subsequent outer loop concentrates on engaged research, e.g. action research, to refine them. Hence, we consider that we individually observe our own practice of PKM (SSO) as also we observe and work with others as they practise PKM (action research). So the SSO method is a crucial part of a reflective study of PKM. That reflection is greatly informed by the discovery of paradox and by learning from mistakes (ours and others). We are working with our information and knowledge base, partially explicit in the form of tables of data and documents relating to teaching and research, but partially also tacit in the sense discussed by (Nonaka and Takeuchi 1995). We interact in a complex network with other intelligent agents. The importance of reflection on practice is described in (Argyris 2000), as is the notion and utility of a double loop; see also (M. K. Smith 2001) for a recent summary of Argyris' work and an assessment of its ongoing significance.

Figure 23 is in fact a small extract of the overall concept map which describes and guided my doctoral research. It is at the same time a developing part, but also a product, of systematic self-observation and of reflection on the learning process.

Later in the process of undertaking this doctorate, I created the Conceprocity concept process reciprocity knowledge modelling language. However, I have left several of the earlier Mot+ / GMOT maps in this thesis since they demonstrate a phenomenon which I will subsequently identify as semiotic morphogenesis – see section 6.2. An evidence for such semiotic morphogenesis is the evolution in the mapping language used.
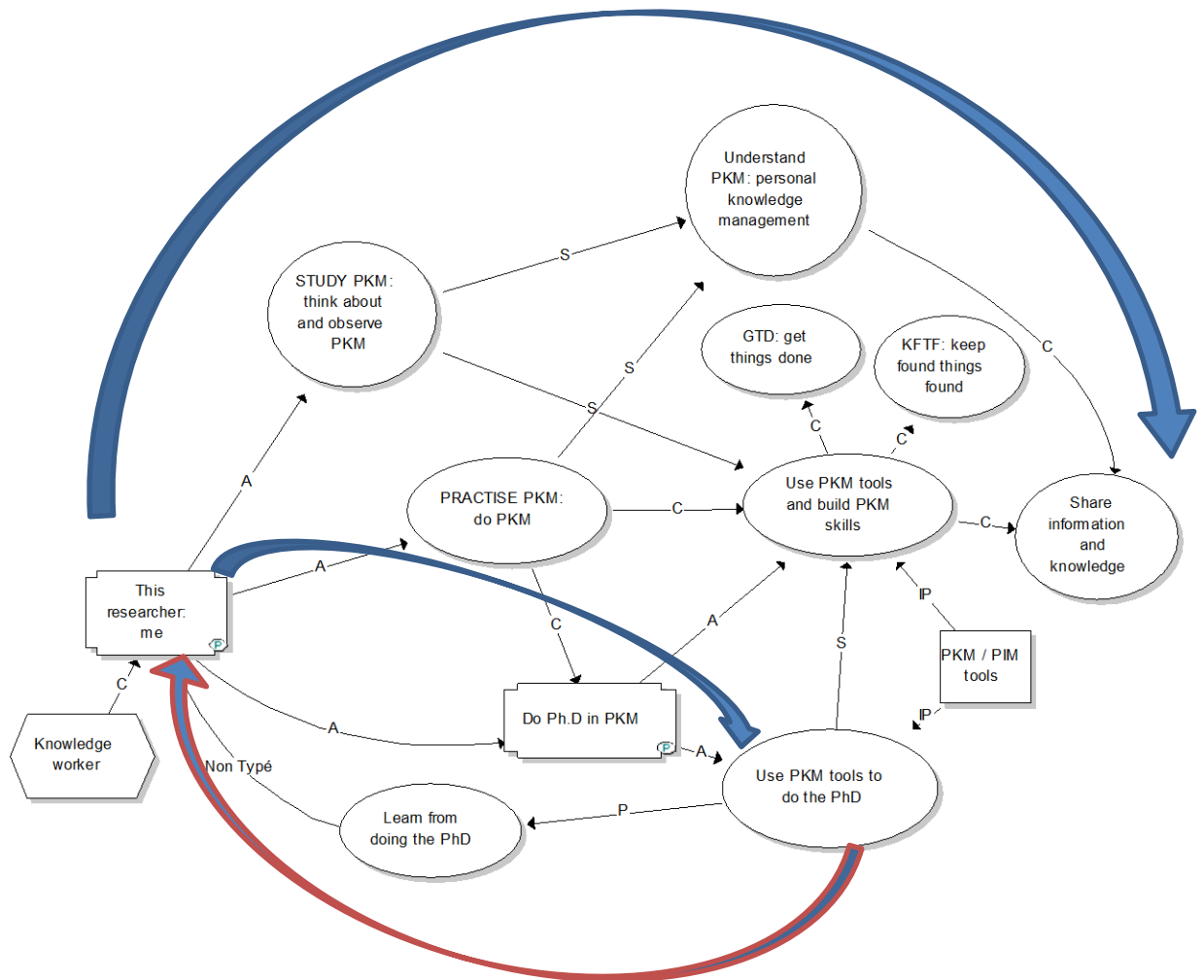
Figure 23 Part of a concept map with forward (high- and low-level) and feedback loops emphasised: a model of undertaking a Ph.D. concerning and using PKM

Example concept map (extract) with meta-annotation

> I distinguish between what I do, how I act; and the knowledge, information and data which I use as I do or act. When I do something, I act: I carry out specific actions, I carry out an activity. In his work systems framework, (Alter 2003) identifies processes as repeatable prototypes for specific actions. Early systems analysis methodologies, such as (Yourdon & Constantine 1976), make a clear distinction

between process and data. In a parallel manner, (Paquette 2010) distinguishes processes from concepts. The specific form that this takes in his Mot+ representation is exemplified in Figure 24. Note the distinction also made between the general class, e.g. of process, and a specific instance.
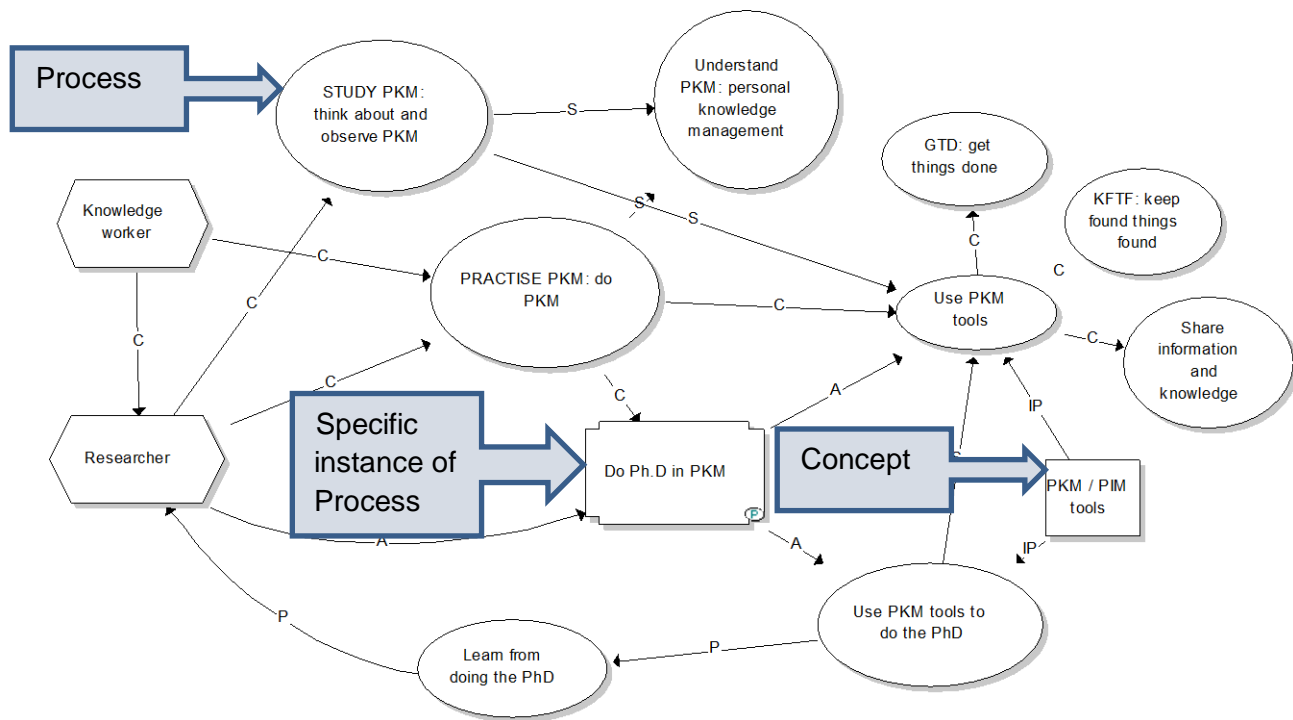

Figure 24 Examples of process, concept and instances in Mot+

It is possible to criticise a clear distinction between process and data, not least because it represents an abstraction which this author has found difficult in practice to teach. Thus, in computer programming, the original clear distinction between algorithm and data that we find for example in (Wirth 1985) gave way to the object-oriented paradigm which sought to encapsulate data and process within so-called objects. Similarly, structured design, with its clear distinction between business process and business data, gave way to object-oriented analysis and design but also to business process modelling.

I argue the pragmatic necessity to make a clear distinction between these concepts:

- *what we do:* our actions (D. Allen 2003), activities, processes and work systems (Alter 2002), (Alter 2003)

- *what we act upon:* our stored data and kept information

- *how we act:* our knowledge and our theories-in-use (Argyris 1982), (Smith 2001)

- *how we act:* the personal data, information and knowledge-representation tools that we use

- *how we act:* the techniques and methodology that we apply as we act and as we solve problems in everyday life

- *how we learn:* both at the low-level "how-to", but also at the higher reflective level

Whence comes this pragmatic necessity? From what I regard as my professional obligation as a teacher of information systems to take a systematic and systems-thinking-led approach which learns from well-established principles. In the immediate methodological context, we note as applicable principles those of *orthogonality* and of *separation of concerns*.

Hbguhjgj

Towards a working model of PKM

Just as (Argyris 2000) demonstrated the need for what he called "double loop learning" in the context of organisational learning, so too my working model of PKM requires an inner-loop and an outer-loop. (For an excellent summary of Chris Argyris' work, I have used (M. K. Smith 2001).)

In an inner loop, I engage in day-to-day doing – I as a researcher do work towards a Ph.D.

I observe myself (autoethnography and action research)

To do this, I observe myself as I PRACTISE PKM.

In an outer loop, I observe others (ethnography) and I work with others (action research) as they PRACTISE PKM.

My observation forms a crucial part of a reflective STUDY of PKM.

That reflection is principally informed by the discovery of paradox and by learning from mistakes (mine and others); more generally, by reflection as introduced by (Argyris and Schön 1974); see also (M. K. Smith 2009). (Smith 1999) considers the origins of the concept of reflection in the work of the American pragmatist John Dewey – see also (Dewey 1933), and (Dewey 1960), going on to consider the development of that thinking in (Schön 1983), (Schön 1987) and the significance of emotions in reflection, quoting (Boud, Keogh, and Walker 1985).

2.8 Information as data associated with meaning

Semiotics

In the current document, which you may be accessing by reading it as a printed document, or which you may read online in some form or another: a string of characters appears, and forms the word which you have just read as 'semiotics'. This character string is a *signifier*, of something (object, concept...) which semiotics refers to as the *signified*. Semiotics was first identified by the European writer de Saussure a century ago, and independently by the American Charles Peirce. (Chandler 2007) emphasises:

"semantics: the relationship of signs to what they stand for;

syntactics (or syntax): the formal or structural relations between signs;

pragmatics: the relation of signs to interpreters. "

Roland Barthes, writing in French, established many useful terms in the field of semiotics. According to (R. Wright and Flores 1998), Barthes defined semiotics thus:

"The noun form of the study of signs and signification, the process of attaching signifieds to signifiers, the study of signs and signifying systems…"

Semiotics began to become a major approach to cultural, communications and media studies in the late 1960s, partly as a result of the work of Roland Barthes. However, its significance for personal knowledge management derives more from the pragmatic American stance of Peirce interpreted by (Morris 1938). Where semantics concerns itself primarily with spoken and written "natural" language, semiotics extends syntax, semantics and pragmatics to all forms of communication. A semiotic approach has therefore become well established and widely used particularly in the field of communication and media studies because, pragmatically, it has been found to be useful in understanding cultural phenomena. Nevertheless, strong proponents such as (Chandler 2014) recognise that semiotics is neither a discipline nor a science in itself. There are competing theoretical assumptions, and even rival camps.

KR knowledge representation: conceptual graphs

The distinction between a conceptual data structure and a more fully-formed knowledge representation is not straightforward, being largely one of degree. (John F. Sowa 2000b) summarises his work on conceptual graphs – based on Peirce's existence graphs. He demonstrates that this graphical model has the expressive power of first order logic and is therefore a candidate knowledge representation (KR) approach in instances when it is valuable to draw automatic inferences from data.

Natural language and linguistics

de Saussure argued that 'nothing is more appropriate than the study of languages to bring out the nature of the semiological problem'. He saw linguistics as a branch of 'semiology'.

However, language is about more than linguistics, as de Saussure recognised in distinguishing between *langue* (language) and *parole* (speech). *Langue* refers to the system of rules and conventions which is independent of, and pre-exists, the individual use and usage to which *parole* refers.

Information Theory

Claude Shannon (Shannon 1948); recently republished as (Shannon 2001) wrote a theoretical paper on the mathematical theory of communication in the Bell [Telephone] System Technical Journal which had an immediate impact when first published in 1948, enhanced the following year when a mathematician colleague Warren Weaver suggested republication in a more widely-read forum.

Shannon and Weaver's papers do not name the subject 'information theory'. Instead, they stated four key concepts which (Aftab et al. 2001) identify as:

Every communication channel has a speed limit, measured in binary digits per second and given by the formula $C_t = W \log_2 \frac{P+N}{N}$; this so-called Shannon Limit, beyond which it is

"mathematically impossible to get error free communication above the limit. No matter how sophisticated an error correction scheme you use, no matter how much you can compress the data, you can not make the channel go faster than the limit without losing some information… below the Shannon Limit, it is possible to transmit information with zero error. Shannon mathematically proved that there were ways of encoding information that would allow one to get up to the limit without any errors: regardless of the amount of noise or static, or how faint the signal was. Of course, one might need to encode the information with more and more bits, so that most of them would get through and those lost could be regenerated from the others. The increased complexity and length of the message would make communication slower and slower, but essentially, below the limit, you could make the probability of error as low as you wanted."

It demonstrates that any communication system can be separated into components, which can be treated independently as distinct mathematical models. Thus, it is possible to completely separate the design of the source from the design of the channel.

Digital representation of the content of a message is irrelevant to its transmission: it does not matter what the message represents. It could be text, sound, image, or video, but it is all 0's and 1's to the channel. Once data is represented digitally, it can be regenerated and transmitted without error.

Coding a source removes redundancy in the information to make the message smaller, thus increasing the efficiency of information representation. The term 'source coding' is today synonymous with 'data compression'.

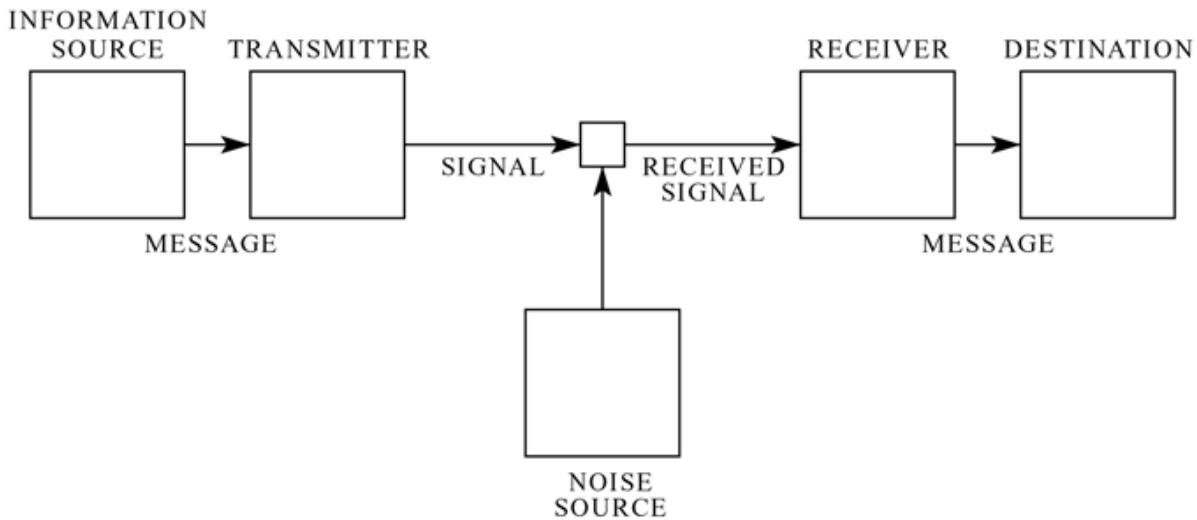(Shannon 1948) represents the situation as:

Figure 25 Shannon's architectural representation of information transmission across a digital data communication channel

We can draw the following implications for our study:

Information can be transmitted across data channels either without loss (if the required rate of transmission falls below the Shannon Limit for the channel) or (above that rate) with a level of loss which can be measured.

Data and information are not the same things. The interpretation of a message is independent of the existence and low-level representation of that message.

This supports the arguments advanced earlier, in section 2.6 concerning the definitions of data, information (and knowledge). (Ison 2013) notes that Heinz von Foerster, reflecting on the Macy conferences, later said that it was an unfortunate linguistic error to use the word information instead of signal.

2.9 Towards meaningful data: making semantics more explicit

In this section, I note how the literature and software support the need to make semantics explicit. This has the incidental effect of making it somewhat more likely that the meaning intended by the initiation of communicated information will be the meaning shared by recipients.

Candidate data management approaches

♦   Outliners and Developed Outliners

The author used NetManage ECCO Pro. Another well-used program is Micro Logic's Info Select 10. The internal data structure of these programs is similar. A data item is given meaning by being shown in its owning hierarchy. Thus, a person's surname is a component of a composite Contact object.

Part of the genius and the weakness of these programs is that the user has considerable control over the structuring of data. Both ECCO and Info Select permit the definition of forms to impose some order on this anarchy. A second aspect of

their genius is that a data item can participate in more than one hierarchy. Thus for example, an appointment for a meeting can appear in an overall agenda or calendar, but also be linked to the name of each participant in the meeting. Effectively, the same datum is classified in more than one way. To the extent that knowledge is a product of the recognition by intelligent agents of connections between information otherwise not explicitly linked, this kind of tool can be used as a mechanism for storing some forms of relatively unsophisticated knowledge.

To give a flavour of this kind of tool, consider this screen capture from ECCO:
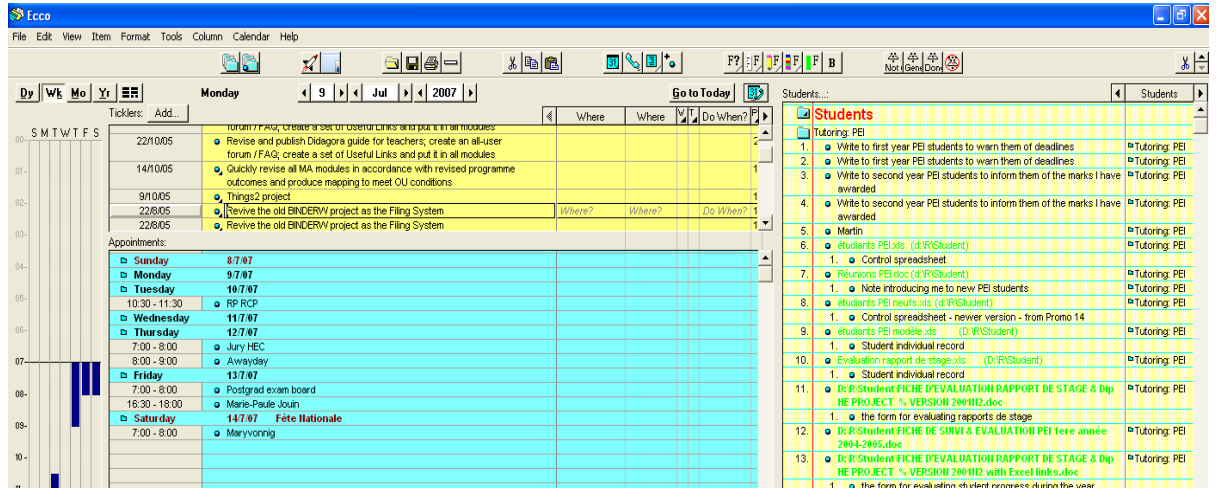
Figure 26 ECCO personal information manager - screenshot

This screenshot shows a user's diary or calendar, and the contents of two user-defined folders: Students and Tutoring.

It will be apparent from the dates on the screenshot that this is a program which I used for more than a decade to manage my personal data and to inform me in my everyday working life. However, outliners have always been a minority interest, used by relatively few knowledge workers. Small companies such as NetManage and Micro Logic have had great difficulty marketing outliners as PIM tools. In part this is because most knowledge workers work within corporate structures which provide standard software sets to the employees. Thus for example in many enterprises the personal productivity aids available to the employee are those which are provided within the Microsoft Office suite. Employees may be discouraged or even banned from using applications which are not corporately approved. Another reason that it has proven difficult to introduce outlining to a wider public is that there is an increasing expectation that software should be free, at least at the point of use. Whether by using open source software or because software is made available by the employer, the individual knowledge worker is not accustomed to having to pay for software. But the creation of new and relatively innovative applications has historically required that a revenue stream accrue to their originators. Thus, there have been many PIM applications developed, very few of which have survived to become mature and well established. NetManage Ecco is still used by a small band of devoted admirers many years after its development ceased – NetManage could not make the profit they needed from the product. Most employees have meanwhile

www.manaraa.com

continued to use tools available from within standard office suites to manage their personal data.

♦ Basic data management tools exist in proliferation: such as spreadsheets and databases

Spreadsheets are a very powerful combination of the nearest approach to widely available end-user computer programming ever invented; and ways of storing (more or less) structured data in which the relationship between items of data is imposed by the use of formulae.

It is possible to use spreadsheets and database management systems as the means by which personal data is stored, in other words, as the means by which a given individual carries out personal information management.

♦ Spreadsheets – in general

There are many problems associated with spreadsheets. See (Burnett et al. 2001) and (Peyton Jones, Blackwell, and Burnett 2003) for a discussion and suggestions of ways forward.

♦ Functional spreadsheets

The Functional spreadsheet is an idea which the author originally devised in 2007. See also (Burnett et al. 2003) and (Wakeling 2007)

A functional spreadsheet deliberately simplifies and restrict the scope of spreadsheets, so that they can be formally represented, modelled, discussed and tested. The idea is based on an insight documented by Simon Peyton Jones, of Microsoft, (Peyton Jones, Blackwell, and Burnett 2003) but goes well beyond that paper (which constrains itself to consider only developments of Excel, not new approaches). A flavour of the concept is provided by this screenshot of a storyboarded interface.

Things2Do		D:\q\Things2\Spreadsheet metaphor.doc			
	Value →	DueDate	InitialPriority	{CurrentPriority}	EffortPersonDays
Text ↓	Group Function →	{GroupMax}		{GroupMin}	{GroupSum}
1. Define user requirements		01/03/2007		1	11.5
1.1. Head 2		19/02/2007	3	1	4
1.2. Head 2		21/02/2007	3	2	5
1.3. Head 2		01/03/2007	3	3	2.5
2. Build interface prototype		01/03/2007		3	
2.1. Head 2		19/02/2007			
2.1.1. Head 3		19/02/2007			
♦ Head 4		21/02/2007			
* Head 5		01/03/2007	4	3	

Figure 27 Potential functional spreadsheet - storyboard

The major advances over current spreadsheets are in two areas. A single function and a single group function applies to each column of the spreadsheet. Nominally user-defined functions are supported. The ideas draw on the possibilities provided by the Oz programming language and Mozart program development environment described in (Van-Roy and Haridi 2004). Although the notion has been storyboarded, it has not been implemented in any practical form. Instead, similar ideas have surfaced in a product called InfoQube which is discussed later in this thesis (section 0).

♦   Relational databases

The currently dominant relational paradigm (albeit now challenged by NoSQL approaches (Stonebraker 2010)) enables arbitrary manipulation: that is to say that queries can be defined which will always have an answer. However, the data is constrained to appear in normalized relations or sets or entities – these terms are equivalent (Date 2003); they are implemented as database tables.

♦   Object-oriented databases

The object-oriented data paradigm allows other kind of associations between entities types; further, the structure of an entity, its class description, is much richer than the normalized model. However, the approach has two disadvantages:

1. There is no software known to this author that permits end users to create and manipulate such databases;

2.   It is no longer possible always to obtain an answer to a question.

There is also a third disadvantage: because there is no rule of normalisation it becomes very difficult for community of users to share the data.

Business database applications generally store data in relational structures while such things as pictures, video, audio etc. are often stored in object-oriented database.

♦   XML documents

The files on a typical computer can be loosely divided into documents and data. Documents, like mail messages, reports and brochures, are read by humans. Data, like calendars, address books, playlists and spreadsheets, are presented using an application program which lets them be viewed, searched and combined in many ways.

Currently, the World Wide Web is based mainly on documents written in Hypertext Markup Language (HTML), a markup convention that is used for coding a body of text interspersed with multimedia objects such as images and interactive forms. A specific vision of the semantic web involves publishing the data in a language, Resource Description Framework (RDF), specifically for data, so that it can be manipulated and combined just as can data files on a local computer (Schwarz 2006).

The HTML language describes documents and the links between them. RDF, by contrast, describes arbitrary things such as people, meetings, and aircraft parts.

* XML

XML (eXtensible Markup Language) is a specification developed by the W3C (World Wide Web Consortium) (XML 2010).

* Why is XML important?

Extensible Markup Language (XML) is a simple, very flexible text format derived from SGML. Originally designed to meet the challenges of large-scale electronic publishing, XML is also playing an increasingly important role in the exchange of a wide variety of data on the Web and elsewhere.

* How does XML compare with other data management approaches?

XML is an excellent data interchange mechanism, and is very widely implemented. It is verbose and less efficient than SQL for database-to-database exchanges. But it is unique in forming the basis for web services and service oriented computing; and as the basis for the Semantic Web.

♦ RDF and OWL: the basis of a semantic web

The Resource Description Framework (RDF) (W3C 2004) integrates a variety of applications from library catalogues and world-wide directories to syndication and aggregation of news, software, and content to personal collections of music, photos, and events using XML as an interchange syntax. The RDF specifications provide a lightweight ontology framework to support the exchange of knowledge on the Web.

Making sense of data: the meaning of meaning

Sense-making (Weick, Sutcliffe, and Obstfeld 2005) is an elaborate and very discursive attempt to make sense of how we make sense.

At the time at which I first encountered the article, I attempted to model it and I wrote:

> "The concept map that follows (Figure 28) is an attempt I have made to make sense (sic) of sense-making understood in organisational behaviour terms. It is not completely accurate: it's an attempt to make sense of sense-making. In part this is due to the fact that the style of literature is outside my normal reading. It may also be due – in part – to unwillingness on the part of the authors to accept constraints such as the limited capacity of human short-term memory. The authors have done little to break their reflections up using headings and sub-headings, for example. The article – which is very rich and very interesting to read – may well communicate better to people more versed in this literature than am I. I needed to make a concept map in order – literally – to begin to make sense of it."
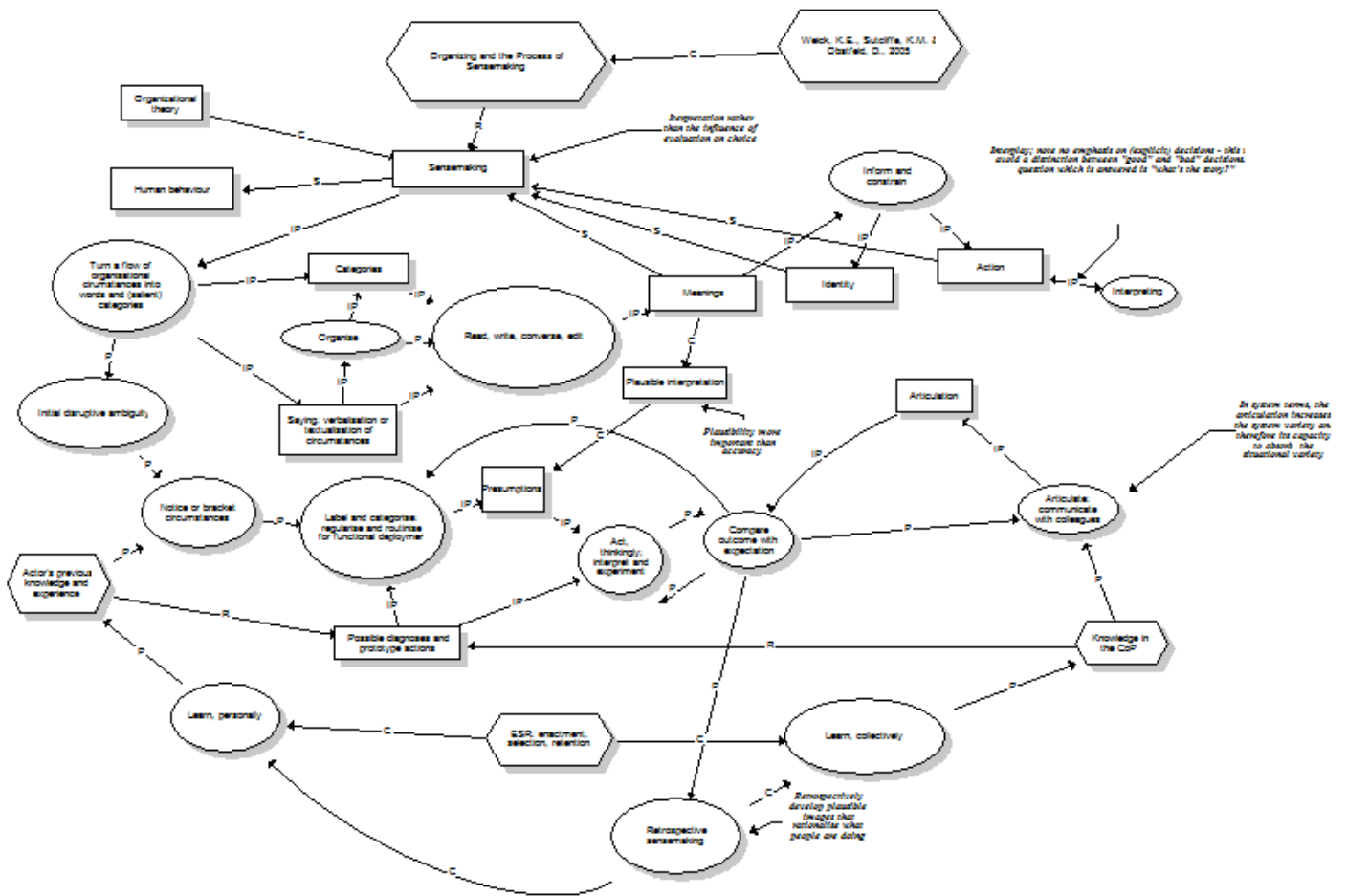
Figure 28 Sense-making according to (Weick, Sutcliffe, and Obstfeld 2005): a Mot+ concept map of the author's own sense-making of sense-making

I observe that sense-making is a complex cognitive and intellectual task which can in some circumstances and for some audiences be clarified by typed concept mapping.

2.10 Paradigms in sociology and the sociology of knowledge

The Emergence of Paradigms

Kuhn defines paradigms as: "universally recognized scientific achievements that for a time provide model problems and solutions to a community of practitioners" (Kuhn [1962] 1996). Burrell and Morgan use the term as a: "commonality of perspective which binds the work of a group of theorists together" (Burrell and Morgan, 1979; p. 23)

(Burrell and Morgan 1979), in their book entitled "Sociological Paradigms and Organisational Analysis" define four paradigms: functionalism, interpretivism, radical structuralism and radical humanism. Others such as (Chua 1986) prefer three primary alternatives: positivism (and its various forms neofunctionalism,

postpostivism, etc.); interpretivism (hermeneutics, phenomenology, ethnomethodology, etc.), and critical (Marxism, Critical Social Theory, etc.). Burrell and Morgan's four paradigms - Functionalist, Interpretive, Radical Humanist and Radical Structuralist - derive from quite distinct intellectual traditions, and present four mutually exclusive views, which stand in their own right, and generate their own distinctive approach to the analysis of social life.

Whereas Burrell and Morgan broadly favour what they call nominalism over realism, my own ontological stance is more realist. What do these words mean?

Nominalism assumes that society is relative. The social world is names, concepts and labels that make the individual structure reality.

Realism assumes that the real world has hard, intangible structures that exist irrespective of our labels. The social world exists separate from the individual's perception of it.

Burrell and Morgan distinguish nomothetic from ideographic methods. Nomothetic accepts the positivist conception of law-based reality borrowed from the natural sciences. Nomothetic focuses on detailed observation of society. Nomothetic involves hypotheses testing and employs methods such as surveys and other standardized research tools.

The impact of paradigm thinking in the information systems field

(Goles and Hirschheim 2000) note w   hat they call the rather surprising importance given to the notion of paradigms in the information systems field. They note that the word as used by (Burrell and Morgan 1979) has a much broader sense than that of Kuhn – for whom it is "universally recognised scientific achievements that for a time provide model problems and solutions to a community of practitioners" (Kuhn [1962] 1996).

They also note the then evidence of the overwhelming preponderance of functionalist research in the IS literature. Most information systems teaching then and now is concentrated in business schools, where positivism is still the dominant influence on research methods and indeed on the research questions which are asked and answered. Although (Goles and Hirschheim 2000) do not discuss critical realism as such, they talk about scientific realism, and they identify as an important author Roy Bhaskar. I include the following extensive quote because it succinctly summarises both realism and the significance and limitations of modelling:

> "Scientific realism holds that while the world exists independently of its being perceived (`classical realism'), the world can only be known through models of the world. The models themselves are not immutable – they never can be known with certainty (`fallibilistic realism'); indeed, the job of science is to develop better models of the world (Hunt 1990)…" (Goles and Hirschheim 2000, p.252)

> "To some extent, it is tempting to draw a parallel between pragmatism and the scientific realism of Bhaskar. For Bhaskar, scientific realism is more than an ontological stance in that it adopts

a particular epistemology as well. His version of scientific realism agrees with Kuhn that knowledge is a social and historical product. The task of science is to invent theories that aim to represent the world. In this way, science generates its own rational criteria that determine which theories are to be accepted or rejected. Crucially, it is possible for these criteria to be rational precisely because there is a world that exists independently of our cognizant experience. The theories which result from these rational criteria may be wrong, since they are based on the known world rather than the world itself. But nonetheless, they are what the community agrees on and is based on a community standard of what constitutes "valid" or "believable" knowledge claims. According to Bhaskar (Bhaskar 1975), it is our knowledge of the world that is circular; the world itself exists, and we experience perceptions of that world. The goal of science is to build sophisticated models using rational criteria to represent the world. As already mentioned, the models represent only what we know of the world and this knowledge is inherently flawed; but as we build successive models we may improve our representation. By making use of cognitive materials and operating under the control of something like a logic of analogy or metaphor, we can postulate a model. We do not believe that the model exactly duplicates the world; but, if this model were to exist and act in the way specified, then it allows us to account for observed phenomena. Lastly, Bhaskar notes that models are composed of abstractions and are untruthful, by definition, since they oversimplify. The greater the level of abstraction, the more this is so since they move further from empirical phenomena and oversimplify by grouping lower level abstractions." (Goles and Hirschheim 2000, p.261)

Knowledge, learning and emergent meaning

My internal supervisor Renaud Macgilchrist (Macgilchrist 2004) has undertaken a cross disciplinary study into a concept which he calls semantic morphogenesis. This study draws particularly from epistemology and from the sociology of knowledge. He identifies the significance of the dynamics of semantics. In summary, it is not possible to take a static view of semantics. Thus, the existing heritage of epistemics and heuristics needs to be refocused on the creation and mutation of meaning, a process which he labels as semantic morphogenesis. Macgilchrist implicitly accepts that semantics is a subset of semiotics, as has been suggested earlier in this review. Macgilchrist notes the mutation in the meaning of words which occurs as a result of epistemics and heuristics causing a paradigm shift which he discusses and illustrates. Macgilchrist points to the work of (Lakoff [1987] 1990) on constructed conceptualisation and the earlier work of (Rosch and Mervis 1975) who demonstrate that people categorise on the basis of how close something is to an ideal member of a category, what they call a prototype. Thus, a robin is more birdlike than an ostrich; the robin is the prototype bird. (Lakoff [1987] 1990) builds

on this prototype theory of categorisation so as to avoid some of the shortcomings, as he views them, of philosophical essentialism. Macgilchrist extends the idea of a prototype to what he calls a paradigm, "an ostensibly coherent and legitimate set of theories that share the same assumptions, in the form of Epistemics, about the workings of a particular aspect of the world... A scientific paradigm is a model of the world relative to a set of well formulated Epistemics". He conjectures that all semantics is encapsulated within "paradigm belief systems" which in turn can best be described by the set of characteristic Epistemics which control their morphogenesis. The related notion of heuristics constitutes the mechanism through which knowledge is discovered, acquired and adapted. Macgilchrist justifies the morphogenetic nature of meaning by examining the roles of Epistemics within semantics. He proposes a model which draws on the catastrophe theory of René Thom (Thom [1980] 1993, [1972] 1989) and on the language game discussed in (Wittgenstein 1953)'s investigations into the nature of language. Macgilchrist adapts the language game to the theoretical framework of decision theory and the mathematical theory of games developed by (Von Neumann et al. 1953). The meaning of a word is then measurable in terms of the scope of decisions it can influence in a particular world. Meaning and hence understanding and communication can be reduced to the exploration of decision spaces. A jump in understanding by an individual leads to an extensive reorganisation of the relationship between semantic signifiers and their related prototypes. Such a jump is a consequence of the change from a lower level of understanding of a word to a higher level via an intermediate stage of initial confusion. Learning, whether general or individual, can thus be seen as a trajectory through a topology of paradigms where Epistemics are progressively acquired and modified. Cognitive mobility depends on the capacity to assimilate, change and reject paradigms through more powerful language systems. Semantic morphogenesis is thus a symptom and an evidence of an evolution of the understanding of meaning.

I have recently worked with Renaud on an updated version of this paper which will be submitted for journal publication during 2016. Where I am referring to the ideas of Renaud I use the citation (Macgilchrist 2004). Where I am referring to ideas which I have contributed to the developing study, I use the citation (Macgilchrist and Gregory 2019). The as-yet unpublished paper (Macgilchrist and Gregory 2019) is a reworking of the earlier paper which includes a more cautious appraisal of the work of George Lakoff which however does not invalidate the main argument of the earlier paper. There is more discussion of the precise nature of morphogenesis both in its original context of evolutionary biology and in its application, particularly from a critical realist stance. Saussurian dyadic semiotics are compared with Peircean triadic signs. The application of the triadic sign, with its interpretant itself being a sign to further semiosis, reinforces the dynamic character of semantic morphogenesis, the morphogenesis of meaning.

2.11 Semiotics, paradigms and the evolution of meaning and understanding by means of morphogenesis

The thinking presented in this section is based primarily on the work of Renaud Macgilchrist notably as presented in (Macgilchrist 2004). However, the critique of the work of George Lakoff is my own addition; see (Macgilchrist and Gregory 2019).

Macgilchrist presents as his main thesis that all semantics is encapsulated within "paradigm belief systems" which in turn can best be described by the set of characteristic epistemics which control their morphogenesis. He regards meaning as an emergence which is subject to evolutionary forces. These forces manifest themselves in the form of topological trajectories where the concept of decidability plays the role of a "potential" - here using the language of René Thom (Thom [1980] 1993, [1972] 1989).

What do we mean by a paradigm? Not, in this context, a complete way of viewing the world adopted by a scientific discipline, as notably presented by (Kuhn [1962] 1996). Instead, we can illustrate our understanding of paradigm by means of a significant example presented by George Lakoff, that of the so-called "objectivist" representation of knowledge.

(Lakoff [1987] 1990, xii–xiii) states:

> "
>
> The traditional view is a philosophical one. It has come out of 2000 years of philosophising about the nature of reason. It is still widely believed despite overwhelming empirical evidence against it… We have all been educated to think in those terms… We will be calling the traditional view objectivism for the following reason: modern attempts to make it work assume that rational thought consists of the manipulation of abstract symbols and that these symbols get their meaning via correspondence with the world, objectively construed, that is independent of the understanding of any organism…. A collection of symbols placing correspondence with an objectively structured world is viewed as a representation of reality…. Thought is the mechanical manipulation of abstract symbols. The mind is an abstract machine, manipulating symbols essentially in the way a computer does, that is, by algorithmic computation. Symbols that correspond to the external world are internal representations of an external reality… Though such views are by no means shared by all cognitive scientists, they are nevertheless widespread, and in fact so common that many of them are often assumed to be true without question or comment. Many, perhaps even most, contemporary discussions of the mind as a computing machine take such views for granted.
>
> "

So Lakoff rejects what he terms objectivism with its notion that rational thought concerns the manipulation of abstract symbols where those symbols gain meaning by correspondence with the world, somehow objectively construed. Lakoff, basing his work to a significant degree upon the earlier work of Eleanor Rosch (Rosch and Mervis, 1975; see also Rosch, 1999), suggests that categorisation is graded: that for

example a robin is a more prototypical member of the category bird than is an ostrich. Nor are categories purely linguistic in character: even in languages which do not have a rich vocabulary, members of the linguistic community are well able to distinguish categories for which no distinct words exist. Rosch eventually defined a prototype as the most central member of a category: for example, chair is a prototype for the category furniture. Furthermore, although categories are hierarchically related, some categories are more basic than others. This may well be related to the difficulty experienced by individuals of providing exemplars at the superordinate and subordinate levels in a hierarchy. Thus, most people can make some attempt at drawing a chair. When asked to draw furniture, most will resort to a more-specific exemplar. Even to provide examples at a subordinate level may prove to be challenging or impossible.

Lakoff had earlier claimed that "our ordinary conceptual system, in terms of which we both think and act, is fundamentally metaphorical in nature" (Lakoff and Johnson [1980] 2008). These metaphors are a conceptual construction without which he holds that no form of abstract thought is possible.

Lakoff claims that the mind is embodied. The functionings of the mind cannot be divorced from bodily manifestations such as the sensorimotor system and emotions. Embodied cognition suggests that the nature of the human mind is significantly determined by its location within the human body. Therefore aspects of cognition are shaped by aspects of the body.

Lakoff is by no means alone in drawing attention to the embodied mind. In particular, see: (Varela, Rosch, and Thompson 1992) and (Mingers and Willcocks 2014).

♦   A critique of the work of George Lakoff

(Vervaeke and Green 1997, 64) strongly attack the work of George Lakoff. They observe that semantic properties and relations must be distinct from epistemic relations if we are to be able to explain how we can use language to overturn even our deepest presuppositions about language and its relation to reality. A true account of meaning cannot just be a theory of how people understand or model the world. If it were, it would leave people hopelessly hamstrung, completely unable in principle to change their understandings. They hold that people typically have more special-purpose categorization schemes in addition to the formal hierarchical structure based on the kind-of relation. What Lakoff refers to as image-schemata are perhaps to be understood as being more like models or diagrams, as presented in (Lakoff and Johnson [1980] 2008). But for (Vervaeke and Green 1997, 64) a diagram is a picture that exists under a description. It is the description which reduces the referential indeterminacy of the picture. So Lakoff is admitting that much of the cognitive work is done by the descriptive – propositional – unique referent to the diagram. Propositional structures must be concerned with reference, consistency, logical structure, accuracy of representation: that is, with truth conditions. This directly contradicts Lakoff's explicit rejection of a truth-conditional account of meaning. Nor can propositional models be reduced to allegedly self-interpreting

mental models as described by (Johnson-Laird 1983). (Wittgenstein 1953) showed the infinite regress of any rule-following argument, since in order to follow a rule one needs to know when to apply it, which itself needs a rule, and so on. Vervaeke and Green conclude that the prototype approach to meaning is untenable.

I continue cautiously to use the language of Lakoff concerning prototypes and paradigms while being aware of the criticisms to which the underlying concepts are open. Specifically, I continue to see semantics as being encapsulated in what Lakoff and Macgilchrist call paradigms leading to a true repertoire of semantic significance.

♦ Macgilchrist's discussion of paradigms

(Macgilchrist 2004) holds that we live through paradigms and we normally retain previous ones – our semantic legacy. Conversely, our own personal increased understanding – and that of collective social knowledge – both require that paradigms evolve and that subsequently knowledge (personal and socially-legitimised) itself does so.

It has for a long time been accepted in the natural sciences as normal that paradigms either evolve, or change "catastrophically" (Kuhn [1962] 1996); we can contrast normal evolution and revolution . Thus, we can talk about before-Newton, Newtonian, Einsteinian and quantum paradigms. Such paradigm shifts inevitably lead to changes in the meaning of words. Words, as semantic signifiers, are signs. Changes in the use of those signs correspond to changes in a linguistic or paradigm system. Such systems always encompass a truth-maintenance system or at the least a belief-maintenance system. Macgilchrist concerns himself in his article with the repertoire of Epistemics which he presents as a meta-repertoire, that is, with words associated with paradigm change.

In (Macgilchrist and Gregory 2019), we consciously choose to use an analogy and specifically an analogy with genetics in which paradigms are the chromosomes. We suggest that there is a close analogy between the process of genetic mutation and the choice that is open to us between random mutation and beneficial mutation in the context of language use. In the same way in which genes contain chromosomes contain alleles, paradigms are based on evolving language and signifiers. Again, just as in genes and in the process of mutation there are both activators and inhibitors, so in language and its use. We note that the brain is capable of creating and to some extent managing an enormous level of variety. Drawing an analogy to a computer, its addressable space is of the order of 10 to the power 100. The brain itself is capable of 10 to the power 208 interconnections using the 10 to the power 111 neurones that we each possess. We note that such mutation has an associated cardinality, and that this cardinality increases with time – we start to use a larger repertoire. Once again, this is true both at the individual and at the societal level. Epistemics permit us to generate "new" variety for this life repertoire. Thus, an epistemic on which I frequently depend in this thesis is that of abductive conjecture which I confront with ontological reality.

2.12 Design science research

(Iivari 2007) on design science research: Introduction

I regard this research essay as very important in setting the parameters of my design science work. I therefore discuss it at length. In his essay, Juhani Iivari discusses ontology, epistemology, methodology and the ethics of research.

∗ Ontology:

The essay suggests that information systems as a design science needs to be based on a sound ontology, including an ontology of IT artefacts.

∗ Epistemology:

The essay emphasises the irreducibility of the prescriptive knowledge of IT artefacts to theoretical descriptive knowledge. They are different kinds of knowledge. The article suggests what it calls constructive research methods, which allow disciplined, rigorous and transparent building of IT artefacts as outcomes of design science research. Information systems as design science cannot be value-free. The essay also briefly discusses the relationship between action research and design science research.

♦ The evolution of an IS ontology and epistemology

Iivari suggests that information systems had an early focus on systems development approaches and methods, distinguishing socio-technical issues from the design science approach. However, more recently mainstream IS research had lost sight of its design science origin. Iivari suggests that this is because of the hegemony of the North-American business-school-oriented IS researchers over the leading IS publication outlets. Thus, the dominant research philosophy has been to develop cumulative, theory-based research and then to go on to make prescriptions. Iivari characterises this as theory with practical implications. He says that it has seriously failed to produce results that are of real interest to practitioners.

The current interest in design science starts with important work by (Nunamaker Jr., Chen, and Purdin 1990), (Walls, Widmeyer, and El Sawy 1992) and then develops through (March and Smith 1995) and (Hevner et al. 2004). These papers should turn our attention to how to do design science research and in particular be more rigorous and more effective over the research process. Iivari quotes (Benbasat and Zmud 2003, 191):

> Our focus should be on how to best design IT artifacts and IS systems
>
> **either**: to increase their compatibility, usefulness, and ease of use
>
> **or:** on how to best manage and support IT or IT-enabled business initiatives.

Iivari applies the framework of Burrell and Morgan but also includes the ethics of research and suggests what he calls constructive research to complement the nomothetic and ideographic research concentrated on by Burrell and Morgan.

Iivari revisits his earlier paradigmatic framework in applying it specifically to design science research. Thus, he considers design science under the headings of ontology,

epistemology, methodology and ethics of research. He seeks a sound ontology for information systems and proposes to use the three worlds of (Popper 1978) as a useful starting point. Iivari suggests a three-level epistemology:

1. Conceptual knowledge
2. Descriptive knowledge
3. Prescriptive knowledge

In particular, he states that the prescriptive knowledge of IT artefacts is a distinct knowledge area that cannot be reduced to that of descriptive knowledge. What distinguishes information systems as a design science from the practice of developing IT artefacts is the use of constructive research methods, which allow disciplined, rigorous and transparent building of IT artefacts as the outcomes of design science research.

♦ Ontology of design science

(Popper 1978) is taken as a starting point for a sound ontology.

World one is about material nature. World two about consciousness and mental states. World three is about products of human social action. Institutions are social constructions that have been objectified, according to (Berger and Luckmann 1967). Artefacts cannot carry a truth value and they are only more or less useful for human purposes.

Table 6 An ontology for design science

World	Explanation	Research phenomenon	Examples
World 1 - material	Nature	IT artefacts plus world 1	Evaluation of IT artefacts against natural phenomena
World 2 - consciousness /mental state	Consciousness and mental states	IT artifacts + World 2	Evaluation of IT artifacts against perceptions, consciousness and mental states
World 3 – products of human social action	Institutions	IT artifacts + World 3 Institutions	Evaluation of organizational information systems
	Theories	IT artifacts + World 3 Theories	New types of theories made possible by IT artifacts
	Artifacts • IT artifacts	IT artifacts + World 3	Evaluation of the performance of artifacts comprising

	• IT applications	Artifacts	embedded computing
	• meta IT artifacts		

Source: (Iivari 2007, Table 1)

(Orlikowski and Iacono 2001) popularised the phrase "IT artefact". They define IT artifacts as "bundles of material and cultural properties packaged in some socially recognizable form such as hardware and/or software" (p. 121). Iivari contends that information systems as a design science should be based on a sound typology of IT artefacts and of IT applications. He finds the classification of IT artefacts into (1) constructs, (2) models, (3) methods and (4) instantiations suggested by (March and Smith 1995) to be too general and difficult to apply – because he holds that its classification strongly reflects data/information modelling.

Iivari holds the view that the primary interest of information systems lies in IT applications. He therefore suggests seven archetypes for each of which he suggests a metaphor and examples. See Table 7.

Table 7 Archetypes of IT applications

Role/function	Metaphors	Examples
To automate	Processor	many embedded systems; many transaction processing systems
To augment	Tool	many personal productivity systems; computer-aided design
To mediate	Medium	email, instant messaging, chat rooms, blogs; electronic storage systems
To informate	Information source	Information systems proper
To entertain	Game	Computer games
To artisticise	Piece of art	Computer art
To accompany	Pet	Digital (virtual and robotic) pets

Source: (Iivari 2007, Table 2)

IT artefacts differ in their design, in their diffusion and in their acceptance. They have begun to invade our consciousness and mental states, affecting our perceptions of the world. They have become significant constituents of institutions such as organisations and societies.

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Epistemology of design science

Design science does not necessarily share with pragmatism the notion of truth as practical utility. Artefacts do not have a truth value, and theories that describe and explain reality outside our mind have truth as correspondence (Niiniluoto 1999a). Iivari quotes the Finnish researcher (Lehtovuori 1973) who reuses a framework from economics to structure IS research. The four levels of research which he identifies are set out in Table 8.

Table 8 Epistemology of design science

type of knowledge	Notions	Level	Illustrations	Notes
conceptual knowledge	Concepts, constructs classifications, taxonomies, typologies, frameworks		Systems concepts, Ontologies et cetera	Much of the knowledge produced by IS research is conceptual by nature
descriptive knowledge	Observational facts empirical regularities theories and hypotheses	Theory – causal laws	X causes A in situation B X tends to cause A in situation B with probability P	
prescriptive knowledge	Design product knowledge	Policy or methods	The artefact: - idea, concept, style - functionality, behaviour - architecture, structure - possible instantiation	The distinction between product knowledge and process knowledge was made by (Walls, Widmeyer, and El Sawy 1992).
	Design process knowledge: technological rules (Bunge 1967)	Rules or norms	In order to achieve A, do actions. If you want to achieve A and you believe you are in situation be then you should or it is	(Bunge 1967) shows that a technological rule is a sequence of acts that prescribe how one should proceed in order to achieve a predetermined goal.

			rational or it is profitable to do X	
normative knowledge		Philosophy		

Based on: (Iivari 2007, Table 3), itself based on (Lehtovuori 1973)

The theoretical basis for information systems has largely been adopted from a number of reference disciplines (Hirschheim and Klein 2003) but the theories are weakly linked to IT artefacts and their design. Despite this weak reliance on descriptive theories people successfully design IT artefacts.

(Walls, Widmeyer, and El Sawy 1992) originated the idea that information systems design science should be rooted in theories. They suggested that IS design theory for a product would consist of meta-requirements, meta-design, kernel theories (theories from the natural and social sciences governing design) and testable design product hypotheses. An IS design theory for a process would comprise a design method, kernel theories and testable design process hypotheses – the latter being used to verify whether the design method results in an artefact which is consistent with the meta-design.

Iivari considers the existence of a kernel theory to be a defining characteristic of a design theory. Such kernel theories are sometimes difficult to identify.

Table 9 Correspondence between types of knowledge

type of knowledge - Iivari	type of knowledge - (Gregor 2006)
conceptual knowledge	Theories for analysing and predicting
descriptive knowledge	Theories for explaining and predicting
prescriptive knowledge	Theories for design and action
normative knowledge	
(No equivalent)	Specific theories such as critical social theory, structuration theory, actor-network theory, activity theory

♦   Methodology of design science

Iivari suggests the phrase "constructive research" to denote the specific research methods required for constructing artefacts. This phrase does not appear in the standard classifications of IS research methods. Building artefacts in design science research should at least ideally be creative. It leaves much space for creative imagination – especially when the artefact in question forms part of a virtual world.

It is the rigour of constructing and evaluating IT artefacts that distinguishes information systems as design science from the practice of building IT artefacts undertaken by professionals. But practitioners, if they carry out the evaluation implicit in design science, are acting as researchers. Systems development is a natural candidate for methods of constructive research. This is particularly relevant when the purpose is to prove a concept by implementing (instantiating) a system. Iivari notes that there may be some conflict between the need for creativity and serendipity essential to innovation on the one hand and the desire to make the building process more disciplined, rigorous and transparent on the other hand.

(Hevner et al. 2004) proposed that the rigour of design science research is derived from the effective use of prior research (existing knowledge base). Thus, Iivari suggests four major sources of ideas for design science research

1. Practical problems and opportunities.
2. Existing artefacts.
3. Analogies and metaphors.
4. Theories.

♦   Summary of (Iivari 2007)

1. Information Systems is ultimately an applied discipline.
2. Prescriptive research is an essential part of Information Systems as an applied discipline.
3. The design science activity of building IT artifacts is an important part of prescriptive research in Information Systems.
4. The primary interest of Information Systems lies in IT applications and therefore Information Systems as a design science should be based on a sound ontology of IT artifacts and especially of IT applications.
5. Information Systems as a design science builds IT meta-artifacts that support the development of concrete IT applications.
6. The resulting IT meta-artifacts essentially entail design product and design process knowledge.
7. Design product and design process knowledge, as prescriptive knowledge, forms a knowledge area of its own and cannot be reduced to the descriptive knowledge of theories and empirical regularities.
8. Constructive research methods should make the process of building IT meta-artifacts disciplined, rigorous and transparent.
9. Explication of the practical problems to be solved, the existing artifacts to be improved, the analogies and metaphors to be used, and/or the kernel theories to be applied is significant in making the building process disciplined, rigorous and transparent.
10. The term 'design theory' should be used only when it is based on a sound kernel theory.
11. Information Systems as a design science cannot be value-free, but it may reflect means-end, interpretive or critical orientation.
12. The values of design science research should be made as explicit as possible.

Iivari makes the interesting observation that the current "obsession" of leading information systems journals with theory may be dysfunctional from the viewpoint

of design science if it is required that all contributions of design science research must have a strong grounding in theory.

(Gregor and Jones 2007) on design science research

(Gregor and Jones 2007) endeavour to specify information systems design theory (ISDT) as a special or particular class of theory. They identify eight separate components:

- purpose and scope
- constructs
- principles of form and function
- artefact mutability
- testable propositions
- justification knowledge (kernel theories)
- principles of implementation
- an expository instantiation.

They conclude that a craft can proceed with the copying of one example of a design artefact by one Artisan after another; *a discipline cannot*.

Amplifying, they go on to suggest that design theory is but one class of theory relevant to information systems and is distinguished by its focus on "how to do something". The context is the sociotechnical system because we are concerned both with material objects and the social system. Further, we are concerned with artefacts, and more generally with the science of the artificial as identified by Herbert Simon. Outside information systems, (Van Aken 2005) in the field of management research considers that more use should be made of what he calls technological rules, which he sees as solution-oriented knowledge. He distinguishes between such rules, which he collectively terms management theory and contrasts this with more description-oriented knowledge which he calls organisation theory. Van Aken introduces this thinking in his desire to add a relevance criterion to the validity criterion more normally invoked to defend academic knowledge. He distinguishes between mode one knowledge whose production is purely academic and mono-disciplinary, while mode two is multidisciplinary and aims at solving complex and relevant field problems. Van Aken suggests as a possible research product of mode two research the "field-tested and grounded technological rule" – knowledge which can be transferred to contexts other than the one in which it was produced. He distinguishes between descriptive and prescriptive knowledge. Prescriptive knowledge is sometimes dismissed as "airport bookstore" management literature, strong on prescription and weak on justification. Van Aken argues at length for what he calls a design science approach in which he explicitly follows Herbert Simon. Thus, the core mission of a design science is to develop knowledge that can be used by professionals in the field in order to design solutions to the problems they encounter there. Specifically, he identifies the typical research product in a design science study as the technological rule originally suggested by (Bunge 1967) rather than the causal model of conventional positivist research. Van Aken quotes the definition of a technological rule given in (Bunge 1967, p.132) as

'an instruction to perform a finite number of acts in a given order and with a given aim'. For van Aken, this is generalised to a chunk of knowledge linking an intervention or artefact with an expected outcome or performance in a certain field of application. A rule is applicable if it can be field-tested and grounded. The general logical form is "if you want to achieve Y in situations Z, then perform action X". The rule will often be heuristic rather than algorithmic. Rules of this kind and principles for their application are commonly encountered in professions such as medicine and engineering. Van Aken argues that a similar approach can be taken to management. The extent to which technological rules are justified increases as they are applied in multiple cases and by third parties. Van Aken names the third party testing approach beta testing, following the practice common in software engineering. Technological rules must be grounded if their use is not to degenerate into mere instrumentalism, as is warned against by (M. S. Archer 1995). Van Aken then goes on to use the language of critical realism as he describes the use of generative mechanisms – which have been introduced into management thinking by (Pawson and Tilley 1997).

"Pawson and Tilley's point of departure is what they call the basic realist formula mechanism + context = outcome. Any social programme can be seen as a coherent set of interventions, applied in some context by some body of actors in order to produce particular desired outcomes. The generative mechanism is the answer on [sic] the question 'why does this intervention (in this context) produce this outcome?'." (Van Aken 2005).

Van Aken goes on to suggest that what he calls "management action", the sound design of interventions and of management structures and systems, can be expressed in the development of technological rules – managing as designing or at least as reflection-in-action (Schön 1983). Management rules are not so much instructions as design exemplars. (Van Aken 2005, 32) himself approvingly quotes Herbert Simon as the latter writes:

'The movement toward natural science and away from the sciences of the artificial proceeded further and faster in engineering, business and medicine than in the other professional fields I have mentioned . . . Such a universal phenomenon must have had a basic cause. It did have a very obvious one. As professional schools . . . were more and more absorbed into the culture of the general university, they hankered after academic respectability.' (Simon [1970] 1996, 112)

Returning now to the work of Gregor and Jones. They note that there is some feeling against recognising design principles as theory. They argue for a broad view of theory where the term encompasses what others might term conjectures, models, frameworks, or bodies of knowledge. Thus, when (Hevner et al. 2004) suggest that there are four outputs of design science – "constructs, models, methods, artefacts" - all but the last can be regarded as components of theory. They approvingly quote (Cross 2001) who agrees that at one level design work can proceed without reflection on theory, but goes on to say that in addition to this informal product knowledge, we need for design research: "the development of more formal knowledge of shape and configuration – theoretical studies of design morphology"

(Cross 2001). Better understanding of the nature of design theory will then provide an avenue for a more systematic specification of design knowledge. (Gregor and Jones 2007) claim to detect the aspects of their overall design theory anatomy as they apply it to the seminal relational database work of Ted Codd (Codd 1970, 1982). They seek an ISDT information systems design theory which builds on the pioneering work of (Walls, Widmeyer, and El Sawy 1992) who at page 36 define an information systems design theory (ISDT) as "a prescriptive theory which integrates normative and descriptive theories into design paths intended to produce more effective information systems".

