
Research methodologies for complex ecosystems: enhancing the societal value of IS

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Abstract

Societal ecosystems are struggling to solve complex problems that could benefit from research by information systems (IS) scholars. However, existing IS research methodologies seek to reduce complexity and so are unsuited to the holistic investigation of complex phenomena. This paper presents a research methodology based on principles of complexity theory consisting of three non-linear phases, namely sensemaking, action and reflection. This complexity-aware methodology requires innovative methods of data collection, analysis and presentation. In order to demonstrate the application of the methodology, an action research project, which investigates the complex challenge of enabling elderly citizens to use IS for social wellbeing, is described. Thus, in addition to the methodological contribution, the results of this IS research provide an instance where IS can contribute to enhanced societal value.

1 Introduction

IS research methodologies generally assume bounded, well-structured research problems that do not effectively address wicked problems in complex societal ecosystems. Global challenges such as climate change, ageing populations and growing inequality are all sources of wicked problems where the field of information systems (IS) could play a significant role with outcomes that could benefit society. However, by their very nature, traditional empirical research approaches are not suited to rigorous holistic research into these topics. We propose that new IS methodologies based on principles of complexity theory are required for investigating such phenomena. This paper develops such a methodology and demonstrates its value and fitness for the purpose of investigating wicked problems in complex societal ecosystems.

This paper is motivated by a particular wicked problem, namely that of the societal challenge facing developed countries due to their ageing populations and the potential adverse impact of these on health, economic and social systems (Harvey & Thurnwald, 2009). It is informed by research we conducted into the social use of Information and Communications

Technologies (ICT) by elderly citizens in Australia where the number of citizens over the age of 65 years is expected to double by 2021 (ABS 2013). Economic consequences of this demographic challenge are high on the national agenda as a smaller workforce must provide for a growing number of retirees who will become increasingly dependent on health care and general living services (Aus Govt 2004). From the societal perspective there is the imperative for senior citizens to live well as they live longer.

Our research explores how ICT can play a positive role in contributing to the social wellbeing and quality of life of the current elderly population who learnt most of their life skills before the digital age.

Isolation of the elderly, either at home or in an aged-care facility, can have negative impacts on their wellbeing leading to loneliness followed by more severe problems such as depression (Luo et al 2012). There is a large body of evidence that remaining socially connected is a major contributor to health and wellbeing, (see e.g. Diene & Chan 2011). Our contention is that ICT can help overcome the social isolation of the elderly, reconnecting them to family, friends, and community to improve their wellbeing and, where appropriate, enabling them to remain productive members of society. Whereas younger people who may become physically isolated would stay connected, few elderly citizens have access to appropriate technologies or have the relevant skills to use them (Hakkarainen 2012).

Two years ago we began an investigation into the potential of ICT to overcome the isolation of elderly citizens. The objective was to determine what type of online activities would have a beneficial impact on the social wellbeing of elderly citizens. After some initial exploratory work, the intention of the main study was to follow an action research approach in which interventions, consisting of the provision of ICT, Internet access and weekly help sessions, would be provided to elderly residents of several aged-care facilities. We also intended to use standard constructs to measure social wellbeing, pre and post these interventions, to determine their effect. However it became abundantly clear that this is a wicked problem with multiple interconnected and contradictory elements. As we explain below, our approach needed the participants to play an active role to make sense of, and reflect on their engagement in the ICT online environment. Moreover, there is no appropriate construct for measuring changes in wellbeing due to ICT use among this cohort over time when their physical and mental capacities are significantly diminishing.

The central challenge of the project thus became to develop an innovative methodology appropriate to action research into this type of complex problem. In doing so we demonstrate the importance of adopting a research orientation based on complexity and a research approach that incorporates Complexity Theory principles into the design and conduct of the research. This in turn has implications for how and what data is collected, how it is analyzed and how the results are presented. We make the claim that only by taking such an approach can meaningful results be obtained from participatory action research projects within complex social ecosystems. We further claim that a methodology that embraces complexity and adopts Complexity Theory principles is novel in IS and the methodology we have developed is a major contribution of the paper. Additional contributions come from our demonstration of the application of this methodology in our case setting and from the findings of the research itself with respect to aspects of wellbeing that can be attributed to the use of ICT by the senior elderly.

The paper is organized in the following way. In the next Section we provide some background material and confirmation from the literature that the potential benefits of the social use of ICT by senior elderly have been neglected both in research and in practice. Following that, we provide evidence of the complexity of this societal challenge. In order to address this complexity, we then examine elements from Complexity Theory, some of which have been previously applied in Information Systems (IS) research and practice, to articulate a methodology for IS research that acknowledges the complexity of societal ecosystems and incorporates Complexity Theory principles. We then apply this methodology in the design of

the participatory action research to be followed in the investigation of the use of ICT by senior elderly citizens for their social wellbeing. The conduct and outcomes of the research are presented demonstrating a case where there is societal value of IS research. The contribution of the research itself and, more particularly the description and demonstration of the methodology based on Complexity Theory, are then discussed.

2 Background

The context of research presented in this paper form a social ecosystem of multiple stakeholders, elderly citizens in a wide range of circumstances and needs, and with varying capability that would affect their ICT use. Items that motivate the research are (1) the increasing isolation of the elderly, (2) the negative consequences that this can have for their wellbeing, (3) the potential of ICT for overcoming social isolation and (4) the low use of ICT among the senior elderly. In order to illustrate the complexity of the research setting, and therefore the imperative for a research methodology informed by Complexity Theory, we provide background evidence and explanation of these items from the literature and from initial discussion with various stakeholders.

2.1 The social wellbeing of the isolated elderly

Isolation is a particular problem in aging populations. A UK study showed that over three million people aged over 65 don't see another person in a week (Campbell, 2010). In Australia the number of single person households, by choice or by necessity, particularly among older people is increasing (McKay 2007, ABS 2013)

There is a popular assumption that it is better for elderly citizens to remain in the familiar surroundings of their own homes for as long as medically possible and only making the move into aged-care facilities as late in life as possible (Porteus & Brownsell 2000). An extensive investigation of residential circumstances of the elderly in Australia (Wells & Herd 2013) provides extensive evidence to the contrary. The study shows that of all over 60 year olds those living in the family home as a 1 or 2 person household have, as a group, the lowest community engagement and express the least amount of intimacy in their lives compared with those in retirement villages and other independent living arrangements. Their reduced mobility and the lack of aged-friendly considerations in the design of local neighborhoods are contributing factors to increased social isolation from family and friends as well as from participation in communal activities. On the other hand, the study also found that making the move to an aged-care facility (also known as a nursing home) at an advanced age is traumatic and disruptive to both the elderly themselves and their families leading to similar experiences of isolation.

