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Abstract

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Keywords

health informatics, implementation, complexity, organisational studies

Disciplines

Business Administration, Management, and Operations | Health and Medical Administration | Physical Sciences and Mathematics

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Complex Adaptive Systems as a Model for Evaluating Organisational Change Caused by the Introduction of Health Information Systems

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Abstract: This paper documents the preliminary development of a framework for evaluating organisational change processes during the implementation of an electronic nursing documentation system in residential aged care facilities. It starts with a brief outline of organisational change processes. This is followed by a more detailed exposition of the principles underlying complex adaptive systems (CAS) theory, where we explain how mathematical concepts can be used to illuminate qualitative research approaches. Finally we present some preliminary findings on the facilitators and barriers for the introduction of the electronic documentation system, explained with reference to the CAS theory, based on analysis of interviews with care staff members in a residential aged care facility. While there are clear benefits from electronic nursing documentation, we also identified significant risks, and possible unintended consequences, both positive and negative.

Introduction

This is a report on the preliminary work examining changes associated with the implementation of an electronic nursing documentation system in a number of aged care facilities in South Eastern New South Wales and Queensland. Our aim is to understand the positive and negative consequences of implementation of the documentation system, with a particular focus on unintended consequences. This is the beginning of a multi-organisation study of multiple sites within each organisation examining the change management practices and their consequences. In a sense this means that we have a natural experimental system whose design is an unbalanced block design, although the work we are doing is not a formal experiment. To understand the change management issues arising from the implementation, our main analysis is at two levels. Firstly we are interested in the variation among sites within each organisation; secondly we are interested in the variation among the partner organisations. At this stage we have conducted interviews with nursing staff at all levels at a single site. Although our research design is that of a natural experiment, interviews provide rich data suitable for qualitative analysis. This paper discusses the context in which organisational change occurs, a theoretical approach to interrogating data about change based on the complex adaptive systems approach (Dooley, 1997), and outlines how this relates to the preliminary data from a single site.

Components of Organisational Change

Organisational change encompasses people, culture and process. Some of the important parameters that occur under these categories are as follows:

- People – demographics, structure of the workforce, educational background, and dispositional factors such as motivation, personality and performance
- Culture – values, leadership, and workplace rituals
- Processes – documentation, work routines, and chain of responsibility

These components overlap. For example in nursing practice, handover is a central process for the sharing of knowledge and dissemination of information. However, it is also an essential part of workplace culture. The personal dimension is also important in handover – which individual staff member is in charge

of delivery, the personality of each staff and what are the human and professional skills of the individuals providing handover to a given organisational unit.

When the introduction of technology is the primary driver of change, a "technological imperative" can occur. Managers and other organisational actors have little control over the nature of the organisational change (Orlikowski, 2002). This technological imperative fundamentally alters aspects of the process dimension in the organisations we study. This also means that some of the drivers for organisational change in our study are outside the direct control of management. Concurrent with the introduction of IT there have also been changes in the funding model for aged care with the implementation of the Aged Care Funding Instrument (ACFI) in March 2008, which replaced the Resident Classification Scheme (RCS) which was the funding model used for the previous 11 years. The interaction between the introduction of ACFI, which results in substantially simplified documentation and assessment requirements, and the electronic documentation system has resulted in significant unintended consequences which will be discussed below. However, initially we will discuss the Complex Adaptive Systems (CAS) theory, and the way that this ontological framework can be used to understand organisational change processes associated with health IT introduction.

Complex Adaptive Systems – Complexity, Chaos and Entropy

Unintended consequences are a form of emergent property. This in turn fits into the theoretical framework of Complex Adaptive Systems (CAS). CAS has its roots in mathematics, and as a result its components are very well defined in a mathematical sense. However, the challenge for social researchers wanting to use this framework is in translating these mathematical ideas into concepts amenable to qualitative analysis. Concurrent high levels of uncertainty with respect to the precision with which variables or situations can be measured and assessed are also a problem. One approach to CAS is to use biological ecosystems to illuminate organisational processes. Dooley (1997) is perhaps the most widely cited example of this approach. CAS has also been used in health informatics research (e.g. Day & Norris, 2007; Ward, Stevens, Brentnall, & Briddon, 2008).

While the use of biological concepts such as ecosystems and autopoesis (self organising systems) are described and applied in Dooley's paper, there is an attempt to examine the underlying role of complexity and interdependence inherent in the CAS view. However, the biological ecosystem view of organisations has been justifiably criticised for its lack of clear connection between the biological concept of species and a corresponding unit of construction in human organisations (Young, 1988). Nonetheless, there is some recognition of the potential of CAS in the human sciences, as well as in the field of health informatics. Therefore, we will attempt to apply the CAS to our domain of study.