Gregor and Jones quote at length from (Simon [1970] 1996) as he presents the view that the knowledge underlying the construction of artefacts has the status of theory. Design theory is concerned with how things ought to be in order to attain goals. An objective of design activity is the description of an artefact in terms of its organisation and functioning, even if only in part capable of being formalised. Both the shape of the design and the shape and organisation of the design process are essential components of a theory of design. Frequently artefacts are designed without a full understanding of the workings of the component parts which may in any event be irrelevant. Since forecasting the likely path of events in a design process is extremely difficult, Simon recommends the mechanisms found in adaptive systems for dealing with change: homeostatic mechanisms that make the system relatively insensitive to the environment and retrospective adjustment to the environment's variation based on feedback.

In the early development of information systems as a field of enquiry there was a strong emphasis on systems development; thus for example (Nunamaker Jr and Chen 1990) provided a multi-methodological approach that included as separate steps theory building (conceptual frameworks, mathematical models and methods), systems development (prototyping, product development and technology transfer), experimentation (complete assimilation, field experiments and laboratory experiments) and observation (case studies, surveys and field studies). More recently, (March and Smith 1995) developed a framework to demonstrate the relationship, activities and outputs of design and natural science research in information technology. Gregor and Jones suggest that the construction of an artefact that is sufficiently novel can be seen as a significant contribution in its own right. However, they also note that (Van Aken 2005) is less concerned with the design of products than with the methods or processes. As they note, all are of interest in information systems. Thus, a design theory for information systems should concentrate both on designed products and on design methodology or process.

Gregor and Jones note that they necessarily depend upon realist ontology where the world contains certain types of entities that exist independently of human beings and of human knowledge of them. They note that both Habermas and Popper discuss three different worlds. Thus, (Habermas 1987) recognises three different worlds – the objective world of actual and possible states of affairs, the subjective world of personal experiences and beliefs and the social world of normatively regulated social relations. They suggest that these are related to the three worlds

evinced by (Popper 1978). As discussed in section 0, Popper suggests that world one is the objective world of material things; world two is the subjective world of mental states; and world three is an objectively existing but abstract world of man-made entities such as language, mathematics, knowledge, science, art, ethics and institutions. Gregor and Jones note the congruence of these realist expressions with the critical realism of Roy Bhaskar as discussed by (Mingers 2011). In applying (Bhaskar 1989) to management science, a realist view of being is established in the ontological domain while in the epistemological domain knowledge remains relativist because socially and historically conditioned. Gregor and Jones note the importance of the instantiation of material artefacts and (more controversially) actions and processes of intervention as the result of design research.

Gregor and Jones appeal empirically to a number of cases in addition to the relational database work of Ted Codd already mentioned. They then go on to discuss their eight theory components; I summarise that discussion in the table which follows:

Table 10 The components of a theory of information systems design

Component	Notes
• **purpose and scope**	This design component says what the system is for, the overall goals of the type of system to which the theory applies. The system cannot be divorced from its environment, which must also be considered. There may also be some comparison with other design artefacts of the same type.
• **constructs**	Either physical phenomena or abstract theoretical terms. These should be defined as clearly as possible. In many cases, a hierarchical breakdown of each construct will be necessary – this being one way to deal with complexity as discussed by (Simon [1970] 1996).
• **principles of form and function**	This component refers to the principles that define the structure, organisation and functioning of the design product or design method or process. This may take the form of abstract blueprint or architecture for a product and the shape and features of a method.
• **artefact mutability**	The information systems artefact has the special characteristic or nature that that is an an almost constant state of change – even of evolution, where flexibility and adaptability may be enabled by feedback loops as the design is refined: Heidegger's poiesis. The evolutionary path – and the emergence – of IT artefacts are seen as key unresolved issues for the IS field.

• **testable propositions**	An ISDT may give rise to testable propositions or hypotheses about the system or tool to be constructed. These might be as general and as powerful as "if these certain principles are instantiated then it will work be better than an alternative".
• **justificatory knowledge (kernel theories)**	This component provides the justificatory, explanatory knowledge that links goals, shape, processes and materials. The types and sources of these justificatory theories may come from many sources. Some will depend upon knowledge of human cognitive capacities – this is particularly true in the area of human computer interfaces. In some cases, the theory can be identified but its internal structure will remain unknown for some while to come. However, justificatory knowledge of this type does provide an exploration of why an artefact is constructed as it is and why it works and is therefore a desirable part of a theory specification. In instances where existing justificatory theoretical knowledge is limited, this is probably an indication of a future research question.
• **principles of implementation**	This component concerns the means by which the design is brought into being – a process involving agents and their actions in inextricably linked process and product. Sometimes referred to as style, both the shape of the design and the organisation of the design process are essential components of a theory of design.
• **an expository instantiation.**	(Hevner et al. 2004) believe that "design research must produce a viable artefact in the form of a construct, model, method or instantiation". A realistic implementation contributes to the identification of potential problems in a theorised design and demonstrates its potential usefulness. However, instantiated artefacts of things in the physical world, while a theory is normally taken as an abstract expression of ideas about such phenomena. The artefact itself may have representational power: Thus, the artefact can assist with the communication of the design principles in a theory.

Based on (Gregor and Jones 2007)

The whole notion of an information systems design theory is itself a theory. It is also a pointer, can be taken as a set of guidelines, as to what should be included in an article or thesis that reports constructive research.

2.12.1.1 Significance of (Gregor and Jones 2007) for design science research

I conclude with the speculation that the set of principles that I am putting forward for the specification and/or evolution of a PIMS within the context of a PWS could be tested against (Gregor and Jones 2007)' design theory components. Even if at this stage the evaluation suggests that the theory remains embryonic and incomplete, it will also tend to indicate where further work is required. Gregor and Jones note that theory recorded after the fact is by no means less of a theory, so long as it still satisfies the requirements of being abstract and general. In the construction of a particular system, it will be necessary to represent the important principles underlying its construction in such a way that they are applicable to other systems as yet not constructed. Multiple iterations might be required in order to clarify the emergent general principles.

Design is a creative activity and some would therefore argue it is not a science as such. However, design knowledge is of vital concern to industry and improving design theorising should increase the relevance of the work of the IS community.

2.13 Technological affordances

Affordances, positive and negative

Affordances were first identified by (Gibson 1977), who noted the perception of affordances by animals in their environment: "The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill. Refers to both the environment and the animal… Implies the complementarity of the animal and the environment."

Affordances were then discussed by (Greeno 1994), who noted that abilities in activity depend on attunements to constraints.

Erol Şahin's formalisation of affordance

(Şahin et al. 2007; Şahin 2008) define affordance as "an acquired relation between a behavior of an agent and an entity in the environment such that the application of the behavior on the entity generates a certain effect". They illustrate it as Figure 29:

(effect, (entity, behavior))

Figure 29 How affordances arise (Şahin et al. 2007; Şahin 2008)
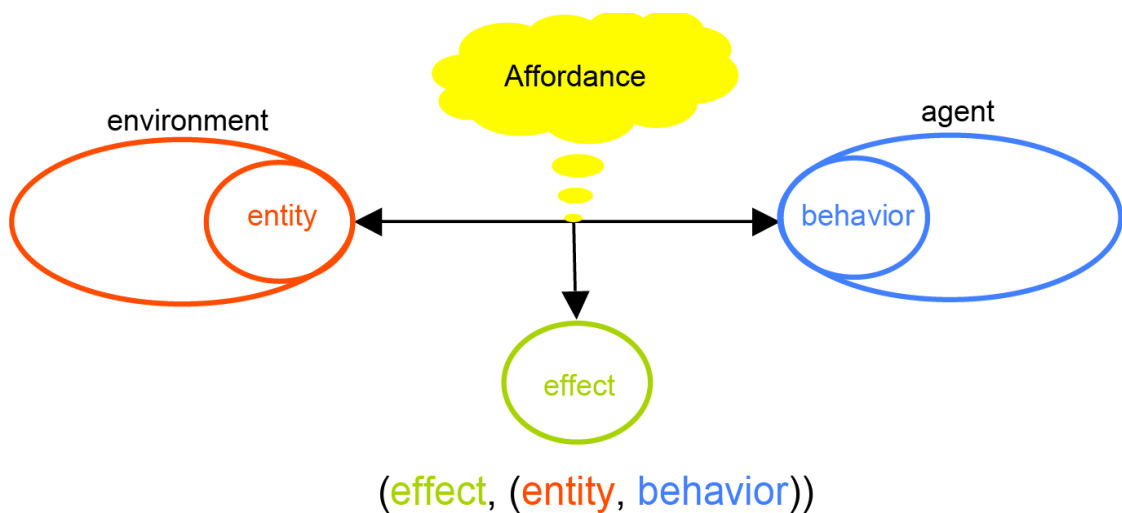
2.14 Baskerville's revised thinking on individual information systems -- (Baskerville 2011a)

♦ Individuals are designing complex systems in which information and communications technologies help process, create and store individual information.

♦ Information systems are viewed as the discipline required in this area of design theorising.

♦ Towards a definition of an individual information system

Baskerville is no longer sure that it is necessary to refer to individual work systems, since there is an implication of a corporate context and of a customer. Personal information system is a possible alternative. Baskerville argues that something closer to the notion of human activity system (Checkland and Scholes 1990) may be more appropriate. Whence his definition: "an individual information system is an activity system in which individual persons, according to idiosyncratic needs and preferences, perform processes and activities using information, technology and other resources to produce informational products and/or services for use by themselves or others."

♦ The individual information system of the pseudonymous Sam Spade

Sam Spade is both a professional and a home computer user. The application of which he makes the most use is the word processor with in the overall productivity software package which also incorporates spreadsheets, presentations and email. He uses Skype. Data related to these major activities is synchronised between his PC, his laptop and his smartphone. Spade also makes use of cloud services provided by his employer and other professional services which he subscribes to. Additionally, he makes use of a cloud of personal finance services. Data from these is synchronised and is directly used in the preparation of tax returns. Parts of his own IIS are also available to other members of his family. In addition, the family shares infrastructure including a LAN and Internet access. The overall individual information system architecture is no longer bounded simply by personal computing. In addition to the computing systems and the network systems, there are a number of other layers in the overall architecture which Spade makes use of. Baskerville suggests that there is a professional activity system which corresponds to his work as an employee and a personal activity system which spans those information-processing activities which fall outside his role as an employee.

♦ Researching individual information systems

Historically, individual information systems have received very little attention from the IS research community. The simultaneous arrival of the personal computer and of office automation in the early 1980s gave rise to some interest in the social and organisational implications of personal computing. However, PCs continued to be regarded as an end node in data networks – as a smarter and more useful device than a dumb terminal but not in essence different. Individuals as users continued to be regarded primarily as end users of corporate information systems. The use or non-use of information systems is far too coarse a distinction; rather individuals may choose to adopt information systems at varying levels of sophistication. It is difficult actually to research the nature of IS usage in any context – Baskerville notes that in general researchers have concentrated on intention towards usage rather than any attempt actually to measure that usage. But intention as opposed to actual behaviour has been used as a more readily operationalised construct – cf. the technology adoption model of (F. D. Davis 1989). There has been interest in the literature in end user and of participative information systems development, but once again it has normally been seen as being in the service of the organisation. Baskerville suggests the possibility of turning this on its head so that consideration be given to the individual's perspective whereby the organisation and its information system are an extension of their own individual information system.

There is a notion of personal information system current in the library and information science community which arose also in the early 80s. Here personal information systems are often viewed from the device's point of view. Baskerville speculates that if senior employees and C-suite executives had access to individual information systems this could lead to better organisational strategy setting and by extension to improve decision-making throughout all levels of an organisation.

Any success in this area has been achieved in the absence of planned management.

♦ Elements of design theorising for individual information systems

Individual information systems are specifically that, they are individual. They are likely to be idiosyncratic in character. Most users will have a limited understanding of ICT and information systems. The necessarily resource-limited and undereducated individual information system designer must therefore learn how to design by experiencing the design activity. Baskerville's paper seeks to develop a practice design theory that focuses on how the designers themselves operate on explanatory design theories.

It is reasonable to expect that some existing information systems theory will be transferable into the realm of individual information system. In particular, research which is closely related to users with a human and social perspective can logically be extended in this direction. Baskerville gives as an example that of the double-loop learning of (Argyris and Schön 1978); this is anchored to the notion that changes in

individuals guide changes in organisations. Baskerville concludes that a subset of existing theories about information systems is likely to hold for individual information systems theories – the extent of the overlap yet to be determined.

Much as in research in information science, individual information systems are likely to be idiosyncratic in character. The values underlying individual information systems may be very different from those associated with corporate systems. Baskerville cites from the literature of PIM, (Bergman et al. 2008), to support his contention that the idiosyncratic nature of individual information systems requires a richer set of subjective attributes in its information management. Social considerations are also more significant in the IIS realm than elsewhere.

The construction of an IIS in terms of ICT components may be very unusual, involve rather complicated workarounds and be accepting of multiple imports and exports in order to maintain some degree of compatibility between otherwise incompatible software packages.

♦ Experiential design

Experiential design occurs when the act of design merges together with the experience of the artefact being designed. The example that Baskerville gives is the construction of a sandcastle by a child. The design emerges as much from the construction of the artefact as vice a versa. Experiential design is a concept similar to action learning in that the design outcome is learned by the designer while the design activity is still unfolding. Because the IIS is rarely replaced as a whole, it will often consist of a hodgepodge of components, of piecemeal assemblies acquired over periods of time with little thought to the Confederation of any overall future system. Instead, it is an emergent product of cumulative elaboration, often based on spur of the moment and Thus, idiosyncratic purchase decisions. Newer purchases are often constrained by previous purchases [thus, buying an iPod eventually leads to a whole Apple infrastructure]. Baskerville attempts a diagrammatic synthesis of the elements of IIS design theorising [which I find rather unconvincing]. Interestingly, as he draws it he distinguishes it as an influence model and not as a process model. Baskerville holds that the process is one of practice design theory that theorises the IIS design activity itself.

♦ Conclusions

Baskerville suggests that his paper is an example of a practice design theory named experiential design. This may also emerge in fields outside individual information systems including emergent systems, agile systems, web systems and the like. Since at this stage only a practice design theory is put forward questions arise about more general explanatory design theories. Functional explanations may be limited because the designs are sometimes completely idiosyncratic and may defy all general explanatory design theories. It might be that every IIS design activity invokes unique explanatory design theories. In such a case, the design science

activity would be indistinguishable from the design activity beneath it. It is necessary to explore the boundaries between the subset of known IIS theories that will hold in an IIS, and those that will not. There may be an extensive overlap but that can only be discovered by extensive empirical investigation. Baskerville notes that his paper only provides an information systems viewpoint. He suggests that there are other viewpoints – but I would comment that many of these have already been addressed in the general PIM literature.

2.15 Insights from existing theory of relevance to PIMS

The material in this section draws inspiration from my conference paper (Gregory and Descubes 2011a).

The original action researcher, Kurt Lewin, stated that "there is nothing so practical as a good theory" (Lewin 1951). Good theory has explanatory power and suggests extrapolation into new applications. As an example of such theory we advance Ross Ashby's Law of Requisite Variety: "Variety absorbs variety, defines the minimum number of states necessary for a controller to control a system of a given number of states" (albeit in a discrete state controller) (Ashby 1956). Ourselves reflecting on that law, we rediscovered (Conant and Ashby 1970). Roger Conant produced his Good Regulator theorem stating that "every good regulator of a system must be a model of that system". The design of a complex regulator includes the making of a model of the system to be regulated. The theorem shows that any regulator that is maximally both successful and simple must be isomorphic with the system being regulated. ***Making a model is thus necessary.***

Drawing together the law of requisite variety and Conant and Ashby's theory, we suggest that a personal work system PWS (viewed broadly as including the person who uses and manages it as well as any computer-based elements) has to be sufficiently rich in its variety and close in its internal models to the processes and actions which its user undertakes if it is to be effective. It must be ***isomorphic*** with the process. Furthermore, when the PWS and its constituent PMIS are being designed they must themselves be modelled and those models must be as simple and accurate as they can be. We aim for simplicity by a ***separation of concerns*** (following (Rzevski 1981), who is himself following (Dijkstra 1974), reproduced as (Dijkstra 1982)).

For this reason, it will often be appropriate and necessary to create more than one complementary model. Specifically, it is necessary to model at least the work system, then the data structures and information outputs required within the processes and activities identified by the work system analysis and to ensure that the information system is capable of producing those outputs because its data structures are adapted and adequate to the creation of those outputs.

*   Synthesis of propositions underlying the current work

We here synthesise certain propositions which we deem to be essential for understanding the personal information and knowledge management that underlie inquiry and learning, specifically learning by means of research:

Number	Proposition	Observation
1.	That knowing and doing are almost inextricably interlinked and meet in individual knowledge and action.	This proposition derives from a reconsideration of the concepts of knowledge, information and data which is synthetic and not original.
2.	That in the early stages of the research process a powerful source of insight is reflection on the researcher's own knowledge and practice.	We have illustrated this in the context of this research. Such autoethnography is not in itself a verifiable source of findings, but can provide initial insight.
3.	That that reflection may take the form of self-observation structured by means of model building.	In this research we highlight concept mapping which explicitly distinguishes processes from concepts.
4.	That Ross Ashby's law of requisite variety continues to have value in justifying modelling in information systems research.	We have re-explored the implications of Requisite Variety and revisited the associated Good Regulator theorem of Ashby and Conant in a teaching context. Their implications and wider application merit further work by ourselves and by other IS researchers, teachers and practitioners.

Table 11 Summary of propositions and observations

To expand upon the fourth proposition in particular. In systems terms, when undertaking research an evolutionary learning or semantic system (Macgilchrist 2004) exists which has to be open if it is to continue to evolve. Every researcher has continually to struggle to make explicit her or his own knowledge and to reflect upon how it needs to change. We need to criticise and to encourage one another as we do that. The gradual process of refining a research question requires a learning and personal knowledge management approach which must be sympathetic to the emergent quality of a research project, at least in its early stages. The process is human and engaged; it can also benefit from effective personal information management systems. Thus, we need to consider, alone and together, the role of information and communications technology (ICT) in improving everything we do. That should include imaginative use of tools and techniques, such as concept maps.

2.16 Learning by enquiry: some parallels with Checkland's LUMAS

We present here a concept map which illustrates, in summary form, some of the propositions that we have discussed.

Figure 30 Inner-and outer-learning loops
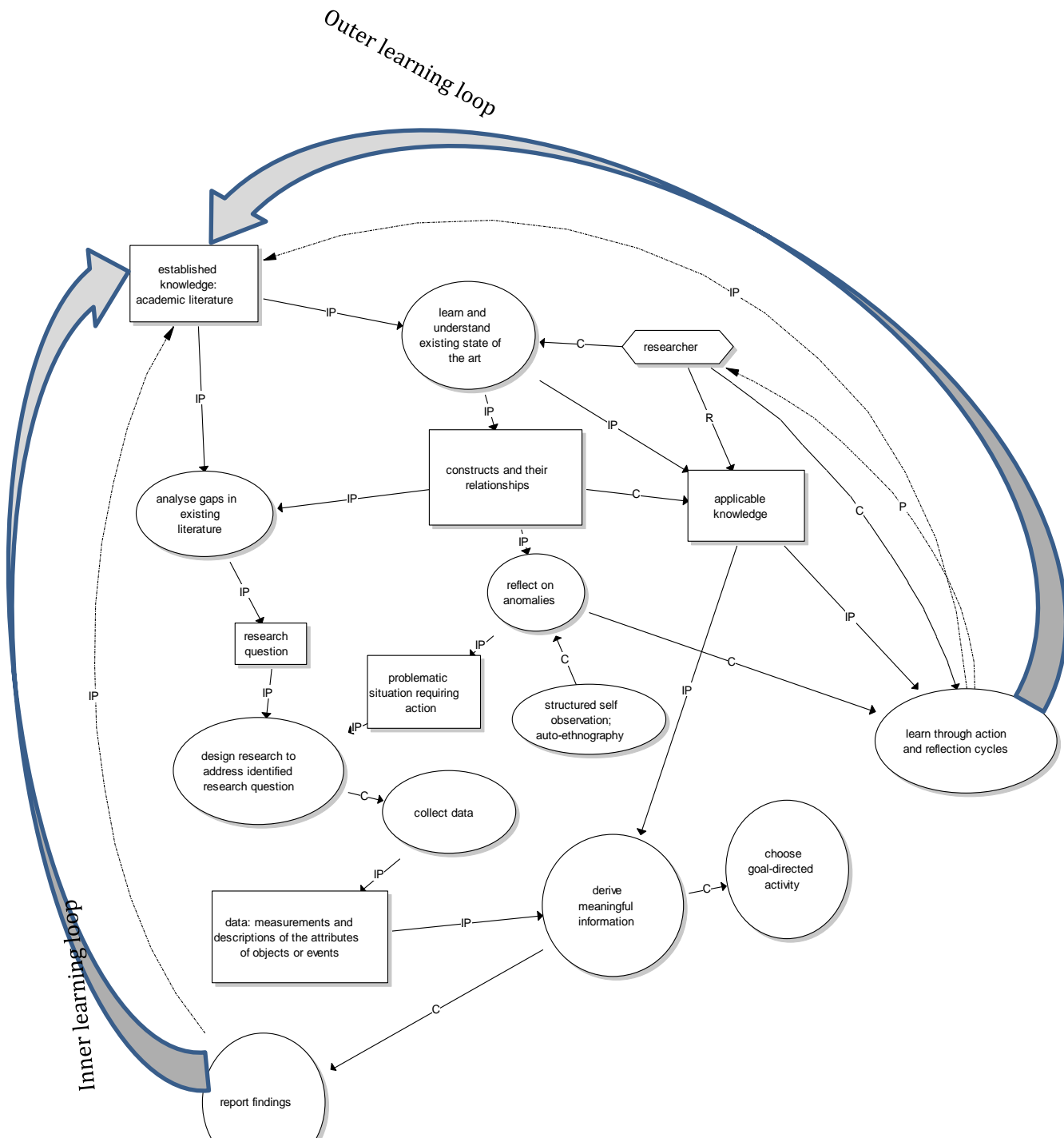
We would comment that this diagram illustrates an ***inner learning loop*** as the researcher engages with perceived reality in accordance with some research methodology. She or he learns in a problem-focussed way as (s)he uses methods in an applied methodology. Just as (Argyris 2000) describes double loop learning in organisations, we suggest that there potentially exists also an ***outer loop*** by means of which the researcher may learn at the more profound level described by Peter Checkland. (Checkland 2000) presents (inter alia)

LUMAS, Learning for a User by a Methodology-informed Approach to a problem Situation. Taking as his definition of methodology 'a body of methods used in a particular activity', Checkland suggests that a user knowledgeable about a methodology perceives a problem situation and uses the methodology to try to improve it. The methodology as a set of principles is converted by the methodology user into a specific method which the user feels to be appropriate for this particular situation at this moment in its history:

"The user U, appreciating a methodology M as a coherent set of principles, and perceiving a problem situation S, asks himself (or herself): What can I do? He or she then tailors from M a specific approach, A, regarded as appropriate for S, and uses it to improve the situation. This generates learning L, which may both change U and his or her appreciations of the methodology: future versions of all the elements [of] LUMAS may be different as a result of each enactment of the process shown." (Checkland 2000)
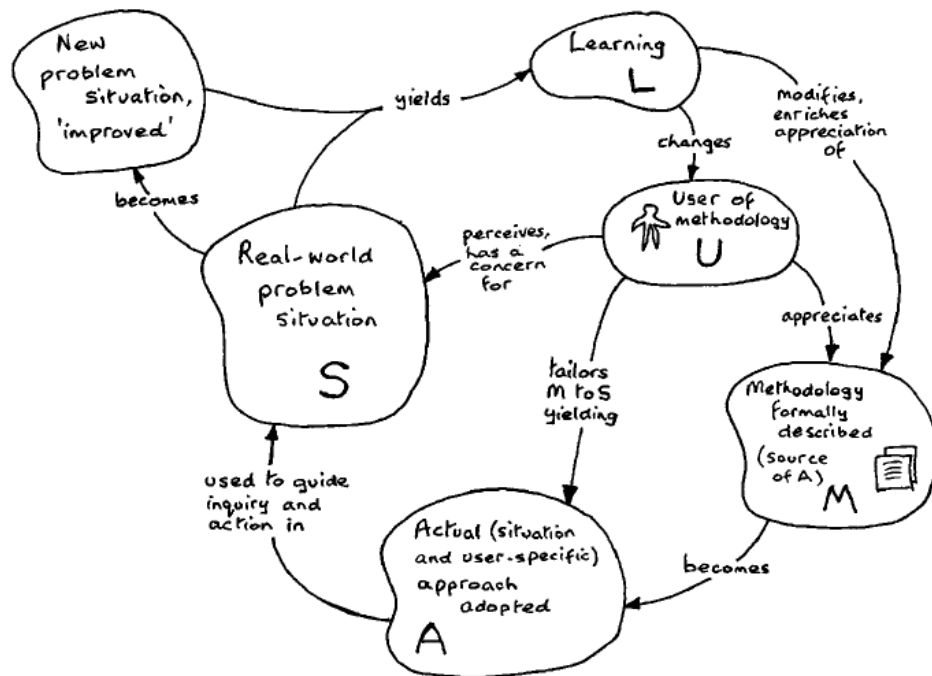
Figure A10.   The LUMAS model: Learning for a User by a Methodology-informed Approach to a problem Situation

Figure 31 Checkland's LUMAS model Source: (Checkland 2000)

Checkland stresses that it is not the methodology which leads to improvement. It is the user as (s)he benefits from using the guidelines, as (s)he takes the formally defined methodology M to create or tailor A, the actual, user- and situation-specific approach adopted to the Real –world problem R that (s)he perceives a concern for.

2.17 Peter Checkland as presented by (Stowell 2013)

Asked recently in an interview by Frank Stowell (Stowell 2013), whether he sees the "systems approach" as "a scientific methodology"; if so, how does it guide scientific inquiry, in your opinion? If not, how would you describe the relationship between a "systems approach" and "scientific inquiry?" Peter Checkland has replied:

"

As for the phrase 'a systems approach' I see it as being the name of any epistemology which encompasses the idea 'system'; defined as the name of the concept of an adaptive whole which can adapt and survive in a changing environment. It thus has only epistemological, not ontological status. This is crucially important for the Systems Movement, this difference between Natural Science and so called 'Social Science'. Thus, Marx has a theory of history, and his ideas change history, which is not law-governed. On the other hand Copernicus and Galileo have different theories concerning whether our local universe is sun-centred or earth-centred; but these ideas can have no effect whatsoever on what is the case out there in the universe, which is law governed. What this means for a 'systems approach' is that if it engages with human and social phenomena it can develop only useful epistemology, not discover laws.

" (Stowell 2013)

Thus, we suggest the existence of **problem-focussed or situational learning** – using methods in an applied methodology; and **higher-level learning** – which will manifest itself in a deepening appreciation of methodology and a concern to develop it further in action. We also suggest the possibility that the outer loop corresponds more-or-less directly to the inquiring / learning cycle of Checkland's Soft Systems Methodology SSM.

2.18 How research questions arise or emerge

(Alvesson and Sandberg 2011) accept that what they call "research gap spotting" is the orthodox way in which research questions are generated. But they argue strongly that what makes a theory interesting and influential is that it challenges our assumptions in some way. In this article, Alvesson & Sandberg propose what they call "problematisation" as a methodology for identifying and challenging assumptions underlying existing literature and, based on that, formulating research questions that are likely to lead to more influential theories. In developing a typology of what types of assumptions can be problematized they propose a set of methodological principles for how this can be done. In doing this they refer to the "large and overlapping body of literature on reflexivity dealing with key aspects of research… Since our emphasis is on how to work with reflexivity when formulating research questions, we only marginally address other issues of reflexivity in research, such as invoking awareness of the researcher him/herself, the role of rhetoric, and ongoing constructions of reality in the research process."

In fact in an earlier book, Alvesson and a different collaborator (Alvesson and Sköldberg 2009) are much more explicit in their insistence upon the abductive logic of enquiry and on the role of reflection or reflexivity in research methodology.

2.19 Literature concerning evaluation

Evaluation of information systems development

(Beynon-Davies, Owens, and Williams 2004) investigate the evaluation of information systems in conjunction with explaining the phenomenon of information systems failure. They suggest that evaluation is necessarily to be linked into the IS development life cycle. They note that there is much greater emphasis on pre-implementation evaluation than on post-implementation. They stress that both product and process required to be evaluated and suggest that there is a need to stimulate organisational learning in relation to information systems development. In this connection, they depend upon the double-loop learning originally suggested by (Argyris and Schön 1978). They lament the vast amount of prescriptive material and the comparative dearth of empirical work on information systems evaluation. Their work is illuminated by a case study.

Evaluation within a critical realist study

(Volkoff, Strong, and Elmes 2007) draw together evaluation criteria originally suggested by (Strauss and Corbin 1998) in the context of grounded theory and by (Miles and Huberman 1994) in research which they suggest takes a critical realist stance.

> "One makes judgments about (1) the data, i.e., the validity, reliability, and credibility of the inputs to the research process, (2) the theory itself, i.e., the credibility of the output of the theory-development process, (3) the adequacy of the research process through which the theory is generated, focusing on analysis methods, and (4) the empirical grounding of the research, i.e., the grounding for the resulting concepts and theory." (Volkoff, Strong, and Elmes 2007))

Evaluation of design science research

(Baskerville, Kaul, and Storey 2015) is entirely devoted to the justification and evaluation of knowledge production within design-science research. They suggest that within the bounds of a single study anything up to four different modes of reasoning, which they dub "genres of enquiry" may come into play. The four genres which they identify are the product of distinctions between two dualities. The first duality is that of design versus science; the second is that between nomothetic and ideographic knowledge production processes.

Nomothetic knowledge production processes aim to produce general theories or concepts applicable to an entire class of cases, or at any rate to an identifiable section of the population of such cases. They identify criteria such as applicability, generalisability, external validity, transferability, consistency, reliability and dependability.

Ideographic knowledge production processes involve the study of particular cases.

Design science research is iterative and incremental. There will be both the production of knowledge and the generation of artefacts, although not necessarily in the same timescales.

They set out criteria for knowledge justification and evaluation criteria for each composite genre: nomothetic design (ND), nomothetic science (NS), ideographic design (ID) and ideographic science (IS). The language used here stems originally from (Burrell and Morgan 1979).

The artefacts generated can take several forms, including constructs, models, methods, and instantiations (March and Smith 1995), design patterns, design propositions, technological rules (Van Aken 2005), design principles (Sein et al. 2011), organizational designs and management practices, new properties of technical, social, and/or informational resources, and design theories (Gregor and Jones 2007); (Walls, Widmeyer, and El Sawy 1992).

(Baskerville, Kaul, and Storey 2015) also reconsider the modes of enquiry originally identified by (Churchman 1971) and summarised in Table 12. See also where I include IS types suggested by (Mason and Mitroff 1973).

Table 12 (Churchman 1971)'s modes of enquiry according to (Mason and Mitroff 1973)

Mode of enquiry (Baskerville, Kaul, and Storey 2015)	(Mason and Mitroff 1973)
Leibniz: Fact nets	Leibnitzian IS
Locke: Consensus	Lockean IS
Kant: Representation	Kantian IS
Hegel: Dialectic	Hegelian IS
Singer: Progress	Singerian-Churchmanian IS
Simon (their addition): Artifice	

"The evolutionary and iterative nature of a design-science study compels different knowledge goals and scope at different moments throughout a project. Because of this momentary nature, a single design-science study can be associated with multiple genres of inquiry." (Baskerville, Kaul, and Storey 2015, p.541)

Evaluation of autoethnographic studies

(Schultze 2000) devotes considerable space to an evaluation of the confessional (autoethnographic) account she gives of knowledge work. She therefore set out to develop evaluation criteria for what she calls confessional writing in table 2 of her article. I here re-present that in an abridged form as. Clearly, these evaluation criteria are only applicable to the confessional element of my research and specifically to the research journal itself and the summary that journal which is given in this thesis. Schultze recommends presenting "raw data"; in accordance with this suggestion, I am making all but those journal entries entries which I have tagged as personal available on my website HTTP://markrogergregory.net for inspection by other researchers.

For reasons primarily of space, I have not included significant extracts from the journal in the thesis; therefore I give here no detailed evaluation of my autoethnography. I have however followed several items of advice given by Schultze.

Table 13 Requirements for high quality ethnographic and confessional writing evaluation

Criterion	Requirement
Authenticity (demonstrate that the ethnographic researcher was indeed immersed in the field)	Provide descriptions of: … the relationship between the fieldnotes and the written-up ethnography. Presenting "raw data" such as fieldnotes, documents, and transcribed interviews; and conducting post-hoc respondent validation.
Plausibility (present the findings as relevant to the common concerns of the audience)	Adhering to academic article genre with specific headings, referencing, and formatting. Justifying the research and differentiating its contribution through the identification of gaps in our understanding or the development of a novel theoretical approach. …
Criticality (move readers to reexamine their own taken-for-granted assumptions)	…
Self-revealing writing	Using personal pronouns; detailing—to the extent that it is relevant to the research—ethnographer's age, gender, race, epistemological assumptions and theoretical point of view; disclosing details that present an unflattering picture of researcher, e.g., mistakes made; rendering canonical the problematic and less-than-optimal research conditions.
Interlacing "actual" and confessional content	Interlacing self-reflexive and autobiographical material with "actual" ethnographic material: limiting autobiographical material to information that has relevance to the subject of the research.

Source: Based on (Schultze 2000, table 2)

Chapter 3 FRAMEWORK

The framework – philosophical, semantic and semiotic - is described and a particular modelling approach, that of Conceprocity, is described at length. The significance of critical realism to this study is discussed.

3.1 Abduction, autoethnography, textual analysis and conceptual modelling

An abductive leap: for me even to be able to complete a PhD in personal information management systems it would be necessary to **build a PIMS** – a piece of **design research** – and possible to carry out **autoethnographic research** on that design process and associated learning.

To build a PIMS is an instance of design science research (Hevner et al. 2004); (Gregor and Hevner 2013); (Iivari 2015); or of Action Design Research (Sein et al. 2011). (Baskerville and Wood-Harper 1998) suggested a catholic approach to a variety of action research approaches. The action design research undertaken in this study further extends their list of action research approaches.

Autoethnography is admissible and fruitful in this initial exploratory research. (Schultze 2000) reports an autoethnographic study that she undertook into the production of informational objects, an activity central to knowledge work. Schultze found it impossible to maintain the objectivity normally demanded of the ethnographer. Instead, as she observed knowledge workers – competitive intelligence analysts, librarians and IS specialists – she became involved in their work. In a process of reflexivity she came to understand a number of informing practices that both they and she undertook in their work, which she identifies as expressing, monitoring and translating. Similarly, both they and she found it necessary to balance subjectivity and objectivity. Her article also points up a major difficulty with publishing autoethnographic research, which is the sheer volume of data to be collected, analysed and presented. I have myself maintained a PhD journal for a little under five years, constructed as a large table in Microsoft Word. It currently extends to nearly 390,000 words.

In order to increase the reflexivity and objectivity of such autoethnography, I have therefore also employed **category** and **textual analysis** together with **conceptual modelling** of aspects of the developing exploration. The highlighted terms are expanded upon later in this chapter.

3.2 Ontological influences on this study

In principle, every piece of research needs to demonstrate its ***epistemology***: how we claim to know what we know.

In this research, it has additionally been necessary to think about and develop both a clear ontological stance and also a specific ***ontology***: specifically, a classification of what I know. This additional insistence upon ontology is essential for two reasons. Firstly, the critical realist stance which I have adopted emphasises ontological reality. So to some degree we have to make explicit the reality of which we speak. The second is that the conceptual modelling approach which I develop in this thesis depends upon both a scientific realist and a social ontology. I have no choice but to be serious about my ontological stance.

Ontology in philosophy

We take ontology to be "that branch of philosophy which deals with the order and structure of reality in the broadest sense possible" – quoted by (Wand, Storey, and Weber 1999, 496).

Ontologies in information science

An ontology is a formal naming and definition of the types, properties, and interrelationships of the entities that really or fundamentally exist for a particular domain of discourse.

It is thus a practical application of philosophical ontology.

Ontologies, formal and personal

A formal ontology (or upper-level ontology) is defined by axioms in a formal language and aims to provide a domain- and application-independent view of reality, which can help the modeller of domain- or application-specific ontologies to avoid perhaps erroneous ontological assumptions. Formal Ontologies have great value in areas such as biology and genetic science. It is much less clear that they can be applied in social or personal contexts.

The notion of a personal ontology is not well-developed but we demonstrate by example that it is fundamental to more exact personal information management and more explicit personal knowledge management. By its very nature a personal ontology is likely to be more relativistic, less objective than is a formal ontology. Crucially, it is not fixed once for all time, in the way suggested the certain upper Ontologies. There is very little in the literature concerning personal ontologies. (Katifori et al. 2008) report on the development of a prototype personal ontology maintenance system within a framework provided by that of HCI research. However, this work did not lead to a reusable tool.

Philosophical historical background

Philosophical ideas tend to develop over much longer timescales than are associated with, for example, developments in information systems theory and practice. Thus,

many of the important ideas are not particularly recent. We note that the concepts of abduction or retroduction; existential graphs to express first order logic; semiotics as signs which lead to further signs and even data as relational tables are all present in the work of the late 19th and early 20th century American polymath and philosopher, Charles Sanders Peirce, e.g. (Peirce 1902). Peirce was arguably a phenomenologist before phenomenology was given that name.

The work of the Argentinian/Canadian philosopher Mario Bunge effectively reconnects to an earlier realist stream which was largely set aside in the 19th and early 20th centuries. Bunge has been concerned to re-establish scientific realism and modelling-as-theory – he devotes two volumes of his "treatise on basic philosophy" to ontology, "the furniture of the world" (Bunge 1977, 1979). He in the first volume applies this to areas such as physics, chemistry, life sciences and in the second to what he identifies as social systems. Bunge's ontology is unabashedly realist in character. It has become very significant in the area of conceptual modelling. Specifically, Ron Weber, Yair Wand and others associated with their particular strand of ontological realism in conceptual modelling (Wand, Storey, and Weber 1999, 496), (Wand and Weber 2002) very explicitly base their work on the ontology originally put forward by Mario Bunge. This ontological approach has become very influential in conceptual modelling for requirements analysis, so much so that it is frequently referred to as the Bunge-Wand-Weber BWW approach.

The Bunge-Wand-Weber BWW ontological constructs

(Green and Rosemann 2000) is a contribution to the literature concerning ontological evaluation of various modelling approaches, largely undertaken by Yair Wand and Ron Weber but in this case by Peter Green and Michael Rosemann. This specific article considers the event process chain EPC approach, as discussed for example by (Scheer 2000; Scheer, Thomas, and Adam 2005). **Error! Reference source not found.** is based on their work but includes commentary *in red italics* on ways in which they depart from Bunge's original formulation.

Ontological Construct	Explanation
THING*	A thing is the elementary unit in the **BWW** ontological model. The real world is made up of things. Two or more things (composite or simple) can be **associated** into a **composite** thing.
PROPERTY*: IN GENERAL IN PARTICULAR HEREDITARY EMERGENT INTRINSIC	Things possess properties. A property is modelled via a function that maps the thing into some value. For example, the attribute "weight" represents a property that all humans possess. In this regard, weight is an attribute standing for a property **in general.** If we focus on the weight of a specific individual, however, we would be concerned with a property **in particular.** A property of a composite thing that belongs to a component thing is

NON-BINDING MUTUAL BINDING MUTUAL ATTRIBUTES	called an **hereditary** property. Otherwise it is called an **emergent** property. Some properties are inherent properties of individual things. Such properties are called **intrinsic.** Other properties are properties of pairs or many things. Such properties are called **mutual. Non-binding mutual properties** are those properties shared by two or more things that do not "make a difference" to the things involved; for example, order relations or equivalence relations. By contrast, **binding mutual properties** are those properties shared by two or more things that do "make a difference" to the things involved. **Attributes** are the names that we use to represent properties of things.
CLASS	A class is a set of things that can be defined via their possessing a single property.
KIND	A kind is a set of things that can be defined only via their possessing two or more common properties.
Event	The vector of values for all property functions of a thing is the state of the thing.
CONCEIVABLE STATE SPACE	The set of all states that the thing might ever assume is the conceivable state space of the thing.
STATE LAW: STABILITY CONDITION CORRECTIVE ACTION	A state law restricts the values of the properties of a thing to a subset that is deemed lawful because of natural laws or human laws. The stability condition specifies the states allowed by the state law. The corrective action specifies how the value of the property function must change to provide a state acceptable under the state law.
LAWFUL STATE SPACE	The lawful state space is the set of states of a thing that comply with the state laws of the thing. The lawful state space is usually a proper subset of the conceivable state space.
EVENT	This element is not present in the first table in the article and is introduced in the second table, where each ontological construct is examined in terms of the various views present in the ARIS product.
PROCESS	This element is not present in the first table in the article and is introduced in the second table, where each ontological construct is examined in terms of the various views present in the ARIS product.
CONCEIVABLE EVENT SPACE	The event space of a thing is the set of all possible events that can occur in the thing.

TRANSFORMATION*	A transformation is a mapping from one state to another state.
LAWFUL TRANSFORMATION: STABILITY CONDITION CORRECTIVE ACTION	A lawful transformation defines which events in a thing are lawful. The stability condition specifies the states that are allowable under the transformation law. The corrective action specifies how the values of the property function(s) must change to provide a state acceptable under the transformation law.
LAWFUL EVENT SPACE	The lawful event space is the set of all events in a thing that are lawful.
HISTORY	The chronologically-ordered states that a thing traverses in time are the history of the thing.
ACTS ON	A thing acts on another thing if its existence affects the history of the other thing.
COUPLING: BINDING MUTUAL PROPERTY	Two things are said to be coupled (or interact) if one thing acts on the other. Furthermore, those two things are said to share a binding mutual property (or relation); that is, they participate in a relation that "makes a difference" to the things.
SYSTEM	A set of things is a system if, for any bi-partitioning of the set, couplings exist among things in the two subsets.
SYSTEM COMPOSITION	The things in the system are its composition.
SYSTEM ENVIRONMENT	Things that are not in the system but interact with things in the system are called the environment of the system.
SYSTEM STRUCTURE	The set of couplings that exist among things within the system, and among things in the environment of the system and things in the system is called the structure.
SUBSYSTEM	A subsystem is a system whose composition and structure are subsets of the composition and structure of another system.
SYSTEM DECOMPOSITION	A decomposition of a system is a set of subsystems such that every component in the system is either one of the subsystems in the decomposition or is included in the composition of one of the subsystems in the decomposition.
LEVEL STRUCTURE	A level structure defines a partial order over the subsystems in a decomposition to show which subsystems are components of other subsystems or the system itself.

EXTERNAL EVENT	An external event is an event that arises in a thing, subsystem, or system by virtue of the action of some thing in the environment on the thing, subsystem, or system.
STABLE STATE*	A stable state is a state in which a thing, subsystem, or system will remain unless forced to change by virtue of the action of a thing in the environment (an external event).
UNSTABLE STATE	An unstable state is a state that will be changed into another state by virtue of the action of transformations in the system.
INTERNAL EVENT	An internal event is an event that arises in a thing, subsystem, or system by virtue of lawful transformations in the thing, subsystem, or system.
WELL-DEFINED EVENT	A well-defined event is an event in which the subsequent state can always be predicted given that the prior state is known.
POORLY-DEFINED EVENT	A poorly-defined event is an event in which the subsequent state cannot be predicted given that the prior state is known.

Figure 32 BWW ontological constructs according to (Green and Rosemann 2000)

Some notes on this table. A thing is an elementary ontological construct which corresponds to an instance of a real-world phenomenon. The authors of the paper introduce two notions which are not present in the original Bunge ontology (or, at least, not under those names). These two notions are those of event and process. Green and Rosemann suggest that a process is represented by the whole process model. A function type that is further decomposed also represents a process. Process modelling languages focus on the behavioural aspects of what is being modelled in contrast with for example, the entity relationship model which concentrates on the static structure. Green and Rosemann point out that what is called an event in the Bunge ontology corresponds to a triple in the event process chain EPC model in which event type leads to function type leads to event type. Thus, the homonym event here requires special attention:

"***Transformations*** are represented by function types in the event-driven process chains while ***states*** are depicted as event types. Accordingly, the triple, event type + function type + event type, in an EPC represents the ontological construct ***event,*** and usually, ***internal events*** that are ***well-defined.*** The homonym between the EPC event type and the ontological ***event*** requires careful attention during the analysis. Similarly, a ***state law*** consisting of a stability condition and a corrective action can be represented by the triple, function type + connector + event type, while a ***lawful transformation*** can be represented by the pattern, event type + connector + function type. An ***external event*** may be represented by the start event type at the

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beginning of an EPC while the final **stable state** (of an object) may be represented by the end event type at the bottom of an EPC." (Green and Rosemann 2000, p.82)

What may appear to be ontological deficiency in the event process chain model may suggest misclassification in the BWW. Thus, a number of ontological analyses of various modelling grammars have consistently identified certain ontological constructs that do not have representations in information systems analysis and design ISAD grammars. These include conceivable state space, conceivable event space and lawful event space. Green and Rosemann argue that the ontology may be over-engineered. I would take an additional perspective and suggest that there are many areas of the real world which can only be expressed in an information system and not the meta-model of an information system constituted by a conceptual model. The BWW model has already extended Bunge's ontology with the notion of the various types of property. Similarly, there is clear value in separately identifying process and event as is done in the table above. The value is to do with the clear separation of event, process and state which again is something that you need in information systems even if you may not necessarily model it at the conceptual level. Green and Rosemann suggest that in practice systems analysts frequently find it impossible to model business rules – the conditions of transformation – adequately using the grammars available to them in conceptual modelling languages and they therefore resort to textual descriptions.

They go on to summarise generic ontological deficiencies:

Ontological Incompleteness (or Construct Deficit) exists unless there is at least one modelling grammatical construct for each ontological construct.

Ontological Clarity is determined by the extent to which the grammar does not exhibit one or more of the following deficiencies:

Construct Overload exists in a modeling grammar if one grammatical construct represents more than one ontological construct.

Construct Redundancy exists if more than one grammatical construct represents the same ontological construct.

Construct Excess exists in a modeling grammar when a grammatical construct is present that does not map into any ontological construct.

Green and Rosemann suggest that these ontological deficiency situations may not be weaknesses in the EPC; rather they might indicate misclassification in the Bunge Wand Weber BWW models. I would point out:

1. That the list does not derive entirely from Bunge; thus process, although discussed by Bunge at some length by him, is not defined by him as a fundamental ontological construct. The volume (Bunge 1977) is entitled "Change" and has an extensive description of process viewed in terms of events and states. DEFINITION **5.6** A complex event [i.e. one formed by the composition **of** two or more events] is called a *process.* (Bunge 1977).

Subsequently process is construed by Bunge in terms of event, state and the state space.

2. That some of the ontological entities are difficult to represent directly in a meta-model. Thus, state itself belongs to a property or attribute; it can only have meaning in a real-world system or an information system. Similarly, although lawful state space can appear in a meta-model, it is rarely if ever realised as a construct within an actual modelling approach.

3. A language or knowledge representation that corresponded to the entire set of ontological constructs would be large, probably unwieldy and difficult to "implement".

♦ Distinguishing between meta-model, model and target information system

The primary purpose of conceptual modelling is often taken to be the analysis of requirements for a target information system. A conceptual modelling language and toolkit is used to create a conceptual model for the target information system. In some instances, the model is active in the sense that a toolkit can make use of it in order to build elements of the target information system directly from the description stored in the conceptual model. Thus, if the conceptual model includes a data model, and the conceptual modelling toolkit acts as an active data dictionary, elements of the required target information system can be generated from the description stored in the dictionary.

3.3 Critical Realism: tenets of significance to this research

Critical Realism CR distinguishes between the real, the actual and the empirical (Bhaskar 1975, 1978, 1989; Collier 1994). It argues for ontological realism (cf. (B. Smith 2014)) as it accepts epistemological relativism: the social world is transitive, can be explained but not predicted. It is characterised by a "Critical attitude, self reflection, awareness of hidden presuppositions, and disclosure of assumptions of various perspectives" (Tsoukas 1992) quoted by (Dobson 2002).

Critical realism and its implications for this research

I have adopted a critical realist stance – Roy Bhaskar (Bhaskar 1975, 1978, 1989; Collier 1994), Margaret Archer (M. S. Archer 1995), Philip Dobson (Dobson 2002); cf. Barry Smith (B. Smith and Ceusters 2010; B. Smith 2014). Accordingly, philosophy is viewed as the "underlabourer and occasional midwife" (Bhaskar) which helps us towards applied and applicable knowledge. Among the reasons for which I have adopted critical realism, its underlying retroduction (abductive) inference mechanism is especially important. Critical realism is attracting increasing importance; the recent paper (Mingers, Mutch, and Willcocks 2013) is a paper which acts as an introduction to a recent special issue of MIS Quarterly on critical realism in IS research. (Mingers and Willcocks 2014) links critical realism, semiotics and information systems. (Zachariadis, Scott, and Barrett 2013) clearly sets out what critical realism is as an introduction and adjunct to a discussion of mixed-methods

research. Some writers, as for example (Carlsson 2006), (Carlsson 2010), explicitly link CR and design science.

3.4 Critical realism and affordances

(Volkoff and Strong 2013) take as their starting point that a central task in developing theories of IT-associated organisational change is to uncover the generative mechanisms by which IT is implicated in organisational change. It is therefore necessary to understand how the concept of generative mechanisms fundamental to critical realism applies in an IS context. They note that convincing arguments have also been made for using the affordances posited by Gibson originally in ecological psychology for developing theories of IT-associated organisational change. They therefore argue that ***affordances are the generative mechanisms which can be identified in the real domain from the relation between organisations and IT artefacts that we can observe in the actual domain.***

3.5 A synthetic model of critical realism

The model shown in Figure 33 is based on the reading already outlined and in particular on my interpretation of (Mutch 2010).
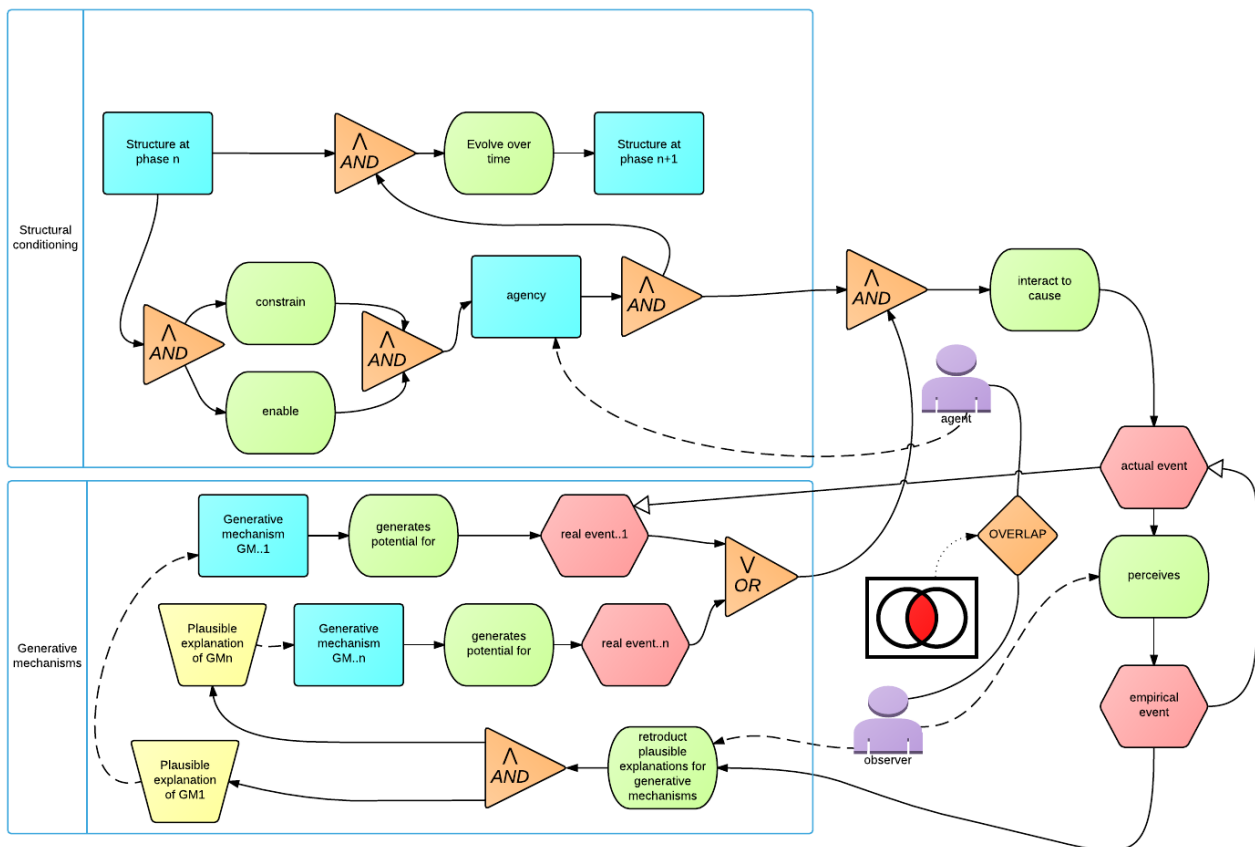
Figure 33 A Conceprocity model of critical realism's main mechanisms

3.6 Cybernetics and systems thinking

(Checkland 2012) sets out four conditions for serious systems thinking and action

- Any entity called a system may also contain within itself functional subsystems and may itself as a whole be a functional part of a wider system. So a system will in principle be part of a *layered structure* making a *hierarchy* of systems.

- To achieve adaptation to change, there will have to be *processes of communication*. These will have to involve both the system and its environment. These processes will enable performance to be monitored so that *a decision to adapt* or not can be taken, whether by automatic processes or by human beings.

- If action to adapt is to be taken, the system will have to have available to it *a number of possible control processes* (responses to the shocks from the environment and to internal failure), which can be appropriately activated to bring about *[adaptive] change*.

- There will be definable *emergent properties* that characterise the particular system or systems of interest, this being the *pre-eminent systems idea*.

Whence we note the principle that we must *recognise* and *make explicit* the *emergent properties* of the *layers* of a system.

The Law of Requisite Variety and PIMS

The law of requisite variety can be stated thus, following (Ashby 1956, p.206) paraphrased:

Variety absorbs variety, defines the minimum number of states necessary for a controller to control a system of a given number of states (in a discrete state controller). If a system is to be stable and / or controlled the number of states of its control mechanism – its regulator - must be greater than or equal to the number of states in the system being controlled.

Ashby elsewhere states the law as "only variety can destroy variety" (Ashby 1956, p.207).

In (Ashby 1958) Ashby sees the law of requisite variety as introductory to Shannon's Information Theory (Shannon and Weaver 1949). This deals with the case of "incessant fluctuations" or noise. Regulation seeks to keep fundamental variables within a system or organism within ranges of values at which that organism can continue to survive. An effective regulator has access to variables which seek to disturb desirable outcomes and thus is able to counter them. This data passes through communication channels whose effectiveness and fundamental limitations had earlier been established by the information theory of Shannon. Ashby states: "R's capacity as a regulator cannot exceed its capacity as a channel for variety." (Ashby 1958). At p. 88, we find: "The law of requisite variety then says that

such regulation cannot be achieved unless the regulator R, as a channel of communication, has more than a certain capacity. Thus, if D threatens to introduce a variety of 10 bits into the outcomes, and if survival demands that the outcomes be restricted to 2 bits, then at each action R must provide variety of at least 8 bits." At p.91, "Our 'disturbance D', which threatens to get through to the outcome, clearly corresponds to the noise…" [affecting Shannon's communication channel] "and his theorem says that the amount of noise that can be prevented from appearing in the outcomes is limited to the entropy that can be transmitted through the correction channel." In a 100% regulated system, there is no message to be transmitted; the message has zero entropy. Ashby gives as an example, in a mammal blood temperature is kept as near as possible to a value which never changes. "Thus, all acts of regulation can be related to the concepts of communication theory by our noticing that the 'goal' is a message of zero entropy, and that the 'disturbances' correspond to noise." (p.91). Ashby then discusses the implication: that any man's intelligence is subject to the fundamental limitation that it cannot exceed his capacity as a transducer. Even a team or organisation is severely limited in its capacity to understand, let alone manage, the phenomena and systems of great complexity which it encounters in its environment. ***Much more so the individual who is the focus of this paper.***

We can note the folowing implications:

- A good PIMS amplifies good variety while attenuating bad variety.

- The principal *adaptive* element in a PIMS is the individual knowledge worker herself.

- She adopts and adapts PIM tools over time. Their use can contribute to improved variety management.

The Good Regulator theorem

Basing their work on Ashby's earlier cybernetic writings and in particular on the information theory of Shannon, (Conant and Ashby 1970) introduced the Good Regulator theorem which requires autonomous systems to acquire an internal model of their environment to persist and achieve stability or dynamic equilibrium. (Conant & Ashby 1970, p.89)'s Good Regulator theorem states that

"Every good regulator of a system must be a model of that system… The design of a complex regulator thus includes the making or maintenance of a model of the system to be regulated. The theorem shows that *any regulator that is maximally both successful and simple must be isomorphic with the system being regulated."*

Applying this to individuals suggests and mandates that the actor (doer) and learning thinker has to absorb and counter threatening variety within her environment by devising (developing and maintaining) a regulator or controller. This controller is analogous to Ross Ashby's homeostat (Ashby 1956); (Ashby

1962). A homeostat exhibits behaviours such as habituation, reinforcement and learning through its ability to maintain appropriate levels of stability in a changing environment.

The shape required of the regulator is that of the situation to be regulated: "the theorem says that the best regulator of a system is one which is a model of that system in the sense that the regulator's actions are merely the system's actions as seen through a mapping." (Conant and Ashby 1970).

The implications of the good regulator theorem are both profound and far-reaching.

(Scholten 2010b) attempts to re-express Conant and Ashby's theorem using more accessible maths than those assumed by the original authors. However, even to understand his simplified approach remains somewhat challenging. Therefore Daniel Scholten has also written (Scholten 2010a); this primer is supported by a simulation model which can be found at http://www.goodregulatorproject.org/. "Every Good Key Must Be A Model Of The Lock It Opens".

Systems thinking and modelling

(Stowell and Welch 2012, xiv) following (Checkland 1981, 198); see also (Stowell 2013); identify as the basic building blocks of systems thinking *(1) emergence*, *(2) hierarchy*, *(3) communication* and *(4) control*. They discuss how a system is defined from the perspective of an observer, who chooses to draw a boundary reflecting a field of interest and giving to the system so defined a name. They remind us of the taxonomy of three systemic models originally identified by Russell Ackoff (Ackoff, Gupta, and Minas 1962) and they extend it with a fourth following Brian Wilson (B. Wilson 1984) to yield:

1. An *iconic* model is a model of reality, the properties of which equate to those of the real article such that (albeit on a different scale) the model can be expected to behave in the same way as the real thing. I would give as an example of such a model the wind tunnel model of a new aircraft.

2. An *analogical* model is an attempt to simulate the behaviour of the original although its physical appearance is quite different to that of the original. Most simulation models fall into this category.

3. An *analytic* model is created from mathematical or logical relationships that are believed to lead to the behaviour of some situation of interest. Typical examples include spreadsheet models. Analytic models may subsequently provide the data for analogical models.

4. A *conceptual* model includes pictures or symbols which are used to represent the subjective and qualitative aspects of a situation.

(Stowell and Welch 2012) present modelling as a kind of surrogate representation of some situation. It is in the process of forming, reforming and structuring that model that we begin to learn about the situation of interest and its similarities and

differences to the situation that we are modelling. Among the dangers inherent in such modelling are that it becomes an end in and of itself. Instead a model is only an abstraction of our perception of reality. As a simplification it is also often subjective.

Checkland's systems thinking

(Stowell and Welch 2012) advocate Checkland's idea of a system (Checkland 1981). In (Stowell 2013), the interviewee Peter Checkland reemphasised his insistence that a system is not something "out there" whose identification any two dispassionate observers could agree upon.

The product of Checkland's thinking, based upon 30 years of action research, is firstly a process of enquiry which through a number of hermeneutic cycles[10] learns its way to the accommodations which enable "action to improve" to be taken. There follows his view of social reality as the ever-changing outcome of the social process in which we all continually negotiate and renegotiate our perceptions and interpretations of the world outside ourselves. Thus, according to Checkland, ***the system is not something in the world; it is the enquiring process.***

(Checkland 2012, 466) states:

> "The bare minimum set of concepts needed to express the nature of an adaptive whole is four in number."