Many studies (e.g. Nikmat et al 2013 Cornwell & Waite 2009 Luo et al 2012) have revealed a distinct association between social disconnectedness and with physical and mental health among older adults. These studies show a relationship between perceived isolation, loneliness and increased mortality risk. Norrie (2012) reports that isolation and loneliness pose an increasing threat to the health of seniors as many are cut off from friends and locals by ill-conceived urban design. Isolation appears to be a universal problem in ageing populations (Erickson and Johnson, 2011). A lack of social interaction can make the elderly more vulnerable to depression and to problems such as excessive drinking, poor diet and a reduction in exercise. Moreover most aged-care policies assume that because elderly people have ceased working, they have also ceased being productive or, at least, proactive in adopting new ways to maintain social connections, as they become less mobile and more disconnected from lifelong social support structures (Harper 2006; Sperry & Prosen 1996).

Despite the acknowledgement of the enormous benefits of social connectedness, bio-medical issues dominate the discussion on the wellbeing of the elderly. Most aged-care

initiatives focus on the medical needs of residents with little attention paid to addressing other aspects of their wellbeing. As King et al (2012) report, there are structural boundaries separating medical from social concerns reflecting the historical separation of health and social care, including aged care.

On a positive note, there is growing evidence that older people are seeking ways to enable themselves to remain actively and productively involved in the community (Harvey & Thurnwald, 2009). A productive ageing paradigm is seen to transcend the physical or functional status of the older person through engagement in activities that are genuine and meaningful, and emotionally satisfying. Maintaining an intellectually challenging and contemplative mindset, and identifying activities that will be meaningful and therefore personally satisfying, lead to productive ageing that is in the best interests of both society and the individual (Kaye, et al 2003).

2.2 Digital literacy and the Elderly

The view that the senior citizen cohort is relatively computer and Web illiterate is changing and varies considerably with age. This is largely determined by their experience with computers at work and at home. For example, the current senior elderly group (i.e. those over 70 years) who now reside in aged-care facilities were not greatly exposed to personal computers that first appeared in the 1980s when the senior elderly were well into their working life with many women out of the workforce. In contrast for those now facing retirement in their 50s and 60s, reports on the use of the Internet in the US in 2010 (Pew, 2010) indicate that the average usage among those over 50 had nearly doubled in the preceding year, from 22% to 42% of those surveyed. Among those using social networking sites, the findings recorded 47% of 50 to 64 year olds and 26% of those 65 years and older. Email was still the main online medium among older users with use of Skype also prominent. The use of social media was increasing. In the US in 2010 numbers using MySpace, Facebook and LinkedIn had grown by 88% among 50-64 year olds and 100% among older users (65 and over), whereas growth among younger users (18-29) (already representing 86% of all users) was only 13% (Madden, 2010; Pew, 2010).

Australian research into Internet use by seniors (Palmer, 2011) pointed to the need for access to training, technical assistance and information as important for this group. The average age of the participants in this study was 72.2 for non-users and 71.3 for users. Earlier studies (referred to in Palmer, 2011) have also suggested lower educational level, income level and workforce participation might be contributing factors in lower usage of Internet based services. Other findings included: lack of skills, anxiety about technology, fear of doing something wrong, concerns about security, interest levels, lack of knowledge and a recurrent concern: lack of time. Lack of services and not knowing where to find help were a concern. For some, the cost of access was a barrier. Users had a generally positive view of the Internet's impact on wellbeing, while non-users thought it would have a negative effect. A concern expressed in the report's conclusion was that, while, in this study, non-users experienced little inconvenience at present, they were concerned that lack of access might be a problem in the future (Palmer, 2011).

There has been a strong focus on teaching seniors what might be considered only very basic skills (for example, see seniors.gov.au) and there is a substantial body of literature relating to this. An Australian Human Rights Commission report (AHRC 2000) recommendations emphasized education and training and provision of appropriate technology ("adapted or customized equipment") to achieve effective Internet access. Among the barriers listed was the need for awareness and training of available options as they are actually used. Parry (2011) states that teaching mobile web literacy is as important as teaching basic literacy. Several research papers, (Kehoe et al, 2009; Xie and Bugge, 2009; Xie and Jaeger, 2008) focus on training seniors in Internet use and emphasize its importance. Internet literacy programs for older users are regarded as an essential first step, but more is required, for

example: using social media, to sustain interest and assist people as they age to gain social media skills.

The elderly are not digital natives and vary in their use, attitude and understanding of ICT and the Web. They also have many particular challenges in using ICT (Burgess et al 2012). These include physical (eyesight, dexterity etc.), cognitive (identity, security etc.) and cultural, where the attitude to social media is often suspicious and negative. What the elderly want and are able to do with ICT will therefore span a wide spectrum of activities that challenge the introduction of programs to engage them in beneficial ICT-based activities.

In a study by Chung et al (2010), factors affecting perceptions of online community participation were investigated. One finding was that ease of use was no more important to older users than it was to younger users. Older users were concerned about privacy issues and this might be a factor influencing their participation in social media sites. Ease of navigation and content relevant to the target audience, regardless of age were important. Perceived quality of sites and web design are thus important to older and younger users alike. Additionally, Klamer and Allouch (2010) suggest that it is important to study hedonic factors in order to get a more complete view of the factors that influence acceptance and use of technology. However, they found no evidence from their study to indicate that hedonic factors, enjoyment and playfulness, were important for the elderly to accept and use technology. Nevertheless, including such factors in the design of systems for older users should be considered.

2.3 Potential of ICT to improve the Social Wellbeing of the Elderly

“Ultimately, virtual communities can combat social isolation by offering a new channel for older Australians to form support networks, maintain contact with friends and family, and participate in different parts of the community.” (ADHA 2011).

As this statement suggests, the ADHA understands the importance of bridging the digital divide for older Australians. As well as the significance for e-health approaches, the report (ADHA, 2011) also acknowledges the potential usefulness of social networking for combatting loneliness and social isolation. One UK digital media commentator, Martha Fox, is adamant that technology could help address some of the disadvantages for the isolated elderly Fox believes that having access to ICT is about social justice, a moral and economic imperative and a basic right, like learning to read. As one newspaper reported “If you’re not helping people to read, clearly, you are massively disadvantaging them.” (Campbell, 2010).

Access to information services by the elderly has long been acknowledged as important. The Australian Human Rights Commission report (AHRC 2000) on access to digital technologies for older Australians, expressed the view that these technologies offered considerable potential for providing greater access to government and to business information services. There were improved prospects for access to education for older Australians and those with disabilities. The potential to provide services at locations and in formats that otherwise might have been difficult to access was also stressed. Concern was expressed that access might not be equitable across the community, with some older Australians not enjoying the same level of access that others took for granted. Areas covered in this report included Internet document access, web page accessibility, telephone banking and bill payment.

Research on the link between ICT use and wellbeing has reported conflicting findings. In a UK study reported in 2006, Dickinson and Gregor (2006) suggested that “computer use had no demonstrated impact on wellbeing in older adults.” A more recent Canadian study of seniors over 60 (Erickson & Johnson, 2011), however, suggested that use of the Internet promoted “higher perceptions of self-efficacy” among seniors using the Internet regularly over those who did not. Similar findings were reported in a US Study (Phoenix Center, 2009; Ford and Ford, 2009), which reported positive results, with 20% reduction in depression,

among elderly American Internet users. This study looked at survey responses from 7,000 American retirees, aged over 55 years. It concluded that there were significant health outcomes to be had from expanding Internet adoption in this age group, with potential economic savings as well. The report's co-author (Ford, G., quoted in Phoenix Center, 2009) stated that: "The positive mental health consequences of Internet use demonstrate, in part the value of demand stimulus programs aimed at older Americans."