We start with the assumption that while the biological approach to analysis of organisations is informative, there are no direct correspondences. That is, we assume the underlying phenomenology of things like resource limitation, the unit of information (i.e. DNA in biology, an unknown entity in organisation studies) between the two fields are sufficiently different so as to be not directly comparable. Ecosystems and organisations are both constrained by resource limitations, by the internal structure of their interacting components and by their relationship to their external environment. However the economics of the underlying resources are substantially different. While ecosystems are generally limited by nutrient availability, the resource limitations for human organisations are material, financial and human. What is common between the two systems is that the flow of these resources are important drivers of change and homeostasis. Therefore it appears that a direct analysis of the dynamic processes that underlie resource flows should be useful in defining a more robust conceptual basis for organisational ecology.

Baranger (2002) provides an excellent non-technical summary of complexity theory which is outlined in the remainder of this section. Because Baranger's disciplinary perspective is from theoretical physics, while his writing remains close to the mathematical underpinnings of complexity theory, his grounding in an application, along with his clear teaching skills is very instructive, as it provides us with a clear logical explanation of how to link the abstract mathematics of complexity to an applied dimension. Complex Adoptive Systems are difficult to understand because of the interaction between two fundamental components – chaos and complexity. Chaos can be a property of simple systems (i.e. systems with few parameters), and the results of chaotic models are by definition intrinsically unpredictable. Baranger states that chaos is "that part of mathematics where calculus does not apply". One of the defining features of chaos is sensitivity dependent on initial conditions (e.g. in our study it may be that the initial training approach can vary between units in small ways, but that these small differences might have dramatic consequences). Complexity is different from chaos. The human body, weather patterns, and ecosystems are all examples of complex systems where the individual constituents self-organise, and the whole is greater than the sum of its parts. Emergence (as in emergent properties) is a phenomenon stemming from complexity where the organisation and interactions at one level of a system

cause changes at another level. A system whose configuration is capable of changing over time is called a dynamic system. A dynamic model is a mathematical model or a set of rules describing the time dependence of a point's position in space (either physical space or a more abstract idea of space). A simple example of a dynamical system as would be described in any introductory physics book is the swinging of a pendulum. Chaos has a close relationship with complexity. Complexity has the property of multiple interacting components each of which may or may not be chaotic subcomponents. The network of interactions is compounded by stochasticity (probabilistically determined variation). In thermodynamics, the statistical model of probabilistic variation is described by the concept of entropy.

An adaptive system is one which interacts with itself and its environment to achieve an end. A simple example of an adaptive system is Stevenson's governor – a mechanical mechanism that prevents excessive speeding of engines. A more complex example is that of homeostatic systems in living systems, for example body temperature regulation.

Entropy is an important part of any system as it helps define whether a system is closed (independent) or open (dependent on other systems). In thermodynamics, the entropy (degree of disorder) of a closed system increases over time. High entropy systems have high levels of disorder, and the components of a high entropy system are generally seen as possessing disorder whose atomic configuration are uninteresting. However, the effects of a transient increase in entropy can be interesting. A substantial outage of the electronic documentation system of our study site is a good example of a transient increase in the rate of the accumulation of entropy, which will be discussed next.

One fascinating property of entropy is that even in the physical sciences, it is a constructed concept, which is used to make "reality" more manageable. The smoothing procedure used for entropy analysis defines the scale beyond which the analyst is unable or unwilling to keep track of details. Smoothing represents a self-imposed (subjective) increase in the entropy of the system – the key to understanding this procedure is to optimise the level of analysis at which it is performed. As our data consist of individual interviews, we need to understand the nature and quality of the data we gather, and at what level we maximise its meaning. This in turn allows us to improve our understanding of the flow of resources within the organisation.

Complex Adoptive Systems' quantitative roots do not exclude its use for solving qualitative problems. For example, a quantitative problem in electronics would be to calculate the change in voltage in a lighting circuit when a change occurs. A qualitative equivalent would be to determine whether the light bulb becomes dimmer or brighter as a result of that change. It should be clear that where the number of parameters is high, or measurement is uncertain, or where a chaotic system is suspected, a qualitative solution will be more achievable and likely more desirable.

This brief summary should illustrate that CAS as an ontology (framework to generate meaning) is capable of bridging the divide between positivist and post-positivist. That is, between the perspective that there is a "true" reality versus the idea of a socially constructed reality (Lichtenstein, 2000). In the search for improved understanding in social research we need to evaluate this way of looking at things in order to determine how useful it is, and to determine whether this lower level of CAS compared to the organisation as ecosystem approach is useful in providing explanations of change processes.