We can summarise these as:

1. ***Emergence*** – (Goldstein 1999) defines emergence as "the arising of novel and coherent structures, patterns and properties during the process of self-organization in complex systems". Checkland calls emergence the pre-eminent systems idea.

2. ***Hierarchy*** – any entity called a system may also contain within itself functional subsystems and may itself be a part of a wider system.

3. ***Communication*** – in order to achieve adaptation to change, there must be processes of communication both within the system and to and from its environment, and human or intelligent decision-making.

4. ***Control*** – processes which responds to shocks in the environment and to internal failure.

Information Systems from a cybernetic perspective

An excellent framework for (inter alia) the initial analysis of information systems requirements is provided by the work systems method of Steven Alter (Alter 2006). Alter defines a Work System as a system in which people and/or machines perform a business process using resources (e.g., information, technology, raw materials) to create products/services for internal or external customers. Supporting the work system will be a number of information systems - although the mapping between

[10] The hermeneutic circle refers to the circle of interpretation that is involved in the understanding of knowledge.

information system and work system is many to many; see (Alter 2002a). Following and extending (Paul 2010) we define an information system as *"information and communications technology in use"*; we here add *"by people".* Simplistically, we can characterise an information system as taking inputs in the form of data, yielding as output information whose purposes may include

- ❑ Better visibility / vision of what's happening

- ❑ Monitoring and control

- ❑ Improved decision making

Generally speaking, information systems are filters on the inward path, amplifiers on the forward path or components of the feedback path used to control a complex system. Thus, for example business information systems BIS may be used to coordinate and control the work of an enterprise. Figure 34, taken from (Schwaninger 2004), illustrates the need for the amplification and attenuation that BIS can provide.
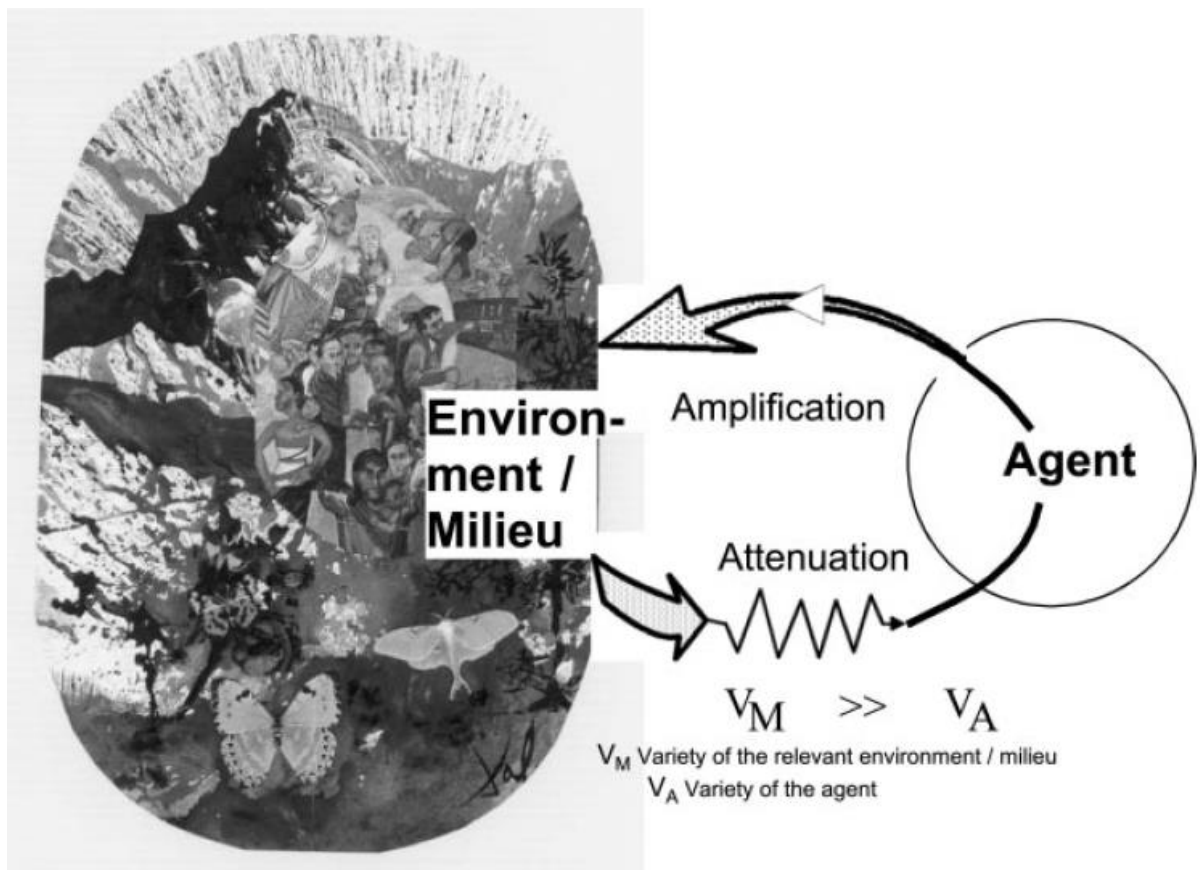
Figure 34 Dealing with the inevitable mismatch between variety in the controller and that in the environment. *Source: (Schwaninger 2004, figure 1).*

Following (Baskerville 2011b), we regard the individual knowledge worker as being the most important component of a personal work system. Following Checkland, we suggest that the only element of an information system – people using information and communications technology – that demonstrates emergent behaviour is the

person herself interacting with the technology; the technology itself does not normally adapt, at any rate in the short term. We posit that the controller (that is homeostat or regulator) for a knowledge worker is her personal work system PWS supported by her personal information management system, which we take to be analogous to her memory extension memex (Bush 1945) in that it embodies her conceptual data structures CDS and the associated data (Völkel and Haller 2009). Her knowing brain constitutes the doing (processing) and variety-generating element within the personal work system by which she gets things done. She can increase her requisite and available variety – her ability to cope with complexity (Backlund 2002) - by information gathering, by learning and by calling upon her network or her mentors. Information here is to be understood as meaningful and true interpretation of data as discussed by (Floridi 2005).

The means by which her knowledge and rule-base is changed is learning. We recognise two kinds of learning: learning existing knowledge as it has already been distilled and published (knowledge diffusion and acquisition); and the discovery of new knowledge (knowledge creation). Learning has the effect of changing the working model that the actor has of her life and purpose. Learning may be achieved, inter alia, via the processes of conventional teaching or with a dialogic mentor (Gregory, Kehal, and Descubes 2012a). The teacher or mentor acts as *deus ex machina* – a source of new purposeful variety. Together and apart the mentor and mentee learn and thus, for a while, survive and thrive.

Based on the good regulator theorem of Conant and Ashby, we posit that ***there must exist a model of the personal working system of each individual*** – since we all do succeed to some extent to Get Things Done (D. Allen 2003) and to Keep Found Things Found (W. P. Jones 2007b). We give this model a name: ***"Personal Working Model"***.

We hold that there must exist this personal working model. The argument runs as follows.

We conjecture that the level of abstraction and the type of the learning and therefore of the Working Model required depend on the nature of the work that the actor has to undertake. Thus, where plumbers use largely tacit techniques, where teachers diffuse knowledge and assist learning and engineers create new artefacts and techniques: the researcher needs to discover or create new knowledge. The new knowledge is here explicit.

The Working Model needs to be as simple as possible but no simpler. Put another way, it should encourage "requisite complexity" (an updating of Ashby's requisite variety, which is very well introduced by (Stowell, 2013, pp. 118–121)). Since, as Ashby and later Stafford Beer (Beer, 1984) demonstrate, it is in practice almost never possible to create more states of variety in a controller than exist in its environment, the pragmatic necessity is to apply appropriate heuristics which filter and absorb inappropriate variety and permit identification of threatening and friendly variety requiring to be countered and dealt with. Perhaps among other approaches, ***the creation, maintenance, development and sometimes conscious***

***design of an appropriate personal information management system have the
potential to make a major contribution to an effective personal work system***.

The roles of theory and of learning in the Working Model

(Conant and Ashby 1970) require that a good regulator model be isomorphic with
the situation to be regulated. In practice isomorphism is usually not achievable;
instead, we achieve various degrees of homomorphism. (Beer 1999) reprises his
earlier (Beer 1966) identification of what he called the yo-yo model, one feature of
which is that isomorphism can be identified between linked ideas each of whose
derivation is homomorphic. In (Gregory and Descubes 2011c), we highlighted a
critical dependence on two phenomena identified by (Argyris and Schön 1974, 6–7);
these are normally discussed in an organisational context but have applicability also
at the individual level. These two phenomena are:

❑ The difference between espoused theory and theory-in-use

❑ The desirability of double-loop learning

> "When someone is asked how he would behave under certain
> circumstances, the answer he usually gives is his espoused theory of
> action for that situation. This is the theory of action to which he gives
> allegiance, and which, upon request, he communicates to others.
> However, the theory that actually governs his actions is this theory-
> in-use." (Argyris and Schön 1974, 6–7)

(M. K. Smith 2001) describes how (Argyris 1980) makes the case that effectiveness
results from developing congruence between theory-in-use and espoused theory.
Smith suggests that where there is a mismatch between intention and outcome,
organisations and individuals may exhibit either single- or double-loop learning.
The latter involves questioning the role of the framing and learning systems which
underlie actual goals and strategies in a process which (Argyris 1982, pp.103-4)
identifies as deeply reflective:

> "Reflection here is more fundamental: the basic assumptions behind
> ideas or policies are confronted… hypotheses are publicly tested…
> processes are disconfirmable not self-seeking".

> This reflective and reflexive double loop learning is a major
> influence on the Working Model.

(M. K. Smith 2001) discusses how Argyris goes on to suggest the necessity for a
model II theory-in-use in which the governing variables are critically reviewed and
change. However, this approach is extremely difficult in practice and has not been
the subject of much (academic) research. Smith prefers the approach, grounded in
Dewey's pragmatism (Dewey 1931; Sleeper 2001) but extending well beyond it,
summarised by (Schön 1983, 69) as ***reflection in action***:

> "The practitioner allows himself to experience surprise, puzzlement,
> or confusion in a situation which he finds uncertain or unique. He
> reflects on the phenomenon before him, and on the prior

understandings which have been implicit in his behaviour. He carries out an experiment which serves to generate both a new understanding of the phenomenon and a change in the situation... He does not keep means and ends separate, but defines them interactively as he frames a problematic situation. He does not separate thinking from doing... Because his experimenting is a kind of action, implementation is built into his enquiry."

See also (M. K. Smith 2009) on the work and influence of Donald Schön and (Finger and Asún 2001) on its implications for learning, teaching and mentoring.

Limitations of models and objections to their use

Modelling was a very large part of information systems thinking and practice in its early days, in for example the dataflow diagrams of Larry Constantine (Yourdon and Constantine 1976) and the entity-relationship modelling of (Chen 1976, 1977) – the latter being particularly valuable because of the ease with which an E/R model can be translated into a relational database design (Codd 1970, 1971). More recent software engineering practice has tended to subsume modelling into design (or even attempted to eliminate it as an explicit step). But the original role of modelling was in the analysis of requirements which should normally precede design and very definitely should inform it. Requirements analysis is difficult precisely because it requires modelling by (or with the very active involvement of) domain specialists: the users and their managers of the information systems built to enable and improve work systems. Without explicit requirements models, there is a very strong likelihood that the model of what is needed will not correspond with the model which the eventual computerised IS actually implements. With appropriate models – that is, models of "reality" and of the domain of application – communication between domain specialists and developers at least becomes possible. Among those who have called for a return to an emphasis on **appropriate** modelling is (Alter 2003a, 2003b). Alter does not call for complex graphical models. Instead he concentrates on getting practising managers to create models which are in essence tables.

The recent revival within the information systems community of interest in design science and in design science research is in this sense a welcome return. See for example (Hevner and Chatterjee 2010b; Hevner et al. 2004; Iivari 2007); see also (Baskerville et al. 2010; Baskerville 2011c)

Beer's suggestion for easing the requirement for strictly isomorphic regulatory models

(Beer 1999) is candid about the difficulty of modelling and of understanding models since models are mental constructs that must never be confused with "reality", which we often only dimly perceive. But he reminds us that starting from simile and passing through analogy we may recognise and achieve a degree of isomorphism (via homomorphism) to a situation which we do know how to manage - this is the

yo-yo analogy previously referred to (section 0). In fact we should be seeking to identify what Beer calls systemic invariance. Feedback mechanisms, attenuation of inappropriate environmental variety, and above all retention and amplification of requisite internal variety, are all desirable characteristics of good management – personal as well as organisational.

Recent insights from cybernetics

The theoretical biologist (Nikolić 2015) applies and extends these cybernetic principles as he considers the mind-body question. He identifies *Practopoiesis:* The key for achieving intelligence through adaptation is that mechanisms at a lower level of organisation, *by their operations and interaction with the environment*, enable creation of mechanisms at a higher level – a phenomenon which he calls the *cybernetic traverse. Practopoiesis* is suggested as a *general cybernetic theory of adaptive systems*. The underlying idea is that each adaptive mechanism, at any level of self-organisation, receives feedback from the environment. Practopoiesis extends existing cybernetic theory, in particular the law of requisite variety and the good regulator theorem, in the sense that it explains how systems obtain their cybernetic capabilities, that is, how they learn what and where to control. Nikolic suggests that there are three essential elements in any system which has the capability to learn to control. These are:

Monitor-and-act machinery: an adaptive system must consist of components that are capable of detecting conditions necessity to act and of acting. An example is a neuron. A monitor-and-act component is capable of detecting information, acting on it and observing the effects of the action. In this sense, it already possesses certain knowledge about the effects that its actions are likely to exert on the world.

Poietic hierarchy: the monitor-and-act units are organised into a hierarchy in which low-level components, by their actions, create, adjust, service and nourish high-level components.

Level-specific environmental feedback: monitor-and-act components receive necessary feedback from the environment to which the system is adapting.

Nikolić identifies what he calls the *Cybernetic knowledge* of a component, for example, knowledge on when to act and how (Ashby 1956). [This is a very low-level notion of knowledge, and has nothing to do with the use more generally made in this thesis.]

Since every component of a system must be able to adjust to its environment, this cybernetic knowledge is necessarily subjected to the good regulator theorem of (Conant and Ashby 1970).

The combination of poiesis and level-specific environmental feedback implies that the process of building the system is also the process of adapting the system which is also the very process of acquiring further cybernetic knowledge. In this way, newly created structures become a model of the system's environment. Provided that they are also capable of generating requisite variety, they become good models.

A practopoietic hierarchy implies transition from high to low levels of generality of knowledge in an active adaptive traverse of knowledge, or simply a *traverse*.

Anapoiesis is the traverse which reuses long-term knowledge in the service of short – the basis for higher-level learning.

In a four-level hierarchy, there are three traverses possible. A system with this characteristic is identified as a T4 system. A T4 system possesses three cybernetic traverses. A T1 system is capable of control and of deduction. A T2 system is capable of supervision and induction. A T3 system is capable of anapoiesis and of abduction; Nikolić calls a T3 system the mind. Anapoiesis of a T3 system can be described as a use of past knowledge to guess which knowledge is correct for a given situation and then evaluating the degree to which the guess matches reality and adjusting the discrepancies that may appear. ***This guess-based logical operation is what is known as abduction, or inference to the best explanation: and is due to Charles Sanders Peirce.*** In a probabilistic form, abduction is described by Bayes theorem.

The key contribution of practopoietic theory is the generalisation of the role of feedback: in any given system, the principles by which the variety is adjusted can be also adjusted themselves by yet another set of principles, and so on. Since each set of principles can have its own variety, the hierarchy can in principle grow indefinitely. Each step in this hierarchy is one traversal of cybernetic knowledge. In practice, systems beyond T3 either do not exist or are not yet significant in our understanding of the world.

A wide range of applications are followed up by Nikolić. The capability of the human mind to conceptualise the world may be accounted for by anapoiesis of knowledge. Thus, our conceptual knowledge, stored in long-term memory, consists of generalised, abstract rules of interacting with the world. These general principles are matched to a specific situation by means of anapoiesis.

The significance of these new cybernetic insights for this current study include a further demonstration of the pervasiveness and global significance of abduction; see also (Tohmé, Caterina, and Gangle 2015). Additionally, these cybernetic mechanisms are generative; their identification provides explanation.

Fundamental questions and putative answers

Q: What is the system under investigation?

A: It is the ***work system*** constituted by the knowledge worker as she gets things done, as she informs her work, and as she reflects and learns

Q: What is the form and function of the model which regulates that system?

A: A « Working Model » which is a dynamic active representation of the life she seeks to live

- The true isomorphic model is likely to be difficult to perceive, changeable, very individual and fragmented

- But the effort has to be made to discern it at least homomorphically and to make it concrete and active

Q: How can we model the model?

A1: In this research, we have chosen to design and develop a ***knowledge mapping semi-formalism,*** called Conceprocity. This knowledge mapping formalism has then been used to create putative models for a single knowledge worker, the author himself. This is a representation of a specific working model.

A2: A PIMS assembled from affordances. The data stored in this PIMS actively influences the actions of the knowledge worker.

Q: What are the generative mechanisms that must exist if personal information management systems are to emerge and be recognisable?

A1: Some element of volition, whether bricolage or explicit design

A2: Technology-enabled affordances

Q: Why is this significant for personal work management?

A: The need for self organisation and control in an open and continuously evolving system mandate systematic and adaptive personal information management

3.7 Critical realism and systems thinking

Systems approach: systems thinking and critical realism

(Mingers 1999) discusses the relations between information and meaning, as generated through the interactions of individuals, and communication, at the level of society, from an autopoietic perspective. He notes the significance of embodied knowledge and cognition.

He proposes a category of organisationally closed, or self-referential, systems. The contribution made in this paper is to link these analyses at the level of the individual up to the social system of communication (based on structuration theory.

(Mingers 2011) makes a careful historical analysis of systems thinking, initially evidenced as hard systems thinking – general systems theory and cybernetics; followed by a second phase of soft systems thinking – SSM; followed by non-linear dynamical systems (complexity theory). Mingers then discusses systemic concepts in the first phase of the work of Roy Bhaskar. He suggests certain equivalences between the concepts in the work of Roy Bhaskar and better defined terms in systems theory. However, Mingers does identify that the CR term generative mechanism has particular value.

The view which Mingers takes is based on the interdependence of emergence and the dynamics of components presented by (Thompson and Varela 2001):

> "so there is a 'reciprocal causality' in play in which the components interact directly and locally, generating and sustaining the behaviour of the whole, while the whole sets the control parameters and boundary conditions for the components. Thompson and Varela give general examples such as autopoiesis and the immune system... Equally we can use the example of social systems within critical

realism. Here, social structure (or system) is only instantiated through the activities of social agents, but at the same time the social structures of roles and practices conditions the activities that agents can undertake." (Mingers 2014, p.45).

The application to my work that immediately comes to mind is the interaction between personal work system and personal information management system. Very clearly, there is an extent to which the personal work system is an emergence based on components such as the personal information management system. But almost as obvious is the shaping of the PIMS by the PWS. Here, the generative mechanisms include the embodiment of the volition of the designer in the shape – the vocabulary and the viewed form – as she arrives at a PIMS, both designed and "bricolé". And although when I model the PWS and the PIMS and the designerly knowledge which go into the realisation of both I shall impose boundaries, those boundaries are very much ones which I perceive and which I draw.

Continuing his discussion of dialectical critical realism, Mingers discusses absence and negativity as major presuppositions in critical realism. An absence can be illustrated by that of not paying a bill. This non-action has a consequence. Mingers suggests that this has its parallel in a concept put forward by Gregory Bateson (Bateson 1972):

> "Causal explanation is usually positive… In contrast to this, cybernetic explanation is always negative. We consider what alternative possibilities could conceivably have occurred and then ask why were many of the alternatives not followed, so that the particular event was one of those few which could, in fact, occur."

Mingers draws the parallel between such absence and the behaviour of a feedback system as it tries always to close a gap (make absent an absence) between the desired state of the system and its actual state. He then goes on to discuss autopoiesis, which takes a concept explicitly present both in systems thinking and in critical realism. Autopoietic systems are self-producing or self-constructing. The concept of autopoiesis is due originally to (Maturana and Varela 1987, 1980). They developed the concept of autopoiesis to explain the special nature of living as opposed to non-living systems. Autopoietic systems are closed and self-referential – they do not primarily transform inputs into outputs; instead they transform themselves into themselves…. They are said to be organisationally closed but interactively open. (Mingers 1995)

Mingers concludes that Roy Bhaskar is heavily informed by systems thinking but fails to reference it in his work. Thus, Mingers holds that many of the fundamental ideas of critical realism have already been developed within the disciplines of systems thinking and cybernetics. Systems thinking sometimes provides clear articulations of key concepts such as circular causality through positive and negative feedback loops. Conversely, critical realism can also be beneficial by providing a more rigorous philosophical underpinning – which systems thinking often lacks.

Particular concepts are better developed in critical realism; he concludes by highlighting absence/negativity; but similarly, he has previously identified generative mechanisms as a conceptual strength of critical realism.

Modelling, CR and the systems approach

(Goles and Hirschheim 2000) do not discuss critical realism as such. Instead, they talk about scientific realism as they identify as an important author Roy Bhaskar.

(Goles and Hirschheim 2000, p.252):

> "Scientific realism holds that while the world exists independently of its being perceived (`classical realism'), the world can only be known through models of the world. The models themselves are not immutable – they never can be known with certainty (`fallibilistic realism'); indeed, the job of science is to develop better models of the world (Hunt 1990)".

(Goles and Hirschheim 2000, p.261) address the scientific realism of Bhaskar. They make the interesting observation:

> "To some extent, it is tempting to draw a parallel between pragmatism and the scientific realism of Bhaskar. For Bhaskar, scientific realism is more than an ontological stance in that it adopts a particular epistemology as well. His version of scientific realism agrees with Kuhn that knowledge is a social and historical product. The task of science is to invent theories that aim to represent the world. In this way, science generates its own rational criteria that determine which theories are to be accepted or rejected. Crucially, it is possible for these criteria to be rational precisely because there is a world that exists independently of our cognizant experience. The theories which result from these rational criteria may be wrong, since they are based on the known world rather than the world itself. But nonetheless, they are what the community agrees on and is based on a community standard of what constitutes ``valid'' or ``believable'' knowledge claims. According to (Bhaskar 1975), it is our knowledge of the world that is circular; the world itself exists, and we experience perceptions of that world. The goal of science is to build sophisticated models using rational criteria to represent the world. As already mentioned, the models represent only what we know of the world and this knowledge is inherently flawed; but as we build successive models we may improve our representation. By making use of cognitive materials and operating under the control of something like a logic of analogy or metaphor, we can postulate a model. We do not believe that the model exactly duplicates the world; but, if this model were to exist and act in the way specified, then it allows us to account for observed phenomena. Lastly, Bhaskar notes that models are composed of abstractions and are untruthful, by definition, since they oversimplify. The greater the level of

abstraction, the more this is so since they move further from empirical phenomena and oversimplify by grouping lower level abstractions."

3.8 Conceprocity: Concept Process Reciprocity

Conceprocity is both a product and a contribution of this research but also a mechanism used within the research itself. I therefore introduce it here in the framework chapter.

Knowledge Representation

(Hjørland and Nicolaisen 2005) discuss knowledge representation. They remind us that "Knowledge representation is thus depending both on the objective pole: what knowledge exists to be represented and on the subjective pole: the representator or selector." (Hjørland and Nicolaisen 2005).

We can summarise their findings in tabular form as Table 14:

Table 14 Knowledge representation according to (Hjørland and Nicolaisen, 2005)
with additional commentary in italics

Framework	Technique	Characteristics
AI: symbol representation and manipulation	Logic based representations	Declarative sentences and inferencing. Comment: We would suggest that propositional calculus, predicate calculus, first order logic and Horn clauses (as used in Prolog) fall within this category.
AI: symbol representation and manipulation	Procedure based representations	The meaning of a knowledge base is in its use.
AI: symbol representation and manipulation	Frame based representations	"Frame-based systems are knowledge representation systems that use frames, a notion originally introduced by (Minsky 1975) as their primary means to represent domain knowledge. A frame is a structure for representing a concept or situation such as "restaurant" or "being in a restaurant". Attached to a frame are several kinds of information, for instance, definitional and descriptive information and how to use the frame. Frames are supposed to capture the essence of concepts or stereotypical situations, for example going out for dinner, by clustering all relevant information for these situations together. This means, in particular, that a great deal of procedurally expressed knowledge should be part of the frames. Collections of such frames are to be

		organized in frame systems in which the frames are interconnected." (Hjørland and Nicolaisen 2005)
AI: artificial neural networks		Parallels are drawn between neural nets and behaviourism. There is an emphasis on noting stimulus and response in an empiricist tradition and comparatively little interest in what is happening within the black box. Feedback and/or feedforward are emphasised.
Statistical analysis of large corpora of data		"The statistical approach to AI involves taking very large corpora of data, and analyzing them in great depth using statistical techniques. These statistics can then be used to guide new tasks. The resulting data, as compared to the knowledge-based approach, are extremely shallow in terms of their semantic content, since the categories extracted must be easily derived from the data, but they can be immensely detailed and precise in terms of statistical relations. Moreover, techniques - such as maximum entropy analysis - exist that allow a collection of statistical indicators, each individually quite weak, to be combined effectively into strong collective evidence. From the point of view of knowledge representation, the most interesting data corpora are online libraries of text. Libraries of pure text exist online containing billions of words; libraries of extensively annotated texts exist containing hundreds of thousands to millions of words, depending on the type of annotation. Now, in 2001, statistical methods of natural language analysis are, in general, comparable in quality to carefully hand-crafted natural language analyzers; however, they can be created for a new language or a new domain at a small fraction of the cost in human labor" (E. Davis 2001) Large corpora of data may be approached by methods related to empiricism, which seems to be what Ernest Davis is suggesting. There is an important difference, however, between traditional empiricist approaches to knowledge representation and "text corpora" approaches. The traditional approach represents what is considered knowledge by the person doing the representation. There is only one voice present. In large corpora of texts many voices are present (what kind of voices varies according to how the text corpus is selected, e.g. if it consists of newspapers or scholarly papers).

		Author's comment: textual analysis tools such as Leximancer are capable of analysing large text corpora and summarising their findings in the form of concept maps. The remark concerning "many voices" is valid and important. For this reason it is pragmatically desirable to subset large text corpora and to analyse them separately as well as together.
Semantic networks	Involve nodes and links between nodes. The nodes represent objects or contents.	

Origins and history of Conceprocity

I initially chose G-MOT as originated by UQAM LICEF - (Paquette 2010), but evolved this as I created my own KR approach. ***Conceprocity*** – **concept ↔ process reciprocity CPR** – is a visual and textual *language* and *toolset* intended for capturing, expressing, communicating and co-creating ***models of topic areas*** of domain ***knowledge*** by domain ***experts*** or ***learners.*** I began to develop it in spring 2013 and was first able to use it with students in the early summer of the same year. It employs semi-formal semantics – human emphasis, used when investigating problem situations; but grammar rules exist and are (currently partially) enforced.

Conceprocity origins

Ancestor: ***existential graph*** meta-model (and pragmatic construction) - (Peirce 1933); (Atkin 2013).

The intellectual roots and origins of Conceprocity lie in the work originally undertaken by the Québecois research group LICEF. This work is part of a ***knowledge mapping*** approach which is studied and used particularly in Francophone countries. Primary theoretical influences on the LICEF approach come from cognitive science and psychology. See (Paquette 2010). However, when I sought to position my approach to concept process mapping, I looked for theoretical roots for my own variant of this approach rather in the ***conceptual modelling*** tradition associated with information systems and specifically with requirements analysis. The reason for this choice is that there is a great deal more published research in the conceptual modelling tradition than there is in the knowledge mapping area. In particular, there is a greater philosophical coherence evident in the conceptual modelling literature than that which I have been able to discover in the knowledge mapping approach.

I believe that I am the first person to attempt to bridge these two streams of research:

1. the conceptual modelling tradition typically associated with the work of Yair Wand, Ron Weber and others who align more or less with the information systems discipline;

2. and the knowledge mapping or knowledge cartography tradition epitomised by the work of Gilbert Paquette – the LICEF research centre which he founded is informed by computer science, artificial intelligence studies, educational studies and by cognitive psychology and studies in cognition.

More generally, we can identify four distinct streams of concept mapping approaches:

∗   Cmap concept mapping

The approach to concept mapping originated by Joseph Novak and Alberto Cañas, which is based on work by the development psychologist David Ausubel. This approach is particularly strong in the American Hispanophone community and for this reason I give it the shorthand designation the *Florida approach*; it is grounded in cognitive psychology. A major application of this approach, and one which has influenced its form, is to initial instruction of, and learning by, schoolchildren in science. It therefore takes a very simple representational form.

∗   G-MOT knowledge mapping

The Francophone approach of Paquette and his collaborators: typed object mapping, clearly informed by object-oriented programming and analysis – but very much also a knowledge organisation approach. This school, which sometimes also identifies itself as knowledge cartography, sees wide applicability of knowledge mapping approaches in areas such as instructional design, business process modelling and even – in a more formalised variant – the construction of formal ontologies RDF and OWL by means of diagrammatic concept maps. I give it the shorthand designation the *LICEF approach*.

∗   Knowledge organisation systems KOS

The community which surrounds the journal Knowledge Organization, whose current editor is Richard Smiraglia. This would appear to draw in particular from the library and information science tradition. It takes a broad view of concept mapping. It does not seek to impose a particular approach, much less a particular modelling language. Recent articles have sought to summarise the semi-formal underpinnings of this approach. (Rocha Souza, Tudhope, and Barcellos Almeida 2010) present a taxonomy of knowledge organisation systems (KOS) itself in the form of a concept map.

I dub this tradition the *KOS approach*.

∗   Bunge Wand Weber BWW conceptual modelling

The information systems requirements analysis conceptual modelling school, whose most significant sub-stream measured by volume of publications is informed by the

so-called **Bunge Wand Weber BWW** approach associated in particular with Yair Wand and Ron Weber. This approach has the strongest theoretical, particularly ontological, basis. However, I would argue that it displays a weakness in that it restricts itself very largely to requirements analysis and does not see a wider role for conceptual modelling. A strength which is also a weakness is the strong commitment to a scientific realist ontology. It is a strength in so far as it gives a philosophical and intellectual coherence to the approach. It is a weakness in that we normally apply the term Information Systems in the area of human activity systems where a social ontology is at least as significant as a strictly scientific realist one. The work of Salvatore March and Gove Allen (March and Allen 2014) suggests the extension of the ontology to include elements of the social ontology of John Searle, and this basic approach is the one which I am developing.

From the evidence available to this author, these four strains have been working largely in ignorance one of another. I think that this raises a very interesting gap which I am perhaps well positioned to fill. In this thesis, all I can do is identify that gap but also suggest that my approach has learned from them all and that I have then extended the BWW ontology so that it meets the challenge in particular of social ontology.

What this new understanding of the uniqueness of Conceprocity gives me is the opportunity to strengthen the contribution which I claim has arisen from the process of its design, the product itself and its use and usefulness. A gap exists because the best theoretically justified approach, that of Bunge Wand Weber BWW, has rarely been applied in the area of conceptual knowledge mapping to which in fact it is well-suited. The LICEF approach helpfully introduces typed object modelling but does not apply it in the area of information systems requirements analysis. In addition, it semiotics are difficult to read and to learn. The Florida approach is too semantically imprecise to be used outside its original application to the education of students and of children. I believe the Conceprocity, with its informal early usage profiles and its much more formal TROPICPEA approach, is both gradually learnable and ultimately fairly semantically precise.

Areas in which Conceprocity has followed G-MOT

There are very many areas in which Conceprocity has followed design decisions made in G-MOT. These include fundamental areas such as the notion of typed objects.

Gilbert Paquette, the originator of the G-MOT approach, has written (Paquette 2010) which discusses the relationship between structured knowledge representation and learning, which he sees as being inextricably linked. Thus, understanding is impossible without identifying and classifying objects and ideas and linking them by association in some organised way. These mental structures or schemas vary in complexity. The concept of schema as the building block of mental structures is now well established in cognitive psychology. The language and the thinking derive initially from the work of Jean Piaget (Inhelder and Piaget 1955), who discussed the meta-concepts of schema, structure, strategy and operation to

describe cognitive processes. According to Piaget, growth of the intellect is achieved through increasingly logical, numerous and complex schemas. Such schemas play a central role in the construction of knowledge which in turn is essential to the learning process.

> "Learning is a process by which a representation of a certain knowledge representation is transformed into another representation of that knowledge. Learning is a process, whereas the representation of knowledge is both the starting point and result." (Paquette 2010)

The G-MOT (and therefore Conceprocity) representation system is based on the theory of schemas. We distinguish between two broad categories of schemas, these being declarative or conceptual; and procedural. The first category involves data while the second includes the procedures and methods used in processing data in order to organise information. We also follow Paquette in recognising a third category of conditional or strategic schemas which consist of principles having one or more conditions that describe context and conditional sequences. Those conditions can either be embedded in principles (in both G-MOT and Conceprocity) or they can be made explicit in the form of logical connectors attached to events (Conceprocity only).

How and why Conceprocity differs from G-MOT

So why not simply reuse the existing G-MOT formalism? Table 15 summarises a (gentle) critique of Mot+ and G-MOT and outlines how Conceprocity differs:

Table 15 How Conceprocity differs from G-MOT

G-MOT	Conceprocity
G-MOT is in part based on the object-oriented (OO) approach extensively used in software engineering, but just as the OO approach is often vague about its philosophical and pragmatic antecedents, so (sometimes) is G-MOT	UML itself is not always crystal-clear about its antecedents and the reasons for which various design choices have been made. Conceprocity is a little closer to UML than is LICEF – particularly in the ways in which concepts are related. However, this thesis attempts to make explicit the antecedents of Conceprocity.
G-MOT is object-influenced, most obviously by class diagrams. But it separates procedures out from concepts, thus eschewing encapsulation	Conceprocity follows G-MOT. Inheritance is explicitly supported between concepts by means of a specialisation- generalisation relationship. The effect of encapsulation can be achieved by deft use of hierarchy: what appears at one level to be an atomic concept is expanded at a lower level in the modelling hierarchy. In addition, Conceprocity 3.0 introduces the package (swimlane) notion, which permits the identification on a single diagram of an element with a closed boundary.

G-MOT	Conceprocity
The visual representation used is sometimes obscure, specifically in the areas of how the different types of relationship are displayed; they are signified by a character label rather than by a visual device	Conceprocity prefers a UML-influenced style in which the type of arrow shows the kind of relationship. This is initially a little more difficult to teach and learn, but subsequently makes Conceprocity models easier to read and to understand. Because it is more difficult to apply initially, in the simple usage profile which is called CIAOPEA, these more complex relationships are not used. They are introduced in the full TROPICPEA usage profile.
The visual representation used is sometimes unclear, particularly the visual distinction between classes and object-instances (although this is better in G-MOT than in the earlier Mot+)	Conceprocity is clearer again in this respect. Instances have a darker colour and a pecked outline which clearly distinguishes them from classes.
The expression is not very visual, depending too much on textual elements and not on images and icons: it does not engage the right brain	Particularly in the simple usage profile, users are actively encouraged to make full use of icons, images and sketches.
It does not permit the clear expression of algorithms, in particular conditionality (if... then... else... endif) and repetition (do while...; repeat until...)	Whereas in G-MOT conditional statements are represented as principles, Conceprocity prefers to make this visually much clearer by using logical connectors and the separate event syntax (here following the event process chain paradigm suggested by (Scheer, Thomas, and Adam 2005)).
The language does not encourage consideration of object state and/or events	Conceprocity uses the event notion to make this much clearer.
Cardinality and ordinality (multiplicity) is not made explicit in associations	Conceprocity follows the conventions of UML class diagrams in this respect, making multiplicity much more evident – if the modeller chooses to make this clear.
G-MOT is a standalone ("desktop") application available only for Windows. It is therefore not SaaS, software as a service – which is needed to make web-based collaboration on concept maps possible and easy	Conceprocity is implemented using the Lucidchart web-based diagramming system, which is SaaS.

3.9 The semantics of Conceprocity

What do we mean by a concept?

This question is very much the province of philosophy. It is also one to which different answers will be given in accordance with the different streams of thought which I have previously identified. Within the realm of analytical philosophy, a prominent thinker is Christopher Peacocke: see in particular (Peacocke 1992) – whose audience is professional analytical philosophers – and the slightly more approachable (Peacocke 1996). The latter holds as axiomatic that a concept is individuated by its possession condition. In the simplest cases, a possession condition is stated by giving a truth-individuating statement of the form:

F is the unique concept C to possess which a thinker must meet the condition A(C)

where A( ) meets certain restrictions. Within A( ), the concept F must not be mentioned. The condition A( ) "will speak of certain canonical ways of coming to accept contents containing the given concept, and/or of certain canonical conclusions that can be drawn from contents containing that concept" (Peacocke 1996). A combination of characteristics should be found to be primitively compelling, without reference to other concepts. Concepts are constituents of complete contents which are themselves evaluable as either true or false. A concept accesses a semantic value. This semantic value must be fixed such that the belief-forming practices mentioned in the condition always yield true beliefs. There must also exist a theory of determination for the proposed possession condition. The theory implies the existence of an observer who is a creature capable of at least rudimentary conceptual thought.

Such formality contrasts vividly with the informality associated with the concept of a concept in the Hispanophone and Francophone traditions previously identified.

Why Conceprocity distinguishes concepts, procedures and principles

In his book (Paquette 2010) the originator of the G-MOT approach Gilbert Paquette suggests as a reason for distinguishing the notions of concepts, procedures and principles the need to address the weaknesses of existing modelling approaches – such as flowcharts and decision trees. Paraphrasing Paquette, these weaknesses can be seen to include:

1. Imprecise meaning of the links between the entities that compose the model.

2. The ambiguities in graphs where objects, actions on objects and statements of properties that those objects possess are all mixed up and are not represented in a way that helps to differentiate them and uncover their relationships. Paquette suggests distinguishing classes of objects as *concepts*, actions on concepts as *procedures* and statements of properties as *principles*.

3. The difficulty of combining in one model objects which at a high summary level in the model need to be developed at a lower level with sub-models whose nature is not the same. Thus for example, a principle at a high level might need to be developed as a procedural or conceptual sub-model.

4. Existing visual representation formalisms have emerged largely from the computer science and software engineering communities. Formalisms such as Entity Relationship models, structured systems analysis in the SSADM and MÉRISE traditions, conceptual graphs (John F. Sowa 2000b; J. F Sowa 1984) following Charles Peirce, the object modelling technique and the successor Unified Modelling Language UML are all representation approaches which have been built primarily for the design of complex software systems. Even to read such diagrams and the links between them is hard, and to create such models requires considerable expertise and an abstraction and conceptualisation capability which may be lacking among the more general knowledge workers whom Paquette (and I) wish to address and empower. Paquette states:

> "Our goal is different. We need a visual representation system that is both simple enough to be used by educational specialists and learners who are not computer scientists, yet general and powerful enough to represent the structure of knowledge and learning / working scenarios. The distinction and the integration of basic types of knowledge and links in the same language are essential… We present three major steps starting with (1) informal visual modelling for the educated layperson, to help represent interesting knowledge. We then (2) move onto semi-formal modelling to help define target competencies and activity scenarios for knowledge and competency acquisition by learners and workers. Finally (3) we present the more formal visual models (Ontologies) that can be used by software agents to ensure execution of knowledge-based processes on the semantic web." [(Paquette 2010) slightly amended for clarity.]

Positioning Conceprocity

- Immediate parent: G-MOT (Paquette 2010)
- => typed concept mapping

Conceptual modelling, as used in traditional IS Requirements Analysis: has employed dataflow diagrams, entity / relationship models, supplemented by rich pictures and concept maps.

Conceprocity is particularly influenced by event process chains (Scheer, Thomas, and Adam 2005).

We position Conceprocity as a knowledge organisation system - (Friedman and Thellefsen 2011), (Friedman and Smiraglia 2013).

We have sought to make the modelling language even more theory-based than its immediate predecessor G-MOT (whose roots lie in cognitive psychology , cognition and modelling of learning and instruction).

We continue to respect realist ontologically-based "BWW" conceptual modelling: (Wand, Storey, and Weber 1999), (Wand and Weber 2002)

- But whereas their primary focus is on information systems requirements analysis
- Ours derived from the need to identify the (conceptual) work system which any personal information management system must support
- Consequently, our ontology is broader, benefitting from critical realist insights

Modelling nuggets in the Conceprocity approach

A Conceprocity model of a "nugget" (a piece of knowledge, often actionable) may include:

- ❑ A set of Conceprocity maps – these are visual representations of aspects of the model

- ❑ A Conceprocity dictionary – this helps to clarify the semantics of the model by naming properties

- ❑ A set of supporting "resources", that is, files which, together with the maps and the dictionary, constitute this nugget

- o For example, for a taught class, these might include a PowerPoint presentation and supporting articles

3.10 Conceprocity semiotics

Conceprocity semiotic notions: main symbol types
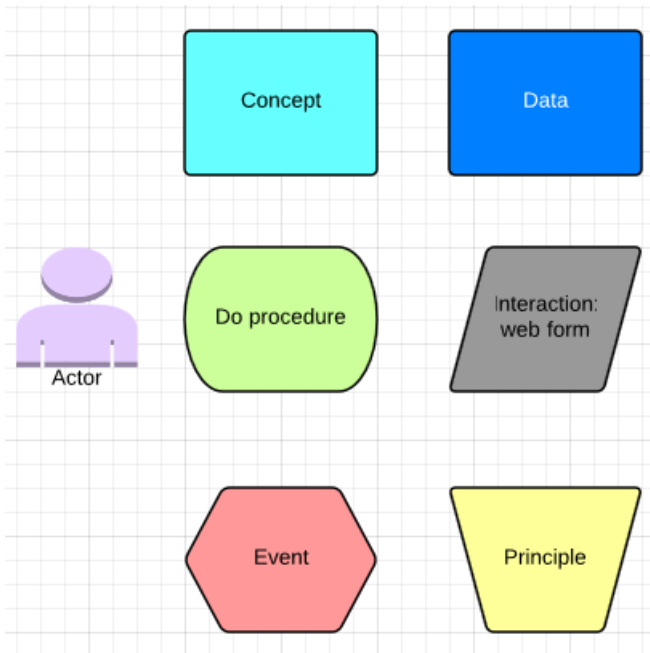
Figure 35 Main Conceprocity notions (object types)

Conceprocity notions
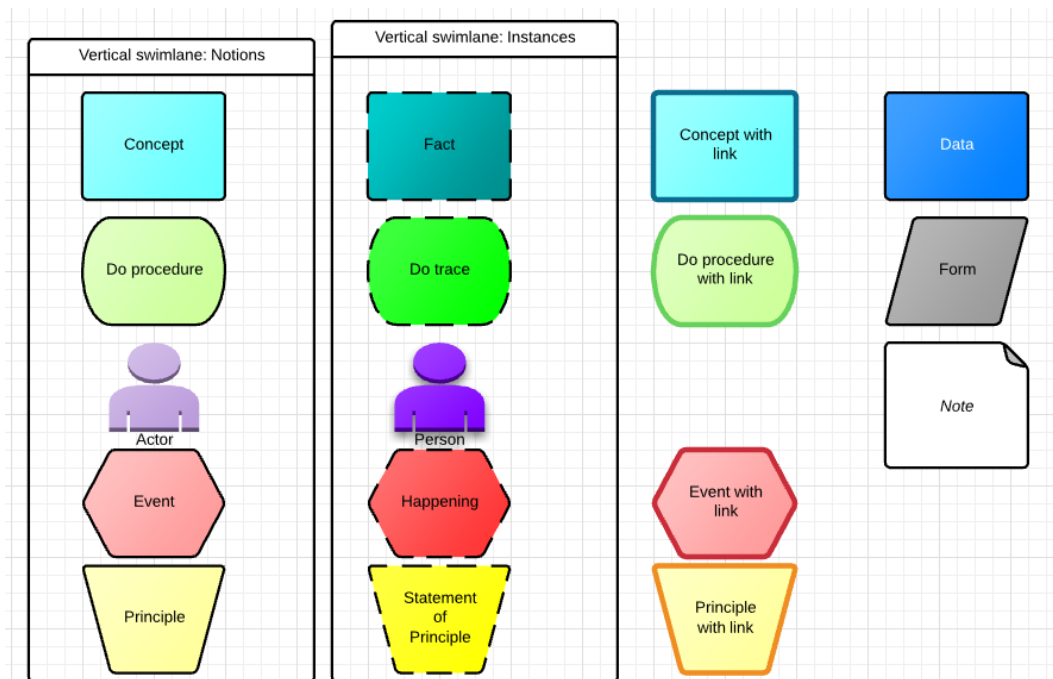
Figure 36 Further basic Conceprocity notions

More semiotics: representing relationships

- Different kinds of arrow are used:

180 / 343
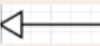
Symbol	Meaning
————	Association. This needs a text label, such as is-a, is-composed-of, etc.
————→	Flow of control or of data; precedence and consequence; LHS *prompts* RHS
·············>	Is instantiated as
– – – –→	An actor or principle *influences* (regulates, controls or governs) a concept or procedure
Notes about principles ············▶	Commentary concerning notions
◆—— ◇—— ◁——	Composition, Aggregation, Generalisation

Figure 37 Relationship types

Sources: (Paquette, 2010); (Booch, Rumbaugh and Jacobson, 2005); (Wand, Storey and Weber, 1999)

More semiotics: example logical connectors

Figure 38 Principal logical connectors

www.manaraa.com
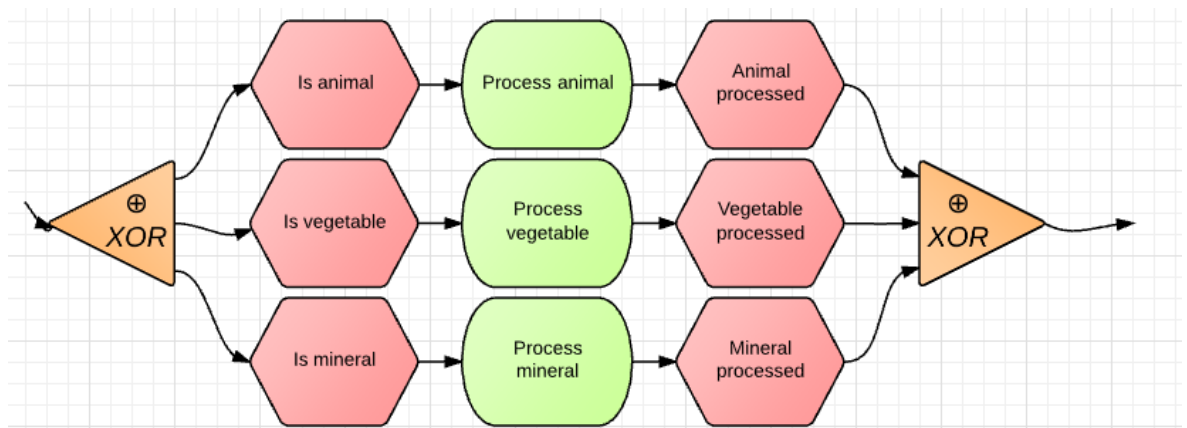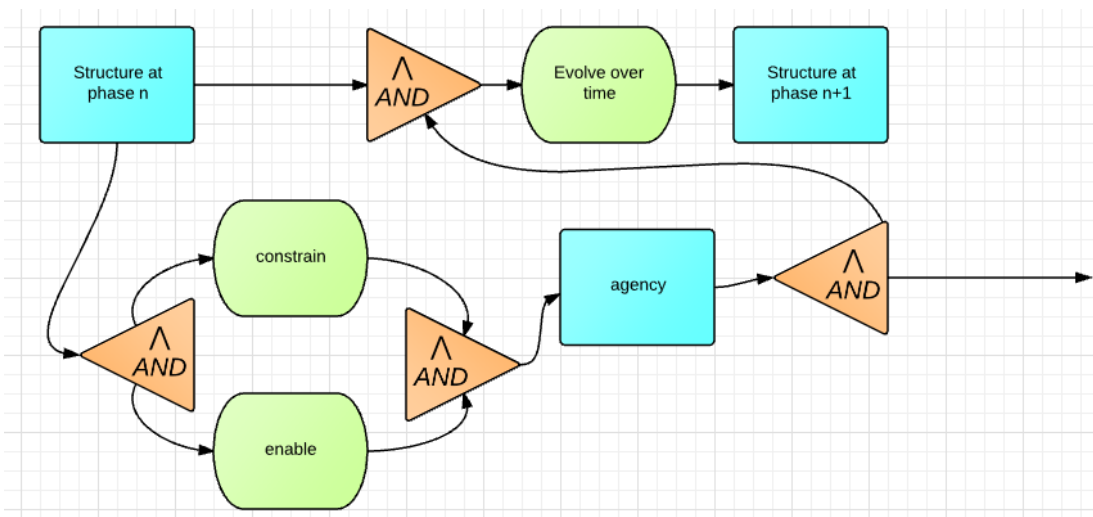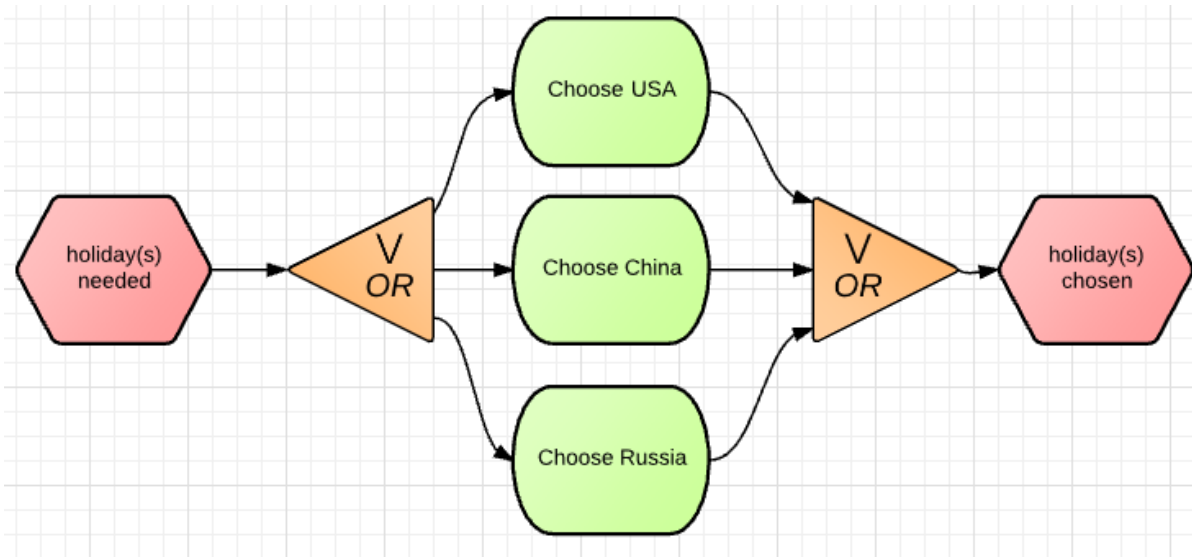
Example KR: a Conceprocity map of the nugget "Planning and doing the shopping"
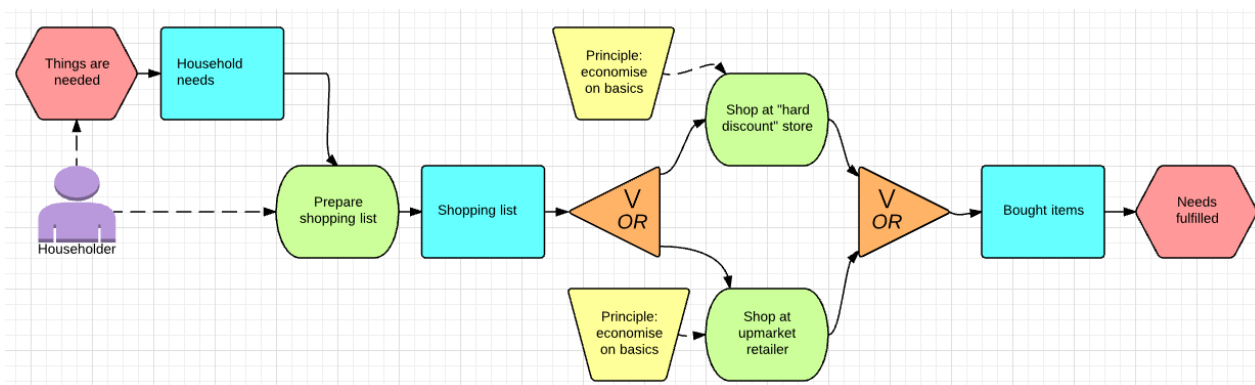
Figure 39 A Conceprocity map of doing the shopping

Dictionary for "Do the shopping"

Figure 40 Dictionary in Microsoft Access

Figure 41 A Conceprocity dictionary stored in UnIQue

No one model is in and of itself sufficient to describe the world. For this reason a Conceprocity knowledge map should always be accompanied by tabular dictionary entries.

3.11 The development of Conceprocity

Types and examples of knowledge

In a revised Bloom's taxonomy, (Krathwohl 2002, p.214) distinguishes the following kinds of knowledge:

- ♦ A. Factual Knowledge – The basic elements that students must know to be acquainted with a discipline or solve problems in it.

  - ∗ A1. Knowledge of terminology

  - ∗ A2. Knowledge of specific details and elements

- ♦ B. Conceptual Knowledge – The interrelationships among the basic elements within a larger structure that enable them to function together.

  - ∗ B1. Knowledge of classifications and categories

  - ∗ B2. Knowledge of principles and generalizations

  - ∗ B3. Knowledge of theories, models, and structures

- ♦ C. Procedural Knowledge – How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods.

  - ∗ C1. Knowledge of subject-specific skills and algorithms

  - ∗ C2. Knowledge of subject-specific techniques and methods

  - ∗ C3. Knowledge of criteria for determining when to use appropriate procedures

- ♦ D. Metacognitive Knowledge – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition.

  - ∗ D1. Strategic knowledge

  - ∗ D2. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge

  - ∗ D3. Self-knowledge

Types and examples of knowledge – G-MOT and Conceprocity

- Factual knowledge (facts). Records of how to fill out a form.

- Conceptual knowledge (concepts). A car, its sub-systems and components.

- Procedural knowledge (procedure). Income tax calculation procedure.

- Prescriptive knowledge (principle). How to design and implement a Conceprocity model of a nugget.

Additional notions in Conceprocity and why they have been added

Conceprocity goes even further than G-MOT in distinguishing between different notions. The following sections identify the additional notions (object types).

Events

The existence of events in Conceprocity is directly influenced by event process chain diagrams (Scheer, Thomas, and Adam 2005). The success of event process chain diagrams owes much to their simplicity and the self-imposed constraint of chaining event to function to event to function. We admire that, and note in passing that business students seem much more adept at creating event process chain diagrams that they are at other formalisms such as entity relationship diagrams. Thus, we have introduced events into Conceprocity. This permits us to restrict the use and meaning of arrows in Conceprocity to a single reading for each direction of the arrow, "gives rise to" ("prompts") or "is the result of". Temporal ordering is indicated by using either a procedure – whose inputs are indicated by an arrow in and whose output is indicated by an arrow out – or an event.

Forms to model interactions

This notion is introduced for the purpose of Information Systems modelling, specifically to extend use case diagrams in what we call usage diagrams. We have made this extension because use case or usage models are intended to model interactions between actors and processes; when a process is computerised, that interaction normally involves completing a form or using a view. An interaction is a representation of a form or view or report.

Data

Data and concepts are closely related but not exactly equivalent. For this reason, we represent data in much the same way as concepts making as a visual distinction the fact that they are dark blue in colour rather than light blue. In addition, we recommend that data notions be maintained in a separate data swimlane when Conceprocity is being used to model requirements for information systems. Data

and form elements can be included in extended event process chain diagrams; these are called event process data diagrams.

Logical operations

An important usage of Conceprocity is in modelling algorithms and heuristics. In modelling algorithms, it is necessary to represent sequence, condition and iteration. We prefer to make condition explicit in the form of XOR, OR or AND, and NOT. (G-MOT uses principles for this purpose.) Conceprocity does not introduce a specific visual representation for iteration. There are a number of iteration primitives, which include do while, repeat until, for and for each. Rather than seek to introduce visual symbols for all of these forms of iteration, we have decided to use logical operators either as means of splitting – that is, the logical operator has one input and two or more outputs; or as a means of joining – that is, the logical operator has multiple inputs and only one output. Iteration can then be represented using a backward precedence arrow (typically the arrow goes up the page) and a joining XOR logical operator. Because Conceprocity encourages the use of visual elements, there is nothing to prevent specific sub-communities from introducing their own conventions.

Set operators

We have introduced further logical connectors, in particular to represent set operations. These are likely to have particular value in showing how concepts relate to one another, for showing for example UNIONs.

Set operators are examples of additional relationship types – somewhat tongue in cheek, we call these special relationships – which have been introduced in Conceprocity version 3.0. consisting either of an isosceles triangle for directed relationships or a lozenge for undirected relationships. The Conceprocity modeller then writes whatever text she wants onto that symbol. She may also choose to include icons that add to the expressiveness of the notation – we suggest the use of Venn diagrams for this purpose. A fairly complete list of special relationships is provided in appendix 2 to this document. However, this list is not complete; users can add to it as they see fit – this provides an element of extensibility to the Conceprocity notation.

Tables and lists as the result and the instigator of action

Tables are also models. They may have a purely descriptive role; but they may also exist in order to inform or bring about action.

The analytic philosopher Elizabeth Anscombe (Anscombe 1957) also used the example of a shopping list as a part of her work on intentionality. Consider:

> "Cognitive states describe the world and are causally derived from the facts or objects they depict. Conative states do not describe the world, but aim to bring something about in the world. Anscombe

used the example of a shopping list to illustrate the difference - see (Anscombe 1957, para. 32). The list can be a straightforward observational report of what is actually bought (thereby acting like a cognitive state), or it can function as a conative state such as a command or desire, dictating what the agent should buy. If the agent fails to buy what is listed, we do not say that the list is untrue or incorrect; we say that the mistake is in the action, not the belief. According to Anscombe, this difference in direction of fit is a major difference between speculative knowledge (theoretical, empirical knowledge) and practical knowledge (knowledge of actions and morals). Whereas 'speculative knowledge' is 'derived from the objects known', practical knowledge is – in a phrase Anscombe lifts from Aquinas – 'the cause of what it understands.' "
http://www.liquisearch.com/g_e_m_anscombe/work/intention

Anscombe showed that the natural and widely accepted picture of what we mean by an intention gives rise to insoluble problems and must be abandoned. Nevertheless, the shopping still needs to get done and pragmatically we accept the value of making a shopping list. Anscombe's essay subsequently informed the discussion by John Searle of intentionality (Searle 1983).

How philosophy is making a difference

The application to conceptual modelling of the philosopher John Searle's **social ontology**, as suggested by (March and Allen 2014), builds a complete new layer of **institutional facts** above what (March and Allen 2014) – following Anscombe and later Bunge - term the "brute facts" in Mario Bunge's ontology.

Bunge might counter that his philosophy is one of scientific realism and he specifically excludes concepts as facts.

By contrast, Conceprocity accepts the reality or validity of **concepts** on the basis of **critical** (rather than **scientific**) **realism.**

Conceprocity changes made because of philosophy

We incorporate from (Searle 2006) via (March and Allen 2014):

- **collective intentionality** as a subtype of principle
- **institution** as a subtype of actor
- **constitutive rule** as a subtype of principle
- **deontic power** as a subtype of principle
- **action** as sometimes a subtype and sometimes an instance of process

We can also model **affordances.**

Conceprocity recent developments - 2015

Conceprocity is also enhanced in the following areas:

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- o Clear separation of attributes and properties
    - Attributes characterise conceptual objects (cf. classes), properties the corresponding instances
    - Either can be represented as a table within a diagram
    - They will more normally be represented in separate tables
- o Sub-typing of major notions
    - This permits a distinction of type between, for example, concrete (Bunge) and social (Searle) notions
- o Representation of nugget, system and subsystem boundaries by means of swimlanes or nested diagrams
- o Wider scope and significance of logical connectors and relationship types

Trope-based conceptual modelling

An alternative ontological basis for conceptual modelling is presented in the work of (Guarino and Guizzardi 2006), (Guizzardi and Halpin 2008), (Guizzardi and Wagner 2008).

Their approach is based on the notion of a **trope**, which is an instance of a property – e.g. the redness of the T-shirt which John is wearing (Guizzardi, Masolo, and Borgo 2006). Tropes are particulars which can only exist in other individuals, i.e. they are existentially dependent on other individuals.

Tropes are arguably more defensible in moving away from excessive essentialism.