Most efforts to date involving the development of ICT for aged-care are concerned with technical biomedical initiatives that are aimed at improving health outcomes for the elderly at lower cost (Hilty et al 2013). ICT-based patient monitoring, remote consultations with health professionals and other telemedicine programs are set up so that elderly citizens can remain living in their own homes for longer into old age thereby reducing the demand on costly residential aged-care facilities (Nikmat et al 2013). Recognizing the potential of information and communications technologies (ICT) to ease the financial burden of looking after these high demand and high cost dependents, governments are funding various initiatives that largely seek medically-focused ICT as the means of improving home-based aged-care services. The potential usefulness of ICT and social media in overcoming isolation, loneliness and depression has some representation in the literature, although it is clear that this is an area where further work is needed.

2.4 Indicators of Social Wellbeing among the elderly

As our research seeks to determine how ICT can contribute to the social wellbeing of the senior elderly, we have investigated whether there are appropriate and meaningful indicators of social wellbeing among this cohort. Wellbeing is normally associated with people's experience of their quality of life determined by the satisfaction with their lives and sense of personal development in their particular social context (NEF 2013). A standard approach to our research problem would be to assess wellbeing using a standard measure before and after interventions involving suitable programs of computer use among a typical population, i.e. treating wellbeing as our dependent variable. Two prominent quality of life assessment regimes are (1) the World Health Organization's Quality of Life index (WHOQOL), an authoritative cross-cultural instrument which includes 24 facets relating to quality of life, which are grouped into 4 larger domains: physical, psychological, social relationships and environment; and (2) the French subjective quality of life profile (SQLP) which covers a broad range of domains (functional, social, material, spiritual). Both can be used as self-administered, predefined checklists and, while well-respected, Carr and Higginson (2001) advise against their general use, as quality of life is highly individual and must take into account the things people regard as important in their lives. Wellbeing "is determined by an individuals' perceptions of their position in life taken in the context of the culture and value systems where they live and in relation to their goals, expectations, standards, and concerns". (Carr and Higginson 2001 p1358).

In addition to such self-reporting surveys, common ways to measure wellbeing are behavioral observations such as the number of smiles (Abel & Kruger 2010) or even physiological responses (Brummel et al 2009). Such measures would not be possible in our case study. However, to establish a statistically significant relationship between ICT use and wellbeing, an approach based on measured changes to a wellbeing indicator would need a large number of participants who were subject to equivalent interventions. Over the time needed to show such a change, many other aspects of the life of the elderly could also change dramatically (physical, mental, circumstantial issues) and these could so significantly impact on the wellbeing of the elderly as to mask the ICT effect. Simple measurement of wellbeing does not make sense in this investigation.

3 Complexity Theory as a Research Methodology

From the background investigation and literature review describe above we concluded that three key themes; **Stakeholders Perceptions**, **Capabilities of Elderly Users** and **Changes to Social Wellbeing** are the focal issues that inform the research design and the data analysis. But these themes are each complex issues and interact with each other in complex ways because of the range and diversity of elements in the critically important challenges of aged-care.

We therefore make the case for taking an approach to our research based on Complexity Theory. We suggest that in all developed countries the area of aged care as a whole should be approached as a complex adaptive system, or even a complex ecosystem. For the purpose of our research we add to these systems the particular challenges of ICT acceptance and use by elderly people as well as their different social circumstances and needs. The elderly have different circumstances, needs, capabilities and challenges that would impact their use of ICT. This makes meaningful measures of changes to wellbeing complex. There are also challenges for the researchers in setting up intervention of ICT use with this cohort given their complex living and social arrangements.

In such contexts taking an incremental, bottom-up approach to both the research and practice based on principles of Complexity Theory makes sense.

In common parlance the word 'complex' is often applied loosely. However, for rigorous research it is necessary to make a clear distinction between situations or problems that are genuinely *complex*, so that research should follow a methodology that acknowledges this complexity, and ones that are merely *complicated*, so that a traditional reductionist research methodology is appropriate (Snowden 2002; Kim & Kaplan 2006). Although composed of many intricate parts, *complicated* systems can be understood by careful examination of its components whereby their future behavior can be predicted. *Complex* systems are fundamentally different as they are "... comprised of populations of interacting entities where the overall system behavior is not predefined but rather emerges through the interactions of its entities" (Kim and Kaplan 2006 p37). In a methodology for complexity, important first steps are understanding complexity principles and identifying complex situations and problems. The researcher is then justified in applying principles of Complexity Theory to studying those situations and tackling those problems in an appropriate way.

A complex problem is often referred to as 'wicked' since it is difficult or impossible to solve because of incomplete, contradictory, and changing requirements that are often difficult to recognize (Rittel and Webber 1973). Moreover, because of complex interdependencies, the effort to solve one aspect of a wicked problem may reveal or create other problems. Stakeholders may hold contradictory but valid views of a wicked problem and how it should be solved. There is often a dialectic relationship (Hegel 1969) between a particular position (a thesis or proposition) and a diametrically opposed position (its antithesis, the negation of the thesis or a reaction to the proposition) where both are valid. Synthesis resolves the conflict between the thesis and antithesis by reconciling their common truths, and forming a new proposition. Thus wicked problems are not 'solved' in the usual sense of the term but are resolved (or dissolved) through synthesis. In time this new proposition is itself challenged creating further wicked problems and this dynamic also contributes to the complexity of the phenomena.

3.1 IS and Complexity Theory

The field of IS is founded on the benefits of taking a systems approach to problem solving (Watson et al 2010). There has recently been recognition that work on Complex Adaptive Systems (CAS) in other fields could be valuable to IS research endeavors. This has been most prominent within IS Development (ISD) where several research teams have applied

CAS organizing principles and suggestions for best practice to an analysis of the ISD process. Meso and Jain (2006) identify seven principles of CAS that apply to ISD, namely: open systems; interactions and relationships; transformative feedback loops; emergent behavior; distributed control; shallow structure; and growth and evolution. Vidgen and Wang (2009), with a focus on co-evolution and agile development, have provided a descriptive framework, which is grounded in the work of Volberda and Levin (2003) on co-evolving self-directed organizations. According to them, CAS can be characterized through the emergence of co-evolutionary, self-organized behavior, structure and order through the interaction of interconnected autonomous agents in a time-paced rhythm balancing at the edge of chaos.

In demonstrating the application of CAS to ISD in practice, Kautz (2012) places the concept of emergence at the centre, highlighting: the emergent order resulting from self-organizing agent interactions; the emergence of team learning as a result of the interaction; emergent self-organization; co-evolutionary based emergent behavior and structure; emergent complexity at the edge of chaos; and the rhythm of working in an emergent state of time pacing; and the emergent balance between exploitation and exploration. However, there is little understanding of how to operationalize these concepts.