Data Collection and Analysis

The authors interviewed 16 nursing staff at a single 101 bed residential aged care facility in South Eastern New South Wales over a two-day period. These were semi-structured interviews that lasted between 10 and 40 minutes depending on the detail of the answers provided. After interviewing management, constraints caused by difficulty obtaining a nurses off the floor required that we used a convenience sample based on carer availability. We interviewed the nursing manager and deputy manager, three registered nurses, three enrolled nurses, three recreational activities officers, one physiotherapy assistant and four personal care workers. Ethical approval was obtained from the University of Wollongong Ethics Committee, and permission was granted for the research to occur from the provider organisation. Although interviews were recorded for later transcription, the data for this paper were obtained from notes taken during the interview. It is intended that once this round of interviews is complete, the transcripts of all interviews will be subjected to a full qualitative analysis using the principles of grounded theory (Strauss, 1990) and symbolic interactionism (Denzin, 2003).

Senior staff members stated that improved access to documentation across the organisation facilitated information flow. This is a direct result of implementing the electronic documentation system. From the perspective of the CAS theory, the system that reduces the rate at which the entropy of the nursing documentation increases over time. This appears to be directly in line with the nature of the managerial nature of the job – with wider responsibilities devolved to individuals working at a lower level, and therefore a greater need to deal with information in bulk, the greater the benefits of the health informatics system.

The interviewees with a managerial function (the service managers and the registered nurses) universally recounted an appreciation of the improvements to reporting and data access that the electronic system provides. However, our CAS perspective also emphasises the importance of interactions across the system. The personal care workers perceived that the change of residential aged care funding model from RCS to ACFI had reduced their documentation workload. This has had two effects. Firstly the nursing assistant staff rely more on verbal communication; secondly a limited number of available computer terminals may also result in a reduced opportunity to access nursing records by the personal care staff. While some of these staff acknowledge that this can be a good thing as it allows them more time to spend with residents, there may be a sense of disempowerment at the junior level. On the contrary, the sense of the increased empowerment at the facility management level is obvious.

The final part of the data that we wish to examine for this paper is the effect of a technology outage. A two-week outage was caused by a networking mishap between the off-site central server and the residential aged care facility. The mishap itself was out of the control of the organisation, but a lack of disaster recovery plan evidently caused a dependence on an external telecom provider to fix the problem. The site returned to paper records during this period. This increased risk, as older documents were not available, resulting in many staff complaints as staff members could only rely on oral communication to pass information around. If we view the electronic documentation system as a low-entropy, low-redundancy system, and the paper based system as its higher entropy counterpoint, we can see that the risks associated with local data loss are relatively high with electronic documentation if the data are only stored off site. In our interviews we also discovered a possible extra source of entropy increase from the effects of network lag. The electronic documentation system at this facility is web based, and concurrently the computer systems are all thin clients, therefore the capacity of the network is likely to be stretched at times of high traffic. While we suspect that the direct impact of this latter type of outage is likely to be small, it is another source of higher entropy in the electronic documentation system, which is not obvious except under close observation.

Conclusion

In this paper we have used the preliminary data gathered from a residential aged care facility to evaluate a complex adaptive systems approach to understanding organisational change. As the primary goal of the computer based record system is to improve quality and efficiency of nursing documentation, our CAS ontological framework does seem attractive. Central to this approach is the idea of entropy – the degree of disorder in a system increasing over time. Thinking about a traditional paper record, and the thick dog-eared folders of patient documentation that accumulate over time, there is clearly a substantial increase in entropy at many levels – in the quality of the paper as it becomes dog-eared, and in the search-accessibility of the information as it becomes more difficult to find. We've clearly demonstrated that while the electronic system is inherently lower entropy than the paper system, there is a certain amount of fragility inherent in it, in terms of trouble dealing with transient and longer-term outages. Having the principles underpinning CAS to guide the analytic process appears to be helpful in performing a systematic analysis of how change occurs, and what factors are most important to ensure its success.

The next step for this research project is to conduct more interviews across different sites, initially for this first participating organisation, and subsequently for different organisations. In order to improve the systematic data analysis process, we will use situational analysis (Clarke, 2005), which is a modernisation of grounded theory. Situational analysis emphasises visualisation of situations uncovered by qualitative research techniques. The ontology of CAS, along with, the epistemology and methodology underlying situational analysis provides a framework to understand the structure of our research problem in a manner compatible with the broader systems view of the firm favoured in some parts of organisation studies. This makes CAS an excellent starting point, and in addition with other methods used in organisation studies and occupational psychology, we hope to provide a detailed and systematic process to describe and guide change management in the implementation of health information system into health and aged care organisations.

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