Areas in which Conceprocity departs from Bunge-Wand-Weber

Bunge, and therefore BWW, insist that properties cannot have properties – but this is "manifestly" indefensible (we distinguish degrees of redness) and is frequently departed from in practice.

(Guizzardi, Masolo, and Borgo 2006) suggest that this is a fundamental weakness of the BWW approach.

However, I am rejecting their alternative trope-based ontological approach at the present time – so far as I am aware, no major conceptual modelling approach has yet adopted it in practice and its proponents appear as yet not to have to put forward a visual modelling language based upon it.

My position is that pragmatically I allow properties to have properties in Conceprocity. The notion is useful in practice.

Other uses of Conceprocity

We have found that **model-based reasoning** (Nersessian 1999) has great practical value, particularly in teaching and learning.

- o There are various interpretations of this phrase, but I illustrate it by the observation that during the construction of a model from a starting list of

notions it frequently becomes evident that other notions and/or relationships are required.

- o For example, consideration of a logical operator such as an XOR may well point to the need for additional notions and relationships.
- o Where it's impossible to identify a structural relationship, a procedure may abductively be identified as necessary to carry out a transformation.

Conceprocity: all things to all people?

Conceprocity is a visual modelling language.

As a language, it is necessarily agnostic about the uses to which that language is put.

In order to permit the expression of ideas, regardless of whether I would agree with those ideas, I have allowed notions about whose validity I am uncertain.

In particular, I admit as useful the trope-derived notion of **resemblance** (via the keyword **like**) a*s* one of the fundamental semantic relationships identified in Table 31, which is based on (Miller 1995).

In any knowledge representation scheme, it will normally be necessary also to represent data.

Conceprocity positioned in accordance with other conceptual data structures

Table 16 is an attempt at a synthetic view and positioning of Conceprocity within the spectrum of *conceptual data structure CDS*, here following (Völkel and Haller 2009):

Table 16 Conceptual data structures and their associated metadata *Source: author*

Technique	Metadata	Expressiveness, precision and recall
Spreadsheets	Pragmatic – the meaning of the data is not explicit, but is partially expressed in the natural language semantics of column and/or row headings; and partially in relationships expressed as formulae between cells	Potentially very expressive and frequently imprecise or even contradictory. Charting permits visually-arresting representations of some of the underlying data.
Relational databases	If the data is normalised (Codd 1971; Date 2003), then the column headings name sets of atomic (non-divisible) data items. This is deliberately constricting, because human-readable metadata, in the form of a natural	Deliberately very restricted expressiveness. All data is constrained to appear as tables to permit generality and precision of subsequent querying. The results of queries are themselves virtual

	language description (name) for each attribute, can be exploited by users as they enquire from the data, enabling precise answers to questions they have.	tables constructed from the original input data.
Outlining and Outliners	The relative positioning of the items in a hierarchy groups and classifies data; and associates meaning with each group and sub-group. The addition of a grid, as in the products Ecco and InfoQube – see (Gregory 2010) - permits further structuring and expressiveness.	Hierarchies themselves are cognitively powerful or not depending on the prior training of the user.
Mindmaps	The relative positioning of the items in a diagram groups and classifies data; and associates meaning with each branch and sub-branch. An image is (potentially) associated with each branch or sub-branch	Visually very powerful, the user perceives both structure and meaning. Querying is very imprecise or non-existent.
Concept maps (Novak and Cañas 2008)	The relative positioning of the items in a diagram groups and classifies data; and associates meaning with each branch and sub-branch.	Visually very powerful, the user perceives both structure and meaning. Relationships are distinguished from concepts. Querying is very imprecise or non-existent in current implementations.
XML, RDF and OWL	The meaning of an XML document is described in an associated Data Type Definition (DTD) or Schema. The RDF Schema carries this forward.	XML-based approaches potentially combine the strengths of outlining and of relational database. Because XML is both a language and a meta-language, it is possible to define specialised languages such as OPML.*
Conceptual graphs or conceptual structures		
Conceprocity maps	The relative positioning of the items in a diagram groups and classifies data; and associates meaning with each branch and sub-branch. An image is (potentially) associated with each branch or sub-branch. Each object has a type, as does each relationship (link). Appropriate use of hierarchy enables encapsulation.	Visually very powerful, the user perceives both structure and meaning. Querying is currently non-existent but because objects are semantically classified it would be relatively straightforward to construct a dictionary for each Conceprocity map and a lexicon (index) across multiple maps.

		The latter in a cloud context might permit the emergence of shared ontologies, especially if the maps are constrained to conform to RDF and OWL standards. The latter is not yet proposed for Conceprocity but has been achieved with extensions to the similar G-MOT approach. See (Paquette 2010)
First order logic and Horn clauses		Expressiveness and precision very high; readability and visual appeal very limited (although these can be enhanced by the use of libraries which create visualisations from Prolog statements). Querying is very general and strong logical inferencing capabilities are offered. Inaccessible to end users without the creation of intermediate interpreters.

3.12 Explicit design and serendipitous bricolage

My research largely takes the form of design science research and action research (design school) or observation (behaviour school) – see (Hevner et al. 2004). The work of (Hevner and Chatterjee 2010b) and (Hevner and Chatterjee 2010c) on design science in IS research, and of (Wand and Weber 2002) on conceptual modelling and information systems have informed both this paper and the design of Conceprocity. To the extent that one potential use of Conceprocity is to conceptualise and therefore support the design of target personal information management systems, the **design** perspective identified by Hevner and his colleagues is perhaps sometimes appropriate. However, since we suspect that most personal information management systems are the result of serendipitous bricolage (Ciborra and Jelassi 1994) rather than the product of deliberate design, it is the more **behavioural** perspective identified by Hevner which is also significant in the study of actual personal information management systems.

3.13 Affordances: bottom-up enablement

Affordances: embedding routines in technology

(Volkoff, Strong, and Elmes 2007), arguing from a critical realist perspective, show how routines and roles acquire a material aspect when they are technologically embedded

I started from tools and have never been able to escape them!

It is the individual who must seize opportunity as she builds bridges between her information needs and the specific *affordances* offered by technology and tools

Affordances arising from the use of InfoQube, an outliner and functional spreadsheet

InfoQube was described in its then state of development in the paper (Gregory 2010). In the seven years since that paper was written, the program described has continued to develop (although it has still yet to achieve a formal release and remains in beta test at the time of writing of this thesis). See (InfoQube 2019).

An example of community knowledge transfer: InfoQube

An aspect of our research into the adoption of PIM tools can be summarised as: "Some will prefer highly expressive, but more difficult to query and to manage, general solutions… Many, perhaps most, will not be able to realise those benefits without knowledgeable 'hand-holding'". The author has himself made extensive use over several years of a product in development called InfoQube (InfoQube 2019)., and observed its development and the role played by its community of users in that development.

♦   Background: Outlining and Outliners

Outlining is a long-established approach to structuring and writing text (Price 1999).

An *outline* is a hierarchical way to display related items of text so as to depict their relationships graphically. The position on the page of one item of text vis-a-vis another piece of text indicates their respective significance in a hierarchical relationship. Frequently this is further highlighted by the use of special symbols, type style or colour. *Outlining* is a technique which may be implemented in general office programs or in specific computer programs known as "*outliners*". An *outliner* is a special text editor that allows text to be structured as an outline. Outliners are typically used for collecting or organizing ideas or as part of the process of designing a computer program. Outlining is the technique widely used in programs such as Microsoft Office PowerPoint, in which the main headings of a presentation appear as separate slides and on each slide appear points and sub-points; and in Microsoft Word's Outline view.

In outlining, an aspect of the meaning of a data item is is given by being shown in its owning hierarchy. Thus, a person's surname may be shown as a component of a composite Contact object.

Realised in Word and formatted in a particular way, an outline has an appearance similar to:

Figure 42 Outline formatted as a hierarchy of points, sub-points, sub-sub-points.

Here, the owner in the hierarchy as shown is 11. Semantic Web. It is the eleventh point in a document – it is implicitly owned by the document of which it forms a part.

It owns items 11.1, 11.2, 11.3, …

11.3 owns 11.3.1, 11.3.2, …

The owning item for 11.2, 11.3 … is 11.

The relative positioning of an item conveys meaning in that the label of the owner classifies or otherwise gives contextual information concerning the owned item.

Outliner programs go further; thus (Ecco 1997) permits the definition of forms to impose some order on the anarchy of poorly-related items that can otherwise result. Further, a data item can participate in more than one hierarchy; an appointment can appear in an overall agenda or calendar, but also be linked to the name of each participant in the meeting. Effectively, the same datum is classified in more than one way.

♦   InfoQube

InfoQube (InfoQube 2019), a Microsoft Windows application developed by NeoTech Systems, is a one-pane outliner (in that hierarchy and rich text can be displayed in the outline itself). It is also technically a two-pane outliner, in that any item in an outline can also be associated with an arbitrary amount of fully-formatted HTML which is displayed in a separate pane. Standard features include task and project management, a calendar which can display any item having a date attribute, basic concept mapping and crucially a grid of values associated with any given item in a list of such items which is governed by the Grid filter. The definition of the grid, and therefore the associated semantics, are entirely under user control. Grids display

item values as a row; forms display them as a column. Technically, a grid is a view of data values which are stored in underlying system-maintained relational tables accessed by behind-the-scenes nested SQL queries. Thus, any field definition (and associated values) can occur multiply and simultaneously in any of an arbitrary number of grids. A grid can also be linked to dynamically from Word or Excel.

IQ implements row-level and column-level equations. The syntax for these is based on Visual Basic (the default scripting engine is VBScript). Further, the program provides a repertoire of system-defined functions. Users with programming skills can program their own functions with the built-in VBScript editor. Thus IQ, by offering both row and column equations, can also be seen as a functional spreadsheet in the sense identified above. Information presentation facilities include sorting, multi-criteria filtering, summary tables, charts, Gantt charts, pivot tables and conditional formatting. Web clippings and emails can be incorporated within the HTML pane. Windows file hierarchies can be linked to dynamically.

IQ was originally developed to meet a specific company's needs. It takes its inspiration from (Ecco 1997), whose development ceased in 1997 but which retains many enthusiastic users. Technically, IQ is built using Visual Basic on a packaged Microsoft Office Access database.

IQ has yet (December 2016) to achieve a formal release. Instead, a growing community of largely enthusiastic users acts as a bank of beta testers. Minor releases occur about fortnightly. The incidence of minor bugs is low and major bugs (ones causing data loss) are almost unheard of. As an Access database application, IQ is inherently multi-user and supports some concurrency.
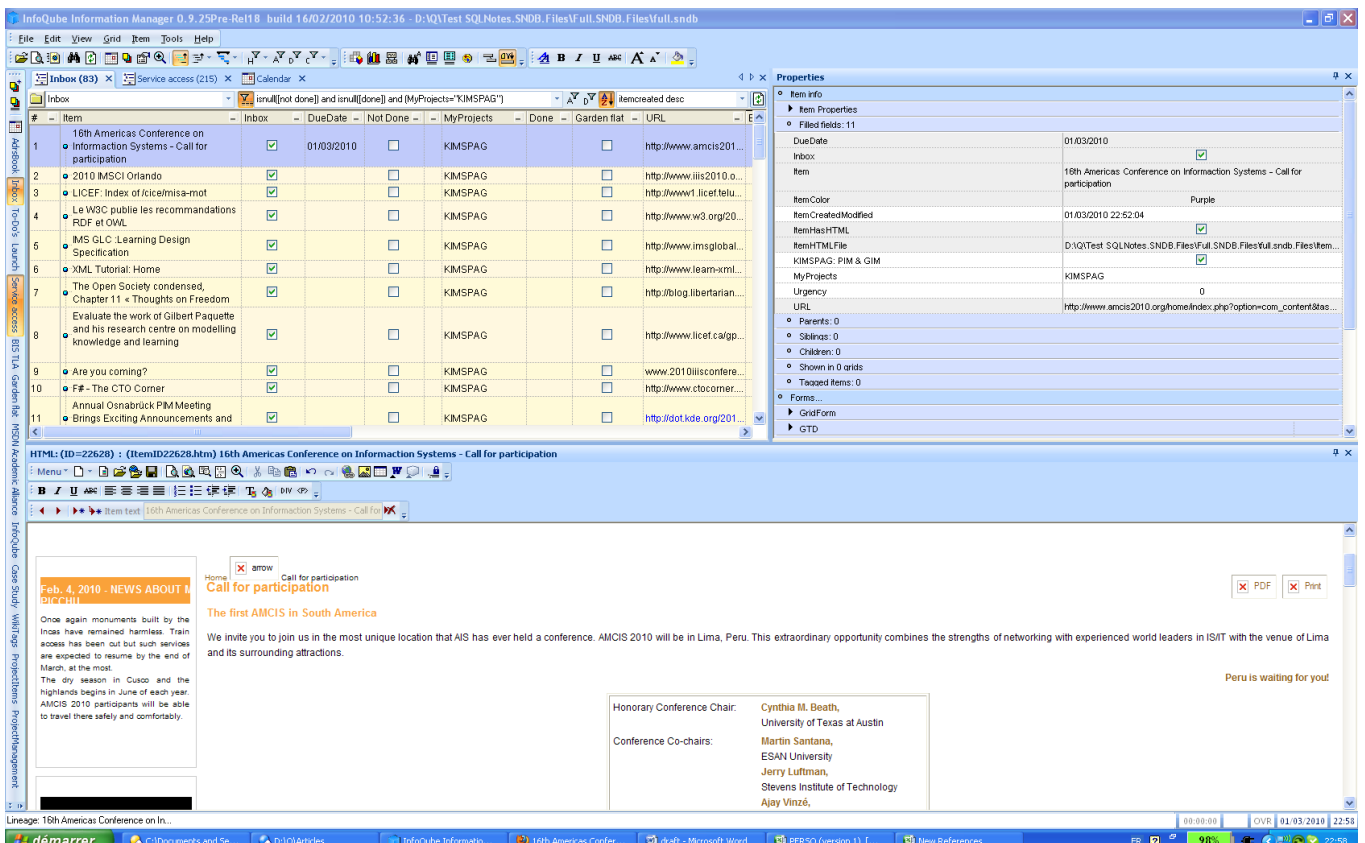
Figure 43 InfoQube screen shot

The software can quickly be modified by its developer as users make suggestions; provided that those requests fall within the "global" architectural vision of its developer (this approach retains architectural coherence and protection of data investment). Both developers and users benefit from this close collaboration.

The user interface is very flexible and supports scripting. This allows its use as a framework for custom software solutions (similar to Microsoft Access).

The underlying database engine is inherently multi-user and supports replication, so the collaboration applies not only to the development of the product but also to the actual finished product use in supporting both connected (i.e. LAN-based) and disconnected (i.e. Web) topologies.

InfoQube permits its users to clip content from browsers and from email clients. Thus, an item is stored which retains a hyperlink to its original source; furthermore the content of the original webpage or email can be stored in the HTML pane referred to above. This content can help the human user to preserve context and thus retain more meaning.

(a)   Exchange between developer and IQ users, and between IQ users

An infrastructure was put in place to connect the users with the developers. NeoTech Systems maintains a forum using the Drupal content management system (Drupal 2010). A small but very active community of users is associated with the site. New users are helped to get started by others with longer experience. NeoTech is very responsive to user suggestions for new functionality provided they are architecturally coherent. Being in beta, the community can and does have a large impact on the development.

Thus, we have identified at least one PIM (InfoQube) which offers a semi-relational database style, outlining, inter-item linking, unification of the system file store and the meta-data it contains about those file and web links, functional-spreadsheet-like capability, classification and wiki-style tagging, and pivot tables which can be dynamically linked to actual spreadsheets. We have indicated the need for peer-to-peer mutual assistance when seeking to maximise the benefits offered by such functionality. Thus, this PIM can be said to meet the preference suggested above for highly expressive, but more difficult to query and to manage, general solutions. Forum users (and importantly, former forum users) report a steep learning curve. It took me several years to reach the point where I could use InfoQube as a system building tool to build an adapted personal information management system. This development, called UnIQue, is a significant part of the research which will be reported in the rest of this thesis.

InfoQube is a very powerful program but one which is therefore also rather difficult to learn initially. A recent review (http://www.pcworld.com/article/2369056/infoqube-review-intricate-information-manager-has-a-steep-learning-curve.html) suggested that its features are intertwined with interface paradigms and assumed usage patterns that are not

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mainstream. The same review noted that "The primary interface for InfoQube is the Grid, which contains items (rows) with fields (columns). You can have many grids open concurrently, each containing different items and columns. Using only a single grid and the default column of "Item," InfoQube works well as a two-pane outliner with several advanced features, such as multiple parents. A single item can be placed into many positions in the hierarchy by using the Ctrl key to drag it around. Items can have multiple fields, including calculated fields. Each item is also associated with an HTML object, which is edited in a WYSIWYG style, and includes a good range of formatting options. Pivot tables (a component must be downloaded from Microsoft to enable them; this is free), summary fields, date and time functions, advanced filtering, and sorting options. One of the more complex concepts that must be learned to take advantage of InfoQube is that data items do not "belong" to grids. Grids display items, and, by default, every item created in a given Grid has a custom fields whose name matches that of the Grid. If you create a Grid called "Contacts," each item created in that Grid has a field called "Contacts." This makes a Grid something like a table in a traditional database—but not completely. Any given item can have any arbitrary set of fields, and what's displayed in a Grid is determined by the "Source" setting for the grid, along with the filter options chosen. This flexibility offers a lot of power, but it also requires a real understanding of how things work, or what you see in a Grid might not be what you expect."

3.14 Framework: summary

- o Philosophy
- o Critical realist objective ontology
- o Systems approach
- o Good regulator theorem
- o The visual modelling approach: Conceprocity
- o Model as regulator
- o Affordances

Framework: concluding remarks

I started the literature review by declaring that my motivations lie in a desire to be involved in relevant, engaged and even passionate research and related teaching. We observe that some of the most influential research and teaching, as too the most entrepreneurial business propositions, are undertaken by iconoclasts whose methods are sometimes unsafe. So also as researchers, rather than always pretending to a positivist or ethnographic objectivity that somehow escapes us, we may believe in and value personal and shared *action* as the cockpit in which knowledge is enacted, tested, refined and in which it evolves. Following the pragmatist and educational pioneer (Dewey 1960) we want knowledge that builds on what we already know and that *we can believe and act upon*. Scientific enquiry

sometimes builds exhaustively on existing research, identifies a knowledge gap and seeks to fill it. But we have argued and illustrated here that the emergence of research questions may also be based on reflective self-observation, perhaps structured by means of personal knowledge management tools, often between and after cycles of action research. So enquiry may initially be informed by structured self-observation and then proceed by further learning, informed by theory and enacted and internalised by means of practice and further reflection.

As the only route to truth such an approach is woefully inadequate. Other logics of enquiry and research designs will be needed in future work, work outside the scope of this PhD. But as a starting point, it has merits, as I hope to demonstrate in the remainder of this study.

Chapter 4 METHODOLOGY

The research methodology is introduced and described.

4.1 Principal research question and design

In summary, the way in which I have addressed the research question and design is as follows:

- ♦ What is the contribution of personal information management systems PIMS to the Working Model and personal work system of knowledge workers?

- ♦ Necessary precursor: appropriate modelling (analysis) and design (synthesis) approaches

- ♦ Initial exploration (1): homomorphic conceptual models – created using Conceprocity

- ♦ Going on to "design" and "test" a regulator which is nearer to an isomorphic model of the system under control – the working life of the individual

- ♦ Initial exploration (2): A proof-of-concept PIMS

  - ∗ Which includes a personal taxonomy and a tagged classification scheme

4.2 Conjectured Learning Informed Action

Summarising the earlier discussion, I conjectured the following basis for learning informed action:

- ♦ For each knowledge worker (Drucker 1999):
  We posit the existence of (1) a Personal Work System PWS. This PWS is individual to each person's (2) Working Model. That PWS is supported by (iii) a Personal Information Management System PIMS: (Gregory and Descubes 2011d, 2011b). This PIMS is broadly the same as the Individual Information Systems IIS supporting personal and work-related Work Systems suggested by (Baskerville 2011b) following (Alter 1999), (Alter 2010).

♦ These together permit Learning Informed Action.

4.3 Unit of analysis and level of analysis

I understand *level of analysis* to be:

> "The level of analysis refers to the level at which that phenomenon occurs i.e. does the phenomenon concern individuals, groups, departments, the organization as a whole, the institutional field, networks, sections of society etc. Deciding level of analysis determines the kind of theoretical resources and previously published empirical research which can be used to explain the phenomena under investigation. Level of analysis therefore delimits the type of explanation that can be applied to the data which have been collected. One would not, for example, use theories of social structure to explain a study of individual psychological traits. The theories apply at a different level of analysis."*(Source: comments on my original probation report – advice by my Open University OU assessor.)*

Concerning *level of enquiry:* (Markus and Robey 1988) made a very strong plea for the theoretical basis of each piece of information systems research to be made more explicit. In discussing what constitutes "good theory", Markus and Robey used three dimensions of the structure of theory: causal agency, logical structure, and level of analysis. For them, level of analysis refers to the entities about which the theory poses concepts and relationships - individuals, groups, organizations, and society.

(Markus and Robey 1988) discuss the problems of inference and ideological biases.

Concerning *inference*, they argue that it is dangerous to generalise about organisational motives on the basis of observations of individuals within those organisations. The levels of analysis have become confused. Therefore although this present study focuses on individual information systems, these of course interact with organisationally-provided IS, which are however not studied here.

Markus and Robey broadly divide *ideological biases* into macro-level and micro-level. They suggest that this distinction is largely associated with the discipline of the researchers concerned. Thus, we might say that anthropologists will differ in their observations and conclusions concerning the same evidence from say sociologists.

They state (the *emphases* are mine):

> "In contrast to our caution against mixing process and variance theory, we believe that mixing levels of analysis may be useful in research and theory on information technology and organizational change. In defense of mixed-level theory (Rousseau 1985) asserts that technologies such as office automation are neither strictly micro nor macro in character. She believes that mixed-level research should abound in an inter-disciplinary field where mixed-level phenomena are the inevitable subject of study (1985; pp. 2-3). That

it does not is a disturbing commentary on the power of discipline-based research groups."

Knowledge workers are continually frustrated by the need to keep and to integrate three levels of information: the corporate, the group and the individual. I feel that I cannot make a presupposition about the "right" level of analysis prior to my empirical research; *it is essentially individual-within-small-group.* I have chosen that level because that is the one which is too infrequently studied – the vast majority of IS literature concerning itself, explicitly or implicitly, with the corporate or departmental work system (Alter 2006) levels of analysis. The very notion that work systems might also be individual was first recognised in the IS literature by (Baskerville 2011b).

4.4 Logics of enquiry

A question which I admit as being of the utmost importance is that of *distinguishing between logics of enquiry*. If we accept the simple distinctions with which Wendy Stainton-Rogers (Stainton-Rogers 2006) frames her discussion of logics of enquiry, we can distinguish at least induction, deduction and abduction. She makes a strong case for considering abduction. My initial approach is abductive and it is pragmatic: I follow Charles Sanders Peirce as interpreted by (Yu 1994). I summarise this as:

"

> The logics of abduction and deduction contribute to our conceptual understanding of a phenomenon, while the logic of induction adds quantitative details to our conceptual knowledge.
>
> Neither induction nor deduction can help us to unveil the internal structure of meaning. As exploratory data analysis performs the function as a model builder for confirmatory data analysis, abduction plays a role of explorer of viable paths to further inquiry.
>
> Hypotheses (or at least, initial questions) should be generated by means of critical thinking applied to pattern recognition. The objective of abduction is to determine which hypothesis or proposition to test, not which one to adopt or assert.
>
> Classification plays a major role in making hypotheses; that is the characters of phenomenon are placed into certain categories.
>
> Researchers must be well-equipped with proper categories in order to sort out the invariant features and patterns of phenomena.

"

Stainton-Rogers links abduction to constructivism. When Peirce first discussed abduction, constructivism had not been explicitly identified. Abduction is pragmatically useful whether or not one accepts a wholeheartedly constructivist stance (which I do not). Peirce defined abduction as "the process of forming an

explanatory hypothesis" (Peirce, n.d.), p.55. Stainton-Rogers describes how Peirce formally defines abduction through *syllogism:*

> Result -- the surprising fact, C, is observed.
>
> Rule -- but if A were true, C would be a matter of course (i.e. not in the least surprising).
>
> Case -- hence, there is reason to suspect that A is true.

One among perhaps many ways of investigating personal (that is, individual) information management is by up-close observation and participation in the personal information management experiences of a sample, however statistically unrepresentative, of individuals who have information to manage. Different individuals will reach different "solutions" or working compromises. Some will build more effective personal information management systems than others. Note my use of the term personal information management systems, which to the best of my knowledge has only ever been used previously by the library scientist Deborah Barreau – see for example (Barreau and Nardi 1995); and by PIM researcher Ofer Bergman (e.g. (Bergman et al. 2008), more recently in collaboration with Steve Whittaker, notably in (Whittaker and Bergman 2016).[11] Yet whenever a computer user sets out to manage some information by making a list and structuring it, she in her use of that list to drive her subsequent actions has constituted a personal information management system (whose primary components are the computerised list, the technology she employs to maintain it and she herself as an active agent or actor). The apparently-trivial example I employed above is that of making and using a shopping list. Viewing that use of technology as an information system highlights a crucial distinction, that between information technology and information systems. This distinction is fundamental to the existence and self-awareness of the information systems discipline or field with which I identify myself. See for example (Paul 2010).

4.5 Research gap: Individual information systems as a research arena

It is a surprising fact that (almost) no research I have been able to find treats personal information-management *systems*.

It is also a surprising fact that almost no academic has discussed how people build personal information management *systems*, nor how they can be helped to do it better – which will always involve learning and might involve teaching and / or mentoring.

My contention is that a personal information management system exists when someone uses IT in a more or less systematic way to store and manage data which

[11] Bergman and Whittaker's work uses the word system, but largely as a term for a collection of inter-dependent components. Much of the value of their work lies in the notion of 'user subjectivity', which is discussed elsewhere in this document; see section 0 (f).

they then use as they act purposefully, based on the information they obtain from that data as interpreted by their knowledge, explicit and tacit.

I sought to enquire into how people learn to build individual information systems and how they can be helped to design a better system by means of observing them and by actively helping them. I initially thought that this could be done using ethnography or that it could be done using action research. To anticipate, the approach which I identified and its subsequent evolution is as follows:

To observe myself as I manage the information I do – this is a research approach which is sometimes called autoethnography and which others have identified as systematic self-observation. This approach is clearly subjective and limited, and thus incapable in itself of leading to generalisable conclusions. It is not, however, devoid of insight. The inspiration for this autoethnographic approach arose in discussions with my external supervisor, David Weir late in 2007 and in the early part of 2008.

It was then my intention, by reference to the considerable literatures on information systems, information technology, computer science, learning, cognitive science and the like, to construct learning materials which have the potential to assist people as they learn to create and (more usually) to improve their personal information management systems. I would then use those learning materials firstly myself, then as an element in active intervention with research volunteers – people who are willing to allow me to mentor them. This is an approach which I identified as mentored action research. I wrote the conference paper (Gregory, Kehal, and Descubes 2012b) in conjunction with my then internal supervisor Mounir Kehal and my colleague Irena Descubes in order to set out this research approach in advance of its application.

In order that I could build up sufficient experience and knowledge I knew that I had firstly to do two things.

One was to read extensively as I sought to understand the role of the learning knowledge worker as she participates in an **open and continuous evolution as part of a self-organising individual work system**. The italicised phrase was suggested to me by my internal supervisor, Renaud Macgilchrist. I have had to learn for myself what it is to be part of such an individual work system.

The second was to experience for myself the process of evolving a **personal information management system** – the data-oriented subsystem – to that individual work system. The construction and evolution of the individual work system, the **personal work system PWS** and of the **personal information management system PIMS** have been achieved by means both of what Claudio Ciborra identified as serendipitous bricolage (Ciborra and Jelassi 1994) and what Richard Baskerville calls experiential design (Baskerville 2013). **I have had to learn before I can mentor.**

This thesis summarises what I have learnt so far. I do not claim that the knowledge gained is scientific in the sense of being fully generalisable. I shall set out reasons why any such knowledge claims will always be only partial. However, the learning I have gained is useful and aspects of it are worthy of dissemination. In this thesis, I go on to justify that assertion.

4.6 Overall research objectives – pre- and post-PhD

Objective 1 - To begin to uncover my working model and to (re-) design my own PWS and PIMS

Objective 2 - To discover by mixed research methods:

- How each individual's Personal (Baskerville 2011b) Work System (Alter 1999), (Alter 2010) PWS can better be supported by her Personal Information Management System PIMS
- Learn how to help people to improve their PIMS and PWS via explicit modelling and implicit learning (by both research volunteers and a researcher-mentor)
- Specifically, to understand how to "surface" the Working Model that underlies the PIMS and PWS

4.7 The role of Conceprocity in my PhD research

Conceprocity is a semi-formal visual knowledge representation language which enables and encourages the modeller to be more precise in defining, bounding and relating conceptual and procedural knowledge.

It is in effect a means to constrain and enhance natural language expression and thereby to increase the precision of the meaning which the modeller seeks to express.

To the extent to which two modellers can agree upon a Conceprocity model, it is also a means to establish and to verify communication of ideas and concepts.

My use of concept maps was originally motivated by the following felt needs:

- Structuring my understanding of the published work of others. For examples, see (elsewhere) my concept maps concerning the work of (Weick, Sutcliffe, and Obstfeld 2005) on sensemaking and of (Polya [1945] 1988) as introduced in the discussion of Polya's heuristics by (Macgilchrist 2004).

- Planning my PhD research, which has conceptual and process elements.

The main initial Conceprocity test use case is in fact work system modelling, particularly personal work system modelling. I first make this explicit three years ago in a PhD journal entry in which I stated that

1. "My thesis, based upon abductive insight and well-established cybernetic theory, is that the effectiveness of the individual knowledge worker depends to a significant degree upon the following factors:

2. Each of us has a more or less explicit personal working model which encapsulates our understanding of how we should organise our personal work. In most cases, that model is inexplicit. I would expect the extent to which our personal working model is an effective regulator of our personal work system to be determined (inter alia) by the faithfulness, the degree of

isomorphism, of that working model with the "reality" with which we have to deal. For I think the first time, there will be some empirical evidence available concerning that conjecture. The risks are that the "inter alia" - unidentified - will interfere with the expected result; or indeed that evidence will contradict the theoretically-based prediction, putting the theory in question.

3. My conjecture is that the effectiveness of personal work can be increased by individuals who more explicitly model - and thus understand - their personal work system before seeking to design improvements to aspects of that system; and that in many cases, individuals will benefit from mentoring as they audit, model and redesign their work system.

4. I have deemed it necessary to create an improved conceptual modelling approach. Called Conceprocity, concept process reciprocity, the approach is a lineal descendant of the existing G-MOT formalism invented by the LICEF research centre in Canada."

4.8 Research motivation, initial and ongoing

I desire to be engaged in relevant and passionate research and related teaching or consultancy.

I desire to influence teaching and practice.

How might I go on to achieve this? some routes which I would intend to follow include:

- Forums

- E-publication

- Academic journal articles

- Educating the educators: working with teacher - researchers

- Executive education

4.9 The research epistemology

This thesis presents ***exploratory*** research which seeks where possible to identify what critical realism calls generative mechanisms – thus yielding some degree of ***explanation***.

The research approach is essentially multi-method, including autoethnography, action design research, content analysis by means of textual analysis, model-based reasoning.

This enquiry is informed by the sequence identified by (Psillos 2009) following C.S. Peirce, but does not directly follow it.

- Abduction – to establish plausible hypotheses.

- Induction: design, bricolage (Ciborra 1992; Ciborra and Jelassi 1994) and model-informed observation – to investigate those hypotheses
- Deduction? First we explore, then later zero-in on more precise questions – perhaps hypothetico-deductive? Such later enquiry is post-PhD.

The method of enquiry put forward by Charles Sanders Peirce is discussed by (Psillos 2009) who delineates two distinct phases in the development of the reasoning process of Peirce, only the latter of which I discuss here. Retroduction, which is the word Peirce uses for explanatory reasoning, particularly on the basis of post-action reflection, is taken as part of a broader three-stage methodological pattern identified as the method of enquiry. Explanatory reasoning continues to be the sole generator of new content. However, its conclusions require further justification which is achieved by means of deduction and induction. That justification will take the form either of deduction of predictions or of confirmation, the word Peirce uses for completed induction. Gradually, beliefs become doubt-resistant. This **First Stage of Inquiry** reasons from consequent to antecedent (Peirce's collected works 6.469).

In the second stage of enquiry, the new hypotheses must be tested by submitting various conditional experiential consequences to testing - deduction and testing.

In the third stage, judgements are made as to whether the hypothesis is sensibly correct or may require some minor modification or may need entirely to be rejected. The characteristic form of reasoning used in this phase is induction.

> "Induction is no less indispensable than abduction in the overall process of inquiry— but its role is clearly different from the role of abduction. Peirce put this point in a picturesque way when he said that our knowledge of nature consists in building a "cantilever bridge of inductions" over the "chasm that yawns between the ultimate goal of science and such ideas of Man's environment", but that "every plank of [this bridge] is first laid by Retroduction alone" (6.475).
> " Peirce quoted by (Psillos 2009, p.34)

4.10 Methodology and techniques

Methodology and techniques considered but not used

- o Quantitative and mixed methods
  - Mixed methods research mainly refers to quantitative and qualitative research in differing mixes.

Methodology and techniques used

- **Autoethnography** (structured self-observation (Rodriguez and Ryave 2002)): telling my own action-story as I seek to understand and to prototype better techniques
  - Means: confessional PhD journal – cf. (Schultze 2000)
  - Outcome: textual and category analysis of PhD journal (2011 to 2016; 390000 words)

- **Design science research**
  - A perspective of this current thesis is that design is necessarily abductively inspired, undertaken within the presence of constraints, respectful of the principle of separation of concerns and thereafter pragmatic.
- **Action design research (Sein et al. 2011)**
  - Outcome: proof of concept PIMS
  - Based in part on serendipitous bricolage (Ciborra and Velasi 1994) and in part on action design
  - Outcome: Conceprocity models of knowledge fragments
  - Outcome: Conceprocity itself
- **The beginnings of mentored action research (Gregory, Kehal, and Descubes 2012b)**
  - Now beginning: Working with some research participants leading to *co-designed* Conceprocity maps and targeted PIMS improvement
  - Outcome: a small number of *cases*, illustrated by narrative and conceptual models
- **Post**-PhD: fuller **mentored action research** – in particular, educating the educators; working with teachers and researchers and, if possible, with doctoral students

Chapter 5 FINDINGS

The PWS is described, as is the PIMS. The practical uses made of UnIQue, Conceprocity and Zotero linked to UnIQue are illustrated.

5.1 Personal working model, work system and information management system
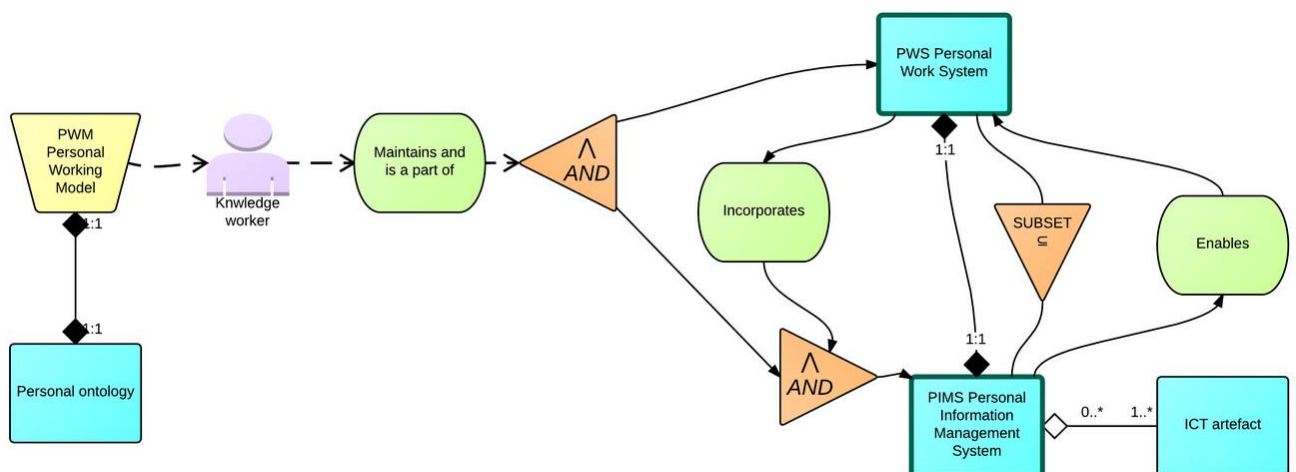
Figure 44 Multiple perspectives: a different viewpoint on PIMS and PWS

This diagram concentrates on the different relationships which exist between the PIMS and PWS. The directional relationship triangle indicates that the PIMS is a subset of the PWS. The procedures `incorporates` and `enables` indicate specific transformations that take place as data flows between the two elements. Finally, the structural relationship indicates that there is exactly one PIMS for exactly one PWS.

At this level of abstraction, the PIMS is regarded as being a collection of ICT artefacts, whose existence is not dependent upon the existence of a PIMS. Conversely, a PIMS cannot exist unless there is at least one ICT (or paper!) artefact.

5.2 The Personal Work System PWS of a knowledge worker
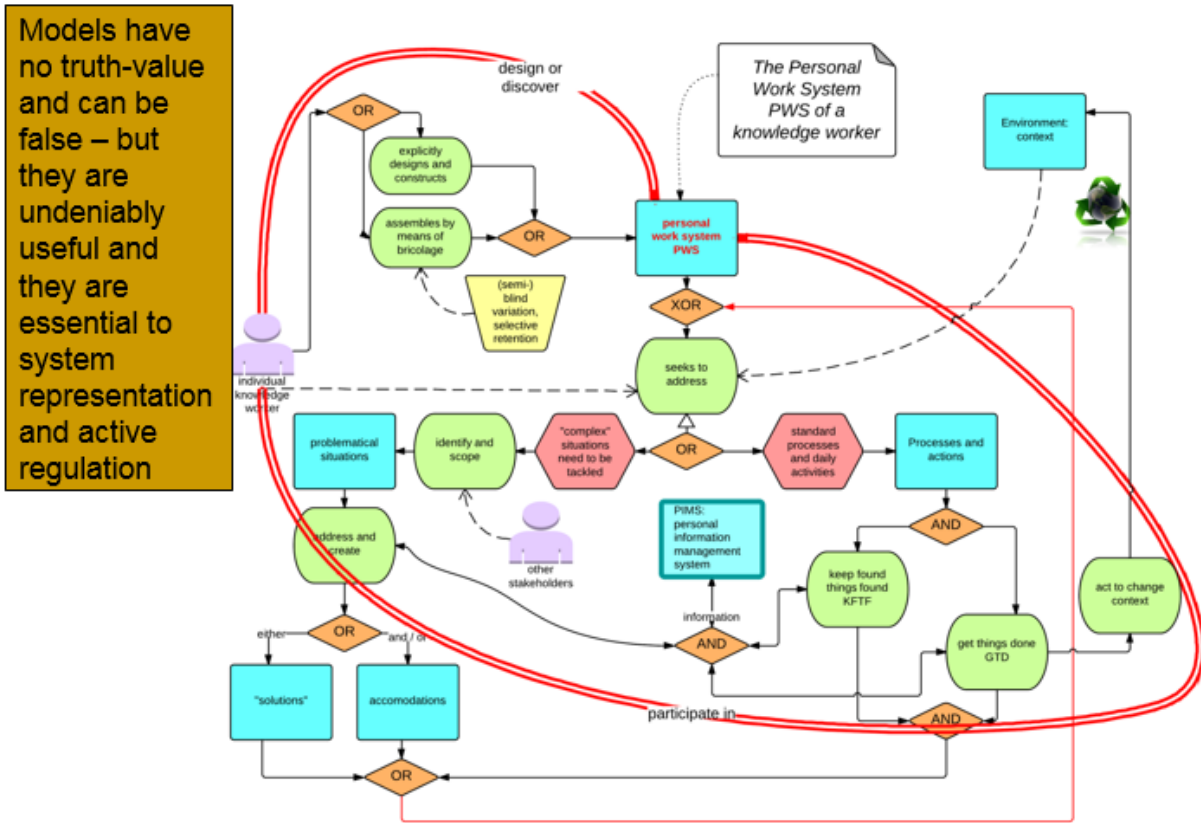
Figure 45 The PWS - larger scale

5.3 Some details concerning my personal work system PWS

Procedures: example use cases / processes in my own personal work system include:

Procedure
Day-to-day time management
Identification & planning of projects (e.g. PhD)
Managing programmes
Delivering teaching modules
Managing research
Stay informed: read academic and practitioner literature, maintain article library, classify and tag – the PWS must be open and evolve
Maintain and improve personal taxonomy – this also provides evidence of semantic morphogenesis

Create and maintain nuggets
Career management
Household management and family matters
Involvement in voluntary organisations
General form: nuggets of actionable knowledge, each represented by a Conceprocity model and by other resources such as a dictionary and a hierarchical outline

5.4 Components of a personal information management system PIMS
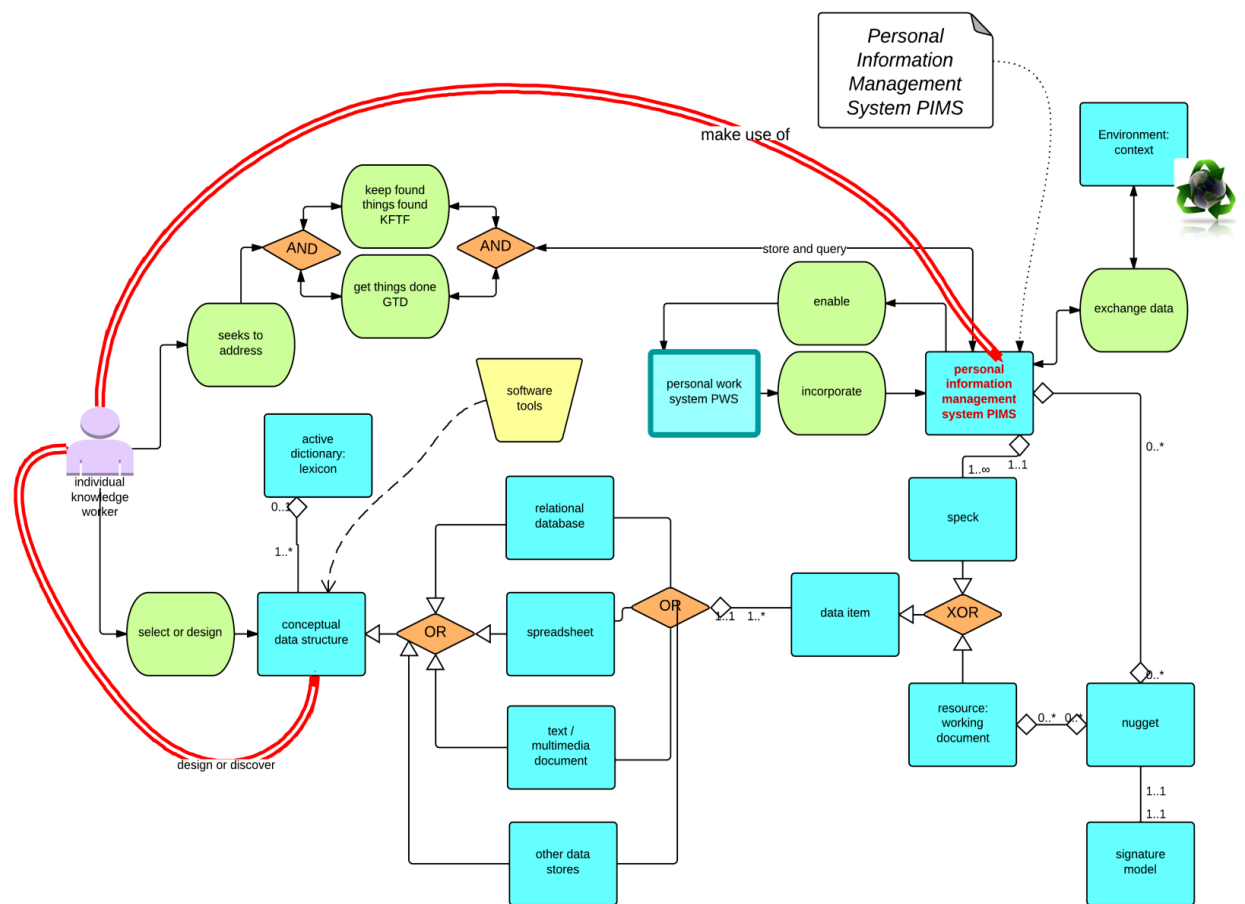
Figure 46 A specific example of a PIMS

Undertaking a large task, a project, such as a Ph.D. has a goal and a structure or architecture with components. Thus, creating what we once referred to as "working documents" and now name nuggets is a major component of the task which a

researcher undertakes. In a sense she is seeking to surface her knowledge bank – to make her knowledge explicit, in the language of (Nonaka 1991).

5.5 Bricolage in PIMS

A « power user » of PIM is characterised by the competence to make the broadest or most general use of computer programs or systems. In this, she both identifies and makes use of affordances, and she ssembles an evolving collection of computer tools which together facilitate her work.

The term "power user", used on forums, does not appear in the academic literature, but the term *bricoleur* does, notably in the witings of Levi-Strauss and of Ciborra.

The software and hardware elements of the UnIQue PIMS can be viewed both as the result of *bricolage* but also as the result of *experiential design*. In particular, I was attracted to InfoQube for a number of reasons among which were its relatively open architecture – thus, for example, the ability to integrate data from an external database using SQL and to enhance its functionality using a scripting language (VBScript).

5.6 UnIQue architecture
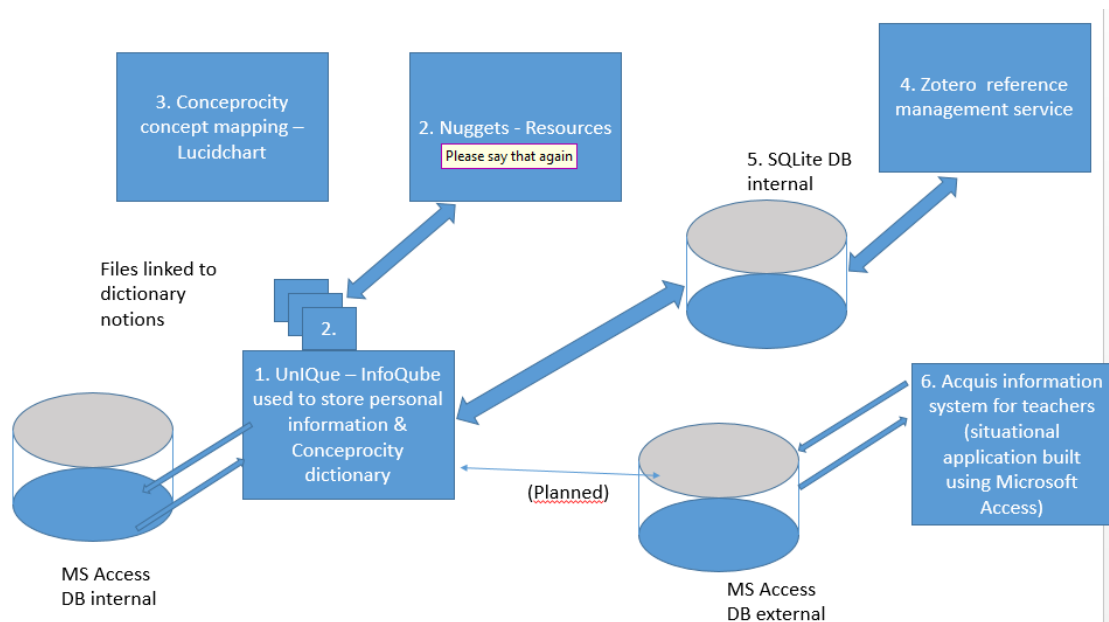
Figure 47 UnIQue architecture

[This diagram is not in fact a Conceprocity map – there is no support for software architecture diagrams in Conceprocity.]

1. The UnIQue PIMS is based on affordances offered by the InfoQube software package. It is shown as a rectangle linked to a database which is internal to InfoQube (but is in fact a Microsoft Access database internal to and managed by InfoQube).

2. Among the data stored in UnIQue are dynamic links to files, labelled here as nuggets/resources. The effect of this is that it is possible to manage – to link, classify, categorise… external files which implement nuggets.
3. Shown as entirely separate is the Conceprocity concept mapping which is managed by Lucidchart.
4. I maintain bibliographic references using a software service called Zotero.
5. The element marked SQLite DB internal is the internal database which stores bibliographic items within a Zotero reference management system. Within UnIQue, I have established links to this Zotero database such that the bibliographic references – stored by Zotero – are visible to and can be managed in UnIQue.
6. Currently shown as separate, but in fact potentially also linked into UnIQue ("planned"), is an example situational application: the Acquis academic quality information system which I have designed and built using Microsoft Access.

5.7 Components of my proof-of-concept personal information management system – 1

InfoQube: data in grids (tables; Gantt view, etc.) - Used very extensively in the PhD research, e.g. for:

Lists of nuggets and resources

Classification (Jacob 2004); this is what (Bunge 1977) calls **kind**

Categorisation (tagging)

Day-to-day and PhD **planning**

Figure 48 The nugget grid in UnIQue

It should be noted that nuggets can be arranged hierarchically, that is to say a nugget can form part of another nugget – a child nugget being nested within a parent nugget. Furthermore, a given nugget may have multiple parents – that is to say, it may be used and reused in multiple contexts.

5.8 Class, kind and tag in UnIQue

Classification and categorisation have latterly been applied both to my journal and to my bibliography. The bibliography grid in UnIQue is maintained by means of an SQL query on the SQLite database which is internal to the Zotero reference management system – thus UnIQue and Zotero are integrated. The values in any field can either be constrained to be a single value from a set – classification – or multiple values from a set – tagging or categorisation. The fact that any field can have a classification or kind is an instance of a property having a property – which Bunge would not admit, but which is of great practical value.

My basis for the choice of InfoQube in my initial evaluation was its support for multi-parent *hierarchical outlining* with *columns* (fields) and the possibility of incorporating *own-code* (VBScript).

An example use of VBScript in horizontal (row) equations is keeping values in step between different fields – there is no notion of referential integrity in InfoQube, so I have had to do some VBScript (row equations) and SQL programming.

An example use of VBScript in vertical (column) equations is calculating roll-up elapsed time in planning grids.

5.9 How I have made use of Conceprocity in this study

A nugget: part of the PhD plan stored in InfoQube

Item	Order	NuggetList	Notes	Extra notes	TaskID	NextTaskID	Start
− Complete PhD	0	PhD thesis			120		28/07
Frontpage.docx							
Contents.docx							
Abstract.dotx							
+ The PhD Thesis structure	1	The PhD Thesis structure			121		31/08/2
− Write the thesis	900				237		12/09/2
Revise the structure of the thesis. Do not worry about achieving perfection; there is a subsequent revision.	905				239	240	28/09/2
− Identify and nuggetise all existing resources. Highlight the current state for each nugget.	910				240	241, 247	02/11/2
Incorporate necessary parts of my earlier Lexicon paper as part of the Ph.D. thesis.	911				241	243	
− Nuggetisation aspects	912				242		02/11/2
Catalogue the existing Conceprocity resources, because we need to nuggetise them.	914				243	246	02/11/2
Identify all likely useful sources of text. These include the probation report, significant journal entries, and my various conference papers – including ones which are not yet complete. Collect them together in one place.	915				246	247	
Revise the structure of the thesis. This is definitive. Below the structure, identify the target nuggets.	925				248	249	12/09/2
Using the ontology, give kind and tag to all existing resources. Quickly map the existing resources to the desired nuggets.	930				249	250	14/09/2
Enhance the ontology by dragging in appropriate bibliographic markers.	935				250	251	14/09/2
Write up the area of application.	940				251	252	15/09/2
− Write up the methodology.	945				255	258	19/09/2
Tell the story of the research, and show where more can be found.	948				83		
− Describe my research framework.	950				252	255	16/09/2

Figure 49 A part of a planning grid in UnIQue, including a Gantt chart

A planning grid in UnIQue exploits Gantt chart functionality, thus offering affordances both to the individual planner and potentially to her « manager ».

A Conceprocity dictionary which names, classifies and tags principal notions

3	− Working model	Principle	5=: Finding
3.1	− Personal knowledge	Package	7: Institutional
3.1.1	+ Personal ontology	Principle	7: Institutional
3.1.2	+ Philosophy / philosophical stance	Principle	7: Institutional
3.1.3	+ Learning	Procedure	3: Observation
3.1.4	− Maintain homeostasis (controlled survival through stability): regulate in accordance with the good regulator theorem of Conant and Ashby and the personal working model	Procedure	5=: Principle
3.1.4.1	Regulation	Concept	8: Scientific
3.1.4.2	Model	Concept	6: Design
3.1.4.3	BVSR: blind variation, selective retention	Principle	5=: Principle
3.1.5	Reflect in and after action: structured self reflection	Procedure	4: Emergence
3.1.6	+ Actors	Actor	5=: Finding
3.1.7	− Enquiring: creating knowledge	Procedure	4: Emergence
3.1.7.1	Auto-ethnography	Principle	3: Observation
3.1.7.2	Design science research	Principle	7: Institutional
3.1.7.3	+ Identify concepts and themes from text	Procedure	4: Emergence
3.1.7.4	Assemble by means of bricolage	Procedure	4: Emergence
3.1.7.5	Explicitly design and construct – experiential design	Procedure	6: Design
3.1.7.6	Multiple method research	Principle	7: Institutional
3.1.7.7	Theory-in-use	Principle	5=: Finding
3.1.7.8	Bricolage	Concept	5=: Principle
3.1.7.9	Experiential design	Concept	5=: Principle
3.1.7.10	Designed artefact	Concept	6: Design
3.2	− Doing and informing	Package	7: Institutional
3.2.1	+ PWS personal work system	Concept	3: Observation
3.2.2	− PIMS personal information management system	Concept	5=: Finding
3.2.2.1	Use PIMS	Procedure	5=: Finding
3.2.2.2	+ Principles of effective PIM	Principle	
3.2.2.3	− UnIQue PIMS	Instance	7: Institutional
3.2.2.3.1	+ Grids	Concept	6: Design
3.2.2.3.2	− Build PIMS	Procedure	6: Design
3.2.2.3.2.1	− Affordances	Concept	7: Institutional
3.2.2.3.2.1.	− PIM technology and tools	Principle	7: Institutional
3.2.2.3.2.1.	Zotero	Principle	8: Scientific
3.2.2.3.2.1.	Lucidchart	Principle	8: Scientific
3.2.2.3.2.1.	InfoQube	Principle	8: Scientific

Figure 50 Dictionary entries used when constructing a complex Conceprocity model

#	Item	EntryText	IsPerso...	Thesis	SummaryVal	WIKITag

2082	20/01/2016 Wednesday	I need to talk to Hervé-Cavaro Artébat
		  Mobile : 07 86 46 69 05
		ARTEBAT HERVE - CAVARO
		  tél : .02 99 71 96 20
			☐	☐		

2083	21/01/2016 Thursday	And yet another interesting article - when will I stop reading and start writing? (Burton-Jones, McLean, and Monod 2015) identify a meta-concept which they call theoretical perspective. They define a theoretical perspective as a researcher's choice of the types of concepts and relationships used to construct a theory. Within the context of the need or desire to build theory they identify three perspectives, which they label process, variance and systems. They criticise what they term the traditional process-variance dichotomy and suggest a broader view defined by conceptual latitude (the types of concepts and relationships available) and conceptual fit (the types of concepts and relationships appropriate for a given study). They particularly emphasise the systems theoretical perspective. Their chosen audience is not philosophical in stance but is an IS researcher who hopes to generate new knowledge and who, as part of that process, wants to build or refine a theoretical model. They demonstrate broad agreement on the existence of two building blocks of theories, these being concepts and relationships. They reject a classical realist ontology, such as that espoused by Mario Bunge because it presupposes a materialist viewpoint which they suggest is not mainstream. There is conflict between such materialist ontology and alternatives such as hermeneutical perspectives or the social ontology of John Searle. I take particular comfort in one aspect of the work reported in this article. The fundamental types which are discussed include concept, relationships, system, actor, event, property, whole, part. Indeed the theoretical perspectives are themselves just categories or classes of theory, and they are ways of looking at theories and how they are organised and represented. I do take comfort in this because the fundamental types which they recognise are the principal notion types within Conceprocity.	☐	☑	5=: Principle	{Conceprocity},{IS theory}
2084	21/01/2016 Thursday	Well, it has happened again or I have done it again - I'm not quite sure which. I have once again lost the user code that I have written in Visual Basic for use in InfoQube. This code is stored in a single file in the folder which contains the InfoQube program and associated configuration files. Slightly good news is that I did backup this code back in the middle of August. Slightly bad news is that that backup was taken quite a while before I made several significant changes in conjunction with Pierre. Slightly good news is that I kept a reasonably good record of what we were seeking to achieve at the time we did that. I know why I didn't take trouble to properly back this code up at the time. I was working very hard against an assumed deadline of 31/08/2015. I therefore cut corners. I am once again up against a deadline, and I shall probably take only limited steps to backup my work while at the same time making sure that I do document what I will have done. However, in the morning, I will continue to prioritise getting the stuff to the accountant.	☐	☐	Bug	{InfoQube}
2085	21/01/2016 Thursday	I here record a typical minor PIM problem and its resolution. I make fairly extensive use of Microsoft Excel. While working to update the spreadsheet which contains the annual accounts of the SCI, I encountered an issue which I have had in recent weeks and months and which has probably cost me quite a lot of time. It is a frequent requirement when working with spreadsheets to want to copy the contents of a range of cells, most frequently a row, and then to insert rows containing the pasted contents of the clipboard. This stopped working for me someone ago, and I could not find a solution to the problem and/or largely ignored it. Today I decided to delve a little further. I had previously assumed that something must have gone wrong with Excel itself, for example, that there had been a change in the implementation of the programme. Today, I found that the problem was in fact an incompatibility between two Microsoft products, Skype - which I used to keep in touch with Caroline - and Excel. The resolution was to remove a feature which I do not use , which is Skype click to call. Once I had removed that program and restarted the PC, I could insert copied rows in the way to which I have been used for many years. This is typical of the kind of little problem which requires a certain tenacity to overcome. I note in this context an important recent article (Hwang, Kettinger, and Yi 2015). The importance of this is that it is the first article of which I am aware in a leading information systems journal which takes a quantitative approach to PIM constructs.	☐	☐	Solution	{Microsoft Excel}

Figure 51Example journal entries

5.10 Components of my proof-of-concept personal information management system – 2 - Bibliography

Figure 52 Bibliography grid in InfoQube linking to data in Zotero SQLite database

Aspects of personal ontology include:

- o Classification by Kind

- o Categorisation by Tag

- o Tagged classification, to give cross-referencing between tags and kinds and thus aid structure and searching

This is based upon the use of a service called Zotero: reference management.

Whence the References at the end of this thesis.

Zotero SQLite bibliography is surfaced in an InfoQube grid which can be filtered by kind or tag

5.11 Modelling nuggets in the Conceprocity approach

A Conceprocity model of a "nugget" (a piece of knowledge, often actionable) may include:

- ❑ A set of Conceprocity maps – these are visual representations of aspects of the model

- ❑ A set of entries in the Conceprocity dictionary – this helps to clarify the semantics of the model by naming notions and deciding their notion type

- ❑ A set of supporting "resources", that is, files which, together with the maps and the dictionary, constitute this nugget

❑ For example, for a taught class, these might include a PowerPoint presentation and supporting articles

Outlining

Outlining is needed to level (hierarchicalise) a nugget model. If the number of notions in the model is large, it is essential to split the model up into more manageable chunks. These chunks may be "obvious", that is, correspond to structural distinctions which are evident. Or they may need to be imposed in a more analytical way, distinguishing sub-nuggets of knowledge, possibly actionable.

There should always be a route map (which is also a root map – incidentally, root and route are pronounced the same in British English) which sets out the main chunks and how they are related. We call this the Level 1 map. Each major chunk can then be represented on a specific Level 2 map.

There are well established principles to be applied when hierarchicalising (levelling) Conceprocity maps.

In particular, we respect the observation of (Miller 1956) concerning "The magical number seven, plus or minus two: some limits on our capacity for processing information". Thus, there should be no more than nine main notions on the route map (or indeed on each level 2 map – this may sometimes require the creation of level 3 maps). The top-level chunks might be identifiable as the themes of the topic which is being modelled.

We exploit the specific multiple inheritance property of InfoQube which permits an item to appear in multiple contexts – to possess multiple parents. This usefully reduces data redundancy with its potential for error.