3.2 Understanding Complexity and Complexity Theory

Although there is no single version of Complexity Theory, it is generally agreed that it is concerned with the behavior over time and space of complex adaptive systems. In such systems, the number of components is sufficiently large that conventional descriptions of relationships between elements are not only impractical, but cease to assist in understanding the system. Components in the system are ignorant of the behavior of the system as a whole, responding only to what is available to them locally. The components also have to interact and their interactions are dynamic, rich and non-linear. New states of the system co-evolve through the self-organization of elements so that unpredicted patterns of behavior emerge (Mitleton-Kelly 2005). The processes of emergence and co-evolution cannot therefore be planned but can be encouraged through the intervention of 'attractors' (such as incentives and rewards) with the imposition suitable 'boundaries' (e.g. a limited budget) (Kurtz & Snowden 2003). Precise outcomes cannot be known in advance but positive outcomes are likely if the attractors and boundaries are chosen well to influence the behavior of the system towards the desired direction.

The distinguishing characteristic of complex co-evolving systems is their ability to create new patterns of order. In human communities this may take the form of new ways of communicating, acting, thinking, and relating or even the creation of a different culture or a new organizational form (Mitleton-Kelly 2005, 2011). Complex systems operate far from equilibrium conditions so that constant change is the norm. The existence of open and ill-defined boundaries adds to the complexity as the system can be understood in different ways from different perspectives.

In seeking a way to operationalize these concepts in our research we explore the ABIDE framework from the open-source movement (Snowden 2002) as a high-level lens for re-thinking complex systems and working towards solutions (Snowden and Boone 2007; Snowden 2012). In the ABIDE approach, *Attractors* (motivators, incentives etc) and *Boundaries* (limits within which participants can act freely) replace the more formal command and control mechanisms of achieving desired behaviors and outcomes. People are then able to establish their own *Identity* within the social system. *Dissent* and *Diversity* are managed but encouraged so that the actors (human and technical) have the level of variety (Ashby 1957) to be creative and innovative. *Dissent* can place the system on the edge of chaos which brings risks of negative outcomes but can also be a stimulus for innovative solutions. Interventions that may lead to dissent must be safe-to-fail, which means that if they fail participants must be able to survive the consequences and recover without penalty.

The underlying enabler for working successfully in the complex domain is the maintenance of a supportive *Environment*. Within such an environment, suitable attractors and boundaries can be applied, diversity welcomed and dissent allowed in a respectful culture. Two critical elements of a supportive environment are 'safe-fail' and 'time pacing'. 'Safe-fail' involves building into a program the possibility for explorative endeavors where the effort of trying something promising that does not work as intended is viewed as a learning exercise not something to be avoided. Sometime unanticipated outcomes to initiatives are, on reflection more appropriate than those planned. 'Time pacing' allows activities to happen at a pace that suits the actors involved and provides a suitable rhythm to events. The elderly are often slow to grasp new skills but can do so if given time and not pushed at the pace of younger people. Both safe-fail and time-pacing are critical when working 'on the edge of chaos'. In such an environment, problems encountered by the actors, will generate many embryonic 'solutions'. From these emergent propositions, the actors may nominate one that shows promise and can be further encouraged and resourced.

3.3 Application of Complexity Theory in Research and Practice

Summarizing and synthesizing the principles of Complexity Theory from those identified above, we propose the following steps the make up a methodology for conducting IS research and practice in complex situations:

1. Understand Complexity Theory principles: so that terms such as edge of chaos, time-pacing, emergence, co-evolution and self-organization can be incorporated into the IS discourse alongside dominant organizational terms such as structured development, BPM, PM, requirements engineering, on time and within budget; rule-based decision support and so on.
2. Recognize complex situations and problems: distinguishing the complex from the complicated
3. Set high-level objectives but not detailed problem formulations: refrain from imposing top-down solutions but rather create an environment for self-organisation and emergence
4. Choose and apply suitable attractors while setting appropriate boundaries
5. Provide a supportive environment, allowing 'safe-fail' in a time-paced rhythm to activities
6. Allow dissent as a source of innovative, community-based solutions to problems
7. Appreciate diversity among the different identities, needs and potential contribution of relevant stakeholders
8. Continually observe and evaluate emergent patterns of activity and behaviors
9. Reward and encourage desirable patterns of activity and behavior that show promise; continue the choice and application of new attractors and boundaries to allow further emergence
10. When appropriate, standardize or systematize any valuable emergent patterns and embed in practice

True to the tenets of Complexity Theory, these steps rarely follow a linear process but can move around the sensemaking-action-reflection arrangement depicted in Figure 1 in response to events and changes in the environment. Certainly, sensemaking and reflection are bound to occur during the action.

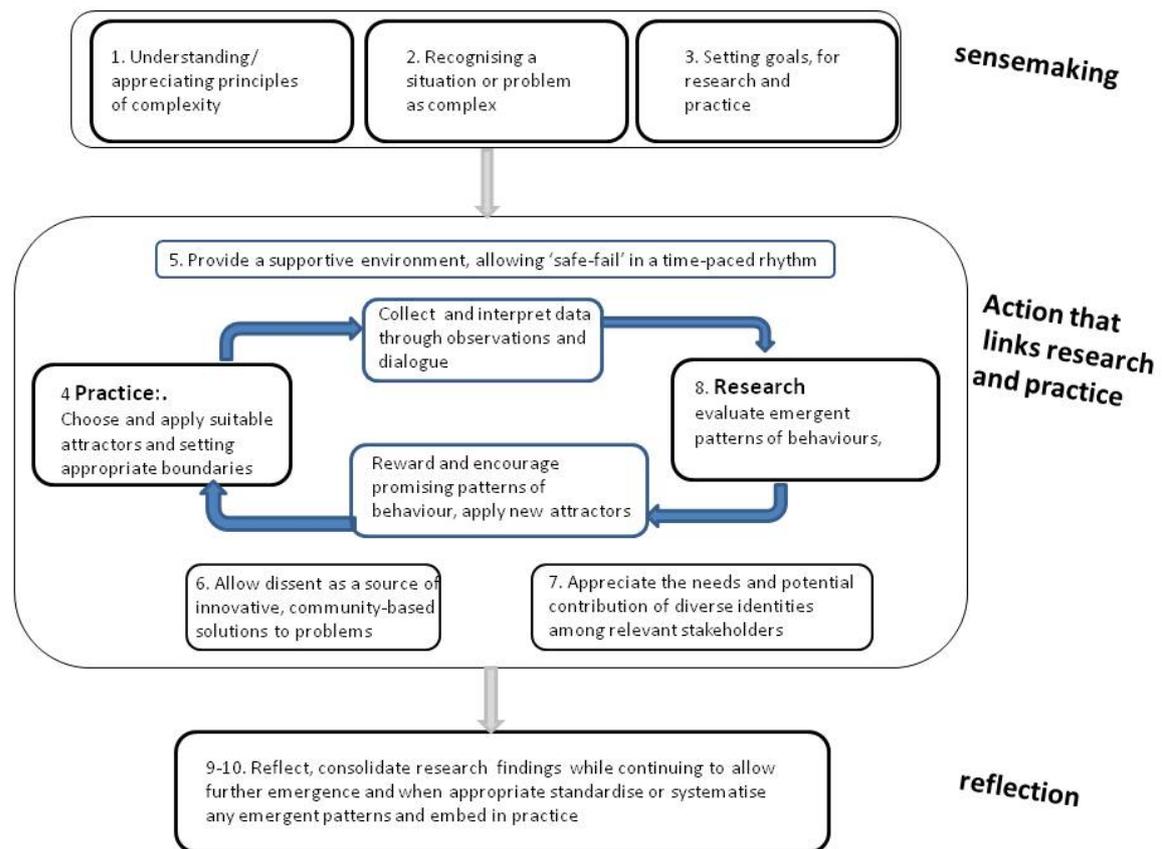


Figure 1 A Complexity-based Methodology in a non-linear sensemaking-action-reflection arrangement