5.12 Components of my proof-of-concept personal information management system – 3

Further elements of the PIMS include:

o Acquis: Microsoft Access implementation of an academic quality information system – a situational application (Cherbakov, Bravery, and Pandya 2008). Provides functionality of great use to a programme manager and to a leader of large teaching modules.

o Cloud-based apps: Lucidchart for Conceprocity (etc.), GSuite (Google Apps) (shared web spreadsheets).

o Website: www.MarkRogerGregory.net - WordPress

o ABBYY PDF Transformer+ (PDF; OCR), Directory Opus and SugarSync.

o Textual analysis and concept identification: Leximancer (A. E. Smith and Humphreys 2006).

o Microsoft Word: multiple uses – e.g. writing nugget text; PhD journal.

- o Microsoft Excel: multiple uses – e.g. maintaining banking, accounts and healthcare records.

- o Microsoft PowerPoint: multiple uses – e.g. structuring nuggets; presenting nuggets.

5.13 Textual analysis using Leximancer

My actual use of Leximancer

I have used Leximancer for the following purposes:

- o An overall analysis of the entire PhD journal (but not of the papers that I have written during the PhD)

- o Purpose: to discover the vocabulary that I have used and how that has evolved over time

- o An overall analysis of a large small part of the PIM literature corpus – for comparison, showing how small is the overlap with my work

- o A focussed analysis of my work at a much finer level of granularity, that of individual journal entries

- o The language used in the writing of William Jones, a leading PIM researcher

A Leximancer analysis of my PhD journal

5.13.1.1 Results without any additional compound terms, August 2015

I carried out a summary analysis of my complete PhD journal. This was then approximately 310,000 words in length. The concept map, with percent visible concepts turned up to 100%, looks like this; the blue arrows are my own additions to highlight the major themes which emerged.
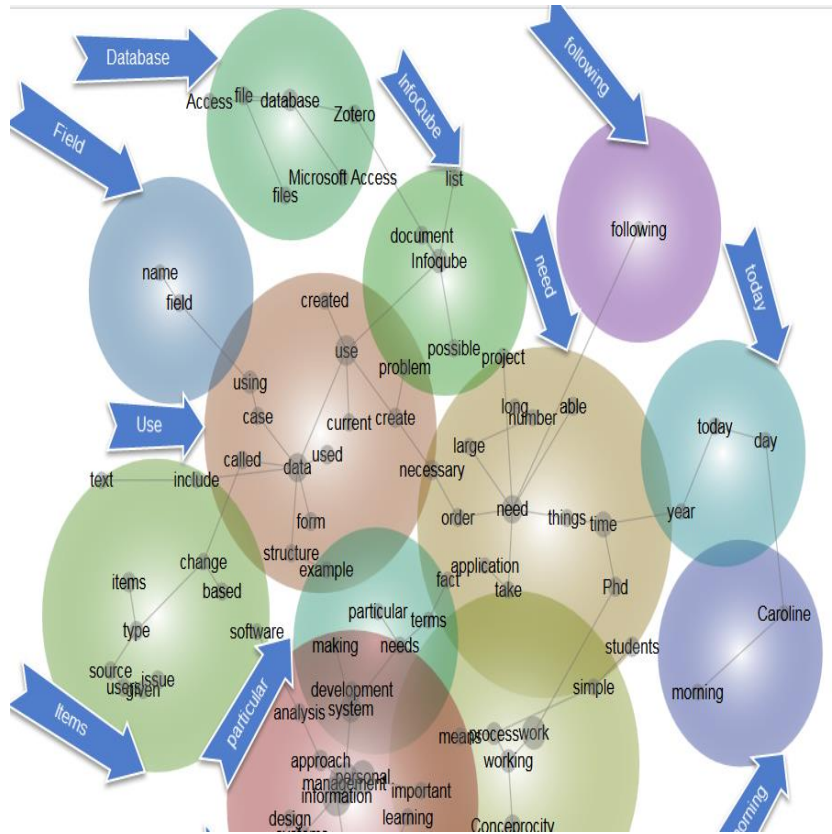
Figure 53 Leximancer analysis of complete PhD journal, August 2015

5.13.1.2 Results with additional compound terms, December 2015

I carried out a summary analysis of my complete PhD journal in December 2015. The journal was by now 362,000 words in length. The concept map, with percent visible concepts turned up to 100%, looks like this; the blue text boxes are my own additions to highlight the major themes which emerged.
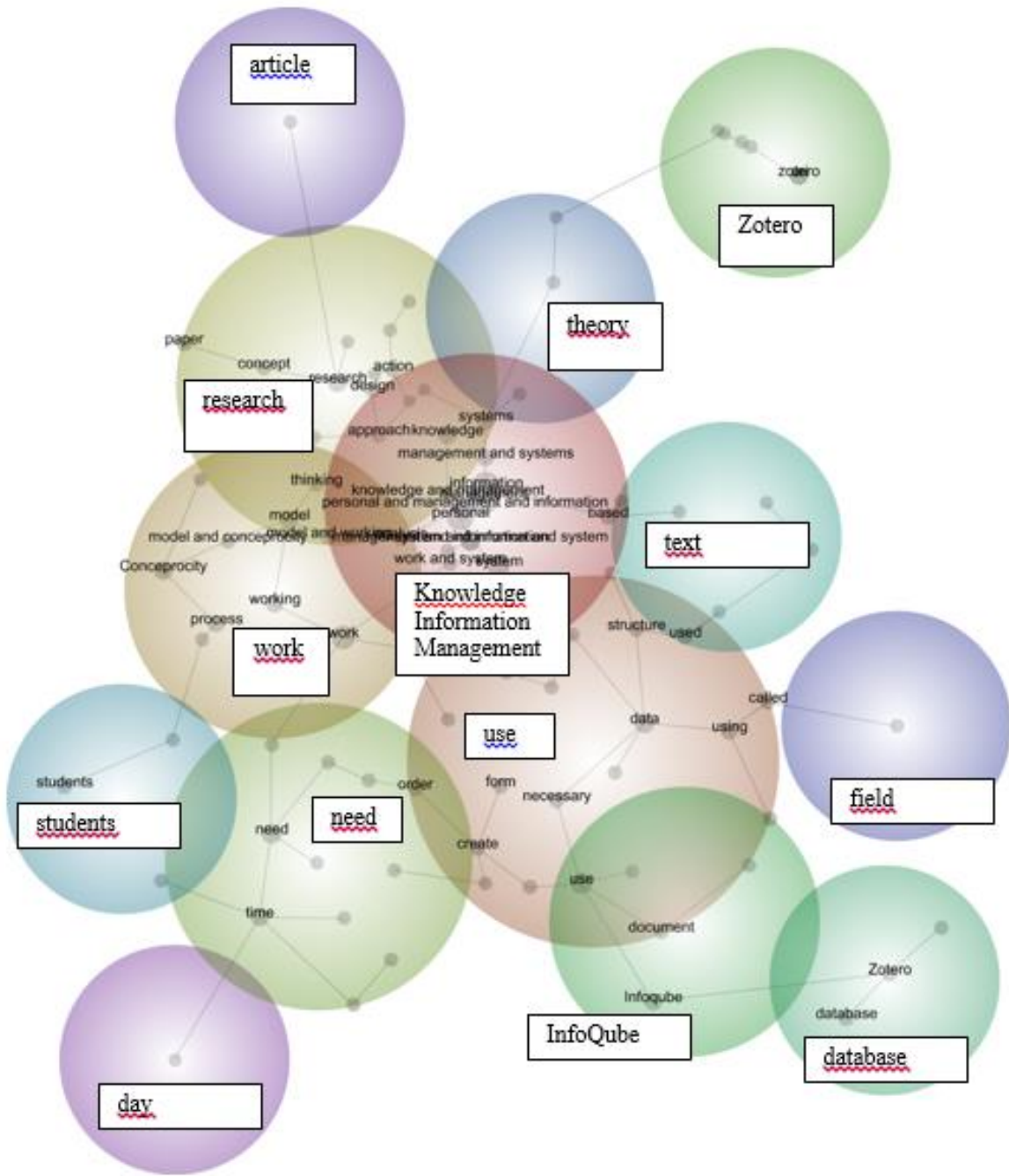
Figure 54 Analysis of entire journal, December 2015
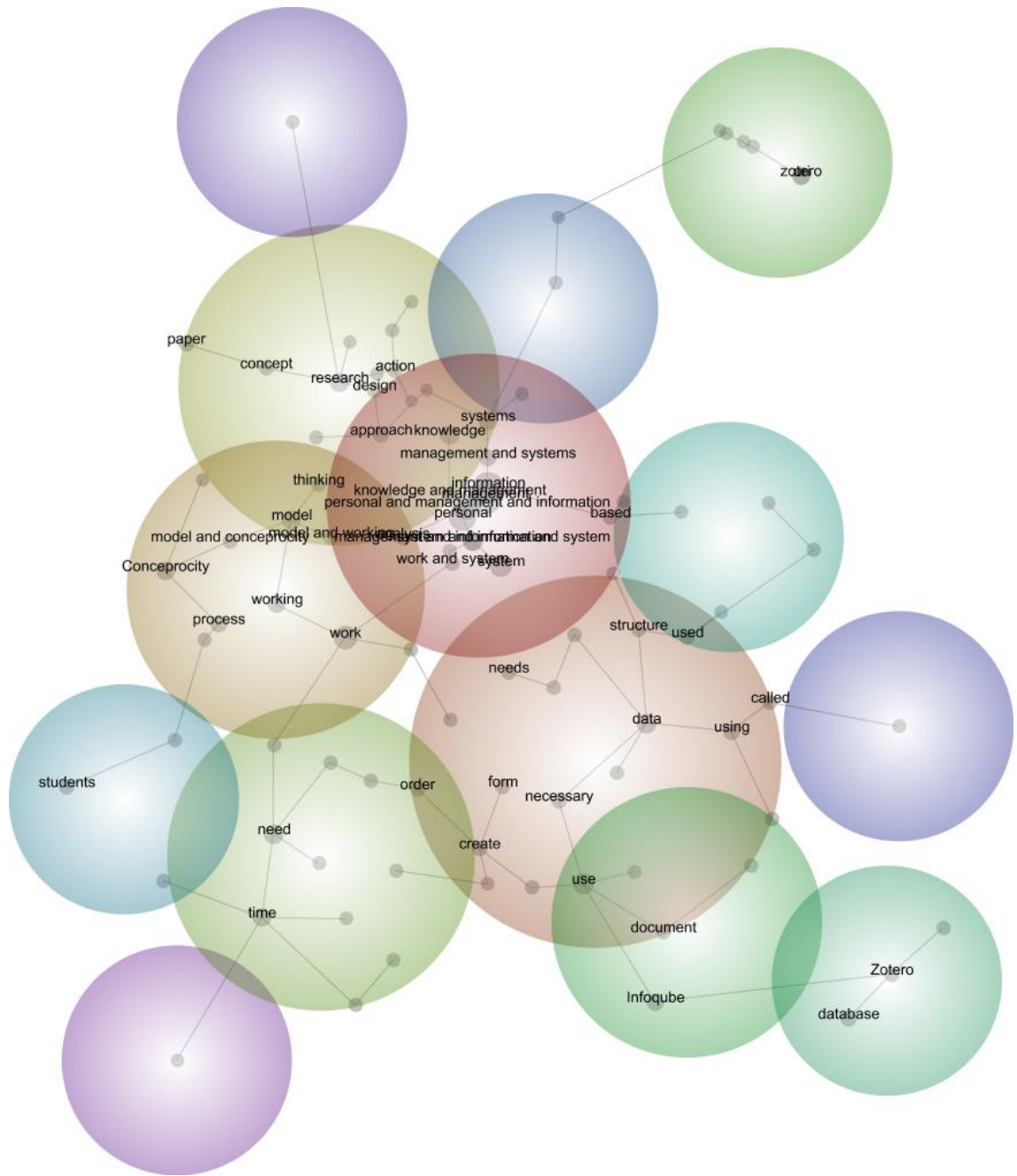
Figure 55 Analysis of journal with additional stopwords

It should be noted that Figure 55 was produced using a list of compound terms; this list is reproduced as Table 17. I also added additional words to the stopword list; this list is reproduced as Table 18.

Table 17 Significant compound terms

On the basis of term frequency information produced by Leximancer and analysed using Excel, I identified the following compound terms which were used to "seed" the analysis presented as Figure 50.

Significant compound terms
personal information management
management information system
knowledge management
systems management
systems approach
information system
personal work system
work system
working model
Conceprocity model
systems thinking
design research
action research

Table 18 Additional stopwords

Additional stopwords
given
family
Caroline
org
PhD
today
morning
evening
afternoon

A Leximancer analysis of two books by a leading PIM researcher
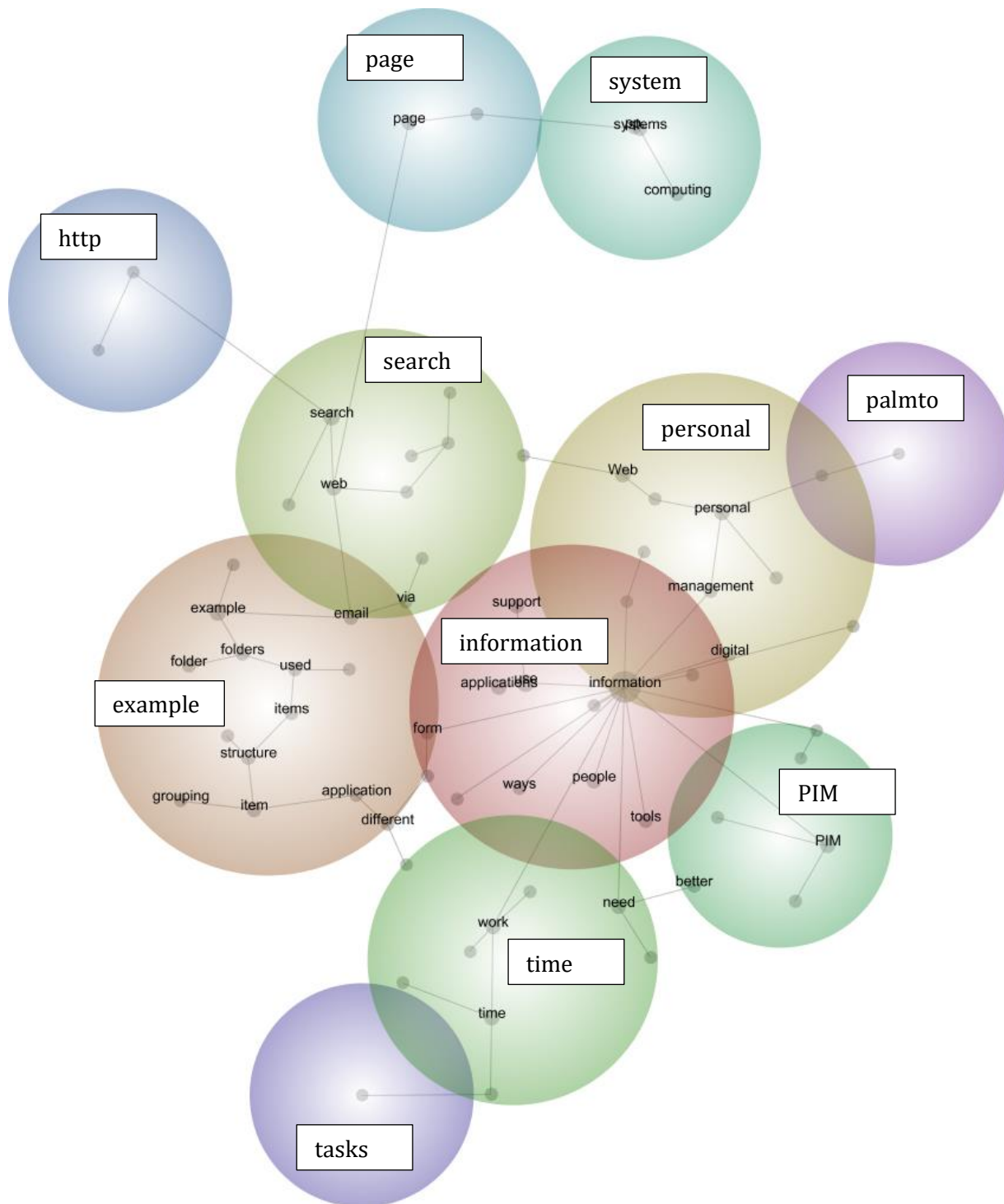
Figure 56 The language used by William Jones, a leading PIM researcher

Of note in Figure 56 and reinforced in the term frequency information supplied by Leximancer:

- In a ranked list of the concepts within the books, in comparison with the most frequently used word which is information (100%), the singular word system achieves a relevance of only 6%, knowledge only 5% and the word learning does not appear at all in the list of concepts.

- The word "systems" is frequently used in the work of William Jones (relevance of 14%). However, it can be seen from the diagram that the theme of systems is physically distant from that of information and closely related to computing-specific terms such as the word computing itself, page, web and search. It is as far removed as it can be from the concepts of work, time and tasks. Thus, the word system is being used primarily in the informal sense frequently used in everyday language, as in "we have introduced a new computer system at work". It is not used in the sense of systems thinking or a systems approach or any reference to cybernetics; nor as information system.

Principal emergent themes

The emergence which I now present is the result of a (further) piece of interpretation and is therefore subject to all the usual caveats concerning the interpretivist approach (Walsham 2006).

Table 19 Terms which I deliberately imposed on the Leximancer analysis

Significant compound terms
personal information management
management information system
knowledge management
systems management
systems approach
information system
personal work system
work system
working model
Conceprocity model
systems thinking
design research
action research

Table 20 Terms which emerge from the Leximancer analysis of the journal

Emergent terms
Action design research
Theory
Zotero (synonym: bibliography management)
Conceprocity modelling
Knowledge information data management
Data use

Table 21 Terms which emerge from the work of William Jones

Emergent terms	Comment
Personal information management (synonym PIM)	This strong emergence merely confirms the existence and perhaps the importance of the topic area.
Folder structure	A strongly emergent theme from the existing PIM literature is that of folder structure, often associated with the observation that practical PIM for many current knowledge workers centres on imposing some kind of structure on their email communications.

Has Leximancer been useful in this research?

As I demonstrate elsewhere, a full categorical analysis in terms of a personal taxonomy is much more revealing than the rather unschooled use I made of Leximancer. It had been my intention to carry out a number of Leximancer analyses on interesting subsets of the existing PIM literature. However, I did not allow myself sufficient time to carry out these analyses before my short-term licence for the product expired and thus before I was able to use Leximancer to investigate whether in fact semantic morphogenesis was being evidenced by objectively measured criteria.

5.14 Evaluating Conceprocity

Evaluating Conceprocity philosophically

Cf. (Wand and Weber 2002) who insist on:

- Grammar – constructs and rules
- Method – ways of using the grammar
- Script – models produced
- Context – modelling setting

Under each of these headings, they set out desirable and essential characteristics.

The Conceprocity language, dictionary and documentation address all of these.

Conceprocity is ontologically informed - but neutral on scientific versus social ontology.

The use of Conceprocity is inevitably epistemologically; but can also be, ontologically: relativist.

You could use Conceprocity to model Tolkien's fictional Middle Earth!

The approach known as Bunge-Wand-Weber BWW is based on the scientific realist ontology of Mario Bunge, notably as expounded in (Bunge 1977, 1979).

However, various evaluations of existing conceptual modelling approaches demonstrate that none completely conform to that ontology and most implement only small parts of it.

See

Evaluation against BWW ontological principles

Table 26.

Evaluating Conceprocity against alternative knowledge mapping approaches

The first pragmatist to take the name, Charles Peirce, created what he called existential graphs and what (John F. Sowa 1992a) has more recently renamed conceptual graphs. A conceptual graph (CG) is a graph representation for logic based on the semantic networks of artificial intelligence and on existential graphs. Conceptual graphs are admirably precise - they can be directly transposed into the RDF semantic Web knowledge representation because both have formal semantics. I prefer concept maps because it is possible to start from the informal stance adopted by people who are not specialists in logic or computer science and then gradually, often by means of dialogue or even by dialogic mentoring, to refine what is understood into ever more precise knowledge maps. These too can be formalised and directly transposed into RDF and OWL if that is appropriate. It is not appropriate when the primary purpose of concept maps is to attempt to give greater precision to the sometimes essentially imprecise or ambiguous notions partially and incompletely understood by individual knowledge workers. We are modelling to understand, to learn and perhaps to act. Thus, pragmatically I have preferred

Conceprocity concept and process maps to more formal knowledge representation techniques.

I am aware that the notion of concepts presented in this thesis is very impoverished when compared with the analytical philosopher's point of view. See for example (Hjørland 2009) and (Peacocke 1996).

5.15 Significance of Conceprocity to this PhD

Uses to date

The original starting point was my need to make sense of scientific papers by means of concept mapping. Subsequently, I made use of G-MOT then of Conceprocity in the following areas:

- Modelling working models, PWS and PIMS

- Analysing requirements and synthesising design approaches

- Modelling « light » processes as nuggets

- Student use in learning and evaluation. This was on a small scale across three modules and about 110 students in 2013/4.

- Student use for information systems analysis – usage modelling, entity-relationship modelling, and event process data – with a small group of students at Coventry University Scarborough Campus. This is effectively mentored action learning because the group size is very small (three students).

Further potential uses

Conceprocity has grown out of two convictions. One is that visual knowledge mapping can be extremely helpful in clarifying understanding of certain kinds of knowledge. The second is that modelling continues to have relevance in terms of helping to express requirements for information systems. This second application area is one in which, for a variety of reasons, the information systems discipline seems to have abdicated the responsibility which it once accepted to the users of information systems, leaving to computer scientists and to developers the need to understand those requirements for themselves.

Chapter 6 LEARNING: MORPHOGENETIC CHANGE IN THE WORKING MODEL

This chapter discusses morphogenesis and then illustrates semantic and semiotic morphogenesis in the individual knowledge worker.

6.1 How I have been learning in this PhD study

On the basis of the PhD research journal produced auto ethnographically (Schultze 2000), I have identified a number of stages of development in my use of language which I suggest are evidence of semantic morphogenesis. The journal records events which show how the Working Model has evolved in accordance with external feedback and external inputs, particularly other published works which I reference and which influence my thinking and action.

6.2 Morphogenesis

Semantic and semiotic morphogenesis

The notion of semantic morphogenesis was first suggested by one of my supervisors, Renaud Macgilchrist in the paper (Macgilchrist 2004).

I and Renaud have been working together on revising this paper which we shall submit for publication in the near future, with the revised title: Conjectures on the morphogenesis of meaning and its part in learning (Macgilchrist and Gregory 2019).

My contribution has been primarily in providing support from the philosophical literature. However, I extend Macgilchrist's thinking towards what I term semiotic morphogenesis.

I contend that semantic and semiotic morphogenesis has been demonstrated in specific , individually small but cumulatively large paradigm shifts occurring in the learning reported by this PhD.

According to (Macgilchrist 2004), semantics is encapsulated within paradigms. Words outside those paradigms have no meaning. We know this from our experience as teachers. Teachers who use words outside the paradigm of the students with whom they are interacting, fail completely to communicate. Conversely, meaning is bootstrapped from existing understanding of meanings

within the context of a repertoire of paradigms whether that is specific to the individual learner or more generally to societal knowledge. In accordance with the law of primacy, semantic paradigms prefigure meaning – you can only understand in terms of your existing repertoire – which you then expand. Consequently, learning – once again, either individual or societal – is evolutionary. This is why we now go on to suggest *a fundamental morphogenesis of learning and of ontology / semantics*.

Morphogenesis as a biological mechanism

The etymology of the word morphogenesis is clear enough: μορφή, shape and γένεση, genesis or beginning.

One of the earlier ideas and mathematical descriptions concerning how physical processes and constraints affect biological growth is due to Alan Turing. Turing predicted the existence and interaction of morphogens, which are the substances governing the pattern of tissue development in the process of biological morphogenesis. A morphogen is a signalling molecule which produces specific cellular responses depending on its local concentration.

One of Alan Turing's published papers (Turing 1952) is an extended abductive conjecture concerning how biological morphogenesis might actually work. In the few remaining years of his life, Turing continued to investigate the mechanisms of morphogenesis, generating solutions to reaction-diffusion systems by means of simulation modelling of his non-linear differential equations using the then-new digital computer. In particular, he studied phylogenesis and phyllotaxis. Phylogenesis is the evolutionary development and diversification of a species or group of organisms, or of a particular feature of an organism. Phyllotaxis is the arrangement of plant organs, as for example in the whorl structure of ferns. Turing's simulations typically involved working with two morphogens and three cells. Thus, different growth-influencing morphogens – chemical signals – one which activates growth and another which deactivates or inhibits it – interact; and these set up patterns of development and growth.

(Rueda-Contreras and Aragón 2014) discuss the Turing instability of his morphogenetic equations of phyllotaxis. (Swinton 2004) discusses what he calls "Turing's last, lost work". This, a paper which he never submitted for publication during his lifetime, has been reconstructed as (Turing 1992). Swinton suggests that one of a number of problems that Turing was trying to solve was the appearance of Fibonacci numbers in the structures of plants. He describes the Fibonacci phyllotaxis problem and speculates about the extent to which Turing had succeeded in understanding it at the time of his death. Swinton reuses *analogical reasoning* that Turing himself used in a somewhat different context: Turing himself employed *model-based reasoning* using a model of cannibals and missionaries. A circular island is supposed to be populated by cannibals and missionaries. The missionaries are all celibate and thus depend on recruitment from the external world to maintain their population. Cannibals also die, but can also reproduce, so that their population naturally increases. However, when two missionaries meet a cannibal, the cannibal

converts and becomes a missionary. This tension between production and transformation means that a balance is reached when both populations are mixed together. If however the island becomes a thin circular atoll so that individuals react (reproduce or convert) only with their immediate neighbours; and if the missionaries have bicycles by means of which they can interact more quickly with more cannibals, a near zone of excess cannibals and a far zone of excess missionaries develops in accordance with the dynamics of the situation. The missionary's bicycle is analogous to the inhibitor morphogen having a higher coefficient of diffusivity. We shall return to the importance of analogy and of model-based reasoning when we discuss how hypotheses arise below.

Applications of the morphogenesis mechanism

The word morphogenesis is now frequently used in contexts remote from its biological origin. Thus, the critical realist sociologist Margaret Archer defends a clear distinction between the agency and the structure central to the structuration theory put forward by Anthony Giddens (Giddens 1986). (M. S. Archer 1995) argues against what she sees as a generic defect in certain social theory which conflates phenomena which should be separately analysed. She argues for analytical dualism, clearly distinguishing the effects of coterminous but distinct phenomena. In particular, she holds that emergent relationships between phenomena must be analysed and not simply reported as co-constitution. In any given dualism, it is possible and necessary to investigate how each factor shapes interactions with others over time in what she calls a morphogenetic sequence. Specifically, she argues against what she sees as the conflation of agency and structure especially by Giddens himself. Agency, in that it involves the action of people, is arguably causative of structure. Social structure is equally clearly dependent on agency: without people, there could be no structures. But Archer argues that they act on different timescales so that sometimes structure constrains agency and agents. The agents interact creating consequences which lead to structural change. This evolved structure is then the context for further agency. Archer sees this as being a morphogenetic process. It remains possible and necessary in her view to give empirical accounts of how the two different phenomena interlink over time rather than hiding behind an interdependence or conflation of the terms.

(Mutch 2010) relates Archer's morphogenetic approach to the use of information and communication technology in organisations. Three gains are seen to accrue from this approach: greater clarity about the material properties of technology, links to broader structural conditions arising from the conceptualisation of the relationship between agency and structure, and the potential to explore the importance of reflexivity in contemporary organisations as they make extensive use of information and communication technology. Just as Margaret Archer argues that the elements of dualism must be analytically separated, so Alistair Mutch discusses data analytics in the context of data warehousing and the interdependent but different contributions that they can make to organisational strategies. The impact on wider aspects of the cultural and structural context is presented by means of a morphogenetic approach.

(Mingers, Mutch, and Willcocks 2013) further discuss the work of Margaret Archer and her contribution to the structure-agency debate. They note how Archer suggests that Giddens' formulation of structures as "memory traces" conflates agency and structure. Therefore they suggest a refreshment of the socio-technical tradition in Information Systems that examines the interplay between the social and the technical-material over time. But they note also her concern for the formulation of agency and its indebtedness to reflexivity, the internal conversation by which humans monitor their central concerns.

Morphogenetic growth processes in our understanding of the meaning of language in the light of abductive and analogical reasoning

We use the word morphogenesis in an analogical fashion, but here in the context of the development both in the individual and in society of the fundamental concept of meaning. We draw parallels between what we view as the mechanisms of semantic morphogenesis and mechanisms found in biological systems. Our thinking is further informed by cybernetics and by the catastrophe theory of René Thom (Thom [1972] 1989).

Semiotics, semantics and the emergence of meaning

Modern semiotics follows two distinct tendencies which derive from two different conceptions of semiotics, sometimes referred to as the Saussurian dyadic and the Peirceian triadic. We closely follow this distinction as it is discussed by (Mingers and Willcocks 2014). We have at least two reasons for doing this. One is that with them we prefer a critical realist, Habermasian-influenced philosophy to the post-structuralist thinking that leads from de Saussure's semiotics to Derrida and to Giddens. We follow Mingers and Willcocks also in preferring Peirce's triadic analysis of semiotic signs to the dyadic signifier (sign) and signified (meaning) reading of Saussurian semiotics. When discussing signs, notably in (Peirce and Welby [1903–1911] 1977); (Peirce 1902), Peirce distinguishes between object (the thing or concept itself), representamen (the icon or symbol or index), and – crucially – the interpretant: the immediate meaning of the sign and its effects as meaning on an interpreter. For Peirce, the sign is all of object, representamen and interpretant. And he holds that one of the effects of the interpretant is to give rise to new signs in the interpreter: thus for him the process of semiosis is continuous. That in turn yields the dynamic character which we will now present as fundamental to our idea of semantic morphogenesis, the morphogenesis of meaning.

Our concern is to recognise that deep knowledge and well-structured knowledge, such as are implicit and necessary for, for example, a semantic web structure: need to be contrasted with current entropy/disorder. We therefore see semantics as being encapsulated in what we call paradigms leading to a true repertoire of semantic significance. Indeed, we live through paradigms and we normally retain previous ones – our semantic legacy. Conversely, our own personal increased understanding – and that of collective social knowledge – both require that

paradigms evolve and that subsequently knowledge (personal and socially-legitimised) itself does so.

It is in this context that we discuss what we identify as being the semantic/epistemic "fabric". Words form a semantic fabric. The semantic fields of meaning of words overlap, that is words have overlapping semantic fields. However, the semantic fabric is much more than that: it is an emergence from those overlapping semantic fields. The cloth that is the semantic fabric changes, it ripples: the result is an emergent behaviour. Indeed, this emergent behaviour is so complex that it can only validly be described in terms of chaos or complexity theory.

To recap: semantics is encapsulated within paradigms. Words outside those paradigms have no meaning.

This is why we have identified a fundamental morphogenesis of learning and of ontology/semantics.

In any conversation, we must establish the level of the language-repertoire that people have before we can begin to interact with them, and specifically to teach them. However, Epistemics give the capacity of further discovery, innovation and of the imagination.

We laugh at a joke because we go beyond the paradigms within which it is expressed to reveal what is either absurdity or paradox. In this way, laughter is a meta-epistemic (or perhaps better here, a meta-heuristic); as we detect an inconsistency in our belief system, we laugh at our previous naiveté. We can only enjoy the joke if we have broken through to the next paradigm. Jokes can cause offence (negative) or relief or amusement (release).

♦　　Extending the genetic analogy

Variety, understood in the sense expressed in the work of Ross Ashby (Ashby 1956, 1958, 1962), does not pre-exist; it is generated. Some biological variety is useful; some is dangerous to the ongoing survival of an organism. Thus, DNA tends to inhibit dangerous mutation – but at the price of being less likely to generate useful mutation. Similarly, in the context of semantics, we see the emergence of a set of coherent beliefs expressed using words that have meaning in a semantic fabric. As a child learns, she sees or senses the absurdity of earlier concepts – this is the genesis of useful variety. But the explosion of variety is not of necessity a good thing. The addressable space of a given fragment of semantic fabric has got to be restricted for a number of reasons. In any given universe of discourse, we can describe objects as a power set of their possible properties. If we are discussing comic characters, we can characterise Superman as being all of blue, yellow, can fly. But what we mean by the property can-fly is deliberately restricted by the paradigm within which it is discussed. In the comic strip, we fully understand that Superman can fly. We also fully understand that if we seek to fly in the same way as did Superman, we will quickly understand the fundamental distinction between him and us – that is, we cannot fly. We have learnt from the fundamental absurdity of the attempt by Icarus to fly.

The semantic fabric associated with such a discussion is not necessarily a partition even of the total power set. We do not necessarily have to have a complete characteristic function which describes the behaviour of the whole. There are a number of reasons why we would not want one. One is that our notions of property, category and the like are necessarily imprecise: they are fuzzy. Another is that the very fact of the incompleteness of our system is key because it leaves the system open and incomplete and dynamic. The messiness of our belief maintenance systems, and the coterminous language systems in which our beliefs are expressed: drive their morphogenesis.

Instabilities will arise at micro and macro levels. Continuing our genetic analogy, changes in chromosomes such as that which gave rise to the evolution of the orang-utan are the result of a major shuffle. This particular reshuffle worked, but most will not. On a more micro scale, changes in alleles may be beneficial – but again, most will not be. Therefore the existence of a sort of genetic parser can be posited leading to more or less viable systems. Making a deliberate analogy with object-oriented programming, we know that multiple inheritance – though very powerful – leads to conflict and is therefore often dangerous. Even potentially beneficial variety, if excessive, can overwhelm an organism. Making an analogy to computer programming, it was necessary to introduce the cut construct into the Prolog programming language (Clocksin and Mellish 1981) in order to restrict the exploration space transited by the inference engine.

There is a close parallel and indeed coterminous nature between belief maintenance systems and language systems. Our language system restricts what we can believe. Within our language system and our truth maintenance system, words act as pointers. The shared use of the word is a Wittgensteinian social contract between language users. The development of that social contract can be illustrated by means of a conversation that takes place between a child and an adult when a child points, and says a word. We correct the word if necessary and we seek more fully to describe the thing that the child is pointing at. The same child – parent relationship exists as language develops in society itself. We need to make the distinction between sense and reference which was originally pointed out by (Frege [1892] 1948). The word-as-pointer resonates in the belief system of a recipient. Here a sign is a pointer to a (non-local) system and its attached complexity. Meaning in such a context is an emergence: that is to say, it is a property of a complex auto-adaptive system. This parallels the way in which (Maturana and Varela 1980) introduce and expand upon the concept of autopoiesis.

Semiotic morphogenesis illustrated: 2011
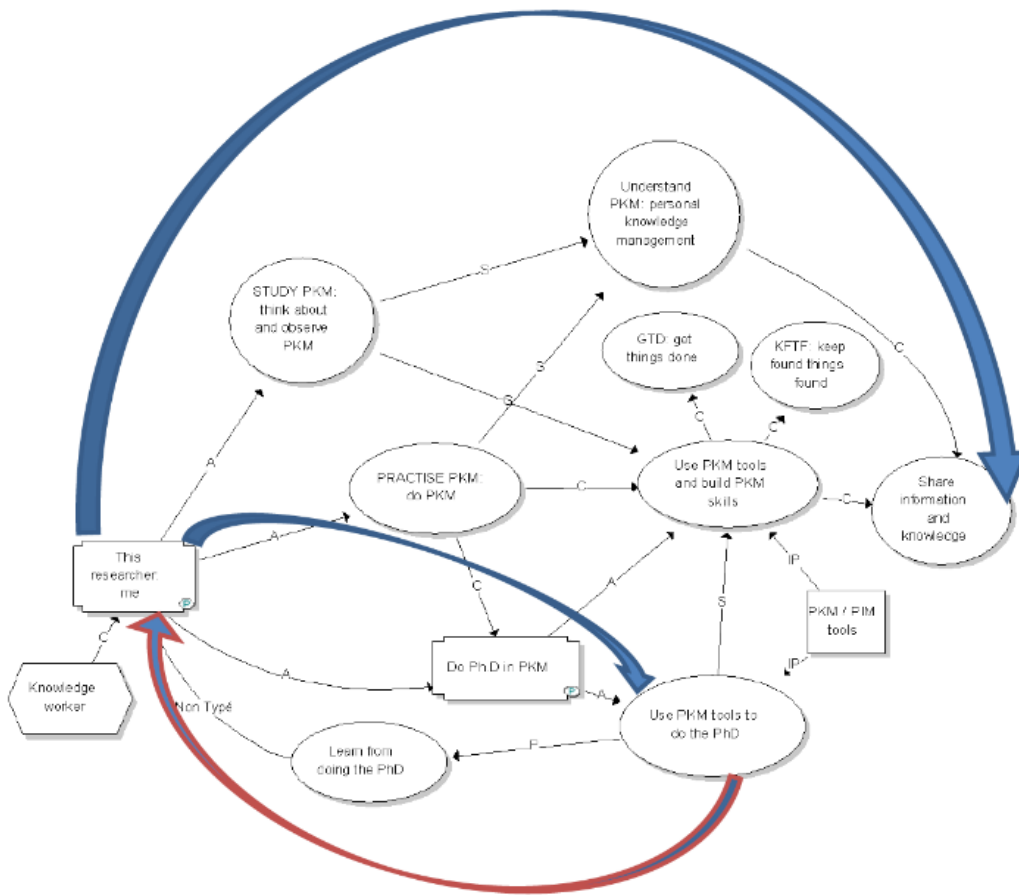
Figure 57 Early concept map – LICEF G-MOT representation

Semiotic morphogenesis illustrated: 2016
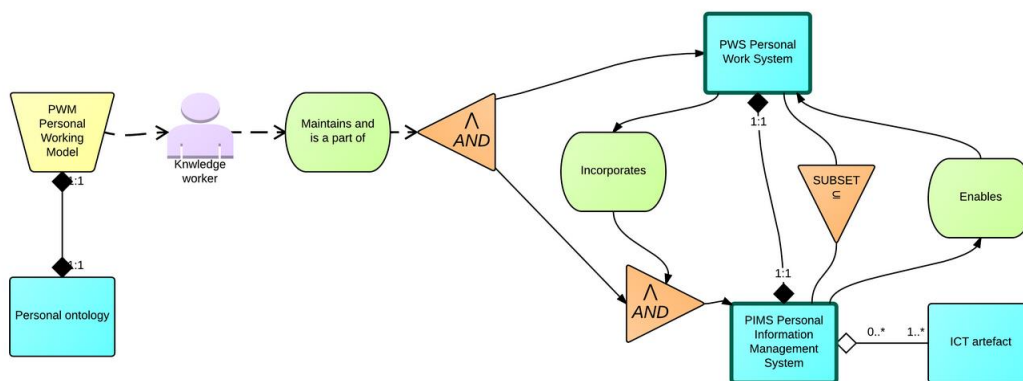
Figure 58 Conceprocity map - semiotic clarity

> We would argue that this is richer, more visual, more expressive, easier to read (though not perhaps to learn?)

6.3 A summary of the development of my thinking – evidence for semantic morphogenesis

In this section, I seek to identify major changes in my thinking across the years of my PhD study. These changes are shown by changes of vocabulary, evidence for semantic morphogenesis.

How my research thinking has developed - 0 – An emphasis on tools and techniques (2008 to 2011)

Initially, my interest was in PIM tools and in their support for conceptual data structures.

I examined technologies such as personal cloud-based relational database, functional spreadsheets and the like. I looked into end-user programming. I chose specific tools, notably InfoQube and Zotero.

I carried out experiments in PIM audit with groups of students; unfortunately, the results were poor because of inadequate preparation on my part. I built situational applications (the small group perspective). But this was always unlikely to be an inadequate approach in isolation – it is wrong to adopt "solutions" to problems which have not been properly analysed.

An important aside: situational applications (1) – dynamic websites

In parallel with undertaking this PhD, and sometimes overlapping with it: I have "perforce" built *situational applications.* I also pursued a long excursion into building web-based content management systems CMS, initially using Drupal (2011/2) and subsequently WordPress (2011 to date) – www.markrogergregory.net

The felt and (partially) met need of this work was enabling action learning and research, both by students and by research volunteers.

An important aside: situational applications (2) – Acquis (2013/4)

I developed **Acquis** (ACademic QUality Information System): a complex and evolving structured database application supporting my work as a teacher and programme manager and providing focused feedback to students. Acquis consists of over 100 tables, 85 queries, 200 forms and 24 reports. However, I confess that I concentrated on the entity-relationship-attribute aspects of the necessary analysis and skimped on functional analysis. My self-critique has however been a strong influence on the design of Conceprocity – we still need information systems requirements analysis tools accessible to "users". This realisation has led to the subsequent extension of Conceprocity to usage modelling, entity-relationship dtaa analysis and event process data diagrams.

How my research thinking has developed - 1 – From tools to systems thinking & philosophy – 2012 onwards

Building out from my initial interest in PIM tools, I gradually I realised that what was important was the notion of a cybernetic **PIM system** in which the **emergent behaviour** is primarily derived from the user herself – adaptive systemic behaviour.

This led to questions about the **nature of a system**: compare the **scientific realism** of (Bunge 1979) and the **phenomenology** of (Checkland 2000); by means of:

- ▪ **Ontology** – what we know *and*

- ▪ **Epistemology** – how we know what we know

How my research thinking has developed – 2 - From data to knowledge and back again (2011; 2015)

The initial research object was me as an information worker and my use of computer-based tools to manage – what? personal knowledge…

Q: But how can such knowledge be represented as computer-manipulable data? The data, though "small", is complex…

A1: Perhaps first order (predicate) logic, « semantic web » technologies for data structures and specifically-written computer programs. But these are not accessible by « end users ».

Q: How can you possibly manage knowledge on a computer?

A2: You can't. But you can store the data and the conceptual data structures that surround that data and begin to explicate its semantics

So: sense - meaning must be made of the data; this can **inform action** (abbreviation: **inform-ation?**) – cf. (Mingers 1995, 1997, 1999, 2004).

How my research thinking has developed – 3 - conceptual modelling (2013 onwards)

I initially sought semi-automatic identification of concepts by means of textual analysis – Leximancer. However,this only "works" well when the concepts are pre-seeded – as summarised in Table 17 and Table 18.

This somewhat disappointing experience confirmed me in my conviction that we need something like Conceprocity: concept-process reciprocity – a visual knowledge modelling language. But it also inspired me to seek a sound ontological basis for conceptual modelling, which I have found in a combination of scientific realism: Bunge-Wand-Weber (Wand and Weber 1990); (Rosemann and Green 2002) and of social ontology: Bunge-Searle (March and Allen 2014).

How my research thinking has developed – 4 – Individual learning and action as morphogenesis (2014)

Macgilchrist presents learning and the creation of knowledge as semantic morphogenesis (Macgilchrist 2004).

I have observed stages of learning and individual transformation in my own doctoral research which do indeed suggest morphogenesis at the level of the individual agent.

This developing knowledge is enacted in research speech acts (Searle 2006) in accordance with the theory of communicative action (Habermas 1984, 1987). Habermas appeals to reason and rationality where rationality is a disposition expressed in behaviour for which good reasons can be given. Communicative rationality aims to achieve, sustain and review consensus – a consensus that rests on intersubjective recognition of criticisable validity claims. Translated to the social sphere, this becomes his theory of communicative action. It depends on two assumptions, that language is (1) social and (2) rational.

My "speech" acts – more accurately, the document acts suggested by (B. Smith 2014) - include:

- The elaboration of my PIMS and of Conceprocity: design research and adaptation, evidencing semiotic morphogenesis.

- Conference papers and planned journal articles.

- The writing of a reflective and, in significant part, conceptual and philosophically-informed thesis.

How my research thinking has developed – 5 – Action Design Research

My development of two prototype applications can be set within the broad spectrum of action research approaches identified by (Baskerville and Wood-Harper 1998).

My work and developing understanding is situated at the intersection of action science and action learning.

Major elements of my work can be positioned as design science research (Hevner et al. 2004); (Gregor and Hevner 2013); (Iivari 2015); or as *Action Design Research* (Sein et al. 2011); cf. (Baskerville and Wood-Harper 1998) and (Papas, O'Keefe, and Seltsikas 2012).

This has resulted in Conceprocity 1.0 (May 2013); Conceprocity 3.0 (late 2015); Conceprocity 3.2 (late 2016). The development of Conceprocity has been pulled by new areas of application (originally knowledge mapping; recently IS requirements analysis) and pushed by a growing understanding of the theoretical foundations of conceptual modelling and of related philosophical issues.

We can view my my construction and use of a proof of concept personal information management system, UnIQue, 2015, as an application of Action Design Research (Sein et al. 2011)*.*

How my research thinking has developed – 6 – boundary considerations and PIMS principles

I have concerned myself with at least two interdependent but distinct systems.

One is the (soft) work system or human activity system which I constitute as I work (alone and in collaboration with others); this is what I normally refer to as my PWS, my personal work system. I now regard the gradual development of a moderately coherent philosophical stance (primarily post-2013) as a major component of this PWS.

The other is the (hard) information system that supports and serves that work system.

Emerging from working with both are certain **principles** which I suggest may have wider application than my own personal accounts – as I share my action learning.

The principles are rarely original, but their juxtaposition is innovative and their application is intended to be practical. Among these is those expressed by (Schön 1983, 40):

"Professionals… are coming to recognise that although **problem setting** is a necessary condition for technical problem solving, it is not itself a technical problem. When we set the problem, we select what we will treat as the "things" of the problem, we set the boundaries of our attention to it, and we impose upon it a coherence which allows us to say what is wrong and in what directions the situation needs to be changed.

"Problem setting is a process in which, interactively, we

name the things to which we will attend [cf. the Conceprocity DICTIONARY]

and

frame the context in which **we will attend to them**." [cf. a Conceprocity MAP].

My experiences and why I have written very little about them in this thesis

Here, by way of illustration, are journal entries made over two consecutive days..

Table 22 Some example PhD journal entries

	I am forced to think, I suspect abductively, in order to solve an information management problem in InfoQube. This is the problem. I am seeking to facilitate a process which I call hierarchical classification. For an academic discussion of this issue, please see: (Silla Jr and Freitas 2011). As one example of the significance of this issue, consider the requirement to file a document in a hierarchical classification system such as a Windows folder hierarchy. But the specific example with which I concern myself at this particular juncture is that of positioning things in a personal taxonomic classification system so as to permit:
	1. use of that personal taxonomic classification system as the basis of a file naming system; this is intended to facilitate relatively unambiguous filing of an item so that it can be discovered again later

www.manaraa.com

2. processing of all the items in a subtree discovered by means of user-specified criteria – for example, do everything that must be done today by means of consulting a list of items marked as today within a hierarchy of days

The process of classification involves assigning an item to one and only one location in a tree (a directed acyclic graph, DAG). InfoQube implements trees in the form of item hierarchy.

So what then is the problem? In order to classify hierarchically, you first choose the level I classifier; then choose from the limited subset of level II classifiers employed by the first; then choose the third classifier, again on the basis of the limited subset implied by the second classifier. This has the advantage that the number of choices to be made at each level in the hierarchy is restricted, ideally to about seven and in practice up to about 10.

There are a couple of problems with this situation. The first is that I'm not actually sure how I can subset choices at a given level in the hierarchy on the basis of the choice already made at a higher level. The second is that such a structured process can receive almost no visual cue beyond the choices available at the current level in the hierarchy. If conversely I took the same approach to classification that I will have to take to categorisation, that is to say, I copy or clone the item into the classifying hierarchy: then I would have the benefit of the visual cues. There would also be consistency of approach between classification and categorisation. The disadvantage is that the item would be classified in accordance with a visual positioning but that the classification would not normally be directly stored in the classified item.

The choice between these two approaches will be made on the entirely pragmatic grounds of which one works best and makes the process swiftest and most effective.

What is the relationship between design and abduction? This is one of my waking thoughts. A quick search on Google Scholar suggests that a Japanese researcher called Takeda has done a lot of thinking in this area: (Takeda et al. 2003).

Following up on the background to this, we note: (Niiniluoto 1999b). We have already come across this gentleman: (Niiniluoto 2002), a book which on further review I very much want to read. It will strongly complement my reading in Mario Bunge.

In (Niiniluoto 1999b), the Finnish philosopher describes the history of abduction and earlier accounts of heuristic reasoning. Working forwards from Charles Sanders Peirce, the author defends inference to the best explanation (one of the characterisations of abduction) and its use in the defence of scientific realism. He suggests the need to distinguish between weaker and stronger forms of abduction and discusses Peircean and Bayesian probabilistic reconstructions of these types of inference.

Why does this matter in the context of my research? My fundamental thesis is that each of us has a personal working model which is defended by morphostasis and developed by morphogenesis. Thinking conceptually: we develop a verisimilitudinous account (dictionary: something that has the appearance of being true or real) which we support by means of collected personal data and explicit knowledge. I think that this model may be the attractor in a morphogenetic account

of constraints and affordances. This may be an example of inference to the most lovable explanation! See (Lipton 2004), who distinguishes between the likeliest and the loveliest explanation. See (Campos 2011) for a discussion of how inference to the best explanation relates to Peircean abduction. Note also that my work recognises the huge significance of diagrammatic reasoning.

My old friend Philip Dobson and his colleagues present a series of case studies in which practising researchers reflect on how their original hypotheses arose and concur that a more explicitly adaptive approach would have been more economical had they but applied it: (Dobson et al. 2012). Another old friend, Michael Hoffman, argues in (Hoffmann 2010)… He cites (Cheng and Simon 1995) and (Nersessian 2008, 161); from the latter:

" Nancy Nersessian answered this question recently in a concise statement that summarizes both the literature on the cognitive functions of diagrams understood in the traditional sense of external, graphical representations and her own extensive case studies: [A] wide range of empirical data support the view that in making explicit, highlighting, or supplying structural and behavioral information, diagrammatic representations provide constraints and affordances for inferences in reasoning processes."

From this whole line of thinking we can conclude that my approach, which has been to design a personal information management system which supports a personal working model: at least has support in the literature.

I think that is quite enough metaphysical speculation for one morning… I have in mind to be slightly wicked, and to return to the practical question of how to link InfoQube and Zotero. As to buying books, that has to wait until I have more money.

On 26/03/2016, there were 2195 journal entries extending to 392673 words. 646 of these journal entries were directly relevant to my thesis. Clearly a direct summary of this ethnographic material would risk dominating the content of the thesis. Instead, various graphical, categorical and classificatory summaries have been attempted.

6.4 Learning: semantic and semiotic morphogenesis in summary

Some principles of PIM which I would suggest are worth promulgating

This section sets out the kind of knowledge in the form of **working rules** which professionals and artisans use as a matter of course, often without actually making them very explicit. This is close to the tacit knowledge of (Polanyi 1962); (Nonaka 1994) and the personal knowledge of (Polanyi 1958); see also (M. K. Smith 2003). This may partly be because sometimes they are difficult to justify! I introduce the notion of warrantability. This is inspired by (Boyles 2006) discussion of Dewey's conception of warranted assertibility. Although warranted assertibility is not precisely the same as my notion of warrantability, it does give weight to my proposition which is indeed a pragmatic, perhaps even instrumentalist, concept.

The warrantability of principles is not necessarily particularly high. However I set out this particular list because it's important to recognise that they do strongly influence the way one actually works. We are once again up against the difference between espoused theory and theory in use. These principles are stored in the UnIQue InfoQube grid called DictNotion. Figure 59 illustrates some such principles and the associated warrantability which I suggest.

#	Item	NotionType	Warrantability	IsModel	IsNugget	IsInstance	Notes
1	General principles			☐	☐	☐	
1.1	Before making anything, model it first. Before doing any non-trivial task, plan it first.	Principle	4: Emergence	☐	☐	☐	This is an application of (Conant & Ashby 1970).
1.2	Individual actions or activities are often repeated in the same or a similar form. Some have sufficient complexity of form to merit planning. Of these, some are relatively straightforward and can be written up as a short Word document or fragment. Thus I use a Word template which notably supports a hierarchical outline. This approach is adequate for small processes but is not so for larger ones.	Principle		☐	☐	☐	
1.3	Choose, learn and use technology appropriate to the task. Prefer technology which makes it easy to share and integrate data between tools.	Principle	3: Observation	☐	☐	☐	
1.4	Data should wherever possible be stored once only. Copies should not be made. Instead links to the original should always be preferred. Where appropriate and possible, share those links with others.			☐	☐	☐	
1.5	When managing personal data, it is necessary to store all significant data in a way which makes its semantics (its meaning) as clear as possible.	Principle	5=: Principle	☐	☐	☐	
1.6	Spreadsheets need structuring and design in very much the same way as do databases. That is to say, one should clearly distinguish tables of more-or-less normalised data from unnormalised (but useful) derived, informative, presentable views of the same data. Views are the result of set manipulation.	Principle	5=: Principle	☐	☐	☐	
1.6.1	Views within a spreadsheet can sometimes be derived using SQL. This is true in Google Docs but not in Excel.	Principle	3: Observation	☐	☐	☐	
1.7	A PWS needs always to incorporate certain very significant files. The PIMS should include a single central list of such files and hyperlinks to get there.			☐	☐	☐	

Figure 59 Principles stored in the grid DictNotion

- Before making anything, model it first. Before doing any non-trivial task, plan it first.

- Individual actions or activities are often repeated in the same or a similar form. Some have sufficient complexity of form to merit planning. Of these, some are relatively straightforward and can be written up as a short Word document or fragment. Thus, I use a Word template which notably supports a hierarchical outline. This approach is adequate for small processes but is not so for larger ones.

- Choose, learn and use technology appropriate to the task. Prefer technology which makes it easy to share and integrate data between tools.

- Data should wherever possible be stored once only. Copies should not be made. Instead links to the original should always be preferred. Where appropriate and possible, share those links with others.

- When managing personal data, it is necessary to store all significant data in a way which makes its semantics (its meaning) as clear as possible.

- One such way which is very common (but not universal) is to store the data in tables. These would ideally be managed by an end-user-accessible online relational database but may in practice be managed by a conventional

database which is not web-accessible or as spreadsheets. The definition of the table embodies in part or in whole its semantics.

- The definition of a table and its relationships with other tables is called a schema. Schemas associate meaning with data, defining the semantics of the data. A schema is more-or-less the same thing as a data dictionary. The semantics associated with a personal data item may not always be stored with the item itself, but it is essential to be able to associate the metadata with the data.

- One table will almost invariably be present in every PIMS. It is a control table. The control table may (and normally will) contain only one record. In a spreadsheet, it can consist of named ranges and is typically named Lookups. It instantiates certain business rules, such as the percentage score associated with a letter grade.

- Spreadsheets need structuring and design in very much the same way as do databases. That is to say, one should clearly distinguish tables of more-or-less normalised data from unnormalised (but useful) derived, informative, presentable views of the same data. Views are the result of set manipulation.

- Views within a spreadsheet can sometimes be derived using SQL. This is true in Google Docs but not in Excel.

- A PWS needs always to incorporate certain very significant files. The PIMS should include a single central list of such files and hyperlinks to get there.

- Fragmentation of personal information is a necessary evil. It is necessary because no one PIM tool can meet all the needs of a PIM user. It is an enemy because it makes it difficult to know where "master" data is stored.

- All scientists and knowledge workers need to maintain notebooks and / or a personal journal of the kind that this document is an example. Something of this sort is essential to effective reflection / reflexivity.

- There are certain conceptual data structures which are either fundamental or very desirable in much personal information management. Among these are:

  - Tables
  - Hierarchic outlines
  - Hyperlinks

- Information concerns things. Things in a database should have names just as the things to which they refer have names. The use of those names, in terms of sense and reference, terms introduced by Frege (Frege [1892] 1948, 1997): should be stored in a database to be termed a Lexicon or Vocab. The name of a thing is often itself crucial to the meaning and thus the usefulness of a thing. (Essentialism.)

- Things can be found again either by searching or by categorisation and classification. There is a fundamental trade-off in information retrieval

between recall and precision. See for example (Manning, Raghavan, and Schutze 2008). Precision is greatly aided by a formal classification scheme. Recall may be aided by necessary-overlapping categories.

- Before knowledge workers can get something done, they need to collect together the necessary information and make it readily available – it needs to be "at hand". They also need to filter out, deliberately to exclude, data which is not relevant to the task in hand. This is specifically true of paper documents relevant to a task. They may include books, journal articles and paper folders.

- A good tool for managing such "work in hand" enables the data to be collected together. This involves collecting links to the data. A very good tool for such a purpose is a hierarchical outliner with links to the data items.

- The benefits of investing in a particular piece of personal information management should greatly exceed the costs; and should normally do so within a very short timeframe. What is meant by very short will vary with context. The justification for this principle is that it is tempting to expend – and therefore to waste – enormous amounts of time for relatively small benefit. This should wherever possible be avoided.

- Any given information item, as viewed by users, possesses properties. Properties are values of attributes. To the user, a property may appear to be tightly bound to its owning information item or may properly be regarded as jointly the concern of two information items, these often having different types. Information items may need to be categorised or they may need to be classified. A classification is a property which mandatorily takes a value from the set of values in a second information item. A categorisation (more commonly this is referred to as a tag) is usually just the attribute value associated with a particular property; it is not constrained to be unique, and thus an information item might have multiple tags.

Constraints and barriers

- Constraints and barriers may have some external cause or justification; however, they are also often what is referred to in common parlance as "psychological". The list which follows is maintained in the same InfoQube grid.

- It's interesting how constraints / barriers come in even on this apparently small and straightforward task. As soon as I start to work on it or think about it, all the usual self-imposed constraints and barriers come crashing in:

-
  • The desire to be doing anything else! The search – always successful – for distraction
  • Losing the thread, almost literally being unable to think about the matter in hand: "my mind has gone blank"

- The pressing need to do something else; there is always something even more urgent
- Blocking actions – you don't start task B because you must do A even more urgently; but somehow task A takes longer than it ought to do (as a result of, for example, perfectionism, etc.)

- While needing to do one thing, you do another. At http://sridattalabs.com/2012/02/06/rabbit-holes-being-smart-hurts-prod/ the blogger Sridatta Thatipamala describes the problem of rabbit holes, why they damage productivity, and why they can nevertheless be valuable.

- I believe myself to be inartistic and therefore I am. Damaging lack of self-belief damages creativity and perhaps productivity – although the damage to creativity is probably more significant.

- Prejudices or false beliefs are really stupid. Example: Twitter is a waste of time. Example: blogs are narcissistic and a waste of time. Example: quantitative techniques are restrictive and boring.

- The tools on which I base my PIMS are not entirely reliable. Since they quite often fail, I need to spend significant amounts of time protecting myself against the danger of data corruption and significant amounts of time recovering from actual data corruption.

- I have a strong tendency to prefer large actions with a big, obvious outcome to small, often essential actions. I am also still too wedded to doing everything myself – I'm not good at delegating or at buying in help.

- I am really reluctant to face up to the real issues. I am feeling my way towards an understanding of larger issues. One is my unwillingness really to prioritise the externally important and / or that which is (often legitimately) required of me, either by managers or others whom I serve (e.g. students). I prefer to do what pleases me.

- When I'm doing something a bit technical – e.g. using a spreadsheet to reformat data into useful information – and when I get to a difficult bit, I often turn aside to read Google News or otherwise waste time. I can sometimes take five or ten minutes out in this way several or even many times in the course of executing a large task.

- I recognise the existence of task interdependencies which block progress. They might be referred to as logjams or even in some cases the "deadly embraces" set out in operating systems design discussions. In operating systems, in the scheduling of nominally-independent tasks which need to share resources, use is made of mechanisms such as semaphores, locks, mutexes and the like to prevent the occurrence of circular deadlock (so-called "deadly embrace"). [For a discussion, see http://blog.feabhas.com/tag/deadly-embrace/ accessed 27/02/2016. The discussion terminates by identifying the need for what Tony Hoare (Hoare 1974) identified as the monitor, that is, an object which encapsulates a

mutex and which cannot be bypassed.] Circular dependence frequently occurs in getting work done. It should where possible be avoided by atomising large tasks and just getting on with them before a large task is allowed to arise. However, in extreme cases, it is necessary to break the logjam by terminating a task before it is properly completed.

- But a final reflection is a clear echo of the starting point for this research. The tools available by means of which to carry out effective personal information management are currently far too clunky, extremely badly integrated if at all, depressingly slow and frequently "buggy" when used in conjunction one with another. To judge from the number of forums that concern commonly used personal information management tools such as Microsoft Excel, and the anger frequently expressed within those forums: I am not alone in bemoaning the current state-of-the-art. It is not that the tools do not work; it is that they do not work well enough together to fit into a reasonable workflow which does not impose too high a cognitive load upon the end-user. The individual frustrations may be small; it is the cumulative effect which becomes offputting and even mildly depressing. Perhaps one third of all my journal entries relate to technical problems or to frustrations relating to the use of PIM tools. For example, I can no longer search my PhD journal quickly because it has become so large. As a direct consequence I have not been able to carry out the more detailed analyses that I had wished to do and really to profit from the content of that journal.

- To take a specific example of the kind of workflow difficulty which I am talking about. Zotero is undoubtedly an excellent reference management system. Nominally, it integrates quite well with Microsoft Word. But you cannot click on a reference held in Microsoft Word and go directly from that back into the Zotero database. That link has not been implemented. The user is forced to work in both tools in order to get her work done.

Review and recap on the notion of a personal working model

I conjecture the following meta-model:
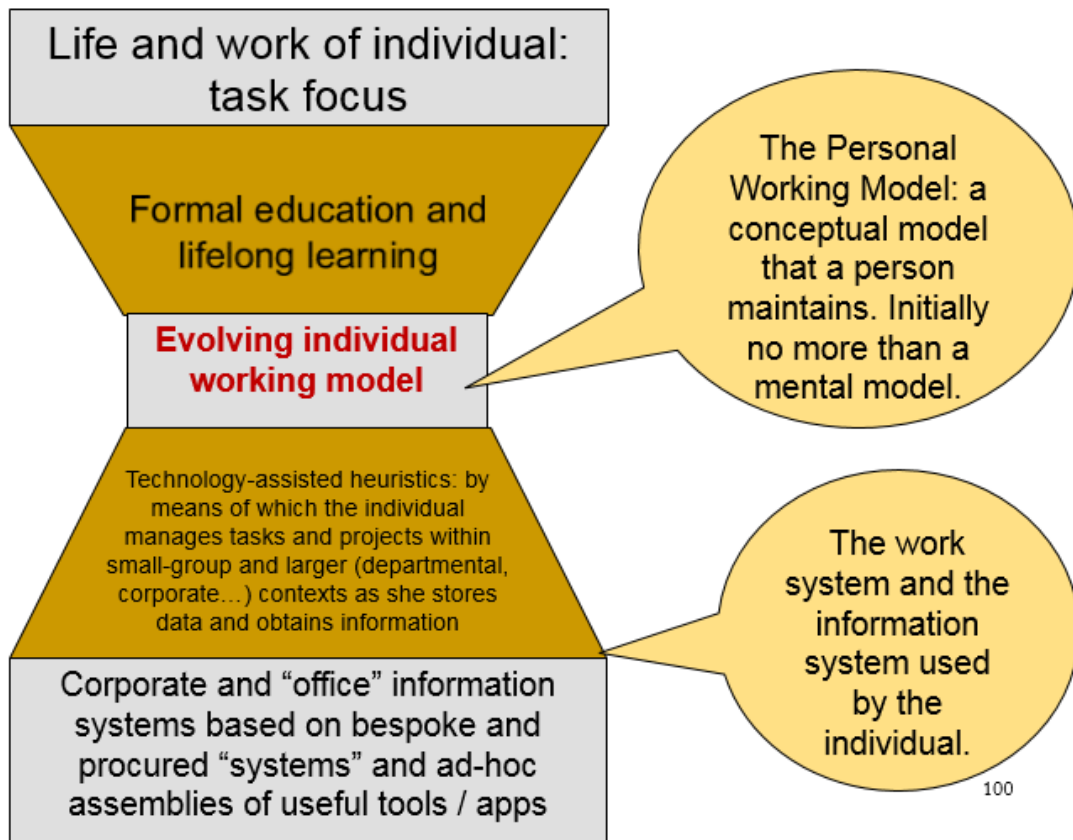
Figure 60 Personal working model and system

6.4.1.1 Re-modelling the personal working model

As a brief illustration of some of the findings of the work, we ask as our topic question 'how might we model the personal working model of a teacher/researcher?' We see in Table 23 a list of some of the notions originally identified at the start of this thesis. This initial vocabulary has been stored as nugget dictionary entries in the DictNotion grid of the current UnIQue IQBase. In Figure 61 we present a top-level Conceprocity model of how those notions might be interrelated in a putative model of a personal working model. The corresponding warrantable findings are *(i) that there exists a PIMS specific to each knowledge worker* who *(ii) understands and regulates her work in accordance with some, frequently inexplicit, personal working model*.

We note here that **model-based reasoning** has great practical value. There are various interpretations of this phrase, e.g. (Nersessian 1999), but here we make the observation that during the construction of a model from a starting list of notions it frequently becomes evident that other notions and/or relationships are required. Thus, for example consideration of a logical operator may well point to the need for additional notions and relationships. Again, where it's impossible to use a structural relationship, a procedure may abductively be surmised then identified.

Table 23 Notions in the Working Model: a hierarchical outline

Item	NotionType	Warrantability
1. Working model	Principle	5=: Finding
1.1. Personal knowledge	Package	7: Institutional
1.1.1. Personal ontology	Principle	7: Institutional
1.1.1.1. Taxonomy	Concept	8: Scientific
1.1.1.1.1. Classifying by kind	Procedure	8: Scientific
1.1.1.1.2. Scientific ontology	Concept	8: Scientific
1.1.1.1.3. Social ontology	Concept	7: Institutional
1.1.1.1.4. Build "initial" taxonomy	Procedure	3: Observation
1.1.1.1.5. Develop taxonomy as activity and understanding changes	Procedure	4: Emergence
1.1.1.2. Categorising by tag: build and maintain the tag set	Procedure	4: Emergence
1.1.1.2.1. Tags	Concept	4: Emergence
1.1.2. Philosophy / philosophical stance	Principle	7: Institutional
1.1.2.1. Critical realism	Principle	7: Institutional
1.1.2.2. Warrantability	Principle	5=: Finding
1.1.2.3. Design the Conceprocity concept process reciprocity modelling language	Procedure	6: Design
1.1.2.3.1. Build Conceprocity map of my personal working model	Procedure	6: Design
1.1.2.3.2. Conceptual knowledge modelling and model-based reasoning	Principle	6: Design
1.1.2.4. Theory-building	Procedure	5=: Finding
1.1.2.5. Creating, maintaining and publishing nuggets and in particular nugget signature models	Procedure	6: Design
1.1.2.6. Recognition and delineation of principles	Procedure	5=: Principle

1.1.3. Learning	Procedure	3: Observation
1.1.3.1. Learning: existing knowledge	Procedure	3: Observation
1.1.3.2. Implicit learning: learning know-how – internalising	Procedure	3: Observation
1.1.3.3. Action learning	Procedure	3: Observation
1.1.4. Maintain homeostasis (controlled survival through stability): regulate in accordance with the good regulator theorem of Conant and Ashby and the personal working model	Procedure	5=: Principle
1.1.4.1. Regulation	Concept	8: Scientific
1.1.4.2. Model	Concept	6: Design
1.1.4.3. BVSR: blind variation, selective retention	Principle	5=: Principle
1.1.5. Reflect in and after action: structured self reflection	Procedure	4: Emergence
1.1.6. Actors	Actor	5=: Finding
1.1.6.1. Mark - researcher	Individual	3: Observation
1.1.6.2. Mark - user	Individual	3: Observation
1.1.6.3. Student	Actor	3: Observation
1.1.6.4. Knowledge worker	Actor	2: Conjecture / abduction
1.1.7. Enquiring: creating knowledge	Procedure	4: Emergence
1.1.7.1. Autoethnography	Principle	3: Observation
1.1.7.2. Design science research	Principle	7: Institutional
1.1.7.3. Identify concepts and themes from text	Procedure	4: Emergence
1.1.7.3.1. Leximancer	Principle	8: Scientific
1.1.7.3.2. Emergent themes and concepts	Concept	4: Emergence
1.1.7.3.3. Theorise	Procedure	7: Institutional
1.1.7.3.3.1. Espoused theories	Principle	3: Observation
1.1.7.3.3.2. Theories-in-use	Principle	3: Observation

1.1.7.4. Assemble by means of bricolage	Procedure	4: Emergence
1.1.7.5. Explicitly design and construct – experiential design	Procedure	6: Design
1.1.7.6. Multiple method research	Principle	7: Institutional
1.1.7.7. Theory-in-use	Principle	5=: Finding
1.1.7.8. Bricolage	Concept	5=: Principle
1.1.7.9. Experiential design	Concept	5=: Principle
1.1.7.10. Designed artefact	Concept	6: Design
1.2. Doing and informing	Package	7: Institutional
1.2.1. PWS personal work system	Concept	3: Observation
1.2.1.1. Mark's PWS	Instance	3: Observation
1.2.1.1.1. Research journal	Instance	3: Observation
1.2.1.1.2. Build and maintain Conceprocity models	Procedure	6: Design
1.2.1.1.2.1. Maintain dictionary	Procedure	6: Design
1.2.1.1.2.2. Maintain maps	Procedure	6: Design
1.2.2. PIMS personal information management system	Concept	5=: Finding
1.2.2.1. Use PIMS	Procedure	5=: Finding
1.2.2.2. Principles of effective PIM	Principle	
1.2.2.3. UnIQue PIMS	Instance	7: Institutional
1.2.2.3.1. Grids	Concept	6: Design
1.2.2.3.2. Build PIMS	Procedure	6: Design
1.2.2.3.2.1. Affordances	Concept	7: Institutional
1.2.2.3.2.1.1. PIM technology and tools	Principle	7: Institutional
1.2.2.3.2.1.1.1. Zotero	Principle	8: Scientific
1.2.2.3.2.1.1.2. Lucidchart	Principle	8: Scientific
1.2.2.3.2.1.1.3. InfoQube	Principle	8: Scientific

2. Future research programme	Instance	6: Design
2.1. Action design research	Instance	6: Design
2.2. Programme of mentored action research	Instance	6: Design
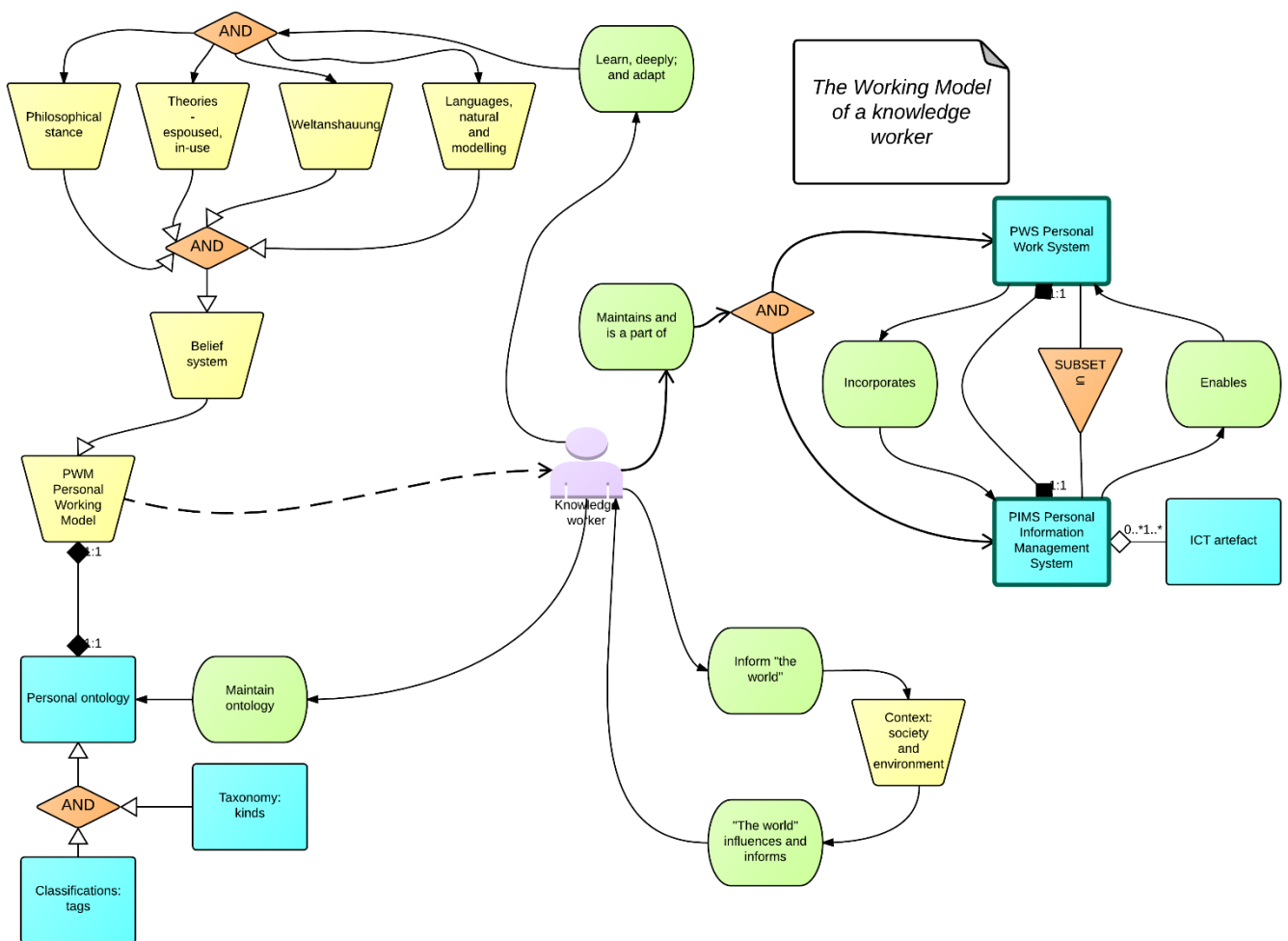
Figure 61 A personal working model – early 2016

Post-PhD mentored action research is discovering that the construction and comparison in Conceprocity of distinct but overlapping IS requirements models (usage, event process data and entity relationship unified by a shared dictionary) permits the early identification of inconsistencies and omissions.

Learning: semantic and semiotic morphogenesis in summary

Evidence for semantic morphogenesis is provided by significant changes of language which indicate a paradigm shift. These are demonstrated in the preceding section headers in this chapter; I have attempted where possible to indicate the approximate date associated with that language.

Semiotic morphogenesis is evident from significant changes in visual expression; these also indicate a paradigm shift – as do changes both in models and the process of modelling.

Figure 61 is a remodelling of the top level working model. Note that I have as yet not sought to change the underlying models of the personal work system nor of the personal information management system. However, my understanding of the more conceptual elements of the working model has considerably evolved. This is evidenced in the very different picture that emerges – compare this early 2016 model with that for 2014, which can be found at: Figure 6. In part, the difference in expression is the result of an evolution of the modelling language. But much more significant has been the introduction of a dictionary. (Vervaeke and Green 1997) suggest that the propositional content of a model cannot depend only on its visual or diagrammatic form – it must also have a descriptive element. Careful observation will indicate that the diagram has in fact diverged from the dictionary elements used in its construction; this is an aspect of model-based reasoning during the construction of the diagram. The next step should be to revise the dictionary in accordance with the understanding that has been created as the visual map has been created – they are in effect co-dependent.

6.4.1.2 Learning as systemic understanding – re-viewing Checkland's FMA and LUMAS models

In section 0.2, I considered and rejected LUMAS as an alternative framing device for this theisis in favour of FMA. In section 0 I noted however the value of LUMAS in learning from enquiry. I have been challenged to consider what I would change if I were to repeat this research or do more along the same lines. On reflection, I would certainly at least extend FMA to include explicit consideration of learning on the forward and especially the feedback paths. By feedback path, I mean the practopoetic traverse which gains variety by interaction with the environment – in this case, the community of learners and scholars. But LUMAS already implicitly considers that with the path from learnng L to methodology M – where L, in my terms outer-loop learning, modifies and enriches M, the methodology. If I am justified in this speculation, then effective learning well reported might indeed continue to feed the development of the methodology M. I must be open to that possibility.

Chapter 7 CONTRIBUTIONS AND FURTHER WORK

Contributions are itemised and are evaluated in diverse ways. A future programme of work is outlined. Some provisional conclusions are drawn, but this work Must Go On...

7.1 So what? Evaluating products, process and intellectual contributions

How does any of this make any useful difference to the world at large?

What are the existing **contributions** of this research?

How will I go on to **develop** them so as to make more of a useful difference?

Evaluation of the changes in the vocabulary that I as a researcher was using in my research journal.

What needs to be evaluated:

- Framework
- Methodology
- Contributions, both process and products

How evaluation has been carried out

- Ongoing evaluation following (Sein et al. 2011): design principles
- Evaluation following (Baskerville, Kaul, and Storey 2015)

7.2 Existing and developing contributions from my Ph.D. research to date - 1

o Visual knowledge mapping as part of personal work system.

o **Strong ontological basis** (Bunge-Wand-Weber BWW (Bunge 1977, 1979); (Wand and Weber 1990);(Rosemann and Green 2002); (Wand, Storey, and Weber 1999), (Wand and Weber 2002); **typed notions** (Booch, Rumbaugh, and Jacobson 2005); (Paquette 2010); **social ontology** (Searle 2006);(March and Allen 2014)).

o Conceprocity's principal dialects.

o CIAOPEA: for students.

- Empirical investigation in S1 2013/4 as M2 students had to model the concepts and relationships present in an academic paper concerning e-commerce – loose guidance.

- S2: tighter guidance to M1 students as they evaluated their own experiments in personal information management and as they sought to model the structure of journal articles in e-commerce.

- TROPICPEA: for and with practitioners; empirical work with research volunteers as I and they model their personal work systems.

7.3 Conceprocity usage profiles

Table 24 Conceprocity usage profiles

Model type	Name	Purpose
Simple concept mapping for beginners	Conceprocity CIAOPEA	Concepts Images Actors Operators Procedures Events Associations . Makes use of a deliberately restricted range of Conceprocity notions. In particular, the only relationship type supported is Association. In order to give more expressiveness, this profile permits Association relationships to be named and encourages it.
Knowledge mapping	Conceprocity TROPICPEA	Very general with the full range of Conceprocity objects, **T**yped-**R**elationships **O**perators **P**rinciples **I**mages **C**oncepts **P**rocedures **E**vents **A**ctors . In this profile, relationships should not normally be named. Instead, the nature of the two notions linked by a typed relationship should normally provide full context sufficient to make the meaning of the relationship clear. Where this is not the case, Conceprocity permits commentary / notes. Typical uses include: self-observation, research design, representing knowledge as-is and as-ought, demonstrating understanding, documenting a body of knowledge and design of teaching, learning and evaluation. In the context of teaching, it is sensible to use such knowledge maps as the "advance organiser" or signposting originally suggested by (Ausubel 1963). This usage profile is also suitable for the representation of algorithms and of heuristics.
Usage diagrams	Conceprocity Usage	Usage models are slightly-extended use case diagrams. Use case diagrams were first proposed by Jacobson and are documented in (Booch, Rumbaugh, and Jacobson 2005). We suggest that no distinction needs or ought to be made between a use case and a procedure. Therefore the symbol used to represent a procedure is also used to represent a use case. However in Conceprocity we address what we perceive to be a weakness in use case analysis as presented by (Booch, Rumbaugh, and Jacobson 2005). That

		weakness is that interactions – which occur at the interface between an actor and a use case – should be explicitly represented. We have therefore introduced a specific symbol for interaction which we have called a form. In cases where a use case diagram represents a computer-based system which is or will be implemented, this interaction will take concrete form as a web page, perhaps as a web form; or as some other element, such as a form, report, query or view in a desktop database. UML stereotypes <<extends>> and <<includes>> are implemented simply as labels on the Association between use cases.
Event-driven process chains	Conceprocity EPC	Conceprocity event process chain diagrams are generally similar to ARIS EPC diagrams but they are optionally extended by incorporating a specific Data swimlane. The data swimlane is populated by concepts, which may subsequently be implemented as data tables, data views, specific file-types or by webpages. The value of the data swimlane is that interactions between it and other (non-data) swimlanes enable the modelling of the data flows (dataflows) that would otherwise require specific dataflow diagrams (DFDs). We suggest that no distinction needs or ought to be made between a function in the usual event-process chain described by (Scheer, Thomas, and Adam 2005), implemented for example in ARIS; and a procedure in Conceprocity. Therefore the symbol used to represent a procedure is also used to represent a function in an event-process chain. Conceprocity already has a specific symbol for an event. The symbols for inclusive OR, exclusive XOR and AND are deliberately not the same as those used in common event-process chain modelling tools such as ARIS.
E/R Data models	Conceprocity E/R	Conceprocity Entity / Relationship diagrams follow the conventions established by (Chen 1976) and subsequent work. However, ordinality, cardinality and multiplicity are shown in the Conceprocity / UML style because this is more expressive (although less visual) than Chen's notation.
System architecture and components		Not implemented.
Taxonomy creation and maintenance		Conceprocity is not currently intended for the representation of full ontologies; it can however be used effectively to represent taxonomies.

7.4 Evidence for the usefulness of Conceprocity

To what extent and in what contexts is Conceprocity really useful?

Research into the Working Model of knowledge workers

◆   The personal working model of the author

I present two top level models, separated in time by two years, as:

Figure 6 A model of a Personal Working Model (2014).

Figure 61 A personal working model – early 2016.

> They are significantly different in their form and in their content. I would like to suggest that the more sophisticated notions present in the later model reflect a greater understanding of the underlying philosophical issues discussed in this thesis. It is interesting that the visible changes are in the top level model, which is the more conceptual and less concrete, less rooted part of the model – the PIMS and PWS have much more obvious manifestations.

◆   The personal working model of other knowledge workers

Although empirical work in this area has begun, it will not be reported upon in this thesis.

Modelling the content of academic articles

◆   By final year master's students

In the first semester of the academic year 2013/4, a small element of the overall assessment of a module entitled IS505E Principles of E-Commerce PEC required each student to select a different academic article concerning e-business and/or information systems. A short teaching session in one class introduced students to the basic usage profile of Conceprocity, at that time entitled CAPRI. In a later session, students were then introduced to the more advanced usage profile, at the time called CAPRICE. The work undertaken by the students was a part only of their assessment for a module. I did not therefore expect them to put a huge amount of effort into these models. Overall, the quality of conceptual understanding was surprisingly good and the degree of respect for the conventions of the modelling language rather poor. However, this was very much a first experiment with a very early version of Conceprocity.

Consequent improvements to Conceprocity

> In part as a response to student experience, it was decided to completely revamp the usage profiles in Conceprocity. Capri has been replaced by CIAOPEA. Caprice has been replaced by TROPICPEA.

Information systems requirement analysis

> I managed the core Information Systems course in a French business school for twelve years. Teaching for almost all that time used an evolving combination of use case diagrams, data flow diagrams and entity relationship modelling. This built upon

a first-year course in which students became moderately competent in the use of Microsoft Access, a rapid application development environment incorporating a small-scale relational database. In the most recent two years, dataflow diagrams were replaced by event process chains. One of my motivations in creating Conceprocity was to prototype an approach to information systems requirements analysis, still based on these historically interesting analysis tools but possessed of a notational consistency sadly lacking when bringing together existing methods.

7.5 A critical evaluation of Conceprocity and some suggestions for future work

The tentative nature of these initial conclusions: further research proposed

Conceprocity is a semi-formal visual knowledge representation language which enables and encourages the modeller to be more precise in defining, bounding and relating conceptual and procedural knowledge. It is in effect a means to constrain and enhance natural language expression and thereby to increase the precision of the meaning which the modeller needs to express. To the extent to which two modellers can agree upon a Conceprocity model, it is also a means to establish and to verify communication of ideas and concepts.

Certainly, Conceprocity is not without its weaknesses. It is arguably an error to permit so much generality of expression in a single modelling approach. The counter-argument is that usage profiles permit a more restricted representation and are therefore less likely to give rise to cognitive overload in users and readers. I would also point out that in knowledge representation schemes such as UML, it is necessary to learn a wide range of different – sometimes annoyingly so – representations. This problem is even starker in the area of conventional structured analysis (Yourdon and Constantine 1976), where a simple notion such as process is represented in different, overlapping and confusing ways – contrast data flow diagrams, event process chains and use case diagrams.

More fundamental difficulties and objections

We have largely accepted as a given the notions put forward by (Paquette 2010) which are themselves based partly on the UML thinking of (Booch, Rumbaugh, and Jacobson 2005). Paquette's thinking also derives in large part from cognitive science; this influence pervades his book and in particular informs chapter 6 on taxonomies of problems and generic skills.

Earlier we suggested that existing visual representation formalisms have emerged largely from the computer science and software engineering communities. It is instructive to reconsider the origins of formalisms such as Entity Relationship models, modern structured systems analysis, conceptual graphs ((John F. Sowa 1992a) following Charles Peirce), the object modelling technique and the successor Unified Modelling Language UML. These are all representation approaches which have been built primarily for the analysis and architectural design of complex

software systems. In Conceprocity as it currently stands we have designed and presented a visual representation system which, following (Paquette, 2010, p.xiv), we wish to be usable by educational specialists and learners who are not computer scientists. It is at the same time general and powerful enough to represent the structure of knowledge and learning/working scenarios.

Paquette goes on to say:

> "We present three major steps starting with (1) informal visual modelling for the educated layperson, to help represent interesting knowledge. We then (2) move onto semi-formal modelling to help define target competencies and activity scenarios for knowledge and competency acquisition by learners and workers. Finally (3) we present the more formal visual models (Ontologies) that can be used by software agents to ensure execution of knowledge-based processes on the semantic web." [(Paquette, 2010, p.xiv) slightly amended for clarity.]

Thus, G-MOT supports three dialects, one for general use, one for instruction design and one for ontology building. Similarly Conceprocity distinguishes ***usage profiles*** within a single visual representation language.

Recall that ***notion*** is the name given in Conceprocity to the modelling meta-concepts of concepts, procedures, actors, principles, events and relationships. A possible alternative word for notions is meta-concepts, that is, concepts about concepts. We now wish further to address the issue of whether Conceprocity has chosen the right notions. In section 0 we discussed why Conceprocity distinguishes concepts, procedures and principles. Here we consider the nature of concept mapping itself and the relationships permitted in Conceprocity.

♦   What is concept mapping anyway?

Much of the literature surrounding concept mapping comes from the field of enquiry known as knowledge organisation which is largely situated within the discipline known as library and information science. (Hjørland 2009) holds that information science and knowledge organization cannot avoid relating to theories of concepts. Knowledge organizing systems (e.g., classification systems, thesauri, and ontologies) should be understood as systems organizing concepts and their semantic relations. Different theories of concepts have different implications for how to construe, evaluate, and use such systems. Based on what he calls "a post-Kuhnian view" of paradigms, Hjørland argues that the best understanding and classification of theories of concepts is to view and classify them in accordance with epistemological theories (he emphasises empiricism, rationalism, historicism, and pragmatism). Different views of concepts are associated with different worldviews and epistemologies which tend to compete with each other. The historicist and pragmatist understandings of concepts are in his view the most fruitful views; he outlines the importance of historicist and pragmatic theories of concepts for information science. For him, the concept is a socially negotiated construct that

should be identified by studying discourses (Hjørland 2009). This view of concept theory has been labelled socio-constructivist.

(Friedman and Thellefsen 2011) discuss knowledge organisation systems and the emergence of concept theory and semiotics in that connection. For them knowledge organisation as a domain has as its focus the order of concepts, both from a theoretical perspective and from an applied perspective. It is therefore important to understand the meaning of a concept found in text and in visual maps. Whatever the epistemological stance one adopts, it is evident that the meaning of a concept is that which was intended by the originator of that concept in accordance with her own particular epistemological stance.

Thus, when (Friedman and Smiraglia 2013) attempt a synthesis of the existing theory concerning concepts and concept mapping they do so within the tradition of library and information science and in particular they identify "knowledge organisation systems", based on earlier work reported as (Friedman and Thellefsen 2011).

♦   Relationships in Conceprocity

Some concepts refer to data. The E/R Entity Relationship model of (Chen 1976) has informed in particular Conceprocity's thinking about associations, cardinality, ordinality and multiplicities.

The ideas of aggregation, generalisation and specialisation were introduced by (J. M. Smith and Smith 1977) and later informed the design of UML and G-MOT. However, it is difficult to discern a single source of inspiration for the conceptualisations underlying UML. Specifically, UML does not possess a meta-model; nor does G-MOT.

Composition and part-whole relationships are the subject of mereology (which is separate from the concept of topology). (Guarino 1995) give a fuller introduction.

(Wand 1996) holds that despite the availability of a large number of systems analysis methods and techniques there does not exist a general underlying foundation for this knowledge domain. The stance which Wand adopts is that an information system is a representation of another "real-world" system. This ontological stance borrows from the philosophy of Mario Bunge, and in particular his ontological formalism as presented in volumes 3 and 4 of his "Treatise on basic philosophy" (Bunge 1977, 1979). Wand sees an information system as a representation that enables us to obtain knowledge about a certain domain without having to observe it. Thus, where the represented domain might be termed the real-world system, an information system is an artificial representation of that real-world system, as perceived by somebody, built to enable information processing functions. (Wand 1996) therefore challenged me to re-engineer Conceprocity starting from a clear ontological stance, which I have sought to achieve. However, the stance I have eventually adopted differs somewhat from that which Yair Wand, Ron Weber and their various co-authors and collaborators assume in their work. See

Towards an ontological evaluation of Conceprocity

Table 26 following.

(Wand and Weber 2002) set out a framework for research on conceptual modelling in connection with information systems which has four main components; see Table 25:

Table 25 Conceptual Modelling Framework Elements (based on (Wand and Weber 2002))

Element	Meaning	Status in Conceprocity 1.0 and in 3.0
Conceptual-modelling *grammar*	Provides a set of constructs and rules that show how to combine the constructs to model real-while domains.	Largely complete. We need to give further consideration in particular to properties, since the current representation (sub-concepts) consumes too much space on the page. Note that we have yet to define the meta-model suggested by (Rosemann and Green 2002) for Conceprocity; we defend this lacuna by emphasising the emergent and pragmatic origins of Conceprocity. We note also the importance of (initially) loosely coupling and controlling systems, then of subsequently tightening them: cf. (Orton and Weick 1990). *In version 3.0, properties can either be modelled as (sub-) concepts or stored separately in dictionary tables.*
Conceptual-modelling *method*	Provides procedures by which a grammar can be used. Such a method needs to prescribe how to make observations of a domain into a model of the domain.	The method is documented in the form of a PowerPoint presentation. See also 'Appendix 1 How to create and maintain Conceprocity models' in this document and the linked web resource.
Conceptual-modelling *script*	A script is the product of the conceptual modelling process.	A Lucidchart template exists and this forms the basis of each script. The scripts themselves are stored in the user's Google Drive.
Context	The context is the setting in which conceptual modelling occurs and in which scripts are subsequently used.	The initial context of use has been identified and some scripts have already been produced. Conceprocity does not itself possess easy means to produce and maintain a dictionary of the

		objects it contains, nor any metrics. Instead, the dictionary is stored elsewhere, for example in Excel, Access or – as in this study – InfoQube.

♦ *Specific ontological issues*

- *Construct Incompleteness* exists in a modelling grammar unless there is at least one modelling grammatical construct for each ontological construct.

- *Construct Overload* exists if one grammatical construct represents more than one ontological construct.

- *Construct Redundancy* exists if more than one grammatical construct represents the same ontological construct.

- *Construct Excess* exists in a modeling grammar when a grammatical construct is present that does not map into any ontological construct.

Table 26 An evaluation of Conceprocity against BWW criteria. Derived from: (Green and Rosemann 2000)

Ontological Construct	Specific ontological issues	Evaluation
THING		Conceprocity conforms well. In particular, it distinguishes instances from classes, which is unusual in modelling languages.
PROPERTY:		Arguably, there is construct excess here. It is possible to represent properties both as sub- concepts and in separate data tables. This is pragmatically very

IN GENERAL
 	
IN PARTICULAR
   HEREDITARY
   EMERGENT INTRINSIC
 	
NON-BINDING MUTUAL
   BINDING MUTUAL
		useful.

ATTRIBUTES		As above.
CLASS		Conforms.
KIND		Conforms.
STATE	This is a system property, not a model property.	
CONCEIVABLE STATE SPACE	This is a system property, not a model property.	
STATE LAW: STABILITY CONDITION CORRECTIVE ACTION		Minimally implemented via principles.

LAWFUL STATE SPACE		Minimally implemented via principles.
EVENT		Implemented by means of the event notion; but we should be cautious because event may have multiple meanings.
PROCESS	Process is discussed by Bunge, but not treated as a specific ontological construct.	Implemented by means of the procedure notion; but procedure is arguably afflicted by construct overload.
CONCEIVABLE EVENT SPACE		This is a system property, not a model property.
TRANSFORMATION		Implemented by means of principle notion; but principle is arguably afflicted by construct overload.
LAWFUL TRANSFORMATION: STABILITY CONDITION CORRECTIVE ACTION		Implemented by means of principle notion; but principle is arguably afflicted by construct overload.
LAWFUL EVENT SPACE		This is a system property, not a model property.
HISTORY		Implement using event instances.

ACTS ON		Implemented.
COUPLING: BINDING MUTUAL PROPERTY		Implemented.
SYSTEM		Implemented by means of swim lane.
SYSTEM COMPOSITION		Implemented.
SYSTEM ENVIRONMENT		Implemented.
SYSTEM STRUCTURE		Implemented.
SUBSYSTEM		Implemented.
SYSTEM DECOMPOSITION		
LEVEL STRUCTURE		Implemented.

EXTERNAL EVENT		Implemented.
STABLE STATE*		This is a system property, not a model property.
UNSTABLE STATE		This is a system property, not a model property.
INTERNAL EVENT		See event.
WELL-DEFINED EVENT		This is a system property, not a model property.
POORLY-DEFINED EVENT		This is a system property, not a model property.

Table 27 Issues associated with Conceprocity constructs

Conceprocity Ontological Construct	Specific ontological issues	Notes
Concept	No distinction is drawn between conceptual notions and concrete	In Conceprocity 3.2, name syntax is extended to permit sub-typing, as in queryOutput : databaseQuery

Images and rich pictures		
Operator		The set of operators is currently fixed; it might be sensible to make this user-extensible. However, semantic relationships (CPR 3.2) have introduced language extensibility
Procedure	Arguable construct overload. Procedure is used for process, function, use case	A design preference.
Event	Slightly more focused in Conceprocity than it is in the Bunge ontology	
Actor	Absent from the Bunge ontology, which is where the deficiency lies	
Principle	Corresponds to a number of notions in the Bunge ontology, such as state law and lawful state space.	We have chosen to follow Paquette's notion here.
Class and instance	Useful clarification	

Form	Is specific to human-computer interaction	
View	Arguably, construct excess. Could simply be a subtype of concept.	Can so be treated in CPR 3.2
Entity	Arguably, construct excess. Could simply be a subtype of concept.	This is the 3.2 implementation
Aggregation		
Composition		
Specialisation		
Typed relationships		
Precedence relationship	Arguable construct overload. There is no visual distinction between precedence relationship, prompts relationship and input product relationship.	The current compromise is justifiable because it is easier to teach and to explain.
Prompts relationship	Arguable construct overload. There is no visual distinction	

	between precedence relationship, prompts relationship and input product relationship.	
Input-product relationship	Arguable construct overload. There is no visual distinction between precedence relationship, prompts relationship and input product relationship.	
Instantiates relationship		A useful clarification.
Regulates relationship		An essential clarification.
Grammar		Insufficiently policed in the existing implementation.
Hierarchical levels	It could be argued that there is construct excess in having both hierarchical levels and swim lanes. However, they are both pragmatically useful.	
Swim lanes		Construct excess – actor could be used for this purpose. Retained for commonality with SAP event process chains.

Set operations		Supported by semantic relationships in CPR 3.2.
Concept to concept relationships		E.g. analogy, metaphor. Supported by semantic relationships in CPR 3.2.
Collective intentionality		
Institution	An important innovation. Most conceptual mapping approaches simply do not recognise the separate existence of social ontology, which is peculiar given that most information systems concern the products of human intentionality rather than natural-world entities.	
Constitutive rule		
Deontic power		
Action		
Semantic relationship		E.g. analogy, metaphor…

7.6 Existing and developing contributions from my Ph.D. research to date - 2

- o Personal working model
  - ▪ Predicted via (Conant and Ashby 1970)
  - ▪ Seeking to get individuals to make this explicit.
- o The identification of Nuggets as outputs from and intermediate products of the personal work system
- o The beginnings of an understanding of personal information management systems
  - ▪ Bootstrapped by the use and investigation of my own personal information management system

- Under-researched by academia

- Potentially massively significant to the ICT and consumer electronics industries

- Thus demanding further academic research.

  - Whence a proof-of-concept personal information management system PIMS (Baskerville 2011b) "UnIQue" – tool and method

    - Relevance: multiple, e.g. classification (kind) and categorisation (tagging) as examples of personal data organization (Jacob 2004) both of nuggets and of a bibliography.

  - Initial diffusion of results

    - Twelve conference papers

    - Website: www.markrogergregory.net, designed to draw in volunteers.

7.7 Design science evaluation: multiple genres of enquiry

As discussed in Section 0, (Baskerville, Kaul, and Storey 2015) identify four different genre of enquiry and show that a single design study may traverse some or all of these genres. Thus, for example the design of Conceprocity has nomothetic elements; its application may have nomothetic and will always have ideographic aspects. They therefore set out corresponding sets of criteria for knowledge justification and evaluation for each genre of enquiry. In appendix B, they set out general quality criteria. They suggest the necessity for prolonged engagement, persistent observation, data triangulation, methodological triangulation, inventiveness, innovativeness, originality, the establishment of principles such as dialogical reasoning and the examination and acceptance or rejection of multiple interpretations. I would contend that these criteria have been respected either in the design of Conceprocity or in the design of UnIQue or in both. Conversely, there are other general qualities which this study has not so far respected: these include confirmability, dependability, transferability, generalisability, investigator triangulation, objectivity and internal and external validity. The knowledge contributions made by this study can sometimes be characterised as nascent design theory; operational principles or architecture including constructs, models, methods, design principles and technological rules – in accordance with (Gregor and Hevner 2013) level 2 knowledge contributions. More often, the contributions can only be characterised as situated artefacts; instantiated software products or implemented processes – these correspond only to level 1 in the knowledge contribution levels identified by Gregor and Hevner. Therefore, I have been purposefully vague in the exact level which I associate with design artefacts in my table of warrantability. Certainly, there is no question of making level 3 claims for a well-developed design theory which includes both mid-range and grand design theories.

7.8 An evaluation of my use of the FMA meta-framework

See section 6.4.1.2.

7.9 Summary list of contributions from my Ph.D. and how they have been evaluated

Table 28 Summary list of contributions and notes on their evaluation

o Contribution	o Evaluation
o **A language and method for explicating and modelling aspects of personal knowledge in a visual form: Conceprocity.**	o See section 7.4 above.
o **A thorough literature review, indicating the existing absence and current need for a philosophically-informed systems perspective on personal information management PIM.**	o As the discussion in section 4.4 makes clear, only two authors appear previously to have written about personal information management systems per se and neither of these contributions are informed by a strong discussion of the nature of systems and in particular of emergence. My analysis in section 0 of the work of William Jones, who is both a prolific author in his own right and whose works include collections of papers from participants in PIM workshops, shows that the word system is used only in the informal sense that any computer on a desk constitutes a system.
o **A justification for an insistence on modelling – Modelling cannot be just an optional extra in situations where regulation is required.**	o As Figure 1.8 and the discussion in section 1.8 together show, data in a personal information management system models aspects of reality and thereby influences behaviour; furthermore, the process of creating and/or interpreting a conceptual model may change the understanding and the actions of a knowledge worker.
o **A demonstration by example of the role that an explicit philosophical stance can take in the working model of a knowledge worker and of the value that can then have in**	o The process of undertaking this PhD and the learning associated with it have changed who I am, how I think and how I act.

influencing the direction of the work done.	
○ **PIMS modelling and implementation must be based on an identified personal ontological stance which is exemplified in the research.**	○ The various classification and categorisation aspects of the UnIQue personal information management system have been put in place because of the fundamental necessity to classify and categorise data. The fundamentally realist perspective adopted is also reflected in the form and content of the various Conceprocity models produced – and of Conceprocity itself, with its insistence on typed objects and relationships.
○ **Conceptualisation and illustration of the individual working models of certain individuals, starting with me: structured self observation.**	○ I have, by means of observation and of modelling, been able to illustrate a specific case of an individual working model.
○ **Use of an evolving PIMS and creation of Conceprocity: design science (Hevner et al. 2004); (Carlsson 2010) or action design research (Sein et al. 2011).**	○
○ **Analysis of unschooled and schooled Conceprocity mapping by students: how useful? - action learning.**	○ Now started in teaching in Scarborough; second cycle in 2017.
○ **Evidence for semiotic and semantic morphogenesis in at least one individual case; this emergence needs further empirical investigation.**	○ Semiotic morphogenesis is evidenced in the development of diagrammatic conventions in old and new diagrams in this thesis.
○ **One of the first applications (as opposed to theoretical discussions) of a critical realist approach in the context of design science research.**	○
○ **The thesis subject matter has imposed an investigative, self-referential research approach which is iconoclastic and richly informative. The morphogenetic development of the personal work system and model demonstrate the benefits of an open, learning approach to learning-while-**	○

doing which may well have applicability in post-experience learning by knowledge workers in other domains.	

7.10 To what extent have I achieved what I set out to do?

When I set out to research personal information management systems, I did so with an explicit statement that I was exploring rather than seeking explanation. I have taken what may appear to be two long and perhaps meandering detours: the first into philosophical concerns and the second into conceptual knowledge modelling. That I have done this is justifiable for the following reasons:

1. I needed to unlearn and relearn an incomplete epistemology and a largely inexplicit ontology. I have been happy to discover critical realism with its emphasis on ontological realism and appropriate epistemological relativism and its emphasis

2. **I knew from the start that I would need to create representational and actionable models.** The need for representational models led me to develop the Conceprocity visual modelling language and toolkit. The need for actionable models led me to develop UnIQue with its emphasis on explicit support for classification and categorisation. I did this because one implication of the Conant and Ashby good regulator theorem is that the regulatory model should be as near as possible isomorphic with the system being regulated. This has the startling and unsettling implication that off-the-shelf, standardised, overly packaged "solutions" are likely to prove inadequate in their regulation of complex situations. Although not reported in this thesis, my second design motivation in the creation of Conceprocity has been the desire to support usage profiles which will help train and support information systems professionals as they analyse system requirements.

3. I am painfully aware that my iconoclastic approach to research risks being seen as too left-field to make it easy to promulgate the results of this research so far. I am equally aware that the largely exploratory nature of the research undertaken so far imposes a significant additional period of work on my part before I gain clearer understanding of some of the issues which I have raised. But I have enjoyed the process so far…

7.11 What next? My post-PhD research programme

This near-future research programme will also consist of multiple elements.

Investigating the working model, personal work system and personal information management system

One part of the research will investigate how to identify and make more explicit the PIMS and personal working model of knowledge workers who agree to act as research volunteers. They will participate in *mentored action research* into the personal working model, personal work systems and supporting personal information management systems of the individual knowledge worker as she functions in the enterprise and in society.

Collaborative conceptual modelling for information systems requirements analysis

A second element of the research extends the scope of application of Conceprocity into the area of *information systems requirements analysis and design*. Already underway, it involves the active collaboration of students and professional knowledge workers.

Conceprocity is structured as a series of usage profiles. These include the CIAOPEA simple knowledge mapping profile and the TROPICPEA comprehensive knowledge mapping profile. This is because during the doctoral research, Conceprocity was used primarily as a knowledge modelling approach. However, it has also been designed for a second area of application, that of information systems requirements analysis. (Pohl 2010) holds that conceptual modelling is an essential complement to requirements analysis based on natural language. I have as a teacher sought over many years to introduce information systems and business students to aspects of conceptual modelling which ought to assist in a reasonably rigorous elicitation and analysis of user requirements for computerised information systems. In my experience and that of others, both the conventional structured approach – usually based on data flow diagrams and/or entity relationship attribute modelling – and approaches based on UML techniques, particularly use case models: tend in practice not to be successful. Students find the techniques difficult to learn and effectively impossible to apply; certainly, the analysis undertaken is not reflected in the design of the artefacts they attempt subsequently to implement.

My conjecture is that a contributory factor to the difficulties which students encounter is the confusion engendered by encountering multiple, overlapping and inconsistent knowledge representation schemas.

I have designed Conceprocity to use the same symbols across a range of different usage profiles. Each usage profile corresponds to a particular kind of model which it may be appropriate to use in some context or other. Where, as in information systems requirements, use is made of multiple models, I have endeavoured to ensure that the same symbol is used for comparable and compatible notion types in each of the models.

Table 29 lists the current Conceprocity usage profiles. The column entitled "Purpose" indicates which model types are best served by the corresponding usage profile.

Table 29 Conceprocity usage profiles

Usage profile	Name	Purpose
Simple concept mapping for beginners	Conceprocity CIAOPEA	**C**oncepts **I**mages **A**ctors **O**perators **P**rocedures **E**vents **A**ssociations. CIAOPEA makes use of a deliberately restricted range of Conceprocity notions. In particular, the only relationship type supported is Association. In order to give more expressiveness, this profile permits Association relationships to be named and encourages it. This usage profile is designed for simple concept mapping, where it is desirable to mask the complexity of different relationship types. It is equally suitable for use in usage modelling (aka use case modelling) and for extended event process chain diagrams.
Knowledge mapping	Conceprocity TROPICPEA	Very general with the full range of Conceprocity objects, **T**yped-**R**elationships **O**perators **P**rinciples **I**mages **C**oncepts **P**rocedures **E**vents **A**ctors . In this profile, relationships should not normally be named. Instead, the nature of the two notions linked by a typed relationship should normally provide full context sufficient to make the meaning of the relationship clear. Where this is not the case, Conceprocity permits commentary / notes. Typical uses include: self-observation, research design, representing knowledge as-is and as-ought, demonstrating understanding, documenting a body of knowledge and design of teaching, learning and evaluation. In the context of teaching, it is sensible to use such knowledge maps as the "advance organiser" or signposting originally suggested by (Ausubel 1963). This usage profile is also suitable for the representation of algorithms and of heuristics.
Usage diagrams	Conceprocity Usage	Usage models are slightly-extended use case diagrams. Use case diagrams were first proposed by Jacobson and are documented in (Booch, Rumbaugh, and Jacobson 2005). We suggest that no distinction needs or ought to be made between a use case and a procedure. Therefore, the symbol used to represent a procedure is also used to represent a use case. We go on in Conceprocity to address what we perceive to be a weakness in use case analysis as presented by (Booch, Rumbaugh, and Jacobson 2005). That weakness is that interactions – which occur at the interface between an actor and a use case – should be explicitly represented. We have therefore introduced a specific symbol for interaction which we have called a form. In cases where a use case diagram represents a computer-based system which is or will be implemented, this interaction will take concrete form as a dynamic web page, or as some other element, such as a form, report, query or view in a desktop database. UML stereotypes

		<<extends>> and <<includes>> are implemented simply as labels on the Association between use cases.
Event-driven process data diagrams	Conceprocity EPD	Conceprocity event process chain diagrams are generally similar to ARIS EPC diagrams (Scheer 2000) but they are optionally extended by incorporating a specific ICT swimlane. The ICT swimlane is populated by concepts, which may subsequently be implemented as data tables, data views, specific file-types or by webpages; or by the forms identified in a usage model. The value of the ICT swimlane is that interactions between data and other (non-ICT) swimlanes enable the modelling of the data flows (dataflows) that would otherwise require specific dataflow diagrams (DFDs). We suggest that no distinction needs or ought to be made between a function in the usual event-process chain described by (Scheer, Thomas, and Adam 2005), implemented for example in ARIS (Scheer 2000); and a procedure in Conceprocity. Therefore, the symbol used to represent a procedure is also used to represent a function in an event-process chain. Conceprocity already has a specific symbol for an event which was inspired by, and is therefore consistent with, an EPC event. The symbols for inclusive OR, exclusive XOR and AND are deliberately not the same as those used in common event-process chain modelling tools such as ARIS. In Conceprocity, a clear visual distinction is made between split and join logical operators.
E/R Data models	Conceprocity E/R	Conceprocity Entity / Relationship diagrams broadly follow the conventions established by (Chen 1976) and subsequent work. Conceprocity permits the use of the crow's foot notation used by Chen. However, ordinality, cardinality and multiplicity can also be shown in the Conceprocity style used in TRPOICPEA. Itself based directly on UML, the TROPICPEA notation is more expressive (although less visual) than Chen's notation.

I am currently experimenting with the use of Conceprocity-based requirements analysis in student teaching and learning. The research approach adopted is that identified as mentored action learning (Gregory, Kehal, and Descubes 2012b) in the context of design ethnography (Baskerville and Myers 2015). Teaching, particularly in small classes, has much in common with mentored action learning. An additional element required by mentored action learning (over and above normal teaching practice) is structured reflection by the teacher.

Further exploitation of the existing research data

I will carry out further analysis of the PhD Journal which I have created over the last five years. The purpose of this analysis will be to:

1. Continue to verify and to improve the classification and categorisation mechanisms put in place in UnIQue.

2. Better understand and delineate principles of effective personal information and work management.

My eventual intention is to set out the specification for an improved knowledge management and personal information management application.

Moving on towards mentored action learning

It continues to be my intention to carry out a process of mentored action research federated by a shared online learning community. In that community individuals will act both as learners and mentors; I refer to both as research volunteers (RVs). Initially I shall perhaps be prima inter pares, the principal research mentor.

In my role as what (Baskerville and Myers 2015) call a design ethnographer, I as researcher will collect many more facts, some of which may also be surprising. These will suggest hypothetical explanations – some of which may later, and by other researchers, be the subject of further empirical investigation by logics of enquiry other than abductive. In the processes of carrying out my research and aiding the learning of others, other contributions – prototype learning resources in the form of working documents which in this current thesis I name nuggets – will be generated and, to some extent, refined. My "conclusions" will continue sometimes to be tentative, almost always partial, perhaps insufficiently rigorous for some journals but of *some relevance or usefulness in practice*. That latter probability motivates me.

The significance of this ongoing research programme

Together, mentored action learning in the context of understanding and improving personal work and the continuing work on Conceprocity-based requirements analysis are indications of how this research programme potentially offers *intensely practical relevance and application* for knowledge workers in service and for students learning how better to manage their knowledge, information and time. I am planning two online courses in the MOOC tradition which will help respectively students and managers in practice to see the benefits of improving their personal information management within the context of a better understanding of their working model. In the case of executives, I intend to give them practical help – mentored action learning – towards a better understanding of who they are and how they work best. However, this has to be within the context of mentored action learning because as yet I have far too little evidence of the generalisability of my currently somewhat tenuous findings. Conceprocity in its current Lucidchart implementation is just about ready for prime-time; however, because Lucidchart is a chargeable service, I need to consider the possibility of re-implementing the entire approach as an open source project.

7.12 Post-PhD research programme as a Conceprocity map

Figure 62 shows the author's post-PhD mentored action learning research process:
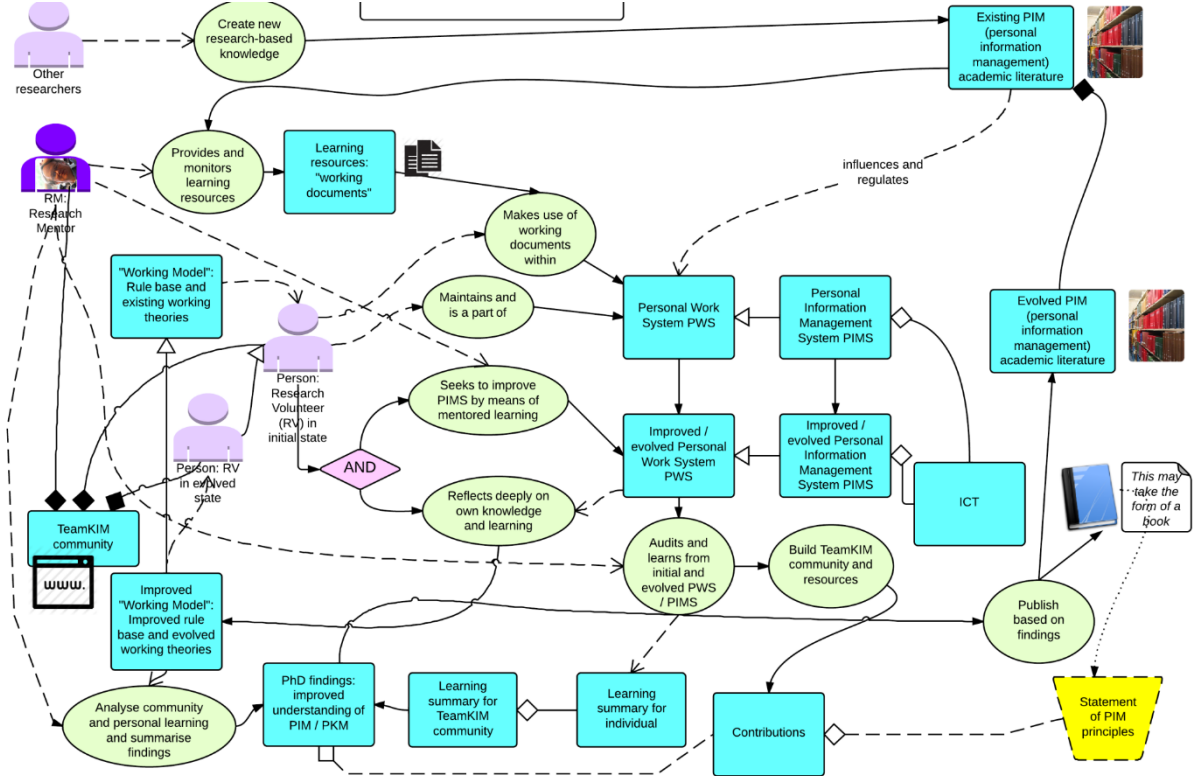
Figure 62 The PhD research process of the author represented as a Conceprocity concept <-> process map

This map is by no means the only possible conceptualisation of post-PhD work. Furthermore, it can easily be criticised on multiple grounds. I have not, for example, followed my own guidelines on the number of notions to be shown on a single map. But the very fact of there being such a model helps to clarify understanding, enables dialogue and offers evaluative possibilities.

7.13 Papers planned following thesis acceptance

Table 30 Papers planned after thesis acceptance

Title	Current co-authors	Target journal and CABS AJG (British) and FNEGE (French national) ranking	Status: initial journal submission expected when?
Enhancing personal knowledge management by	Gregory, Mark	Information Systems Journal	Written and presented at conference as (Gregory, Kehal, and Descubes 2012a).

mentored action learning	Descubes, Irena	– AJG: 3; FNEGE: 2	A small amount of additional empirical research is required. Early 2017.
A Personal Working Model	Gregory, Mark Macgilchrist, Renaud Descubes, Irena	European Journal of Information Systems – AJG: 3; FNEGE: 1	Written and presented at conference. (Gregory and Macgilchrist 2014). Awaits minor revision. 2017.
Action learning and structured reflection in information systems teaching and research	Gregory, Mark Descubes, Irena	Systèmes d'Information et Management – AJG: not ranked; FNEGE: 2	Written and presented at conference. (Gregory and Descubes 2011c). Awaits minor revision. Journal submission early in 2017.
Knowledge Organisation by Concept Process Mapping	Gregory, Mark	Information and Organization – AJG: 3; FNEGE: 2 or Journal of Information Science – AJG:2; FNEGE: NR or Journal of the American Society for Information Science and Technology – AJG: 3; FNEGE: NR	Written; awaits minor revision and incorporation of additional empirical data before imminent submission. See: http://markrogergregory.files.wordpress.com/2013/10/knowledge-organisation-by-means-of-concept-process-mapping1.docx for an early draft of this paper.
A complex adaptive systems perspective on personal information management systems	Gregory, Mark Macgilchrist, Renaud	Systemic Practice and Action Research – AJG: 2; FNEGE: NR	An empirical analysis of emergent concepts in the literature of Personal Information Management PIM, demonstrating the absence of a systems view in the literature and arguing for its necessity. 2017
An evolutionary model-driven approach to information systems construction and procurement	Gregory, Mark	Academy of Management Perspectives - AJG: 2; FNEGE: 2	2017

Building bridges from each side of the river: end user oriented requirements specification and analysis by means of Concept Process Reciprocity modelling	Gregory, Mark	Information Systems Frontiers – AJG: 3; FNEGE: 4	2017
Conjectures on the morphogenesis of meaning and its part in learning	Macgilchrist, Renaud Gregory, Mark	Academy of Management Learning and Education – AJG: 4; FNEGE: 2	Early 2017. Originally written by Renaud; I have significantly revised and extended this paper, particularly in the area of its philosophical underpinnings.
Model-based reasoning in the service of conceptualisation: a concept <-> process reciprocity approach	Gregory, Mark	Academy of Management Discoveries – not ranked (too new?)	2017
Teaching as action learning: a design science perspective	Gregory, Mark	Academy of Management Learning and Education – AJG: 4; FNEGE: 2	2018; co-author sought. A reflective evaluation of the cycles of action learning, particularly by the teacher, implicit in repeated and evolving course delivery involving practical techniques. Each delivery is seen as an experiment from which lessons are learnt for subsequent cycles.

7.14 Emergent principles

This section summarise principles which I recognised as I kept my research journal. I am certain that there are more principles waiting to be discovered when I carry out further analysis of that journal. The warrantability of principles of this kind is low but to suggest them and perhaps then to test them is better than simply to ignore their possibility

- o Philosophy (sometimes) matters.

    - ▪ Especially if trying to get articles published in top IS journals!

- Only by taking a systems perspective can we recognise the existence of personal work and information systems, their overlap and their distinctions.
    - Even then, we need to take care to align the content and structure of our PIMS to the world that we recognise.
    - Thus, personal ontological categories can be of the real, purely conceptual or indeed fictional.
    - A suitably-ambiguous example: storing details about a household – the people who live at an address.
- Similarly, *models* – which are always conceptual abstractions – can be of the real, conceptual or fictional.
    - Models are *necessary;* the IS community with which I identify has a duty to help people understand that.
        - The alternative to models is not no models, but bad models because they remain inexplicit mental models.
        - Models take different forms but *must be "surfaced";* we must help to make them more explicit and perhaps to improve them
        - *Conceptual* modelling, for example Conceprocity, can greatly help here.
        - Aspects of certain models are active or dynamic, e.g. tables of summary data used to support decisions.
- Control – management – needs and should mandate *good modelling* aiding *requisite variety.*
- We should endeavour to build good regulators – a good Working Model – and to help others to do so.

In my discussion of the work of (Gregor and Jones 2007) on the anatomy of a design theory, in section 0, I concluded with the speculation that the set of principles I would put forward for the specification and/or evolution of a PIMS within a PWS could be tested against the design theory components summarised in Table 10. as I analyse, design and specify better tools for personal information and knowledge management, I shall in parallel apply these design theory components and subsequently report my work.

7.15 Some reflections and two conclusions

I have so far failed to meet a personal objective, which was to have carried out sufficient mentored action research to be in a position to yield results empirically informed by the PIMS of people other than myself.

I have learnt a great deal from my doctoral studies, but clearly have much still to learn.

In particular, I still look for "solutions" to insufficiently defined or perhaps irrelevant problems – cf. Soft Systems Methodology SSM (Checkland and Poulter 2006).

1. Each knowledge worker should learn continuously to improve the individual enacted knowledge model and system of data organisation which informs and is informed by their daily work.

2. Any knowledge worker can benefit from systemic and systematic personal information management by means of:

    - Inspired bricolage and principled design.
    - Theory-informed clarity of conceptualisation.
    - Multiple points of view and tools appropriate to each.
    - Reflection and shared learning.

7.16 A summary

The effective regulation of the work and life of the individual knowledge worker depends upon having a homomorphic model of that life and what she is seeking to achieve within it. This observation is not original – it is based on the work of Conant and Ashby – but its application to the individual is believed to be novel. Making such a homomorphic Personal Working Model explicit is difficult but highly desirable and therefore merits hard work. The model is partial and its various expressions require elements which are visual, analogical and the understanding of which will necessarily involve model-based reasoning. Certain elements of this personal working model are best expressed visually; others are best expressed as tables of elements which can to some extent be presented hierarchically but are in fact often of a network underlying structure. The elements both of the tables and of the visual models are an expression of the personal ontology of the individual knowledge worker. By ontology, I mean the kinds of things with which she must deal and how they relate one to another.

My initial research epistemology concentrates on my use of a personal information management system in order to study, and in particular to model, personal information management systems PIMS. My PIMS is the result of an assembly by bricolage and experiential design of various elements which enable me to store the personal data which informs my working life.

1. In my investigation of the nature of this model, I have perforce to use formalisms. I have chosen pragmatically to concentrate on two semi-formal means of expression. *Conceprocity* – **concept <-> process reciprocity** – is a visual and textual *language* and *toolset* of my own devising which is intended for capturing, expressing, communicating and co-creating *models of topic areas* of domain *knowledge* by domain *experts* or *learners.*

2. I have also made use of a software tool called InfoQube. The fundamental information management technique supported by InfoQube is that of a hierarchic outline with columns which are database queries. Its most prominent advance on earlier outlining tools is that any information item can appear in more than one hierarchy simultaneously. Furthermore, the item can appear as a row in one or more grids, each column of which permits the storage of user-defined values such as text, numbers, lists, hyperlinks and pictures.