The central tenet of this methodology (Steps 4-8) resembles the core of the action research cycle, widely adopted as an interventionist approach to the acquisition of knowledge in social science research. The action research process needs to appreciate the dual imperatives of the research agenda and solving practical problems (McKay & Marshall 2001). In linking the separate trajectories of these two imperatives, a series of planned interventions by the researchers are followed by reflective analysis of their effect on practice (Baskerville & Wood-Harper 1996). In the language of Complexity Theory, the *interventions* would take the form of suitable *attractors* introduced into the complex situation under investigation.

In the approach advocated by McKay and Marshall (2001 p 47) "... the action researcher is viewed as a key participant in the research process, working collaboratively with other concerned and/or affected actors to bring about change in the problem context". The problem owners (in our case our elderly participants) collaborate with the researchers utilizing each other's skill, experiences, and insights to achieve both practical problem solving and the aim of the research in generating new knowledge and understanding. While the researchers bring an intellectual framework and rigor to the investigative process, the problem owner brings knowledge of context.

In the development of a general complexity-aware methodology for our research, we emphasize the importance of Steps 1 to 3 (sense-making) where researchers understand and appreciate the principles of Complexity Theory so that they can clearly identify a situation or problem as complex and, while some high-level objectives are needed, the researchers avoid the imposition of detailed hypotheses, propositions or intended outcomes. In a complexity-aware methodology, the interventions of an action research project cannot

involve formal planning and application. As identified by Kautz (2012) it is essential to allow emergence in the range of areas, in particular as stated above, “the emergent order resulting from self-organizing agent interactions” and “the emergent balance between exploitation (of what is known and available) and exploration (of what is possible and beneficial)”. From the ABIDE Framework we emphasize the need to allow safe-fail, to encourage respectful dissent for innovation, and to acknowledge the diversity of identities assessing progress and success in terms of individual goals and needs.

During Steps 4-8 data is appropriately collected, analyzed and interpreted by the researchers and participants to achieve mutually beneficial outcomes so that in Steps 9-10 (reflection) what has been learnt becomes the research findings and informs practice, which are both contributions to knowledge (McKay & Marshall 2001). There may be innovative methods for data collection and analysis within the complexity paradigm but it is more likely to be inductive rather than deductive. In our case we identify major themes from literature and exploratory research. Then in the main phase of the research we refined these themes and used them to structure our reporting on the findings that dynamically emerged through observation and discussion among stakeholders.

4 Applying the complex-aware methodology

Following our complex-aware methodology developed above we now describe, analyze and report on the conduct and outcomes of our research.

4.1 Phase 1: Sense-making in our Research

We have already presented the first two of the sense-making steps in our project by describing our understanding of complexity principles in Section 3 above (Step 1) and providing evidence of the complexity of the problem in Section 2 (Step 2). The high-level objectives (Step 3), are (1) for the *research*, to explore and understand the means by which ICT can enhance the social wellbeing of the elderly and, (2) for *practice*, to engage the elderly in using ICT for their wellbeing as perceived by all stakeholders concerned with their care and the national challenges of an ageing population. To meet these objectives we developed programs (interventions) whereby elderly residents in aged-care could be provided with computers, Internet access and help in group sessions to use these in whatever way would be best for each participant (i.e. these are the attractors of Step 4). The setting for this study, Australia, is a Western developed country with a high level of IT and Internet use and the challenges of an ageing population.

4.2 Phase 2: Actions that link Research and Practice

Our research action began with an exploratory phase when we identified and interviewed stakeholders and held focus groups at seniors computer clubs. This was followed by the action research consisting of interventions of computer sessions with residents of two aged-care facilities. As this action progressed we determine how data would be collected and analyzing and refined the themes that would guide our presentation of findings.

4.2.1 Focus Groups and Interviews with Stakeholders

In the first exploratory phase of our research we identified a range of stakeholders in aged care including government officials, community workers, owners and managers of aged-care facilities, staff in these facilities, service providers, families and carers. In order to determine the viability of our investigation on the social use of ICT among the elderly, we conducted:

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- informal interviews with representative stakeholders in the Aged Care Sector to determine from their knowledge and experience, the social needs of the elderly and potential benefits of online social interaction among senior citizens.
 - focus groups with senior members of a local Computer Club on their use of the Internet and attitudes to social media.

As reported elsewhere (reference removed for reviewing) this exploratory research confirmed the following:

- that the emphasis on current e-health research was on technical and medical issues;
- that among the senior elderly (those over 70) computer ownership and use is particularly low;
- that loneliness was a major problem as people aged and had a significant effect on their health and wellbeing, often leading to depression;
- that ICT and the Internet could be used as part of an approach to reduce the isolation of the elderly. However a variety of systems would be required to suit people in different circumstances and conditions.

Managers and activity officers were interviewed in five aged-care facilities where the operation and benefits of the program were explained. We offered to provide computers, independent Wi-Fi Internet connection and run classes free of charge for their residents. The practical allocation of resources and arrangements for the interventions has been complicated by many factors. Owners and managers of the facilities were concerned that already busy staff at the facility would be expected to help residents who have problems with the computers. They were also reluctant to allow us to conduct research other than overt observations of activities that take place during these interventions. Two of the facilities then come on board where our research approach has been adjusted to allow for these constraints.

4.2.2 Sessions of ICT use by the Elderly

In the two aged-care facilities that supported our research, we supplied computers (second-hand laptops and iPads) to several elderly individuals who had very little knowledge of computers. We spent time with them setting up the computers to suit their particular needs, then observed and recorded their reactions, their level of understanding, their capability and challenges.

One of these facilities is maintained by a public provider who had, previous to our involvement, taken a few residents to government-run computer classes in the local town. They had discontinued the effort as the elderly participants had found that the teachers went too fast and did not have the time or patience to suit them. Also between classes many had no device on which to practice and those that did have a computer or tablet had no-one to help them when they encountered problems. Following the insistence of the group of 10 residents who had been taken to the classes, the facility manager reluctantly approved our project but only on the express understanding that the nursing staff would not be expected to spend time helping participants with computer problems. The second facility is one of 23 across the state belonging to a private group whose owners were very supportive of what we wanted to do. The manager of the facility was also supportive and had been pushing to get free WiFi in the facility for residents and visitors. There were, however, no requests from the residents for this program and when we called for volunteers among the residents, it took a while before we eventually had five takers. The contrast between progress in the programs at the two facilities has been significant. In the public facility the initial enthusiasm of the residents drove the program from the bottom up whereas in the private facility the push was top-down. The more rapid success in the former provides evidence that a bottom-up emergent approach may work better in a complex environment.

In both facilities we arranged weekly classes and general help sessions on how to use of these devices and what they could be used for. Some of these classes were run by the

researchers and some by other suitable instructors. The researchers would often pop into these sessions via Skype. Attention has been paid to a happy, fun and relaxed environment satisfying the safe-fail, time-pacing, dissent and diversity elements of a complex context. During these activities the researchers observe, take notes and engage in discussion with all stakeholders: facility owners and managers, the instructors, residents, staff and volunteers who participated as well as other visitors to the facilities, family and friends of residents. In this way extensive qualitative data has been collected from these activities involving over 30 participants over a period of one and a half years. As the research proceeded themes were identified and as these accumulated we reported them to experts experienced in aged-care research for verification, comments and suggestions for other candidate themes that we may not have noticed.

Although progress has been slow due to the time-pacing of the elderly, we have now identified many factors that should now be reported. In the public facility, the manager and activities officer, once reticent, are now enthusiastic supporters and are setting up a web-kiosk with more laptops and involving more residents in a second facility. Students from the local high-school will visit to give extra assistance. The private facility has just appointed a new manager with instructions from the owners to keep the project going there. In both programs there have been many observed incidents of improved wellbeing among the residents, which we describe as themes in the following section.

4.2.3 Experiences and Observations of the Action

In order to structure and code the data, we began the action phase of the research with the three main themes that had emerged by that stage

1. the theme identified in the literature review, namely the attitudes and characteristics of the elderly as computer users
2. the theme that emerged from the initial exploratory research, namely the variety of perceptions, attitudes and imperatives of different stakeholders
3. the theme that emerged from the main phase of the research, namely aspects of social wellbeing that would be relevant to determining the benefits of the interventions.

While each theme focused on different phases of the sense-act-reflect approach, the issues relevant to each theme was continually evolving as emerging issues required us to cycle through the phases in order to appropriately understand and incorporate the issues. However we are presenting a more linear account of the project from the perspective of having completed this aspect of the project.

4.2.4 Theme 1: Attitudes, Characteristics and Capability of the Elderly as Computer Users

Our literature review reported many of the challenges that face elderly computer users. The themes of usefulness, attitudes, ease of use, learning, hedonic factors and usability that emerged from the literature involve a mix of physical and cognitive factors together with the affordances of the technology. Time and again we observed the importance of matching the technology to the user. For some complete novices, the intuitive iPad interface was immediately enticing; for others who saw the computer as a way to remain a productive member of society, the iPad was seen as a frivolous toy. We report observations to illustrate the main themes.

As observed in the initial phase of the research, the main physical usability issues we encountered were eyesight and dexterity. Changing screen resolution helped those with poor eyesight but often meant confusion as there was less to see on the screen and a greater need for scrolling. For some, pressing Ctrl Alt Del was not possible so we found a way to

disable this on the laptops we provided. The sensitivity of touch screens were also a problem for some.

The cognitive challenges we recorded are more prevalent and more pervasive. Just remembering how to boot the computer, make an Internet connection, open applications, find files, deal with error messages and pop ups was daunting for many. Many of the characteristics of computer use that are accepted as common knowledge by most of us, often cause confusion. At one session there was a long discussion on the difference between a user ID that you could tell others (e.g. your email address) and a password that you kept private. For elderly it is particularly important to choose passwords that are secure but easy to remember. These issues are particularly challenging as users increasingly access different applications, each with their own login and passwords. Many were motivated to gain computer skills so they could control their own finances with access to online banking, purchasing and bookings. The advice they had always been given was to choose passwords that were hard for others to guess, not to write down their password or give it to anyone; to change passwords regularly and not to use the same password for everything. However, they also worried that heeding such advice would strain their already failing memories. Choosing passwords was often discussed and a favorite joke concerns the elderly gentleman who said his password was "incorrect" because if he got it wrong he would get the message "your password is incorrect"

It was astonishing how many concepts, which are ubiquitous for the majority of computer users, had to be explained, often many times over, to the elderly users. These include word wrapping, cut and paste, saving, managing and retrieving files, inbox, sent mail, drafts, clicks and double clicks. One lady introduced to email still looked for a received email in her real mailbox. The cloud is also quite confusing. One man had separate itunes IDs for each of his devices and was quite confused as to where his different purchases were. For many security and identity theft issues were either blissfully ignored or quite frightening.

Most of the participants were initially only interested in learning one or two computer applications although some expanded their interest over time when they saw what other were doing. There was always a balance between not giving too much information, so as not to confuse, but giving enough knowledge to get something done successfully. Another lady was given a computer by her daughter so the mother could type up her thesis. All her daughter showed her was how to turn on the computer, open Windows Explorer and double click on the file name on a USB stick, type and save. At each visit, her daughter took a copy of the file before providing her mother with more to type. By the time the lady joined the project the document was quite large and she need help managing it. Showing her some of the ways of working with large Word documents would help but was risky. We did not want her to try things that could damage her important document; a little knowledge can be a dangerous thing. We asked her if she kept a backup and she thought it must be on the computer somewhere, which of course it wasn't. Working with the elderly means spending time and having the awareness to give just enough of the basics needed by each individual as their capability grows.

For us the findings have provided fresh eyes on the diversity of human-computer interactions within the modern virtual world that most of us take for granted. In particular, many of the elderly, who never thought that computers could enrich their lives, have been converted with the intuitive touch screen interface of the iPad/tablet. However, iPads/tablets do not suit everyone. Those who used computers a few decades ago prefer the computers they used then with a keyboard and large screen. We were told that people with dementia can often function quite well with a skill learnt earlier in life while they struggle to learn something new.

Contrary to the findings of the Kramer et al (2009) study mentioned above, we have found that hedonic are an important factor in the acceptance of technology by our elderly participants. When our participants Skyped each other, took pictures and used Google Maps to look at places where they had lived, the laughter that ensued attracted attention from other

residents who then asked to join in the next session. Much joy is felt when distance is overcome by an email message from a friend; or a grandchild waves on Skype; when memories are aroused as they browse through photographs from their travels; or when they come across fascinating websites while surfing the net. There is also a sense of satisfaction as they acquire new skills and become part of the global virtual environment that younger people inhabit. They feel more in control of their lives as they can manage their own affairs online. Participants often express the sentiment that they may not have much time left so they should use it as enjoyably and productively as possible.

4.2.5 Theme 2 Perceptions, Attitudes and Imperatives of Different Stakeholders

During the initial phase of the research interviews, focus groups and workshops were held with a wide range of stakeholders including government officials, research funding bodies, community workers, owners and managers of aged-care facilities, staff in these facilities, service providers, families, carers and elderly computer users. In the main phase of the research, notes were kept of interactions with stakeholders involved in the arrangement of the interventions, the conduct of the interventions and reporting of results to expert researchers and practitioners in the area of aged-care.