Thus, in my own model of my own working life I have chosen to represent the semantic structure, the dictionary, of that model by means of InfoQube data grids and Conceprocity visual maps. Much of the target data is stored in InfoQube grids.

I go on to summarise the nature of the ontology.

There are things. Every thing has a kind. Things (and kinds of things) have properties. Things sometimes offer affordances to actors. Some things have a clear real-world existence. The ontology of the brute things with which I am concerned follows Mario Bunge. The ontology of the institutional things with which I am concerned broadly follows John Searle.

Things are transformed by actions. Repeated actions may be generalised into processes. Every instance of a thing and every kind of thing – the latter corresponding to a concept – has a name. Collections of things, which I refer to as concepts, can be related to other concepts either by **structural** relationships or by actions which transform one concept to another: **transformations**. In Conceprocity, we might represent an action as having input concepts and output concepts.

Conceprocity is a semiotic system. I and therefore I suspect many others react against the exactness and the formalism of the existential graphs of Charles Sanders Peirce and the conceptual graphs of John Sowa. That is why I have devised Conceprocity. It is a compromise between formality and approachability. It may initially appear to be a step too far for certain learners, but a modeller can concentrate on visual icons that speak to her – and hopefully to other users of the map.

I hope that I have begun to show how personal information is used by the knowledge worker in what we stress to be ***an open, self-organising system demonstrating continuous evolution and learning.***

7.17 A wider public?

Information systems used to be a practical subject and it should be again. It is the individual who has the most to gain from being more effective in her work and information management and it is individual information systems which, as Richard Baskerville has suggested, hold the greatest promise for new and exciting research questions and projects. I also believe that information systems researchers and teachers continue to be the best placed people to introduce the potential of ICT – the most potent current source of business innovation – and specifically to introduce, train and help people to capitalize on the enormous and somewhat lost significance

of modelling.I am planning two online courses in the MOOC tradition which will help respectively students and managers in practice to see the benefits of improving their personal information management within the context of a better understanding of their working model. In the case of executives, I intend to give them practical help – mentored action learning – towards a better understanding of who they are and how they work best. However, this has to be within the context of mentored action learning because as yet I have far too little evidence of the generalisability of my currently somewhat tenuous findings. Conceprocity in its current Lucidchart implementation is just about ready for prime-time; however, because Lucidchart is a chargeable service, I need to consider the possibility of re-implementing the entire approach as an open source project.

7.18 Some final words

The thesis which I here present is the culmination of several years of thinking and of research. It is of course incomplete and is at best just another brick in the wall. However, I feel happy that I have been able to do what I set out to do at this stage in the development of my work.

My professor of geography and urban planning at the University of Reading in the early 1970s was Sir Peter Hall, a truly inspiring teacher who died in 2014. Sir Peter advised his PhD student Carmen Hass-Klau to rewrite the final chapter of her PhD when she had answered to her own satisfaction the question:

> "'Why did you want to write this PhD and what do you really want to say after three years of work?'. So I did and in later life I quite often used this advice with my own PhD students."

The Argentinian philosopher Mario Bunge approvingly quotes his own teacher of philosophy in the preface to his treatise on philosophy (Bunge 1979):

> "The author dedicates this work to his philosophy teacher Kanenas T. Pota in gratitude for his advice: "Do your own thing. Your reward will be doing it, your punishment having done it"."

Elsewhere, Bunge quotes the same teacher:

> "Philosophy without exactness is mushy - but can be nourishing. Exactness without depth is sheer gymnastics — and boring."

Earlier in the same preface, Bunge states:

> "Now a word of apology for attempting to build a system of basic philosophy. As we are supposed to live in the age of analysis, it may well be wondered whether there is any room left, except in the cemeteries of ideas, for philosophical syntheses. The author's opinion is that analysis, though necessary, is insufficient - except of course for destruction. The ultimate goal of theoretical research, be it in philosophy, science, or mathematics, is the construction of systems, i.e. theories. Moreover those theories should be articulated into systems rather than being disjoint, let alone mutually at odds. Once we have got a system we may proceed to taking it apart. First

the tree, then the sawdust. And having attained the sawdust stage we should move on to the next, namely the building of further systems. And this for three reasons: because the world itself is systemic, because no idea can become fully clear unless it is embedded in some system or other, and because sawdust philosophy is rather boring."

I am glad that, much closer to the end of my working life than to its beginning, I have been able to write and to present a PhD thesis which gives a potentially useful partial answer to the question posed in its title. I have identified, exemplified and begun to model the three fundamental systemic concepts included in that title, those of Working Model, personal work system and personal information management systems (PIMS). My apology is to those in my entourage who have had to wait so long while I have "done my own thing", or at least (be afraid...) made a start on it.

Mark Gregory, Hull, 21/12/2016.

1. Appendix 1 How to create and maintain Conceprocity models

For reasons of space, the full version of this appendix has been moved to my website where it can be accessed via the address
http://markrogergregory.net/2016/03/31/thesis-resources/

§0 Illustrating Concepts

Concepts may be held both visually and linguistically, whence:

Mind Maps –Tony Buzan (Buzan and Buzan 1996).

Concept maps – Joseph Novak and collaborators (Novak and Cañas 2008) following David Ausubel (Ausubel 1963) and (Ausubel 2000).

Concept maps with typed concepts and relationships: LICEF (Université de Québec à Montréal UQAM) (Paquette 2010); (Basque 2013).

Concept <-> Process maps: Conceprocity: Mark Gregory (www.markrogergregory.net).

Using both the visual and the linguistic (written and spoken language) stimulates better understanding of a situation and thus better learning.

§1 Using both the Left and Right Brain

The concept of right brain and left brain thinking developed from the late 1960s research of psycho-biologist Roger W Sperry, who discovered that the human brain has two very different ways of thinking (Sperry 1975).

Right brain is visual and processes information in an intuitive and simultaneous way, looking first at the whole picture then the details.

Left brain is verbal and processes information in an analytical and sequential way, looking first at the pieces then putting them together to get the whole.

§2 Tony Buzan's Mind Maps

(Buzan and Buzan 1996)
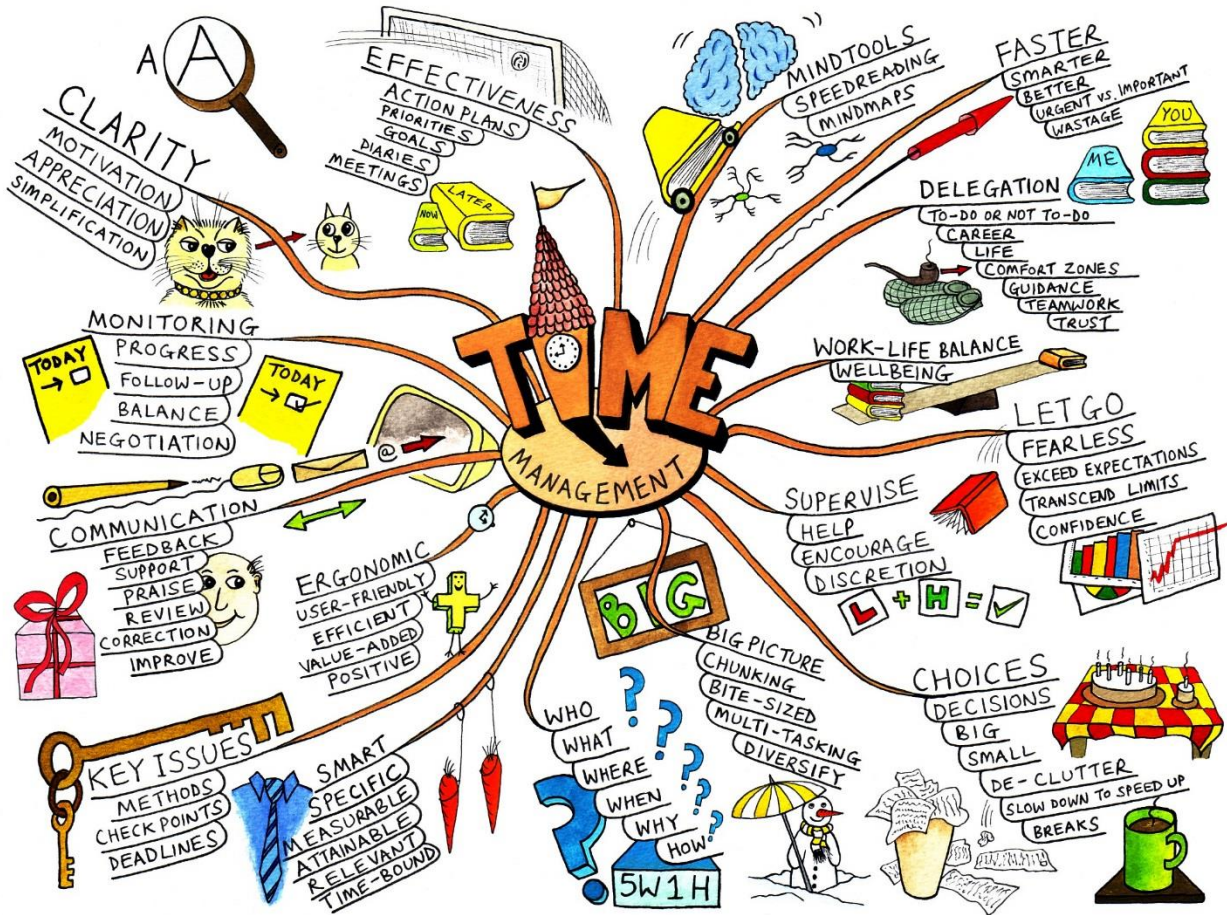
Figure 63 An example mind map

Tony Buzan's Mind Maps are highly visual. However, their insistence on a single centre is unnecessarily restrictive and their strict hierarchy prevents conceptual cross-linking *between* branches of the tree.

§3   Conceprocity: An Introduction

Conceprocity – **concept <-> process reciprocity** – is a visual and textual *language* and *toolset* intended for capturing, expressing, communicating and co-creating *models of topic areas* of domain *knowledge* by domain *experts* or *learners.*

You, as an expert or a learner in your domain, decide the *vocabulary.*

You follow what are initially very simple grammar rules as you build a *visual model* of your understanding of a topic within your domain of interest.

§4   Conceprocity: for teaching and learning

I as a *teacher* wish to:

Provide learners with *signposts to* and *syntheses of* course material – (Ausubel 1963) and (Ausubel 2000)'s "advance organisers".

www.manaraa.com

Stimulate and assist student learning as students themselves create their own concept maps.

Evaluate and *enhance* student learning.

Both students and I can use Conceprocity maps for these purposes.

§5   Conceprocity: in research practice

I as a researcher need to map concepts and their relationships in order to:

Model *personal work systems* – the subject of my research; these PWS might belong to me or to research volunteers.

Clarify and record my *understanding of complex issues* and sometimes of complex *articles* or *working documents* that I read or write.

and

To *communicate* that understanding to others.

Conceprocity aims to be a simple, relevant, easily-applicable way to represent, manage and facilitate the communication of *personal knowledge.*

§6   Conceprocity: as a contribution to research methods

I as a *researcher of personal information management* have chosen as one of my research methods *autoethnography* (Alvesson and Sköldberg 2009); (S. H. Jones 2005), which can be characterised by *structured self-observation* (Rodriguez and Ryave 2002).

One way of structuring that self-observation is to create concept maps; precisely in order to give structure to my self-observation and to that of other collaborators.

§7   Simple Conceprocity: CIAOPEA

Within Conceprocity there is a *beginners' profile* "**Simple concept mapping for beginners**", in which the only available relationship between concepts is **association** .

This simple concept mapping for beginners usage profile is called **CIAOPEA**: **C**oncepts **I**mages **A**ssociations **O**perators **P**rocedures **E**vents **A**ctors .

Strong emphasis on the use of sketches, icons and images to stimulate right brain involvement.

There are other usage profiles which are not mentioned further in the first part of this presentation.

They make use of a further notion – *principles;* and of *typed relationships* rather than associations

§8   An example Conceprocity model and how it has been created - 1

Start with a simple English sentence: "The cat sat on the mat".

Give a specific instance: "The cat called Kat sat on the mat in my lounge".

A *concrete* Conceprocity map is as right.

Identify concepts (things), any static relationships and any activities.

Create a specific and a more general model using the meta-concepts (we call them Conceprocity *notions*) of *concept*, *procedure* and *relationship.*

We firstly consider *concrete* then *abstract* representations.

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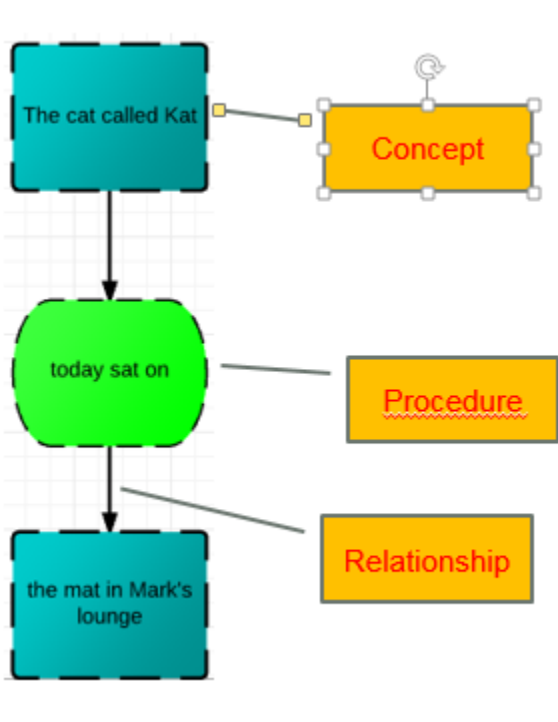
§9   An example Conceprocity model and how it has been created - 2

Observe, maybe *discuss* and then *refine* the resulting map.

Here we choose to remove the concrete and retain the abstract elements in a *conceptual model* of the general situation of creatures acting in a spatial context.

The model that results depends upon the viewpoint and the purpose of the modeller.

A cat specialist (and a cat lover!) will take a different view from an expert in cognitive science applied to animals.

But the process of dialogue and of mutual understanding can be aided by visual concept mapping and by centring the dialogue around the models.

(Concrete notions are indicated by a pecked border and a slightly darker colour whereas abstract notions have a solid border and a slightly lighter colour.)
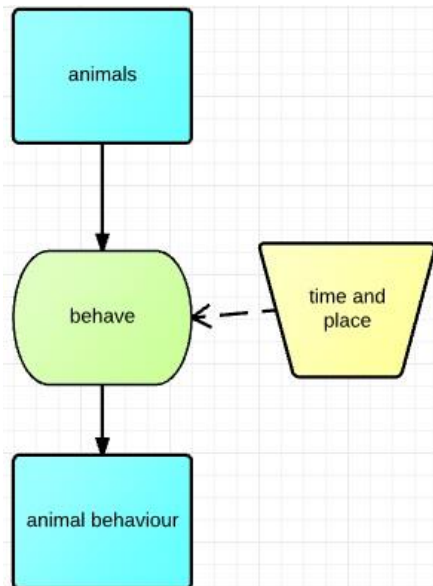
§10   Simple Conceprocity CIAOPEA: Fundamentals

Conceprocity distinguishes between *types* (classes) of objects:- following LICEF's G-MOT.

Concepts – (kinds of) things, ideas, etc.; these are usable and (sometimes) decidable *classes* of knowledge or data
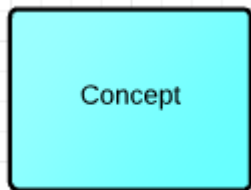
Images: images illustrate concepts or any other notion

Associations: concepts are related by relationships or relationship instances (links). In CIAOPEA the only available type of relationship is an association; this should normally be given a name and perhaps a direction - arrow
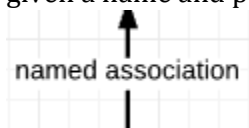
Operators: logical operators NOT, XOR, OR or AND
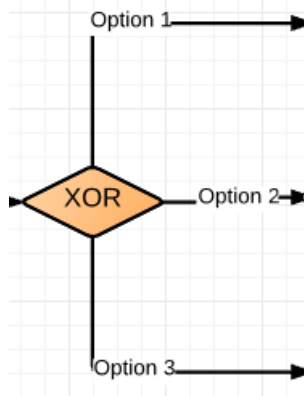
Procedures - the means of *enacting knowledge* in the form of specific *activities,* repeatable *actions* and *processes* – the latter being templates for repeated actions
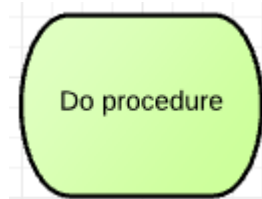
Events: EITHER occurrences in time that change the state of a class of objects OR named states of class of objects

Actors - people, organisations, external systems
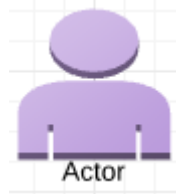
§11 Further examples and positioning
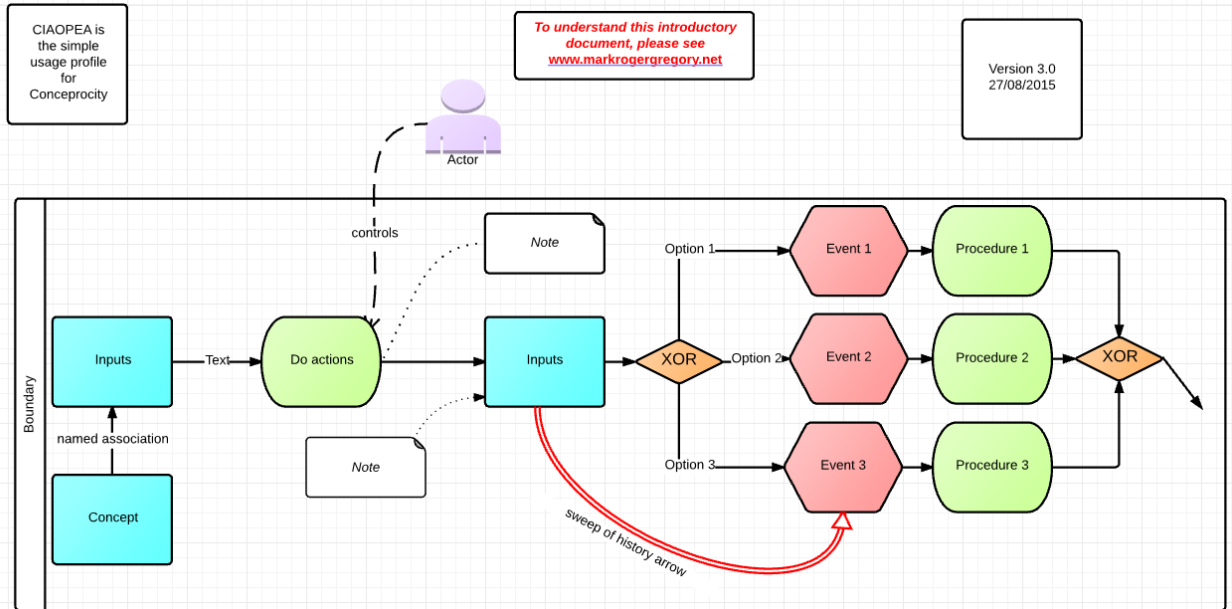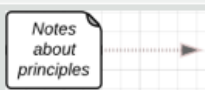
Simple Conceprocity CIAOPEA: Representation
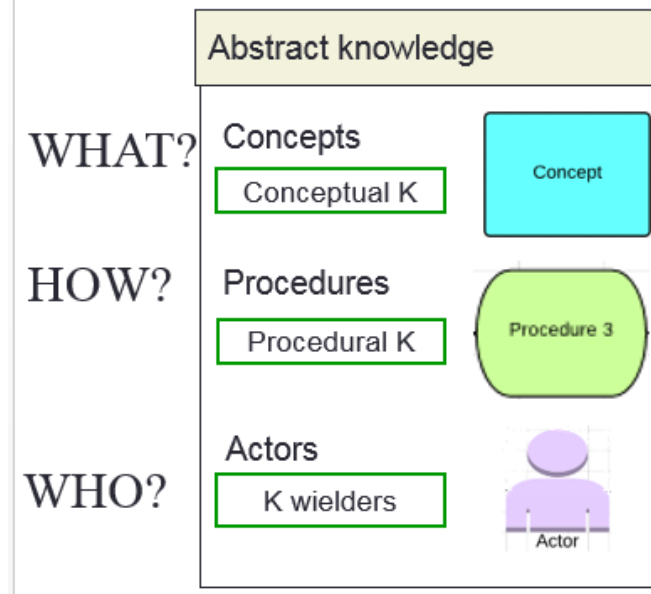
Representing Simple Conceprocity CIAOPEA relationships

Different kinds of arrow (arcs) are used:; principally the Regulates relationship, the Prompts relationship and the Instantiates relationship:

Symbol	Meaning
———————	Association between concepts. This needs a text label, such as is-a, is-composed-of, etc.
————————▶	First notion prompts the second. Flow of control or of data; precedence and consequence
············▹	Is instantiated as – between an abstract and a concrete notion
− − − −▹	Influences or regulates. An actor or principle controls or governs a concept or procedure
Notes about principles ·········▶	Commentary concerning the diagram
"sweep of history" arrow	"Sweep of history" arrows – used to indicate broad trends in a model

§12   Images: Conceprocity for the Right Brain

Conceprocity makes it easy to include visual elements. Beyond Conceprocity's own symbols, we can include images and icons.

You can either locate these for yourself, or you can use Google Images search, or you can make sketches using apps such as ArtRage. Sketches (e.g. fragments of rich pictures) can also be drawn freehand on paper and then photographed and uploaded.

Sketches – less formal diagrams – sometimes have a role, particularly in the early development or the informal presentation of a model (especially during whiteboard sessions). This is the way in which a concept process model can include and embrace rich pictures or elements of a rich picture. Rich pictures were originally introduced by Peter Checkland (Checkland 1981); see also (Avison, Golder, and Shah 1992) and (Checkland and Tsouvalis 1997). A recent application is reported by (Berg and Pooley 2012). We note that the recent widespread use of tablet computers makes it much easier to create such sketches and then to incorporate them in Conceprocity models. We note too that sketches can be created using pen and paper and then captured digitally as images: the person responsible for the sketch takes a photograph of the outcome using her smartphone or

tablet.

§13   Modelling businesses using rich pictures

Use few words.

Use lots of pictures.
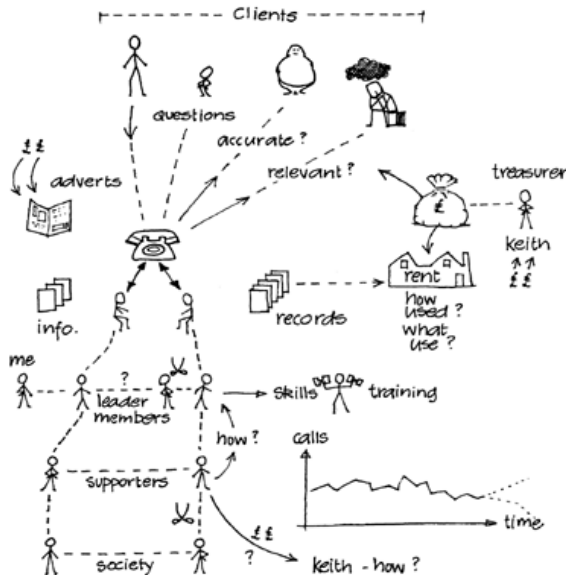
Although a Conceprocity model usually includes rich pictures as an element of a Conceprocity map, a rich picture can in fact stand alone as a Conceprocity model.

§14   Making rich pictures

Rich pictures (situation summaries) are used to depict complicated situations.

Encapsulate the real situation through a no-holds-barred, cartoon representation of layout, connections, relationships, influences, cause-and-effect etc. - *objective* notions.

Should also try to depict *subjective* elements such as character and characteristics, points of view and prejudices, spirit and human nature – since these often get eliminated far too soon in conceptual modelling.

If possible, involve the actors themselves rather than focusing on your own interpretation of the situation.

Allow *competing* pictures, and indeed complete models - don't "reconcile"; but do perhaps "accommodate"?

Prefer sketches to the reuse of images found on the Web – the former involve modellers and readers much more.

§15 Begin to build a model

- o What is the question or topic area that you are addressing?
- o What are the top five or so concepts?
- o Are there any direct relationships (associations) between these concepts?
  - ▪ E.g.: is-a-kind-of, consists-of…
- o Otherwise: what processes link or transform the concepts?
- o Make lists of likely concepts and procedures.
- o Perhaps keep these lists in a formal *Conceprocity dictionary*?
- o Sketch out an initial CIAOPEA model – on a large sheet of paper or on a whiteboard – preserve this using a smartphone picture.
- o Include rich picture elements as images on the CIAOPEA map.

§16 How to get started with a CIAOPEA model

Identify and make lists of *concepts* and their "obvious" structural *links / associations.*

Example: Kat is-instance-of cat; beech is-a-kind-of tree.

Identify procedures or *processes* which link concepts and is still validly a part of where one needs to be changed or transformed in some way which goes beyond a structural association.

farmer buys bull

cow gives-birth-to calf

(But here, better – structural - models are possible, expressed in terms of parent and child).

§17 A student tutorial example: Modelling a marketing campaign

Your task: to create a simple Conceprocity CIAOPEA model of the general principles of an e-marketing campaign.

Over to you:

Twenty minutes as separate teams.

Present, compare, contrast, reject, synthesise for five minutes.

Tell / show us your tentative conclusions on the flipboard.

§18   Full Conceprocity: TROPICPEA

TROPICPEA: **T**yped-**R**elationships **O**perators **P**rinciples **I**mages **C**oncepts **P**rocedures **E**vents **A**ctors*.*

More emphasis on principles and on events.

Associations are clarified as *fully typed relationships.*

Examples: a wing *is-part-of* aircraft.

Follows and extends LICEF G-MOT.

Intended for use by more experienced modellers or by learners who have access to a skilled mentor.

You are advised to start with CIAOPEA and perhaps progress to TROPICPEA.

§19   Full Conceprocity TROPICPEA fundamentals
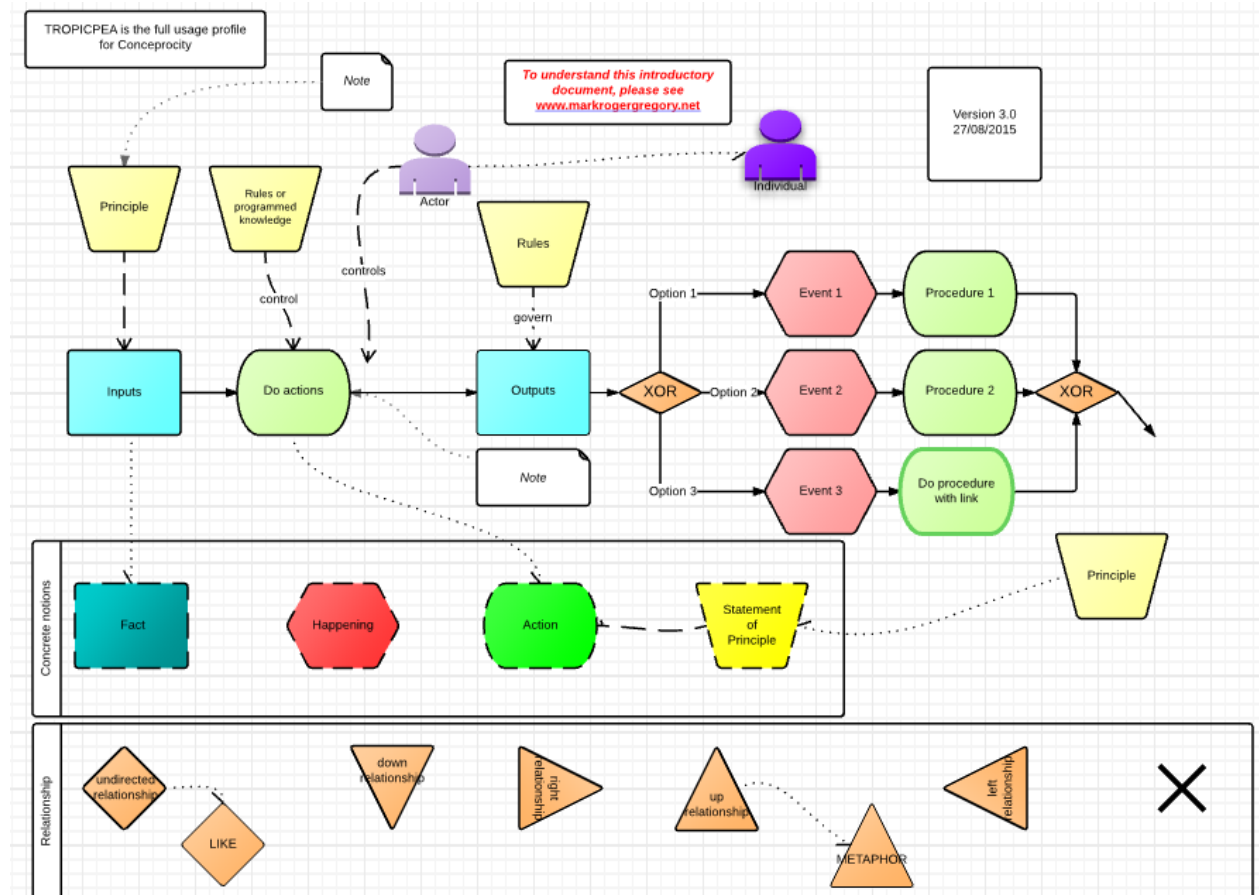
The remainder of this appendix is to be found at:
https://markrogergregory.net/conceprocity-version-3-0-2016/

2. Appendix 2 Conceprocity's special relationships

Conceprocity 3.0 introduces generalized relationship symbols which can be marked with text and/or icon. There are two generalised relationship symbols, one directional, the other not. They look like this:
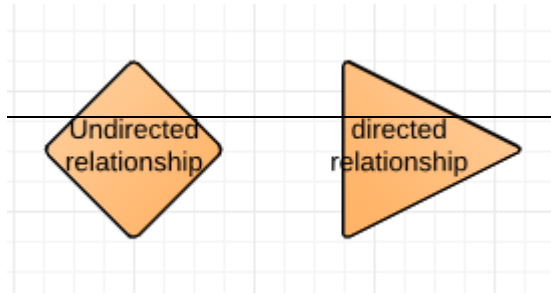
Figure 64 Undirected and directed generalised relationship symbols

Table 31 Semantic relations
Source: (Miller 1995) with extensions)

Semantic relation	Syntactic category	Examples	Commentary	Direction	Relation name	Conceprocity
Synonymy (similar)	N, V, Aj, Av	Pipe, tube	A word or phrase with a meaning that is the same as, or very similar[12] to, another word or phrase.	Non-directional	synonym_of	◆ synonym
		Rise, ascend				Similarity is probably too imprecise a term to use in the context of conceptual
		Sad, unhappy				

[12] We are aware that the notion of similarity is difficult because similarity can occur in a number of different and sometimes conflicting ways. "Very similar" is an attempt to get round these undoubted difficulties. (Vervaeke and Green 1997, 70) remind us that "similarity is vacuous as an explanatory concept

Semantic relation	Syntactic category	Examples	Commentary	Direction	Relation name	Conceprocity
		Rapidly, speedily	Synonymy is WordNet's basic relation, because WordNet uses sets of synonyms (synsets) to represent word senses. Synonymy (syn same, onyma name) is a etric relation between word forms.			modelling. It is necessary to ask: similar in what terms? Allowed, but must be made specific.
Antonymy (opposite)	Aj, Av, (N, V)	Wet, dry	A word which has the opposite meaning to another. Antonymy (opposing-name) is also a symmetric semantic relation between word forms, especially important in organizing the meanings of adjectives and adverbs.	Non-directional	antonym_of	◆ antonym Antonymy is probably as difficult to make precise as similarity. Allowed, but must be made specific.
		Powerful, powerless				
		Friendly, unfriendly				
		Rapidly, slowly				
Hypernymy (super-ordinate)	N	Ship, catamaran	A superordinate grouping word or phrase which includes subordinate terms. Hypernymy (super-name) and its inverse, hyponymy (sub-name)), are transitive relations between synsets. Because there is usually only one hypernym, this	Transitive - directional	hypernym_of	Concept aggregation

because any two objects are similar in infinitely many different ways. What causes our general agreement on the relative similarity of objects is more strongly a function of the inherent structure of our cognitive mechanisms, which more or less automatically select those dimensions along which objects are compared. That is, it is an effect of categorization, not its cause."

Semantic relation	Syntactic category	Examples	Commentary	Direction	Relation name	Conceprocity
			semantic relation organizes the meanings of nouns into a hierarchical structure.			
Hyponymy (subordinate)	N	Sugar maple, maple	A more specific term; a subordinate grouping word or phrase. Hyponymy (sub-name) and its inverse, hypernymy (super-name), are transitive relations between synsets. Because there is usually only one hypernym, this semantic relation organizes the meanings of nouns into a hierarchical structure.	Transitive - directional	hyponym_ of	Concept aggregation
		Maple, tree				
		Tree, plant				
Holonymy (part)	N	Brim, hat	In relation to a given term, a term—word or phrase—that denotes a whole whose part is denoted by the other term, such as "face" in relation to "eye". Holonymy (whole-name) and its inverse, meronymy (part-name), are complex semantic relations.	Transitive - directional	holonym_of	Concept composition
Meronymy (part)	N	Brim, hat	A term that denotes a part of the whole that is denoted by another term. Meronymy (part-name) and its inverse, holonymy (whole-name), are complex semantic relations. WordNet distinguishes component parts, substantive parts, and member parts.	Transitive - directional	meronym_ of	Concept composition
		Gin, Martini				
		Ship, Fleet				

Semantic relation	Syntactic category	Examples	Commentary	Direction	Relation name	Conceprocity
Troponymy (manner)	V	March, walk	Troponymy (manner-name) is for verbs what hyponymy is for nouns, although the resulting hierarchies are much shallower.	Transitive - directional	troponym_ of	Procedure composition: sub-procedures
		Whisper, speak				
Entailment	V	Drive, ride	Entailment relations between verbs are also coded in WordNet.	Transitive – directional	entails	Event – procedure linked by prompts relationship
		Divorce, marry				
Analogy	N, V, Aj, Av		The use of a similar example or model to explain or to extrapolate from. Analogy (from Greek ἀναλογία, analogia, "proportion") is a cognitive process of transferring information or meaning from a particular subject (the analogue or source) to another particular subject (the target), or a linguistic expression corresponding to such a process. In a narrower sense, analogy is an inference or an argument from one particular to another particular, as opposed to deduction, induction, and abduction, where at least one of the premises or the conclusion is general. In Conceprocity, at least one side of such an analogy	Transitive - directional	analogous_ to	→ analogy

Semantic relation	Syntactic category	Examples	Commentary	Direction	Relation name	Conceprocity
			relationship must be an instance and not a class.			
Metaphor		"All the world's a stage, And all the men and women merely players; They have their exits and their entrances…"	A metaphor is a form of analogy which states that A is B or substitutes B for A. It is a figure of speech that identifies one thing as being the same as some unrelated other thing, thus strongly implying the similarities between the two.	Transitive - directional	metaphor_ for	→ METAPHOR
Simile			A figure of speech that directly compares two things through the explicit use of connecting words (such as *like, as, so, than,* or various verbs such as *resemble*). A simile is a form of analogy which states that A is like B. It is less strong than metaphor.	Non-directional	simile_for	◆ LIKE
Homonym	N, V, Aj, Av		A word that both sounds and is spelled the same as another word but has a different meaning.	Non-directional	homonym_ for	◆ UNLIKE

Semantic relation	Syntactic category	Examples	Commentary	Direction	Relation name	Conceprocity
Metonym	N, V, Aj, Av	"Hollywood" is used as a metonym for the U.S. film industry	A word that names an object from a single characteristic of it or of a closely related object. It is a figure of speech in which a thing or concept is called not by its own name but rather by the name of something associated in meaning with that thing or concept. The words "metonymy" and "metonym" come from the Greek: μετωνυμία, *metōnymía*, "a change of name", from μετά, *metá*, "after, beyond" and -ωνυμία, *-ōnymía*, a suffix used to name figures of speech, from ὄνομα, *ónoma*, "name".	Non-directional	metonym_for	◆ METONYM
Ambiguity	N, V, Aj, Av		Something liable to more than one interpretation, explanation or meaning, if that meaning etc. cannot be determined from its context.	Non-directional	Ambiguity	◆ RESOLVES Or: If there is ambiguity, then this is the occasion for the modeller to make clear similarities and distinctions.
Note: N = nouns, Aj = adjectives, V						

Semantic relation	Syntactic category	Examples	Commentary	Direction	Relation name	Conceprocity
= verbs, Av = adverbs						
Super-venience			An ontological relation that is used to describe cases where the lower-level properties of a system determine its higher level properties	Transitive - directional	supervenes_on	None. The notion is inadmissible (Bunge 2004b). Model by means of feedback via environment.
Resemblance			"In the tropology of classical rhetoric, the place assigned to metaphor among the figures of signification is defined specifically by the role that the relationship of resemblance has in the transference from initial idea to new idea. Metaphor is the trope of resemblance *par excellence.*" (Ricoeur [1986] 2004, 205).			

3.   References

Ackoff, Russell L. 1971. 'Towards a System of Systems Concepts'. *Management Science* 17 (11): 661–71.

———. 1987. *The Art of Problem Solving: Accompanied by Ackoff's Fables*. Wiley.

———. 1994. 'Systems Thinking and Thinking Systems'. *System Dynamics Review* 10 (2–3): 175–188.

———. 1997. 'Systems, Messes and Interactive Planning'. *The Societal Engagement of Social Science* 3: 417–438.

———. 1999. 'On Learning and the Systems That Facilitate It'. *Reflections: The SoL Journal* 1 (1): 14–24.

Ackoff, Russell L., Shiv K. Gupta, and J. Sayer Minas. 1962. *Scientific Method: Optimizing Applied Research Decisions*. Vol. 41. Wiley New York.

Aftab, Cheung, Thakkar, and Yeddanapudi. 2001. 'Information Theory and the Digital Age'. http://mit.edu/6.933/www/Fall2001/Shannon2.pdf.

Ågerfalk, Pär J., Göran Goldkuhl, B. Fitzgerald, and L. Bannon. 2006. 'Reflecting on Action in Language, Organisations and Information Systems'. *European Journal of Information Systems* 15 (1): 4–8.

Agnihotri, R., and M.D. Troutt. 2009. 'The Effective Use of Technology in Personal Knowledge Management: A Framework of Skills, Tools and User Context'. *Online Information Review* 33 (2): 329–342.

Alavi, M., and Dorothy E. Leidner. 2001. 'Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues'. *MIS Quarterly* 25 (1): 107–136.

Allen, David. 2003. *Getting Things Done: The Art of Stress-Free Productivity*. Penguin Books.

Allen, David K., Andrew Brown, Stan Karanasios, and Alistair Norman. 2013. 'How Should Technology-Mediated Organizational Change Be Explained? A Comparison of the Contributions of Critical Realism and Activity Theory'. *MIS Q.* 37 (3): 835–854.

Alter, Steven. 1999. 'A General, yet Useful Theory of Information Systems'. *Communications of the AIS* 1 (3es): 3.

———. 2002a. *Information Systems: Foundation of E-Business, 4/e*. 4th ed. Pearson Education.

———. 2002b. 'The Work System Method for Understanding Information Systems and Information System Research'. *Communications of the Association for Information Systems (Volume 9, 2002)* 90 (104): 104.

———. 2003a. '18 Reasons Why IT-Reliant Work Systems Should Replace "the IT Artefact" as the Core Subject Matter of the IS Field.' *Communications of AIS* 2003 (12): 365–94. https://doi.org/Article.

———. 2003b. 'Sidestepping the IT Artefact, Scrapping the IS Silo, and Laying Claim to "Systems in Organisations".' *Communications of AIS* 2003 (12): 494–526. https://doi.org/Article.

———. 2006. *The Work System Method: Connecting People, Processes, and IT for Business Results*. Work System Press.

———. 2008. 'Defining Information Systems as Work Systems: Implications for the IS Field'. *European Journal of Information Systems* 17 (5): 448–469.

———. 2010. 'Work System Concepts as the Core for Teaching Information Systems and Operations Management'. *AMCIS 2010 Proceedings*, 533.

Alvesson, Mats, and Jörgen Sandberg. 2011. 'Generating Research Questions through Problematization'. *The Academy of Management Review (AMR)* 36 (2): 247–271.

Alvesson, Mats, and K. Sköldberg. 2009. *Reflexive Methodology: New Vistas for Qualitative Research*. Sage Publications Ltd.

Anscombe, Gertrude Elizabeth Margaret. 1957. *Intention*. Harvard University Press.

Apshvalka, Dace, and Peter Wendorff. 2005. *A Framework of Personal Knowledge Management in the Context of Organisational Knowledge Management*. ECKM 2005. http://integrative-paradigm.org/papers/Eckm2005Dace_156.pdf.

Archer, Bruce. 1979. 'Design as a Discipline'. *Design Studies* 1 (1): 17–20.

Archer, Margaret S. 1982. 'Morphogenesis versus Structuration: On Combining Structure and Action'. *The British Journal of Sociology* 33 (4): 455–83. https://doi.org/10.2307/589357.

———. 1995. *Realist Social Theory: The Morphogenetic Approach*. Cambridge Univ Pr.

———. 2007. 'The Trajectory of the Morphogenetic Approach'. *Sociologia, Problemas e Práticas*, no. 54: 35–47.

———. 2010. 'Routine, Reflexivity, and Realism*'. *Sociological Theory* 28 (3): 272–303.

———. 2014. 'The Morphogenetic Approach'. presented at the A dialogue between critical realism and phenomenology in educational and pedagogical research, June 14. http://blogs.heacademy.ac.uk/social-sciences/2014/06/16/a-dialogue-between-critical-realism-and-phenomenology-in-educational-and-pedagogical-research/.

Archer, Margaret S., Roy Bhaskar, Andrew Collier, Tony Lawson, and Alan Norrie. 1998. *Critical Realism: Essential Readings*. Routledge.

Argyris, Chris. 1980. *Inner Contradictions of Rigorous Research*. Academic Press New York. http://www.getcited.org/pub/102064037.

———. 1982. *Reasoning, Learning, and Action*. Jossey-Bass.

———. 2000. 'Double Loop Learning in Organizations'. *Classics in Management Thought*, 115–25.

Argyris, Chris, and Donald A. Schön. 1974. *Theory in Practice: Increasing Professional Effectiveness*. Oxford, England.

———. 1978. *Organizational Learning: A Theory of Action Perspective*. Reading, MA: Addison Wesley.

Ashby, W. Ross. 1956. *An Introduction to Cybernetics*. Chapman & Hall London. http://pcp.vub.ac.be/books/IntroCyb.pdf.

———. 1958. 'Requisite Variety and Its Implications for the Control of Complex Systems'. *Cybernetica* 1 (2): 83–99.

———. 1962. 'Principles of the Self-Organizing System'. In *Principles of Self-Organization - Foerster, H. & Zopf, G.W., 1962. Principles of Self-Organization. In Trans. of the University of Illinois Symposium on Self-Organization*, 255–278.

Atkin, Albert. 2013. 'Peirce's Theory of Signs'. In *The Stanford Encyclopedia of Philosophy*, edited by Edward N. Zalta, Summer 2013. http://plato.stanford.edu/archives/sum2013/entries/peirce-semiotics/.

Ausubel, David P. 1963. 'The Psychology of Meaningful Verbal Learning.' http://psycnet.apa.org/psycinfo/1964-10399-000.

———. 2000. *The Acquisition and Retention of Knowledge: A Cognitive View*. Kluwer Academic Pub.

Avison, David E., P. A. Golder, and H. U. Shah. 1992. 'Towards an SSM Toolkit: Rich Picture Diagramming'. *European Journal of Information Systems* 1 (6): 397–408.

Backlund, Alexander. 2002. 'The Concept of Complexity in Organisations and Information Systems'. *Kybernetes* 31 (1): 30–43.

Barreau, Deborah K. 1995. 'Context as a Factor in Personal Information Management Systems'. *Journal of the American Society for Information Science* 46 (5): 327–339.

Barreau, Deborah K., and Bonnie A. Nardi. 1995. 'Finding and Reminding: File Organization from the Desktop'. *ACM SIGCHI Bulletin* 27 (3): 43.

Barsalou, Lawrence W. 1989. 'The Instability of Graded Structure: Implications for the Nature of Concepts'. In *Concepts and Conceptual Development: Ecological and Intellectual Factors in Categorization*, by Ulric Neisser, 101–40. 1. CUP Archive.

Baskerville, Richard L. 2011a. 'Design Theorizing Individual Information Systems.' In *PACIS*, 25. http://aisel.aisnet.org/cgi/viewcontent.cgi?article=1024&context=pacis2011.

———. 2011b. 'Individual Information Systems as a Research Arena'. *European Journal of Information Systems* 20 (3): 251–54. https://doi.org/10.1057/ejis.2011.8.

———. 2011c. 'Information Design'. *European Journal of Information Systems* 20 (4): 375–77. https://doi.org/10.1057/ejis.2011.22.

———. 2013. 'The Enterprise as the Experiential Design Platform'. In *Digital Enterprise Design and Management 2013*, edited by Pierre-Jean Benghozi, Daniel Krob, and Frantz Rowe, 9–21. Advances in Intelligent Systems and Computing 205. Springer Berlin Heidelberg.

Baskerville, Richard L., Mala Kaul, and Veda C. Storey. 2015. 'Genres of Inquiry in Design-Science Research: Justification and Evaluation of Knowledge Production'. *MIS Quarterly* 39 (3): 541–564.

Baskerville, Richard L., Kalle Lyytinen, Vallabh Sambamurthy, and Detmar Straub. 2010. 'A Response to the Design-Oriented Information Systems Research Memorandum'. *European Journal of Information Systems* 20 (1): 11–15. https://doi.org/10.1057/ejis.2010.56.

Baskerville, Richard L., and Michael D. Myers. 2015. 'Design Ethnography in Information Systems'. *Information Systems Journal* 25 (1): 23–46. https://doi.org/10.1111/isj.12055.

Baskerville, Richard L., and A. Trevor Wood-Harper. 1998. 'Diversity in Information Systems Action Research Methods'. *European Journal of Information Systems* 7 (2): 90–107.

Basque, Josianne. 2013. 'Les cartes de connaissances en pédagogie universitaire'. Université du Québec à Trois Rivières, March 27. https://oraprdnt.uqtr.uquebec.ca/pls/public/docs/FWG/GSC/Publication/1518/93/1924/1/52315/13/F2080926314_UQTR_midi_p_dago_27mars13_VFF.pdf.

Bateson, Gregory. 1972. *Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology*. University of Chicago Press.

Beer, Stafford. 1966. *Decision and Control*. Chichester: Wiley.

———. 1999. 'On the Nature of Models: Let Us Now Praise Famous Men and Women, from Warren McCulloch to Candace Pert.' *InformingSciJ* 2: 69–82.

Benbasat, Izak, and Robert W. Zmud. 2003. 'The Identity Crisis within the IS Discipline: Defining and Communicating the Discipline's Core Properties'. *MIS Quarterly* 27 (2): 183–194.

Bennedsen, Jens, and Michael E. Caspersen. 2008. 'Abstraction Ability as an Indicator of Success for Learning Computing Science?' In *Proceeding of the Fourth International Workshop on Computing Education Research*, 15–26.

Bennett, Simon, Ray Farmer, and Stave McRobb. 2010. *Object-Oriented Systems Analysis and Design Using UML*. McGraw-Hill Education.

Berg, Tessa, and R. J. Pooley. 2012. 'Rich Pictures: A Valuable Means to Explore Complex IS Issues'. *UK Academy for Information Systems Conference Proceedings 2012*, March. http://aisel.aisnet.org/ukais2012/1.

Berger, P., and T. Luckmann. 1967. *The Social Construction of Reality: A Treatise in the Sociology of Knowledge*. Anchor.

Bergman, Ofer, Ruth Beyth-Marom, and Rafi Nachmias. 2003. 'The User-Subjective Approach to Personal Information Management Systems Design: Evidence and Implementations'. *Journal of the American Society for Information Science and Technology* 59 (2): 235–246.

Bergman, Ofer, Ruth Beyth-Marom, Rafi Nachmias, and Steve Whittaker. 2008. 'The User-Subjective Approach: A New Direction for PIM Systems Design'. In *Third International CHI Workshop on Personal Information Management (PIM'08), Florence, Italy. Retrieved*.

Bergman, Ofer, Richard Boardman, Jacek Gwizdka, and William P. Jones. 2004. 'Personal Information Management'. In *CHI'04 Extended Abstracts on Human Factors in Computing Systems*, 1599.

Beynon-Davies, Paul, I. Owens, and M. D Williams. 2004. 'Information Systems Evaluation and the Information Systems Development Process'. *Journal of Enterprise Information Management* 17 (4): 276–282.

Bhaskar, Roy. 1975. *A Realist Theory of Science*. Sussex: Harvester Press.

———. 1978. *The Possibility of Naturalism: A Philosophical Critique of the Contemporary Human Sciences*. Routledge.

———. 1989. *Reclaiming Reality: A Critical Introduction to Contemporary Philosophy*. Taylor & Francis.

———. (1986) 2009. *Scientific Realism and Human Emancipation*. 2nd ed. Routledge.

Biehl, M., H. Kim, and M. Wade. 2006. 'Relationships among the Academic Business Disciplines: A Multi-Method Citation Analysis'. *Omega* 34 (4): 359–371.

Boardman, Richard. 2004. 'Improving Tool Support for Personal Information Management'. London: Imperial College: Dept. of Electronic and Electrical Engineering.

Boardman, Richard, and M. A Sasse. 2004. 'Stuff Goes into the Computer and Doesn't Come out: A Cross-Tool Study of Personal Information Management'. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 590.

Boisot, Max, and Agustí Canals. 2004. 'Data, Information and Knowledge: Have We Got It Right?' *Journal of Evolutionary Economics* 14 (1): 43–67.

Boje, D., and J. A Tyler. 2009. 'Story and Narrative Noticing: Workaholism Autoethnographies'. *Journal of Business Ethics* 84: 173–194.

Booch, Grady, Robert A. Maksimchuk, Michael W. Engle, Bobbi J. Young, Jim Conallen, and Kelli A. Houston. 2007. *Object Oriented Analysis & Design with Applications*. 3rd ed. Pearson Education.

Booch, Grady, James Rumbaugh, and Ivar Jacobson. 2005. *Unified Modeling Language User Guide, The (2nd Edition) (Addison-Wesley Object Technology Series)*. Addison-Wesley Professional.

Bostrom, R. P, and J. S Heinen. 1977. 'MIS Problems and Failures: A Socio-Technical Perspective. Part I: The Causes'. *MIS Quarterly*, 17–32.

Boud, D., R. Keogh, and D. Walker. 1985. 'Promoting Reflection in Learning: A Model'. *Reflection: Turning Experience into Learning*, 18–40.

Boyles, Deron R. 2006. 'Dewey's Epistemology: An Argument for Warranted Assertions, Knowing, and Meaningful Classroom Practice'. *Educational Theory* 56 (1): 57–68.

Boyne, Steven. 2009. 'The PhD Literature Review: Its Structure and Contribution'. In *Proceedings of the Plymouth Postgraduate Symposium 2009*. Plymouth, UK.

Bozeman, B., and M. K Feeney. 2007. 'Toward a Useful Theory of Mentoring: A Conceptual Analysis and Critique.' *Administration & Society* 39 (6): 719–39.

Brown, John Seeley, A. Collins, and P. Duguid. 1989. 'Situated Cognition and the Culture of Learning'. *Educational Researcher* 18 (1): 32.

Bruning, R. H, G. J Schraw, and R. R Ronning. 1999. *Cognitive Psychology and Instruction*. Prentice Hall PTR Upper Saddle River, NJ, USA.

Buckley, W. F. 1968. *Modern Systems Research for the Behavioral Scientist: A Sourcebook*. Aldine.

Bunge, Mario Augusto. 1967. *Scientific Research II: The Search for Truth*. Springer Science & Business Media.

———. 1977. *Treatise on Basic Philosophy: Volume 3: Ontology 1: The Furniture of the World*. Vol. 3. Dordrecht: Reidel.

———. 1979. *Treatise on Basic Philosophy. Volume 4: Ontology II: A World of Systems*. Vol. 4. Dordrecht: Reidel.

———. 2003. *Emergence and Convergence: Qualitative Novelty and the Unity of Knowledge*. University of Toronto Press.

———. 2004a. 'How Does It Work?: The Search for Explanatory Mechanisms'. *Philosophy of the Social Sciences* 34 (2): 182–210. https://doi.org/10.1177/0048393103262550.

———. 2004b. 'Clarifying Some Misunderstandings about Social Systems and Their Mechanisms'. *Philosophy of the Social Sciences* 34 (3): 371–81. https://doi.org/10.1177/0048393104266860.

Burnett, Margaret M., J. Atwood, R. Walpole Djang, J. Reichwein, H. Gottfried, and S. Yang. 2001. 'Forms/3: A First-Order Visual Language to Explore the Boundaries of the Spreadsheet Paradigm'. *Journal of Functional Programming* 11 (02): 155–206.

Burnett, Margaret M., C. Cook, O. Pendse, G. Rothermel, J. Summet, and C. Wallace. 2003. 'End-User Software Engineering with Assertions in the Spreadsheet Paradigm'. In *Proceedings of the 25th International Conference on Software Engineering*, 103.

Burrell, Gibson, and Gareth Morgan. 1979. *Sociological Paradigms and Organisational Analysis*. Vol. 248. London: Heinemann.

Bush, Vannevar. 1945. 'As We May Think'. *Atlantic Monthly*, 1945.

Buzan, Tony, and Barry Buzan. 1996. *The Mind Map Book: How to Use Radiant Thinking to Maximize Your Brain's Untapped Potential*. Plume Books.

Bygstad, Bendik, Bjørn Erik Munkvold, and Olga Volkoff. 2016. 'Identifying Generative Mechanisms through Affordances: A Framework for Critical Realist Data Analysis'. *Journal of Information Technology* 31 (1): 83–96. https://doi.org/10.1057/jit.2015.13.

Campos, Daniel G. 2011. 'On the Distinction between Peirce's Abduction and Lipton's Inference to the Best Explanation'. *Synthese* 180 (3): 419–42.

Cañas, Alberto J., and Joseph D. Novak. 2006. 'Re-Examining the Foundations for Effective Use of Concept Maps'. In *Concept Maps: Theory, Methodology, Technology. Proceedings of the Second International Conference on Concept Mapping*, 1:494–502.

Capurro, R., and Birger Hjørland. 2003. 'The Concept of Information'. *Annual Review of Information Science and Technology* 37 (1): 343–411.

Carlsson, Sven A. 2006. 'Design Science Research in Information Systems: A Critical Realist Perspective'. *ACIS 2006 Proceedings*, 40.

———. 2010. 'Design Science Research in Information Systems: A Critical Realist Approach'. In *Design Research in Information Systems*, edited by Alan R. Hevner and Samir Chatterjee, 209–33. Integrated Series in Information Systems 22. Springer US.

Caspi, Eylon, A.J. Shankar, and Jingtaow Wang. 2004. 'Vannevar Bush: "As We May Think" -- CS294-6 Reading The Classics 9/21/04'.

Catarci, Tiziana, Luna Dong, Alon Halevy, and Antonella Poggi. 2007. 'Structure Everything'. In *In : Jones, W.P. & Teevan, J., 2007. Personal Information Management., University of Washington Press.*, 108–26.

Chandler, Daniel. 2007. *Semiotics: The Basics*. 2 edition. London ; New York: Routledge.

———. 2014. 'Semiotics for Beginners'. 2014. http://visual-memory.co.uk/daniel/Documents/S4B/sem02.html.

Chandrasekaran, B., J. R. Josephson, and V. R. Benjamins. 1999. 'What Are Ontologies, and Why Do We Need Them?' *IEEE Intelligent Systems and Their Applications* 14 (1): 20–26.

Checkland, Peter. 1981. *Systems Thinking, Systems Practice*. Chichester: Wiley.

———. 2000. 'Soft Systems Methodology: A Thirty Year Retrospective'. *Syst. Res* 17: S11–S58.

———. 2012. 'Four Conditions for Serious Systems Thinking and Action'. *Systems Research and Behavioral Science* 29 (5): 465–469.

Checkland, Peter, and L. Davies. 1986. 'The Use of the Term Weltanschauung in Soft Systems Methodology'. *Journal of Applied Systems Analysis* 13 (2): 109–115.

Checkland, Peter, and Sue Holwell. 1998a. 'Action Research: Its Nature and Validity'. *Systemic Practice and Action Research* 11 (1): 9–21.

———. 1998b. *Information, Systems and Information Systems: Making Sense of the Field*. J. Wiley.

———. 2005. 'Data, Capta, Information and Knowledge'. In *Introducing Information Management: The Business Approach*, edited by Matthew Hinton, 47–55. Butterworth-Heinemann.

Checkland, Peter, and John Poulter. 2006. *Learning for Action: A Short Definitive Account of Soft Systems Methodology, and Its Use Practitioners, Teachers and Students*. John Wiley & Sons.

Checkland, Peter, and J. Scholes. 1990. *Soft Systems Methodology in Action*. Chichester, Wiley.

Checkland, Peter, and Costas Tsouvalis. 1997. 'Reflecting on SSM: The Link Between Root Definitions and Conceptual Models'. *Syst. Res. Behav. Sci.* 14 (3): 153–168.

Chen, Peter Pin-Shan. 1976. 'The Entity-Relationship Model—toward a Unified View of Data'. *ACM Transactions on Database Systems (TODS)* 1 (1): 36.

———. 1977. 'The Entity-Relationship Model: A Basis for the Enterprise View of Data'. In *Proceedings of the June 13-16, 1977, National Computer Conference*, 77–84.

Cheng, Peter CH, and Herbert A. Simon. 1995. 'Scientific Discovery and Creative Reasoning with Diagrams'. *The Creative Cognition Approach*, 205–228.

Cherbakov, L., A. J. F. Bravery, and Aroop Pandya. 2008. 'SOA Meets Situational Applications, Part 1: Changing Computing in the Enterprise'. IBM DeveloperWorks. 2008. http://www.ibm.com/developerworks/webservices/library/ws-soa-situational1/.

Chua, Wai Fong. 1986. 'Radical Developments in Accounting Thought'. *Accounting Review*, 601–632.

Church, Alonzo. 1940. 'A Formulation of the Simple Theory of Types'. *The Journal of Symbolic Logic* 5 (2): 56–68. https://doi.org/10.2307/2266170.

Churchman, C. West. 1968. 'The Systems Approach'. *Delta, NY.*

———. 1971. *The Design of Inquiring Systems: Basic Concepts of Systems and Organization.* Basic Books New York.

———. 1979. *The Systems Approach and Its Enemies.* Basic Books, New York.

Ciborra, Claudio U. 1992. 'From Thinking to Tinkering: The Grassroots of Strategic Information Systems'. *The Information Society* 8 (4): 297–309.

Ciborra, Claudio U., and Tawfik Jelassi. 1994. *Strategic Information Systems: A European Perspective.*

Clancey, William J. 1997. *Situated Cognition: On Human Knowledge and Computer Representations.* Cambridge, U.K. ; New York, NY, USA: Cambridge University Press.

Clocksin, W. F., and C. S. Mellish. 1981. *Programming in Prolog.* Springer-Verlag.

Coase, R. H. 1937. 'The Nature of the Firm'. *Economica* 4 (16): 386–405.

Codd, Edgar F. 1970. 'A Relational Model of Data for Large Shared Data Banks'. *Communications of the ACM* 13 (6): 387.

———. 1971. 'Normalized Data Base Structure: A Brief Tutorial'. In *Proceedings of the 1971 ACM SIGFIDET (Now SIGMOD) Workshop on Data Description, Access and Control*, 1–17.

———. 1982. 'Relational Database: A Practical Foundation for Productivity'. *Communications of the ACM* 25 (2): 109–117.

Collier, Andrew. 1994. *Critical Realism: An Introduction to the Philosophy of Roy Bhaskar.* London: Verso.

Conant, Roger C., and W. Ross Ashby. 1970. 'Every Good Regulator of a System Must Be a Model of That System'. *International Journal of Systems Science* 1 (2): 89–97.

Craik, Kenneth James Williams. 1967. *The Nature of Explanation.* CUP Archive. https://books.google.com/books?hl=en&lr=&id=wT04AAAAIAAJ&oi=fnd&pg=PA1&dq=craik+nature+explanation&ots=06w-OsjRw3&sig=ZwmtTM9uOL64JehVAVNCTI0r2a4.

Croasdell, David T., Lee A. Freeman, and Andrew Urbaczewski. 2003. 'Concept Maps for Teaching and Assessment.' *Communications of AIS* 12: 396–405.

Cross, Nigel. 2001. 'Design/Science/Research: Developing a Discipline'. In *Fifth Asian Design Conference: International Symposium on Design Science, Su Jeong Dang Printing Company, Seoul, Korea.* http://web.science.mq.edu.au/~isvr/Documents/pdf%20files/presence-design-philosophy/DesignScienceResearch.pdf.

———. 2007. 'Forty Years of Design Research'. *Design Studies* 28 (1): 1–4. https://doi.org/10.1016/j.destud.2006.11.004.

Crotty, M. 1998. *The Foundations of Social Research: Meaning and Perspective in the Research Process.* Sage Publications Ltd.

Crowston, K., B. Fitzgerald, P. Gloor, U. Schultze, and Y. Yoo. 2010. 'Shifting Boundaries: How Should IS Researchers Study Non-Organizational Uses of ICT?' *Proceedings of the International Conference on Information Systems ICIS 2010, Saint Louis, Missouri.*

Date, Chris J. 2003. *An Introduction to Database Systems*. 8th ed. Addison Wesley.

Davenport, Thomas H., and L. Prusak. 1998. *Working Knowledge: How Organizations Manage What They Know*. Harvard Business Press.

Davies, J., R. Studer, and P. Warren. 2006. *Semantic Web Technologies*. John Wiley & Sons.

Davies, S., J. Velez-Morales, and R. King. 2005. 'Building the Memex Sixty Years Later: Trends and Directions in Personal Knowledge Bases'.

Davis, E. 2001. 'Knowledge Representation'. In *International Encyclopedia of the Social & Behavioral Sciences*, edited by Neil J. Smelser and Paul B. Baltes, 11:8132–39. Elsevier Amsterdam/New York, NY. http://www.law.harvard.edu/faculty/shavell/pdf/12_Inter_Ency_Soc_8446.pdf.

Davis, F. D. 1989. 'Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology'. *MIS Quarterly* 13 (3): 319–340.

De Geus, A. P. 1988. 'Planning as Learning'. *Harvard Business Review* 66 (2): 70–74.

Deacon, John. 2005. *Object-Oriented Analysis and Design: A Pragmatic Approach*. Addison-Wesley; Pearson Education.

Denzin, Norman K., and Yvonna S. Lincoln. 2000. 'The Discipline and Practice of Qualitative Research' 2: 1–28.

———. 2005. *The SAGE Handbook of Qualitative Research*. Sage Publications.

DesAutels, P. 2011. 'UGIS: Understanding the Nature of User-Generated Information Systems'. *Business Horizons* 54 (3): 185–92.

Dewey, John. 1931. 'The Development of American Pragmatism'. In *Philosophy and Civilization*. New York: Minton, Balch & Co.

———. 1933. *How We Think (Rev. Ed.)*. Boston: DC Heath.

———. 1941. 'Propositions, Warranted Assertibility, and Truth'. *The Journal of Philosophy* 38 (7): 169.

———. 1960. *The Quest for Certainty*. Capricorn Books.

Dobson, Philip. 2002. 'Critical Realism and Information Systems Research: Why Bother with Philosophy'. *Information Research* 7 (2): 7–2.

Dobson, Philip, Denise Gengatharen, Richard Fulford, Lllandis Barrett-Pugh, Susanne Bahn, and Anne-Claire Larsen. 2012. 'Eureka Moments in Research: Exploring Abductive Processes Using Four Case Examples'. In *ACIS 2012: Location, Location, Location: Proceedings of the 23rd Australasian Conference on Information Systems 2012*, 1–9. ACIS. http://dro.deakin.edu.au/view/DU:30049133.

Doyle, John Comstock, Bruce A. Francis, and Allen R. Tannenbaum. 1992. *Feedback Control Theory*. Vol. 1. Macmillan Publishing Company New York.

Drucker, Peter Ferdinand. 1994. *Post-Capitalist Society*. Oxford: Butterworth-Heinemann.

———. 1999. 'Knowledge-Worker Productivity: The Biggest Challenge'. *The Knowledge Management Yearbook 2000–2001*.

Drupal. 2010. 'Drupal: Drupal.Org'. 2010. http://drupal.org/.

Ecco. 1997. 'Ecco_pro : Ecco Pro Software :: Support & Extension'. 2010 1997. http://tech.groups.yahoo.com/group/ecco_pro/.

Ellis, Carolyn. 1997. 'Evocative Autoethnography: Writing Emotionally about Our Lives'. In *Tierney, W.G. & Lincoln, Y.S., 1997: Representation and the Text: Re-Framing the Narrative Voice.*, 115–139.

———. 2002. 'Take No Chances'. *Qualitative Inquiry* 8 (2): 170–75.

Elsweiler, D. 2008. 'Supporting Human Memory in Personal Information Management'. In *ACM SIGIR Forum*, 42:75–76.

Elsweiler, D., and I. Ruthven. 2007. 'Towards Task-Based Personal Information Management Evaluations'. In *Proceedings of the 30th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval*, 30.

Fingar, Peter. 2009. *Dot.Cloud*. Meghan-Kiffer Press.

Finger, Matthias, and Jose Manuel Asún. 2001. *Adult Education At the Crossroads: Learning Our Way Out*. Zed Books.

Flood, Robert Louis. 1996. 'Total Systems Intervention'. *Critical Systems Thinking*, 95–115.

Flood, Robert Louis, and Norma R.A Romm. 1996. *Diversity Management: Triple Loop Learning*. Wiley Chichester.

Flood, Robert Louis, and Werner Ulrich. 1990. 'Testament to Conversations on Critical Systems Thinking between Two Systems Practitioners'. *Systemic Practice and Action Research* 3 (1): 7–29.

Floridi, Luciano. 2005. 'Is Semantic Information Meaningful Data?' *Philosophy and Phenomenological Research* 70 (2): 351–370.

Frand, Jason, and Carol Hixon. 1999. 'Personal Knowledge Management: Who, What, Why, When, Where, How?' *Working Paper, UCLA Anderson School of Management*. http://www.anderson.ucla.edu/faculty/jason.frand/researcher/speeches/PKM.htm.

Frege, Gottlob. (1892) 1948. 'Sense and Reference'. *The Philosophical Review*, 209–230.

———. 1997. 'On Sense and Meaning'. *Contemporary Analytic Philosophy* 23.

Friedman, Alon, and Richard P. Smiraglia. 2013. 'Nodes and Arcs: Concept Map, Semiotics, and Knowledge Organization'. *Journal of Documentation* 69 (1): 27–48.

Friedman, Alon, and Martin Thellefsen. 2011. 'Concept Theory and Semiotics in Knowledge Organization'. *Journal of Documentation* 67 (4): 644–74.

Georgiou, Ion. 2007. *Thinking through Systems Thinking*. Routledge London.

Gibson, James J. 1977. 'The Theory of Affordances'. *Hilldale, USA*.

Giddens, Anthony. 1986. *The Constitution of Society*. Polity Press Cambridge.

Goldstein, Jeffrey. 1999. 'Emergence as a Construct: History and Issues'. *Emergence* 1 (1): 49–72.

Goles, Tim, and Rudy Hirschheim. 2000. 'The Paradigm Is Dead, the Paradigm Is Dead... Long Live the Paradigm: The Legacy of Burrell and Morgan'. *Omega* 28 (3): 249–268.

Greca, Ileana Maria, and Marco Antonio Moreira. 2000. 'Mental Models, Conceptual Models, and Modelling'. *International Journal of Science Education* 22 (1): 1–11.

Green, Peter F., and Michael Rosemann. 2000. 'Integrated Process Modeling: An Ontological Evaluation'. *Information Systems* 25 (2): 73–87.

Greeno, James G. 1994. 'Gibson's Affordances.' *Psychological Review* 101 (2): 336–42.

Gregor, Shirley. 2006. 'The Nature of Theory in Information Systems'. *Management Information Systems Quarterly* 30 (3): 611.

Gregor, Shirley, and Alan R. Hevner. 2013. 'Positioning and Presenting Design Science Research for Maximum Impact'. *MIS Quarterly* 37 (2): 337-A6.

Gregor, Shirley, and David Jones. 2007. 'The Anatomy of a Design Theory'. *Journal of the Association for Information Systems* 8 (5): 312.

Gregory, Mark. 2010. 'Collaboration and End-User Information Management Tools.' In . Lima, Peru.

Gregory, Mark, and Irena Descubes. 2011a. 'Structured Reflection in Information Systems Teaching and Research'. In *Proceedings of the UK Academy for Information Systems Conference 2011*. Oxford, GB. http://aisel.aisnet.org/cgi/viewcontent.cgi?article=1017&context=ukais2011.

———. 2011b. 'Understanding PIMS: Personal Information Management Systems'. *Research Journal of Economics, Business and ICT* 3: 31–37.

———. 2011c. 'Structured Reflection in Information Systems Teaching and Research'. In . Oxford, England.

———. 2011d. 'Personal Knowledge Management: PIMS/IIS/UGIS - A Research in Progress'. In . Prague, CZ.

Gregory, Mark, Irena Descubes, and Petr Makovsky. 2010. 'Data, Information and Knowledge: A Candid and Pragmatic Discussion'. *Proceedings of the 4th International Conference on Advanced and Systematic Research, Zagreb, Croatia, Nov. 11th.-13th, 2010*.

Gregory, Mark, Mounir Kehal, and Irena Descubes. 2012a. 'Mentored Action Learning Applied to Personal Knowledge Management - a Research in Progress'. In *UKAIS 2012: Proceedings of the 17th Conference of the United Kingdom Academy for Information Systems, New College, Oxford, March 2012. Also Available in AISeL, the AIS Electronic Library.* Oxford, GB.

———. 2012b. 'Mentored Action Learning Applied to Personal Knowledge Management - a Research in Progress'. *UK Academy for Information Systems Conference Proceedings 2012*, March. http://aisel.aisnet.org/ukais2012/24.

Gregory, Mark, and Renaud S. R. Macgilchrist. 2014. 'A Personal Working Model'. In *UKAIS 2014: Proceedings of the 19th Conference of the United Kingdom Academy for Information Systems, St. Catherine's College, Oxford, April 2014. Available in AISeL, the AIS Electronic Library: Http://Aisel.Aisnet.Org/Ukais2014/28/*. Available at SSRN: http://ssrn.com/abstract=2439206.

Gregory, Mark, and Mario Norbis. 2008a. 'The Business of Personal Knowledge.' In . Cambridge University, United Kingdom.

———. 2008b. 'Towards a Systematic Evaluation of Personal and Small Group Information and Knowledge Management.' In . Orlando, FA.

———. 2009a. 'Auditing Personal Information Management.' In . St. Anne's College, Oxford.

———. 2009b. 'Evaluating Situational Applications Builders.' In . Orlando, FA.

Gruber, Thomas R. 1993. 'A Translation Approach to Portable Ontology Specifications'. *Knowledge Acquisition* 5: 199–199.

Grundspenkis, J. 2007. 'Agent Based Approach for Organization and Personal Knowledge Modelling: Knowledge Management Perspective'. *Journal of Intelligent Manufacturing* 18 (4): 451–457.

Guarino, Nicola. 1995. 'Formal Ontology, Conceptual Analysis and Knowledge Representation'. *International Journal of Human Computer Studies* 43 (5): 625–640.

Guarino, Nicola, and Giancarlo Guizzardi. 2006. 'In the Defense of Ontological Foundations for Conceptual Modeling'. *Scandinavian Journal of Information Systems* 18 (1): 1.

Guizzardi, Giancarlo, and Terry Halpin. 2008. 'Ontological Foundations for Conceptual Modelling'. *Applied Ontology* 3 (1/2): 1–12.

Guizzardi, Giancarlo, Claudio Masolo, and Stefano Borgo. 2006. 'In Defense of a Trope-Based Ontology for Conceptual Modeling: An Example with the Foundations of Attributes, Weak Entities and Datatypes'. In *Conceptual Modeling-ER 2006*, 112–125. Springer.

Guizzardi, Giancarlo, and Gerd Wagner. 2008. 'What's in a Relationship: An Ontological Analysis'. In *Conceptual Modeling - ER 2008*, edited by Qing Li, Stefano Spaccapietra, Eric Yu, and Antoni Olivé, 83–97. Lecture Notes in Computer Science 5231. Springer Berlin Heidelberg.

Gwizdka, Jacek, and Mark Chignell. 2007. 'PIM: Individual Differences'. In *In : Jones, W.P. & Teevan, J., 2007. Personal Information Management., University of Washington Press.*, 206–20.

Habermas, Jürgen. 1984. *The Theory of Communicative Action, Vol. I: Reason and the Rationalization of Society*. Boston MA: Beacon Press (MA).

———. 1987. *The Theory of Communicative Action, Vol II: Lifeworld and System: A Critique of Functionalist Reason*. Boston MA: Beacon Press (MA).

Hartshorne, C., P. Weiss, and A. Burks. 1931. *Collected Papers of Charles Sanders Peirce (Volumes 1-8)*. Cambridge, MA: Harvard University Press.

Herrscher, Enrique G. 2006. 'Systemics: Knowledge or Passion? (Summary of the Outgoing Presidential Speech on 1 July 2005)'. *Systems Research & Behavioral Science* 23 (5): 709–11. https://doi.org/10.1002/sres.798.

Hevner, Alan R., and Samir Chatterjee. 2010a. *Design Science Research in Information Systems*. Springer. http://link.springer.com/chapter/10.1007/978-1-4419-5653-8_2.

———. 2010b. 'Design Science Research in Information Systems'. *Design Research in Information Systems*, 9–22.

———. 2010c. *Design Research in Information Systems: Theory and Practice*. New York: Springer.

Hevner, Alan R., Salvatore T. March, Jinsoo Park, and Sudha Ram. 2004. 'Design Science in Information Systems Research'. *MIS Quarterly* 28 (1): 75–105.

Heylighen, Francis. 1992. 'Principles of Systems and Cybernetics: An Evolutionary Perspective'. *Cybernetics and Systems* 92: 3–10.

Hirschheim, Rudy, and Heinz K. Klein. 2003. 'Crisis in the IS Field? A Critical Reflection on the State of the Discipline'. *Journal of the Association for Information Systems* 4 (5): 237–293.

Hjørland, Birger. 2009. 'Concept Theory'. *Journal of the American Society for Information Science and Technology* 60 (8): 1519–1536.

Hjørland, Birger, and Jeppe Nicolaisen. 2005. 'The Epistemological Lifeboat'. *Epistemology and Philosophy of Science for Information Scientists, Available at: Www. Db. Dk/Jni/Lifeboat/Home. Htm*.

Hoare, Charles Antony Richard. 1972. 'Notes on Data Structuring'. *Structured Programming*, 83–220.

———. 1974. *Monitors: An Operating System Structuring Concept*. Springer. http://link.springer.com/chapter/10.1007/978-1-4757-3472-0_10.

Hoffmann, Michael HG. 2010. 'Diagrams as Scaffolds for Abductive Insights'. In *Workshops at the Twenty-Fourth AAAI Conference on Artificial Intelligence*. http://www.aaai.org/ocs/index.php/ws/aaaiw10/paper/download/2027/2433.

Holbrook, M. B. 2005. 'Customer Value and Autoethnography: Subjective Personal Introspection and the Meanings of a Photograph Collection'. *Journal of Business Research* 58 (1): 45–61.

Holwell, Sue. 1997. 'Soft Systems Methodology and Its Role in Information Systems'. British Library Document Supply Centre.

———. 2004. 'Themes, Iteration, and Recoverability in Action Research'. In *Information Systems Research - Relevant Theory and Informed | Bonnie Kaplan | Springer*, edited by Bonnie Kaplan, Duane P. Truex, David G. Wastell, A. Trevor Wood-Harper, and Janice I. DeGross, 353–362. http://www.springer.com/gb/book/9781402080944.

Humphreys, Michael. 2005. 'Getting Personal: Reflexivity and Autoethnographic Vignettes'. *Qualitative Inquiry* 11 (6): 840.

Hunt, Shelby D. 1990. 'Truth in Marketing Theory and Research'. *Journal of Marketing* 54 (3): 1–15.

Hwang, Yujong, William J. Kettinger, and Mun Y. Yi. 2015. 'Personal Information Management Effectiveness of Knowledge Workers: Conceptual Development and Empirical Validation'. *European Journal of Information Systems* 24 (6): 588–606.

Iivari, Juhani. 2007. 'A Paradigmatic Analysis of Information Systems as a Design Science'. *Scandinavian Journal of Information Systems* 19 (2): 5.

———. 2015. 'Distinguishing and Contrasting Two Strategies for Design Science Research'. *European Journal of Information Systems* 24 (1): 107–115.

InfoQube. 2019. 'InfoQube Information Management System'. 2019. http://www.infoqube.biz/.

Inhelder, B., and J. Piaget. 1955. *De La Logique de l'enfant à La Logique de l'adolescent: Essai Sur La Construction Des Structures Opératoires Formelles*. Presses universitaires de France.

Ison, Ray. 2013. 'Systems Thinking and Practice for Action Research'. In *The SAGE Handbook of Action Research: Participative Inquiry and Practice*, edited by Peter Reason and Hilary Bradbury. SAGE.

Jackson, Michael C. 1991. 'The Origins and Nature of Critical Systems Thinking'. *Systemic Practice and Action Research* 4 (2): 131–149.

Jacob, Elin K. 2004. 'Classification and Categorization: A Difference That Makes a Difference'. *Library Trends* 52 (3): 515–540.

Johnson, M. 2007. 'Review of "Realising Systems Thinking: Knowledge and Action in Management Science". By John Mingers. New York: Springer, 2006.' *Journal of Critical Realism* 6 (2): 312.

Johnson-Laird, Philip N. 1983. *Mental Models: Towards a Cognitive Science of Language, Inference, and Consciousness*. 6. Harvard University Press.

Jones, E., H. Bruce, P. Klasnja, and William P. Jones. 2009. 'I Give up! Five Factors That Contribute to the Abandonment of Information Management Strategies'. *Proceedings of the American Society for Information Science and Technology* 45 (1): 1–6.

Jones, Stacy Holman. 2005. 'Autoethnography: Making the Personal Political'. In *The SAGE Handbook of Qualitative Research*, edited by Norman K. Denzin and Yvonna S. Lincoln, 763–91. Sage Publications.

Jones, William P. 2007a. 'How People Keep and Organize Personal Information'. In *In : Jones, W.P. & Teevan, J., 2007. Personal Information Management., University of Washington Press.*, 35–56.

———. 2007b. *Keeping Found Things Found: The Study and Practice of Personal Information Management*. Morgan Kaufmann Pub.

———. 2012. *Future of Personal Information Management, Part 2: Transforming Technologies to Manage Our Information*. San Rafael: Morgan & Claypool.

———. 2013. *The Future of Personal Information Management, Part 1: Our Information, Always and Forever*. Morgan & Claypool Publishers.

———. 2015. *Building a Better World with Our Information: The Future of Personal Information Management, Part 3*. Morgan & Claypool Publishers.

Jones, William P., and H. Bruce. 2006. 'NSF Award#0534386 - Structuring Personal Information Collections'. 2006. http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0534386.

Jones, William P., A. J Phuwanartnurak, R. Gill, and H. Bruce. 2005. 'Don't Take My Folders Away!: Organizing Personal Information to Get Things Done'. In *CHI'05 Extended Abstracts on Human Factors in Computing Systems*, 1508.

Jones, William P., and B. Ross. 2006. 'Human Cognition and Personal Information Management'. *Handbook of Applied Cognition. Chichester: John Wiley & Sons*.

Jones, William P., and Jaime Teevan. 2007a. 'Introduction'. In *Personal Information Management.*, 3–21. University of Washington Press.

———. 2007b. *Personal Information Management.* University of Washington Press.

———. 2007c. 'Personal Information Management: Conclusion'. In *In : Jones, W.P. & Teevan, J., 2007. Personal Information Management., University of Washington Press.*, 269–75.

Karat, Clare-Marie, John Karat, and Carolyn Brodie. 2007. 'Management of Personal Information Disclosure: The Interdependence of Privacy, Security and Trust.' In *In: Jones, W.P. & Teevan, J., 2007. Personal Information Management., University of Washington Press.*, 248–60.

Karger, David R. 2007. 'Unify Everything: It's All the Same to Me'. In *In : Jones, W.P. & Teevan, J., 2007. Personal Information Management., University of Washington Press.*, 127–52.

Katifori, Akrivi, C. Vassilakis, I. Daradimos, G. Lepouras, Y. Ioannidis, Alan Dix, A. Poggi, and Tiziana Catarci. 2008. 'Personal Ontology Creation and Visualization for a Personal Interaction Management System'. In *Workshop on Personal Information Management, in CHI*.

Kelly, D. 2006. 'Evaluating Personal Information Management Behaviors and Tools'. *Communications of the ACM* 49 (1): 86.

Kelly, Diane, and Jaime Teevan. 2007. 'Understanding What Works: Evaluating PIM Tools'. In *In : Jones, W.P. & Teevan, J., 2007. Personal Information Management., University of Washington Press.*, 190–205.

Kettinger, William J., and Yuan Li. 2010. 'The Infological Equation Extended: Towards Conceptual Clarity in the Relationship between Data, Information and Knowledge'. *European Journal of Information Systems* 19 (May): 409–21.

Kintsch, W. 1998. *Comprehension: A Paradigm for Cognition*. Cambridge Univ Pr.

Klein, Heinz K., and Frantz Rowe. 2008. 'Marshaling the Professional Experience of Doctoral Students: A Contribution to the Practical Relevance Debate'. *Management Information Systems Quarterly* 32 (4): 675–686.

Kramer, J. 2007. 'Is Abstraction the Key to Computing?' *Communications of the ACM* 50 (4): 42.

Krathwohl, David R. 2002. 'A Revision of Bloom's Taxonomy: An Overview'. *Theory Into Practice* 41 (4): 212. https://doi.org/10.1207/s15430421tip4104_2.

Kuhn, Thomas S. (1962) 1996. *The Structure of Scientific Revolutions.* 3rd ed. University of Chicago press Chicago.

Lakoff, George. (1987) 1990. *Women, Fire, and Dangerous Things*. Univ. of Chicago Press.

Lakoff, George, and Mark Johnson. (1980) 2008. *Metaphors We Live By*. University of Chicago press.

Langefors, B. 1980. 'Infological Models and Information User Views'. *Information Systems* 5 (1): 17–32.

Lansdale, M. W. 1988. 'The Psychology of Personal Information Management'. *Applied Ergonomics* 19 (1): 55–66.

Ledgard, H. F, and R. W Taylor. 1977. 'Two Views of Data Abstraction'. *Communications of the ACM* 20 (6): 382–384.

Lehtovuori, Jouko. 1973. *Liiketaloustieteen Metodologista Taustaa*. Turun Kauppakorkeakoulu.

Leonard, Allenna. 2009. 'The Viable System Model and Its Application to Complex Organizations'. *Systemic Practice & Action Research* 22 (4): 223–33. https://doi.org/10.1007/s11213-009-9126-z.

Lévi-Strauss, Claude. 1966. *The Savage Mind*. University of Chicago Press.

Lewin, Kurt. 1951. 'Field Theory in Social Science: Selected Theoretical Papers (Edited by Dorwin Cartwright.)'. *Harpers*.

'Leximancer'. 2016. Leximancer. 2016. http://info.leximancer.com/.

Lindsay, P. H, and D. A Norman. 1977. *Human Information Processing: An Introduction to Psychology*. Academic Press.

Lipton, Peter. 2004. *Inference to the Best Explanation*. Psychology Press.

Lucidchart. 2016. 'Lucidchart for Education | Lucidchart'. 2016. https://www.lucidchart.com/pages/usecase/education.

Lutters, Wayne G., and Mark S. Ackerman. 2007. 'Group Information Management'. In *In : Jones, W.P. & Teevan, J., 2007. Personal Information Management., University of Washington Press.*, 236–48.

Macgilchrist, Renaud S. R. 2004. 'The Contribution of Epistemics and Heuristics to the Semantics of the Knowledge Web'. Recherche LAREMA - A.D.G., Ecole de Management de Bordeaux.

Macgilchrist, Renaud S. R., and Mark Gregory. 2019. 'Conjectures on the Morphogenesis of Meaning and Its Part in Learning'. *(Under Development)*.

Magnani, Lorenzo. 2009. 'Morphodynamical Abduction'. In *Abductive Cognition*, 417–53. Cognitive Systems Monographs 3. Springer Berlin Heidelberg. http://link.springer.com.libezproxy.open.ac.uk/chapter/10.1007/978-3-642-03631-6_8.

Maier, Jonathan RA, and Georges M. Fadel. 2009. 'Affordance Based Design: A Relational Theory for Design'. *Research in Engineering Design* 20 (1): 13–27.

Manning, C. D, P. Raghavan, and H. Schutze. 2008. *Introduction to Information Retrieval*. Vol. 1. Cambridge University Press Cambridge.

March, Salvatore T., and Gove N. Allen. 2014. 'Toward a Social Ontology for Conceptual Modeling'. *Communications of the Association for Information Systems* 34 (70): 147–59.

March, Salvatore T., and Gerald F. Smith. 1995. 'Design and Natural Science Research on Information Technology'. *Decision Support Systems* 15 (4): 251–66.

Markus, M. Lynne, and Daniel Robey. 1988. 'Information Technology and Organizational Change: Causal Structure in Theory and Research'. *Management Science* 34 (5): 583–98.

Marshall, Catherine C. 2007. 'How People Manage Information over a Lifetime'. In *In : Jones, W.P. & Teevan, J., 2007. Personal Information Management., University of Washington Press.*, 57–75.

Mason, Richard O., and Ian I. Mitroff. 1973. 'A Program for Research on Management Information Systems'. *Management Science* 19 (5): 475–487.

Maturana, Humberto R., and Francisco G. Varela. 1980. *Autopoiesis and Cognition: The Realization of the Living*. Springer.

———. 1987. *The Tree of Knowledge: The Biological Roots of Human Understanding*. Shambhala Boston, MA.

McIlveen, P. 2008. 'Autoethnography as a Method for Reflexive Research and Practice in Vocational Psychology'. *Australian Journal of Career Development* 17 (2): 13–20.

Miles, M., and M. Huberman. 1994. *Qualitative Data Analysis*. Thousand Oaks, CA: Sage.

Miller, George A. 1956. 'The Magical Number Seven, plus or Minus Two: Some Limits on Our Capacity for Processing Information.' *Psychological Review* 63 (2): 81.

———. 1995. 'WordNet: A Lexical Database for English'. *Commun. ACM* 38 (11): 39–41.

Mingers, John. 1995. 'Information and Meaning: Foundations for an Intersubjective Account'. *Information Systems Journal* 5 (4): 285–306.

———. 1997. 'Systems Typologies in the Light of Autopoiesis: A Reconceptualization of Boulding's Hierarchy, and a Typology of Self-Referential Systems'. *Systems Research and Behavioral Science* 14 (5): 303–13.

———. 1999. 'Information, Meaning, and Communication: An Autopoietic Approach to Linking the Social and the Individual'. *Cybernetics & Human Knowing* 6 (4): 25–41.

———. 2001. 'Combining IS Research Methods: Towards a Pluralist Methodology.' *Information Systems Research* 12 (3): 240.

———. 2004. 'Re-Establishing the Real: Critical Realism and Information Systems'. In *Social Theory and Philosophy for Information Systems.*, 372–406. John Wiley Series in Information Systems. John Wiley & Sons.

———. 2006. *Realising Systems Thinking: Knowledge and Action in Management Science*. Springer.

———. 2011. 'The Contribution of Systemic Thought to Critical Realism'. *Journal of Critical Realism* 10 (3): 303–30.

———. 2014. *Systems Thinking, Critical Realism and Philosophy: A Confluence of Ideas*. 1 edition. London ; New York: Routledge.

Mingers, John, Alistair Mutch, and Leslie Willcocks. 2013. 'Critical Realism in Information Systems Research'. *MIS Quarterly* 37 (3): 795–802.

Mingers, John, and Leslie Willcocks. 2014. 'An Integrative Semiotic Framework for Information Systems: The Social, Personal and Material Worlds'. *Information and Organization* 24 (1): 48–70.

Minsky, Marvin. 1975. 'A Framework for Representing Knowledge': In *The Psychology of Computer Vision*, edited by P. H Winston, 211–277. McGraw-Hill: New York.

Moen, Anne. 2007. 'Personal Health Information Management'. In *In : Jones, W.P. & Teevan, J., 2007. Personal Information Management., University of Washington Press.*, 221–35.

Moray, Neville. 1990. 'A Lattice Theory Approach to the Structure of Mental Models'. *Philosophical Transactions of the Royal Society of London. B, Biological Sciences* 327 (1241): 577–83.

———. 1997. 'Models of Models Of… Mental Models'. In *Perspectives on the Human Controller: Essays in Honor of Henk G. Stassen*, by Henk G. Stassen, Thomas B. Sheridan, and Ton Van Lunteren. CRC.

Morris, C. W. 1938. *Foundations of the Theory of Signs*. University of Chicago Press.

Mumford, Enid, and M. Weir. 1979. *Computer Systems in Work Design-the ETHICS Method*. Ass. Business Press.

Mutch, Alistair. 2010. 'Technology, Organization, and Structure-a Morphogenetic Approach'. *Organization Science* 21 (2): 507–520.

Nardi, Bonnie A. 1996. *Context and Consciousness: Activity Theory and Human-Computer Interaction*. The MIT Press.

Naumer, Charles M., and Karen E. Fisher. 2007. 'Naturalistic Approaches for Understanding PIM'. In *In : Jones, W.P. & Teevan, J., 2007. Personal Information Management., University of Washington Press.*, 76–88.

Nersessian, Nancy J. 1992. 'How Do Scientists Think? Capturing the Dynamics of Conceptual Change in Science'. *Cognitive Models of Science* 15: 3–44.

———. 1995. 'Should Physicists Preach What They Practice?' *Science & Education* 4 (3): 203–226.

———. 1999. 'Model-Based Reasoning in Conceptual Change'. In *Model-Based Reasoning in Scientific Discovery*, edited by Lorenzo Magnani, Nancy J. Nersessian, and Paul Thagard, 5–22. Springer US.

———. 2002. 'The Cognitive Basis of Model-Based Reasoning in Science'. *The Cognitive Basis of Science*, 133–153.

———. 2008. *Creating Scientific Concepts*. Cambridge, Mass: MIT Press.

Niiniluoto, Ilkka. 1999a. 'Critical Scientific Realism'. http://philpapers.org/rec/NIICSR.

———. 1999b. 'Defending Abduction'. *Philosophy of Science* 66 (September): S436–51.

———. 2002. *Critical Scientific Realism*. Oxford University Press.

Nikolić, Danko. 2015. 'Practopoiesis: Or How Life Fosters a Mind'. *Journal of Theoretical Biology* 373 (May): 40–61.

Nonaka, Ikujiro. 1991. 'The Knowledge-Creating Company'. *Harvard Business Review*, December. http://search.ebscohost.com/login.aspx?direct=true&db=buh&AN=9201061306&site=ehost-live.

———. 1994. 'A Dynamic Theory of Organizational Knowledge Creation'. *Organization Science* 5 (1): 14–37.

Nonaka, Ikujiro, and N. Konno. 1999. 'The Concept of "Ba": Building a Foundation for Knowledge Creation'. *The Knowledge Management Yearbook 1999-2000*, 37.

Nonaka, Ikujiro, and H. Takeuchi. 1995. *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*. Oxford University Press, USA.

Novak, Joseph D., and Alberto J. Cañas. 2008. 'The Theory Underlying Concept Maps and How to Construct and Use Them'. *Florida Institute for Human and Machine Cognition Pensacola Fl, Www. Ihmc. Us.[Http://Cmap. Ihmc. Us/Publications/ResearchPapers/T HeoryCmaps/TheoryUnderlyingConceptMaps. Htm]*.

Nunamaker Jr, Jay F., and Minder Chen. 1990. 'Systems Development in Information Systems Research'. In *System Sciences, 1990., Proceedings of the Twenty-Third Annual Hawaii International Conference On*, 3:631–640. IEEE. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=205401.

Nunamaker Jr., Jay F., Minder Chen, and Titus D.M. Purdin. 1990. 'Systems Development in Information Systems Research'. *Journal of Management Information Systems* 7 (3): 89–106.

Orlikowski, Wanda J., and C. Suzanne Iacono. 2001. 'Research Commentary: Desperately Seeking the "IT" in IT Research—a Call to Theorizing the IT Artifact'. *Information Systems Research* 12 (2): 121–134.

Orlikowski, Wanda J., and Susan V. Scott. 2008. 'Sociomateriality: Challenging the Separation of Technology, Work and Organization'. *The Academy of Management Annals* 2 (1): 433–474.

Orton, J. Douglas, and Karl E. Weick. 1990. 'Loosely Coupled Systems: A Reconceptualization'. *Academy of Management Review* 15 (2): 203–23. https://doi.org/10.5465/AMR.1990.4308154.

Papas, N., R.M. O'Keefe, and P. Seltsikas. 2012. 'The Action Research vs Design Science Debate: Reflections from an Intervention in EGovernment'. *European Journal of Information Systems* 21 (2): 147–59.

Paquette, Gilbert. 2010. *Visual Knowledge and Competency Modeling - From Informal Learning Models to Semantic Web Ontologies.* Hershey, PA: IGI Global.

Paul, Ray J. 2010. 'Motivation for Writing the Paper What an Information System Is, and Why Is It Important to Know This: Why I Give Lectures and Seminars'. *Journal of Computing and Information Technology* 18 (2).

Pauleen, David J. 2009. 'Personal Knowledge Management: Putting the "person" Back into the Knowledge Equation'. *Online Information Review* 33 (2): 221–224.

Pawson, Ray, and Nick Tilley. 1997. *Realistic Evaluation*. Sage.

Peacocke, Christopher. 1992. *A Study of Concepts*. The MIT Press. http://psycnet.apa.org/psycinfo/1992-98742-000.

———. 1996. 'Précis of A Study of Concepts'. *Philosophy and Phenomenological Research* 56 (2): 407–11. https://doi.org/10.2307/2108531.

Peirce, Charles Sanders. 1902. 'Logic as Semiotic: The Theory of Signs'. http://philpapers.org/rec/peilas.

———. 1933. *Collected Papers of Charles Sanders Peirce, Volumes III and IV: Exact Logic (Published Papers) and The Simplest Mathematics*. Edited by Charles Hartshorne and Paul Weiss. Vol. III–IV. Harvard University Press. http://www.hup.harvard.edu/catalog.php?isbn=9780674138001.

———. 1935. *Collected Papers of Charles Sanders Peirce, Volumes V and VI: Pragmatism and Pragmaticism and Scientific Metaphysics*. Edited by Charles Hartshorne and Paul Weiss. Vol. V–VI. Harvard University Press.

———. n.d. *The Essential Peirce, Volume 2: Selected Philosophical Writings (1893-1913)*. Edited by Nathan Houser and Christian J. W. Kloesel. Bloomington, IN: Indiana University Press.

Peirce, Charles Sanders, and Lady Victoria Welby. (1903–1911) 1977. *Semiotic and Significs: The Correspondence between Charles S. Peirce and Lady Victoria Welby*. Edited by Charles Hardwick. Indiana University Press.

Peyton Jones, Simon, Alan F. Blackwell, and Margaret M. Burnett. 2003. 'A User-Centred Approach to Functions in Excel'. In *Proceedings of the Eighth ACM SIGPLAN International Conference on Functional Programming*, 176.

Piaget, J. (1955) 1999. *The Construction of Reality in the Child*. Routledge.

Pohl, Klaus. 2010. *Requirements Engineering: Fundamentals, Principles, and Techniques*. 1st ed. Springer Publishing Company, Incorporated.

Polanyi, Michael. 1958. *Personal Knowledge: Towards a Post-Critical Philosophy*. Routledge & Kegan Paul London.

———. 1962. *The Tacit Dimension*. Peter Smith Gloucester, MA. http://books.google.com/books?hl=en&lr=&id=zfsb-eZHPy0C&oi=fnd&pg=PR6&dq=polanyi+tacit&ots=HblAQAAmhK&sig=zmyAHTjOCMDkynPnKNjzzxaEobs.

Pollard, Dave. 2008. *PKM: A Bottom-up Approach to Knowledge Management. In Knowledge Management in Practice: Connections and Context, Ed. T.K. Srikantaiah and M.E.D. Koenig*. Information Today.

Polya, George. (1945) 1988. *How to Solve It*. Princeton University Press Princeton, NJ.

Popper, Karl Raimund. 1963. *Conjectures and Refutations: The Growth of Scientific Knowledge*. Routledge.

———. 1972. *Objective Knowledge: An Evolutionary Approach*. Clarendon Press.

———. 1978. 'Three Worlds'. In *The Tanner Lectures on Human Values*, 141–67. University of Michigan.

Price, Jonathan. 1999. *Outlining Goes Electronic*. Greenwood Publishing Group.

Prigogine, Ilya, and Isabelle Stengers. 1985. 'Order out of Chaos'. *British Journal for the Philosophy of Science 36 (3):352-354 (1985)* 36 (3): 352–54.

Psillos, Stathis. 2009. 'An Explorer upon Untrodden Ground: Peirce on Abduction'. *Handbook of the History of Logic: Inductive Logic* 10: 117–151.

Rapaport, A. 1970. 'Modern Systems Theory–an Outlook for Coping with Change'. *General Systems* 15: 15–25.

Revans, Reg William. 1998. *ABC of Action Learning*. Lemos & Crane London.

Ricoeur, Paul. (1986) 2004. *The Rule of Metaphor: The Creation of Meaning in Language*. Routledge.

Rocha Souza, Renato, Douglas Tudhope, and Maurício Barcellos Almeida. 2010. 'Towards a Taxonomy of KOS: Dimensions for Classifying Knowledge Organization Systems'. In . Rome. http://mba.eci.ufmg.br/downloads/Souza_Tudhope_Almeida_-_KOS_Taxonomy.Submitted.pdf.

Rodriguez, Noelie, and Alan Ryave. 2002. *Systematic Self-Observation*. Sage Publications, Inc.

Rosch, Eleanor. 1999. 'Principles of Categorization'. In *Concepts: Core Readings*, edited by Eric Margolis and Stephen Laurence, 189–206. MIT Press.

Rosch, Eleanor, and Carolyn B Mervis. 1975. 'Family Resemblances: Studies in the Internal Structure of Categories'. *Cognitive Psychology* 7 (4): 573–605.

Rosemann, Michael, and Peter F. Green. 2002. 'Developing a Meta Model for the Bunge–Wand–Weber Ontological Constructs'. *Information Systems* 27 (2): 75–91.

Rosenblueth, A., N. Wiener, and J. Bigelow. 1943. 'Behavior, Purpose and Teleology'. *Philosophy of Science* 10 (1): 18–24.

Rouse, William B., and Nancy M. Morris. 1985. 'On Looking into the Black Box: Prospects and Limits in the Search for Mental Models'. DTIC Document. http://www.dtic.mil/docs/citations/ADA159080.

Rousseau, D. M. 1985. 'Issues of Levels in Organizational Research: Multi-Level and Cross-Level'. *Research in Organizational Behavior* 7: 1–37.

Rueda-Contreras, M. D., and J. L. Aragón. 2014. 'Alan Turing's Chemical Theory of Phyllotaxis'. *Revista Mexicana de Física E* 60 (1): 1–12.

Russell, David M., and Steve Lawrence. 2007. 'Search Everything'. In *In : Jones, W.P. & Teevan, J., 2007. Personal Information Management., University of Washington Press.*, 153–66.

Şahin, Erol. 2008. 'State-of-the-Art and Formalization for Robotics'. presented at the MACS Final Review Meeting Feb. 15, 2008, February 15.

Şahin, Erol, Maya Çakmak, Mehmet R. Doğar, Emre Uğur, and Göktürk Üçoluk. 2007. 'To Afford or Not to Afford: A New Formalization of Affordances toward Affordance-Based Robot Control'. *Adaptive Behavior* 15 (4): 447–472.

Salner, Marcia. 1986. 'Adult Cognitive and Epistemological Development in Systems Education'. *Systems Research* 3 (4): 225–32. https://doi.org/10.1002/sres.3850030406.

Sauermann, L. 2005a. 'The Gnowsis Semantic Desktop for Information Integration'. In *Proceedings of the 3rd Conference Professional Knowledge Management*.

———. 2005b. 'The Semantic Desktop-a Basis for Personal Knowledge Management'. In *Proceedings of the I-KNOW*, 5:294–301.

Sauermann, L., Ansgar Bernardi, and A. Dengel. 2005. 'Overview and Outlook on the Semantic Desktop'. In *Proceedings of the 1st Workshop on The Semantic Desktop at the ISWC 2005 Conference*, 175:1–19.

Sauermann, L., R. Cyganiak, and Max Völkel. 2008. 'Cool URIs for the Semantic Web'. *Working Draft, W3C.*

Sauermann, L., and S. Schwarz. 2004. 'Introducing the Gnowsis Semantic Desktop'. In *Proceedings of the International Semantic Web Conference*. Vol. 2004.

Scheer, August-Wilhelm. 2000. *ARIS--Business Process Modeling*. Springer.

Scheer, August-Wilhelm, O. Thomas, and O. Adam. 2005. 'Process Modeling Using Event-Driven Process Chains'. In *Process-Aware Information Systems: Bridging People and Software Through Process Technology*, edited by Marlon Dumas, Wil M. P. van der Aalst, and Arthur H. M. ter Hofstede. John Wiley & Sons.

Scholten, Daniel P. 2010a. 'A Primer For Conant & Ashby's "Good-Regulator Theorem"'. http://www.goodregulatorproject.org/images/A_Primer_For_Conant_And_Ashby_s_Good-Regulator_Theorem.pdf.

———. 2010b. 'Every Good Key Must Be A Model Of The Lock It Opens (The Conant & Ashby Theorem Revisited)'. http://www.goodregulatorproject.org/images/A_Primer_For_Conant_And_Ashby_s_Good-Regulator_Theorem.pdf.

Schön, Donald A. 1983. *The Reflective Practitioner: How Professionals Think in Action*. Basic Books.

———. 1987. *Educating the Reflective Practitioner*. Jossey-Bass San Francisco.

Schubert, Lenhart K. 2005. 'Some Knowledge Representation and Reasoning Requirements for Self-Awareness'. *Metacognition in Computation*, 106–113.

Schultze, Ulrike. 2000. 'A Confessional Account of an Ethnography about Knowledge Work'. *MIS Quarterly*, 3–41.

Schwaninger, Markus. 2004. 'What Can Cybernetics Contribute to the Conscious Evolution of Organizations and Society?' *Systems Research and Behavioral Science* 21: 515–27.

Schwarz, Sven. 2006. 'A Context Model for Personal Knowledge Management Applications'. In *Modeling and Retrieval of Context*, 18–33. http://dx.doi.org/10.1007/11740674_2.

Searle, John R. 1983. *Intentionality: An Essay in the Philosophy of Mind*. Cambridge University Press Cambridge, UK.

———. 2006. 'Social Ontology: Some Basic Principles'. *Anthropological Theory* 6 (1): 12–29.

Sein, Maung K., Ola Henfridsson, Sandeep Purao, Matti Rossi, and Rikard Lindgren. 2011. 'Action Design Research'. *MIS Quarterly* 35 (1).

Shadbolt, Nigel, W. Hall, and Tim Berners-Lee. 2006. 'The Semantic Web Revisited'. *IEEE Intelligent Systems* 21 (3): 96–101.

Shamos, Michael. 2007. 'Privacy and Public Records'. In *In: Jones, W.P. & Teevan, J., 2007. Personal Information Management., University of Washington Press.*, 261–68.

Shannon, Claude E. 1948. 'A Mathematical Theory of Communication'. *Bell Syst. Tech. J* 27 (1): 379–423.

———. 1953. 'The Lattice Theory of Information'. *Transactions of the IRE Professional Group on Information Theory* 1 (1): 105–107.

———. 2001. 'A Mathematical Theory of Communication'. *ACM SIGMOBILE Mobile Computing and Communications Review* 5 (1): 55.

Shannon, Claude E., and Warren Weaver. 1949. 'The Mathematical Theory of Communication'. *Urbana, Univ. Illinois Press*.

Shapiro, S. C. 2001. 'Review of Knowledge Representation: Logical, Philosophical, and Computational Foundations by John F. Sowa. Brooks/Cole 2000.' *Computational Linguistics* 27 (2): 286–294.

Shiu, Ling-po., and Chor-yiu. Sin. 2006. 'Top-down, Middle-out, and Bottom-up Processes: A Cognitive Perspective of Teaching and Learning Economics'. *International Review of Economic Education* 5 (1): 60–72.

Silla Jr, Carlos N., and Alex A. Freitas. 2011. 'A Survey of Hierarchical Classification across Different Application Domains'. *Data Mining and Knowledge Discovery* 22 (1–2): 31–72.

Simon, Herbert A. (1970) 1996. *The Sciences of the Artificial*. The MIT Press.

Simon, Herbert A., G. B Dantzig, R. Hogarth, C. R Plott, H. Raiffa, T. C Schelling, K. A Shepsle, R. Thaler, A. Tversky, and S. Winter. 1987. 'Decision Making and Problem Solving'. *Interfaces* 17 (5): 11–31.

Sinclair, James. 2008. 'Categorisation in Knowledge Contexts'. http://jrsinclair.com/academic/categorisation-knowledge-contexts.

Sinclair, James Robert. 2007. 'Categorisation for Small-Medium Sized Information Systems - an Exploration'. Australian National University. https://digitalcollections.anu.edu.au/handle/1885/9469.

Sleeper, Ralph W. 2001. *The Necessity of Pragmatism: John Dewey's Conception of Philosophy*. University of Illinois Press.

Smedley, Jo. 2009. 'Modelling Personal Knowledge Management'. *OR Insight* 22 (4): 221–233.

Smith, Andrew E., and Michael S. Humphreys. 2006. 'Evaluation of Unsupervised Semantic Mapping of Natural Language with Leximancer Concept Mapping'. *Behavior Research Methods* 38 (2): 262–279.

Smith, Barry. 2014. 'Document Acts'. In *Institutions, Emotions, and Group Agents*, edited by A. Konzelmann-Ziv and H.B. Schmid, 19–31. Springer.

Smith, Barry, and Werner Ceusters. 2010. 'Ontological Realism: A Methodology for Coordinated Evolution of Scientific Ontologies'. *Applied Ontology* 5 (3): 139–88.

Smith, John Miles, and Diane C. P. Smith. 1977. 'Database Abstractions: Aggregation and Generalization'. *ACM Trans. Database Syst.* 2 (2): 105–133. https://doi.org/10.1145/320544.320546.

Smith, Mark K. 2001. 'Chris Argyris: Theories of Action, Double-Loop Learning and Organizational Learning'. The Encyclopedia of Informal Education. 2009 2001. http://www.infed.org/thinkers/argyris.htm.

———. 2003. 'Michael Polanyi and Tacit Knowledge'. *The Encyclopedia of Informal Education* 2008 (12/15/2008): 1–4.

———. 2009. 'Donald Schon (Schön) - Learning, Reflection and Change'. The Encyclopedia of Informal Education. 2009. http://www.infed.org/thinkers/et-schon.htm.

Snowden, David, and David J. Pauleen. 2008. *Knowledge Management and the Individual: It's Nothing Personal—an Interview with Dave Snowden by David J. Pauleen*. http://pauleen.massey.ac.nz.

Sowa, J. F. 1984. 'Conceptual Structures: Information Processing in Mind and Machine'. *Reading, MA*.

Sowa, John F. 1992a. 'Conceptual Graph Summary'. *Conceptual Structures: Current Research and Practice. Ellis Horwood, New York London Toronto*, 3–66.

———. 1992b. 'Semantic Networks'. *Encyclopedia of Artificial Intelligence*.

———. 2000a. *Knowledge Representation: Logical, Philosophical, and Computational Foundations*. Brooks/Cole.

———. 2000b. 'Ontology, Metadata, and Semiotics'. *Conceptual Structures: Logical, Linguistic, and Computational Issues*, 55–81.

Sperry, Roger W. 1975. 'Left-Brain, Right-Brain'. *Saturday Review* 2 (9): 30–33.

Stainton-Rogers, W. 2006. 'Logics of Enquiry'. *Doing Postgraduate Research*, 73–91.

Stonebraker, Michael. 2010. 'SQL Databases V. NoSQL Databases'. *Commun. ACM* 53 (4): 10–11. https://doi.org/10.1145/1721654.1721659.

Stowell, Frank. 2013. 'Peter Checkland Interview'. *International Journal of Information Technology and Systems Approach* 6 (2): 53–60.

Stowell, Frank, and Christine Welch. 2012. *The Manager's Guide to Systems Practice: Making Sense of Complex Problems*. John Wiley & Sons.

Strassmann, Paul A. 1997. *The Squandered Computer*. Strassmann, Inc.

———. 1999. *Information Productivity*. Strassmann, Inc.

Strauss, Anselm, and Juliet Corbin. 1998. *Basics of Qualitative Research: Procedures and Techniques for Developing Grounded Theory*. Thousand Oaks, CA: Sage.

Świgoń, Marzena. 2013. 'Personal Knowledge and Information Management – Conception and Exemplification'. *Journal of Information Science* 39 (6): 832–45.

Swinton, Jonathan. 2004. *Watching the Daisies Grow: Turing and Fibonacci Phyllotaxis*. Springer. http://link.springer.com/chapter/10.1007/978-3-662-05642-4_20.

Takeda, Hideaki, Hiromitsu Sasaki, Yutaka Nomaguchi, Masaharu Yoshioka, Yoshiki Shimomura, Tetsuo Tomiyama, and others. 2003. 'Universal Abduction Studio-Proposal of a Design Support Environment for Creative Thinking in Design'. In *DS 31: Proceedings of ICED 03, the 14th International Conference on Engineering Design, Stockholm*. Stockholm. http://www.designsociety.org/download-

publication/24083/universal_abduction_studio-proposal_of_a_design_support_environment_for_creative_thinking_in_design.

Tales of PIM. 2016. 'Tales of PIM'. 2016. http://talesofpim.org/.

Tan, Desney, Emma Berry, Mary Czerwinski, Gordon Bell, Jim Gemmell, Steve Hodges, Narinder Kapur, et al. 2007. 'Save Everything: Supporting Human Memory with a Personal Digital Lifetime Store'. In *In : Jones, W.P. & Teevan, J., 2007. Personal Information Management., University of Washington Press.*, 90–107.

Taylor, F. W. 1911. *The Principles of Scientific Management*. Adamant Media Corporation.

Teevan, Jaime, Robert Capra, and Manuel Perez-Quiñones. 2007. 'How People Find Personal Information'. In *In : Jones, W.P. & Teevan, J., 2007. Personal Information Management., University of Washington Press.*, 22–34.

Teevan, Jaime, and William P. Jones. 2008. 'The Disappearing Desktop: Pim 2008'.

Teevan, Jaime, William P. Jones, and Benjamin B. Bederson. 2006. 'Personal Information Management'. *Communications of the ACM* 49 (1): 40–43.

Teevan, Jaime, William P. Jones, and Robert Capra. 2008. 'Personal Information Management (PIM) 2008'. In *ACM SIGIR Forum*, 42:96–103.

Thom, René. (1972) 1989. *Structural Stability and Morphogenesis*. Addison-Wesley.

———. (1980) 1993. *Modèles mathématiques de la morphogénèse*. Paris: Christian Bourgois.

Thompson, Evan, and Francisco J. Varela. 2001. 'Radical Embodiment: Neural Dynamics and Consciousness'. *Trends in Cognitive Sciences* 5 (10): 418–425.

Tierney, W. G, and Yvonna S. Lincoln. 1997. *Representation and the Text: Re-Framing the Narrative Voice*. State University of New York Press.

Tohmé, Fernando, Gianluca Caterina, and Rocco Gangle. 2015. 'Abduction: A Categorical Characterization'. *Journal of Applied Logic* 13 (1): 78–90.

Tsekeris, Charalambos, and Nicos Katrivesis. 2009. 'Ethical Reflexivity and Epistemological Weakness'. *Tamara Journal* 7 (3).

Tsoukas, Haridimos. 1992. 'Panoptic Reason and the Search for Totality: A Critical Assessment of the Critical Systems Perspective'. *Human Relations* 45 (7): 637–57. https://doi.org/10.1177/001872679204500701.

Tsuchiya, S. 1993. 'Improving Knowledge Creation Ability through Organizational Learning'. In *International Symposium on the Management of Industrial and Corporate Knowledge. Compiègne, France: UTC-IIIA, ISMICK*. Vol. 93.

Tuomi, I. 1999. 'Data Is More than Knowledge: Implications of the Reversed Knowledge Hierarchy for Knowledge Management and Organizational Memory'. *Journal of Management Information Systems* 16 (3): p103-117.

Turing, Alan Mathison. 1952. 'The Chemical Basis of Morphogenesis'. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences* 237 (641): 37–72.

———. 1992. 'Morphogen Theory of Phyllotaxis'. In *Morphogenesis: Collected Works of A.M. Turing*, edited by P.T. Saunders. Amsterdam: North-Holland. Original manuscript available at: http://www.turingarchive.org/browse.php/C/8.

Van Aken, Joan Ernst. 2005. 'Management Research as a Design Science: Articulating the Research Products of Mode 2 Knowledge Production in Management'. *British Journal of Management* 16 (1): 19–36.

Van de Ven, Andrew H. 2007. *Engaged Scholarship: A Guide for Organizational and Social Research*. Oxford University Press, USA.

Van-Roy, P., and S. Haridi. 2004. *Concepts, Techniques, and Models of Computer Programming*. The MIT Press.

Varela, Francisco J., Eleanor Rosch, and Evan Thompson. 1992. *The Embodied Mind: Cognitive Science and Human Experience*. MIT press.

Verjans, Steven. 2005. 'Bricolage as a Way of Life–Improvisation and Irony in Information Systems'. *European Journal of Information Systems* 14 (5): 504–506.

Vervaeke, John, and Christopher D. Green. 1997. 'Women, Fire, and Dangerous Theories: A Critique of Lakoff's Theory of Categorization'. *Metaphor and Symbol* 12 (1): 59–80.

Völkel, Max, and Andreas Abecker. 2008. 'Cost-Benefit Analysis for the Design of Personal Knowledge Management Systems'. In . Proc. of 10th International Conference on Enterprise Information Systems. http://www.aifb.uni-karlsruhe.de/Publikationen/showPublikation_english?publ_id=1735.

Völkel, Max, and Heiko Haller. 2009. 'Conceptual Data Structures for Personal Knowledge Management'. *Online Information Review* 33 (2): 298–315.

Volkoff, Olga, and Diane M. Strong. 2013. 'Critical Realism and Affordances: Theorizing IT-Associated Organizational Change Processes'. *MIS Quarterly* 37 (3): 819–34.

Volkoff, Olga, Diane M. Strong, and Michael B. Elmes. 2007. 'Technological Embeddedness and Organizational Change'. *Organization Science* 18 (5): 832–848.

Von Bertalanffy, L. 1968. *General System Theory: Foundations, Development, Applications: Rev. Ed.* George Braziller New York.

———. 1972. 'The History and Status of General Systems Theory'. *Academy of Management Journal* 15 (4): 407–426.

Von Foerster, H. 2003. 'Cybernetics of Cybernetics'. *Understanding Understanding: Essays on Cybernetics and Cognition*, 283.

Von Neumann, J., O. Morgenstern, H. W Kuhn, and A. Rubinstein. 1953. *Theory of Games and Economic Behavior*. Princeton university press Princeton, NJ.

W3C. 2004. 'RDF/XML Syntax Specification (Revised)'. 2004. https://www.w3.org/TR/REC-rdf-syntax/.

Wakeling, D. 2007. 'Spreadsheet Functional Programming'. *Journal of Functional Programming* 17 (01): 131–143.

Wall, Sarah. 2006. 'An Autoethnography on Learning about Autoethnography'. *International Journal of Qualitative Methods* 5 (2): 146.

Walls, Joseph G., George R. Widmeyer, and Omar A. El Sawy. 1992. 'Building an Information System Design Theory for Vigilant EIS'. *Information Systems Research* 3 (1): 36–59.

Walonick, D.S. 1993. 'General Systems Theory'. *Statpac. Http://Www. Survey-Softwaresolutions. Com/Walonick/Systems-Theory. Htm (Accessed on November 24, 2007)*.

Walsham, Geoff. 2006. 'Doing Interpretive Research'. *European Journal of Information Systems* 15 (June): 320–30. https://doi.org/10.1057/palgrave.ejis.3000589.

Wand, Yair. 1996. 'Ontology as a Foundation for Meta-Modelling and Method Engineering'. *Information and Software Technology* 38 (4): 281–87.

Wand, Yair, Veda C. Storey, and Ron Weber. 1999. 'An Ontological Analysis of the Relationship Construct in Conceptual Modeling'. *ACM Transactions on Database Systems (TODS)* 24 (4): 494–528.

Wand, Yair, and Ron Weber. 1990. 'Mario Bunge's Ontology as a Formal Foundation for Information Systems Concepts'. In *Studies on Mario Bunge's Treatise*, edited by Paul Weingartner and Georg JW Dorn, 18:123–49. Atlanta: Rodopi.

———. 2002. 'Research Commentary: Information Systems and Conceptual Modeling--A Research Agenda'. *Information Systems Research* 13 (4): 363–76.

Weick, Karl E., Kathleen M. Sutcliffe, and David Obstfeld. 2005. 'Organizing and the Process of Sensemaking'. *Organization Science* 16 (4): 409–421.

Wenger, Etienne C. 1998. 'Communities of Practice: Learning as a Social System'. *Systems Thinker* 9 (5): 1–5.

Whittaker, Steve, Victoria Bellotti, and Jacek Gwizdka. 2007. 'Everything through Email'. In *In : Jones, W.P. & Teevan, J., 2007. Personal Information Management., University of Washington Press.*, 167–89.

Whittaker, Steve, and Ofer Bergman. 2016. *The Science of Managing Our Digital Stuff*. MIT Press Cambridge, MA.

Wiener, N. 1965. *Cybernetics or Control and Communication in the Animal and the Machine*. The MIT Press.

———. 1973. *Cybernetics or Control and Communication in the Animal and the Machine...* MIT press.

Wilson, Brian. 1984. *Systems: Concepts, Methodologies, and Applications*. New York, NY, USA: John Wiley & Sons, Inc.

Wilson, T. D. 2002. 'The Nonsense of Knowledge Management'. *Information Research* 8 (1): 8–1.

Wirth, Niklaus. 1985. *Algorithms + Data Structures=programs*. Prentice Hall Englewood Cliffs, New Jersey.

Wittgenstein, Ludwig. 1953. *Philosophical Investigations*. Translated by G. Elizabeth M. Anscombe. Blackwell.

Wood, J. R. G., and A. Trevor Wood-Harper. 1993. 'Information Technology in Support of Individual Decision-Making'. *Information Systems Journal* 3 (2): 85–101.

Wright, Kirby. 2005. 'Personal Knowledge Management: Supporting Individual Knowledge Worker Performance'. *Knowledge Management Research and Practice* 3 (3): 156–165.

———. 2007. *Rethinking Knowledge Work: Supporting Work and Learning through Personal Knowledge Management*. KRW Knowledge Resources. http://www.knowledgeresources.ca/Knowledge_Resources/PKM_Model.html.

Wright, Ron, and Mary Flores. 1998. 'COMM 300 - Semiology - Barthes - Terms'. 1998. http://www.ic.arizona.edu/~comm300/mary/semiotics/barthes.terms.html#semiotics (dead link: 2013-07-18).

Wynn Jr, Donald E., Olga Volkoff, Clay K. Williams, and Diane M. Strong. 2013. 'Critical Realism and Mechanisms: Moving from the Philosophical to the Empirical in the Search for Causal Explanations'. *AMCIS 2013 Proceedings*, June. http://aisel.aisnet.org/amcis2013/Panels/PanelSubmissions/7.

Wynn Jr, Donald E., and Clay K. Williams. 2012. 'Principles for Conducting Critical Realist Case Study Research in Information Systems'. *MIS Quarterly* 36 (3): 787–810.

XML. 2010. 'Extensible Markup Language (XML)'. 2010. http://www.w3.org/XML/.

Yourdon, Edward Nash, and Larry LeRoy Constantine. 1976. *Structured Design*. Yourdon, Inc.

Yu, Chong Ho. 1994. 'Abduction? Deduction? Induction? Is There a Logic of Exploratory Data Analysis?' In *Annual Meeting of the American Educational Research Association, New Orleans, LA, April*.

Zachariadis, Markos, Susan Scott, and Michael Barrett. 2013. 'Methodological Implications of Critical Realism for Mixed-Methods Research'. *MIS Quarterly* 37 (3): 855–79.

Zahran, F. S. 1981. 'A Universal Data Model Holder for Data Dictionary Systems'. *The Computer Journal* 24 (3): 193.

Zhang, Zuopeng. 2009. 'Personalising Organisational Knowledge and Organisationalising Personal Knowledge'. *Online Information Review* 33 (2): 237–256.

Zotero. 2019. 'Zotero | Home'. 2019. https://www.zotero.org/.

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