The interviews and subsequent discussions to plan the research interventions revealed how extensive was the range of stakeholders in aged-care: from staff in relevant Departments at all levels of government; owners, managers and staff of aged-care facilities, community organizations and volunteers; and the elderly themselves with their carers, families and friends. In the aged-care industry there is government support for the elderly in their own homes, independent living arrangements (retirement villages) as well as low and high care in hostel-type facilities (nursing homes). Some of the complicated issues surround: costs (of the elderly clients and the providers, public and private); quality issues of standards and accreditation; and issues of integration and coordination of services to the end user (individual elderly citizens with a complicated set of needs and circumstances). We could not even assume that all stakeholders, particular those concerned with the increasing costs of aged-care, see increased wellbeing as a desirable objective.

The Australian government recognizes that seniors need support in this area and has funded the Broadband for Seniors Program¹ in order to increase computer use among senior citizens. This program sets up computer kiosks in suitable public venues such as bowling clubs and community technology centers for use by seniors. We have encountered some of these and observed that the program is only partially successful as it targets those younger and mobile seniors with some computer competency.

Among relevant government departments there have been programs that could potentially support our work. They include the National Broadband for Seniors initiative and the State Senior Tech Savvy program. These predominantly provide technology and training for those who are still mobile and ignore those who are housebound or in care. We are petitioning them to consider some recommendations from our findings. However, both are currently being reviewed and we understand that they may be wound down.

The focus groups conducted at meetings of two seniors computer clubs included a mixture of elderly citizens in their 60s and the senior elderly aged 70 years and above. Although there is great variety of computer literacy within these two groups, a general observation is that while many of those in their 60s have had exposure to the use of desktop computers at work and personal computers, laptops and tablets at home, this is far less likely for those aged 70 or above. People in this cohort currently form the majority of residents in aged-care facilities in Australia.

¹see <http://www.necseniors.net.au/>

Among the senior elderly at the computer clubs, acceptance of different technologies was strongly dependent on whether they had experience of computers when they were in the workforce. Some older men had worked with mainframes in engineering firms and/or had built personal computers themselves as a hobby. Women who had been in the workforce were more likely to be familiar with office machines of the 1980s and 1990s. People, who had been introduced to computers more recently outside work, often had a computer that had been given to them by the family. If they had bought one themselves, their choice depended firstly on their financial situation, secondly on what they intended to do with it and thirdly, advice from others.

Among all those who were personal carers for family or friends there was enthusiastic support for our proposal. Many had stories of a son or daughter who had set up a computer and Internet connection for an elderly parent that they wanted to be able to contact and who lived at a distance. Time after time this had not worked well and the computer was not being used. Strong support was also found among those interviewed who had extensive professional front-line experience. However, they noted that as people age a whole range of special needs develop which may impact on their ability to use computers. Many of those interviewed belonged to a Dementia Support Network and indicated that dementia patients would be a particular challenge but one worth pursuing.

Typical expressions of enthusiastic support for the project from different stakeholders are:

My mother lives alone in another state and at my last visit I set her up with a computer so I could at least Skype with her. However, she just doesn't seem to be willing to give it a go and I worry about her,

I worked in aged-care for over 40 years seen how quickly the elderly go downhill when they can no longer get out. They often just watch TV and look forward to the daily visit from the district nurse. Since I retired and can't get about as easily, I rely more and more on the Internet to keep this from happening to me.

Grandpa was always very critical of how much time I spent on my iPad and said he would never touch one. Then, a mate of his showed him some of the things he did. Now Grandpa has one and is a real addict and good on him.

We own 23 facilities in the state and are starting to put Wi-Fi in each of these so that staff can use mobile devices to record and get access to information. We would like to trial free for residents and visitors. There may not be many takers with current residents but it won't be long before it catches on.

When we have reported our findings to expert researchers and practitioners in aged care they acknowledge that this is a valuable adjunct to the mainstream of aged-care which focuses on bio-medical health outcomes, identification and distribution of life services, appropriate residential choices; all within available public and private resources. Although extremely complicated this mainstream involves structured planning, measurement, reporting and accountability. In the unstructured sessions we run, there are no tests or real expectation. Instead the sessions are geared to having fun, growing together and helping each other; laughing at mistakes in the secure knowledge that there is someone there to help. Any successes are celebrated but not tested or measured. This is important and appropriate in this complex setting.

Our work attracted the attention of the Australian Human Rights Commissioner for the Aged who was concerned about an attitude of ageism among these stakeholders. This same concern was expressed by our other experts and we also observed instance of this from time to time that we addressed through long discussions. This is one aspect that we could investigate in more detail in future research.

As predicted by complexity principles, dissent and diversity among stakeholders has often been apparent. Our elderly participants often complain of misguided help: community

computer classes where the instructor doesn't appreciate their particular problems or do not have time to help; or well-meaning family members who change something on their computer that they don't understand.

As our research is an emergent process, it is often hard to convince owners, managers and government officials who want to support this initiative that many of its outcomes are hard to measure or even predict.

4.2.6 Theme 3: Indicators of Social Wellbeing acquired through the ICT Interventions

As previously indicated, an initial objective of our research project was to determine what type of online activities would appeal to the elderly and have a beneficial impact on their social wellbeing. In the context of a traditional research methodology social wellbeing would thus be the dependent variable whose value would be determined before and after our interventions during which participants would engage in online activities. We have however argued that this cannot be meaningfully done in this situation as there are no suitable measures of this cohort and because the wellbeing of the elderly is very changeable under the influence of many factors that would mask any changes due to the ICT interventions.

We have proposed and followed an alternative methodology arguing that it is appropriate for such complex problems. This theme is critical to the contributions of the research. The emergent themes of the wellbeing theme are: connection, occupation, self-sufficiency, self-worth/esteem, productivity, personal development, being in control, and enjoyment. To illustrate these themes we have composed vignettes of typical instances of each. Some examples are presented below. Note that all names are pseudonyms.

Fred is a male in his mid-eighties who was moved from self-care into secured high care with multiple health issues. While the other high-care residents had varying degrees of dementia he did not but was not allowed to leave the facility at will. After just weeks in this unit, Fred reported to us that he had become increasingly depressed at having no one with whom he could carry on a normal conversation. He heard about our project with other low-care and self-care residents and asked to be involved. He has since learned to use basic ICT's and has been able to re-establish connections with an old school friend outside the country and his daughter interstate. They had become estranged but now communicate via email and have sorted out the difficulties that arose when they conversed by phone. He attends the weekly sessions at the facility and is looking forward to being able to use other applications in the future to further expand his connectedness. He now reports an enhanced feeling of wellbeing and relief from the isolation and loneliness he previously endured.

Outcome: connection

Wendy is not very mobile and is in hostel low care. She does not have any close family or friends that she can really trust but can no longer get out to manage her affairs. In our sessions she has learnt to do this online. She can check her bank account, pay bills and do other transactions. She feels more in control and no longer worries that others may be taking advantage of her position.

Outcome: being in control.

Ted is 97 but can still function well in low care. He gets tired after an hour but has no real physical and only mild cognitive issues when using a computer. He used very early computers before he retired from work. He is not attracted by the iPad but when we gave him access to an old laptop he wanted to use it to write his memoirs. He comes to each session, has learnt to use the rudiments of Word and now has several pages of text of his life as an airline pilot which is fascinating reading. He now needs help to research for relevant details on the Web as he has trouble remembering the name of places he wants to write about. Although a bit reluctant, we are trying to convince him to publish his writings online.

Outcome: productivity

Stan has advanced dementia and hovered around some of our sessions mildly interested. He became intrigued when someone started playing patience on an old desktop machine that has been given to the facility but was not connected to the Internet. He has learnt to switch on the machine and we have set up a large icon on the desktop that he double clicks to get started. He will sit there and play for hours often laughing to himself if he wins. The nursing staff are delighted that he is occupied and even think it may be some stimulation for his brain

Outcome: occupation

Valery is in self-care and reasonably well off. She has a daughter who works in the computing industry who has set Valery up with numerous applications on an iPad. Valery had tried to use these but did not really understand what she was doing. Her daughter only saw her occasionally and was frustrated that her mother could not grasp the basics. At her first session with us she mastered Skype. Then she wanted to be able to buy old movies on Amazon, a passion that her daughter did not appreciate. We helped her set up an account and received an excited Skype call when her first package of DVDs arrived. Her next project is to master ebay.

Outcome self-sufficiency

Jan and **Mary** in self-care, love to travel but cannot afford to do so. They just come along to the session and surf the Internet to plan where they would go if they could. They love to do virtual tours of towns, museums, historic sites and gardens all over the world.

Outcome: enjoyment.

4.3 Phase 3: Reflection

4.3.1 Consolidating our findings: embedding emergent practices

Some general findings have emerged from the reflections of participants and researchers and these are being embedded in the practices of the aged-care facilities and other stakeholders. The sessions began as interventions by the researchers and they have been quite informal, allowing for emergence while offering help to participants as needed. After more than a year of these sessions this stage of our research is coming to an end and the core group of participants, with occasional help, are able to manage the sessions themselves as a computer club. The participants now express a desire for more regular formal classes once a fortnight to learn more advanced topics and are willing to pay a small amount each for these classes. We have found someone to do this who will also from time to time run beginners classes for newcomers. Participants still want to have some ad hoc help and are negotiating with the local high schools and service associations for volunteers. The researchers have recognized the value of ubiquitous free wifi and are running a campaign with the owners and with telecommunications companies to find ways to provide this even if it is limited to the facility's common room.

4.3.2 Reflections on our project

As IS researchers, we were familiar with the ehealth literature but at the outset of this project we had little knowledge of literature in the field of aged care. Our review of the ICT related literature in aged-care publications confirmed our naïve understanding that increasing isolation among the growing population of elderly citizens is reducing their quality of life, whereas social connection can improve their wellbeing. It also confirmed our suspicions that, while there was extensive development of ICT-based systems for medical support of isolated elderly, little attention has been paid to the potential of ICT to meet their needs for social interaction.

Throughout this research the message we have received from most stakeholders we encounter is that senior citizens who remain at home until an advanced age or who move into an aged-care facility suffer social isolation as lack of mobility and little informal support restricts their ability to interact with others or engage in productive activities. Many withdraw from community life altogether whereas in similar circumstances, younger people would stay connected and productive online. While few senior Australians now have this capability, our research is showing that, given the right technology and help, this can change. For over two years we have set up and run successful computer groups in residential aged care where residents even well into their 90s are improving their quality of life through what they learn to do online.

Our research has designed and trialled a program whereby isolated elderly in aged-care facilities have been given help to acquire and learn to use digital technology and connect to the Internet. Observing and documenting their progress we show: (1) how the elderly learn to use appropriate technology for suitable activities and (2) how such use can help to improve their social wellbeing and enable them to remain productive members of society.

This has been personally very affirming and rewarding and we claim that what we have done with our knowledge and skills as IS professionals has been of societal value. When we tell colleagues and acquaintances of our study they find the project interesting and many have tales to tell of elderly members of their own family who would benefit from such a program.

On reflection we believe that our understanding of, and adherence to, principles of complexity theory was crucial to the positive outcomes of both the practice and the investigation aspects of this action research project. The programs we have put in place are now well embedded in the practice of the aged-care facilities and should continue to grow. It has also provided us with a wealth of understanding of how the elderly can learn to use digital technology and what they are able to do with it to greatly improve their social and general wellbeing. Our overriding message is that when the elderly who have not used ICT before are motivated to 'have a go', their individual challenges, needs, prior knowledge and learning pace must be taken into account. They should learn on the device that will continue to use and on a device that suits them. They may need ongoing help from someone with lots of patience and whom they trust. They may only master one application over considerable time. However, whatever they do, as long as it is of their own choosing, it can make a large difference to their quality of life.

5 Conclusion

The most significant contribution of the paper is the complexity-based methodology. This claim is strengthened by the fact that the research in its own right has generated significant and insightful findings on the value of ICT to the wellbeing of the elderly thus illustrating and confirming the value and validity of the methodology.

Although it may seem obvious, we affirm that in the sense-making phase it is critical for a researcher using the methodology to first recognize that the problem is complex, to have sufficient appreciation of complexity and to understand the principles of complexity, in particular the key concept of emergence and the general unknowability of the future. This methodology is not compatible with a traditional research approach that proves or disproves an hypothesis; confirms a proposition or even answers a research question clearly state at the outset. Allowing for outcomes to emerge is a difficult concept for many researchers, and reviewers, as it contradicts the dominant scientific models of research.

The action phase requires an innovative and insightful research design appropriate to the circumstances. Our research is just one example of this where we were compelled to find a novel approach to collecting data, analysis it and presenting the findings. We are certain that our approach has produced findings that are valid and meaningful.

The reflection phase benefits from the involvement of as many stakeholders as possible and include benefits for practice in addition to new research knowledge. This phase is grounded in Schön's Reflective Practitioner (1991) as a learning strategy. However the sense-act-reflect approach is a novel means to generate (theoretical) knowledge.

It should be noted that, consistent with the behavior of all complex systems, this methodology may not work if the sense-act-reflect approach is followed in a linear fashion. Informed by complexity theory, these phases blended together to form a robust methodology for the study of wicked problems as demonstrated in our case.

The findings of the research are a significant contribution to knowledge concerning the use of ICT for the social wellbeing of the elderly. While this cohort is experiencing diminishing physical and mental capability we don't believe it possible to apply some general measure of wellbeing before and after a significant intervention of ICT use. Most participants have never used ICT before or used very old technology some time ago. There is a significant learning involved and any continued activity could be considered a positive outcome. We have detected positive aspects of wellbeing that come with ICT use by the elderly as: connection, occupation, self-sufficiency, self-worth/esteem, productivity, personal development, being in control, and enjoyment. Although we have described typical instance of these aspects, our participants typically exhibited a range of these aspects that collectively contribute to their wellbeing. We have also reported emergent outcomes that become embedded in practice such as a computer club for mutual support and formal classes to grow their range of computer use.

We assert that such significant findings are only possible by adopting a complexity based methodology such as the one described in this paper.

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