Accepted to BIT

Using Mobile Devices and Apps to Support Reflective Learning about Older People with Dementia

Kristine Pitts[1], Kevin Pudney[3], Konstantinos Zachos[1], Neil Maiden[1], Birgit Krogstie[2], Sara Jones[1], Malcolm Rose[3], Julie MacManus[4], Ian Turner[3]

[1]Centre for Creativity in Professional Practice, City University London, Northampton Square, London EC1V0HB, UK

[2]Department of Computer and Information Science, Norwegian University of Science and Technology, IT building, Trondheim, Norway

[3]Registered Nursing Home Association, Tunnel Lane, Birmingham B30 3JN, UK

[4]MediaTel Ltd, 77 Endell Street, London WC2H 9DZ, UK

Keywords

Dementia care; reflective learning; mobile apps; formative evaluations

Abstract

There has been little research to develop computing technologies to support the care for people with dementia care, in spite of the growing challenges that the condition poses for society. To design such technologies, an existing model of computer-support reflective learning was instantiated with findings from a pre-design study in one residential home. The result was a mobile device running an adapted enterprise social media app to support person-centred care. Evaluations of the device and app and in two residential homes revealed that use of the app both motivated and increased different styles of care note recording, but little reflective learning was identified or reported. The results suggest the need for more comprehensive and flexible computer-based support for reflective learning about residents in their care – and new designs of this more comprehensive support are also introduced.

1. Introduction

Dementia is a condition related to ageing. Symptoms range from memory loss to decreased reasoning and communication skills [Graham & Warner 2009]. The number of people with dementia worldwide is estimated at 35 million, a figure expected to double in the next 20 years [Wimo & Prince 2010]. People with dementia in advanced economies worldwide where attaining great age has become the norm are increasingly cared for in residential homes by paid carers – typically busy women, often mothers and housewives, not highly paid, practical, and under-pressure to balance care and administrative duties [Help The Aged, 2006 p.33]. In the United Kingdom, their work is often afforded low social status, which contributes to high staff turnover and numbers of inexperienced carers [All-Party Parliamentary Group on Dementia, 2009]. Increasing the quality of care given in such constraining environments has become a pressing issue in the United Kingdom [Department of Health 2012] and similar economies such as Japan [Sugihara et al. 2013] and France [Santi 2013] with increasing aging populations. The 2010 World Alzheimer Report [Wortmann & Fletcher 2013] estimated that the annual societal costs of dementia worldwide were US$604 billion, or 1% of the aggregated worldwide Gross Domestic Product, and 80% of these costs are incurred in high income countries.

Computing technologies have the potential to improve the quality of the care given, reduce paperwork and raise the social standing of care work provided in residential homes. However, most residential homes have used desktop computers only to manage their finances and resident records. Wireless networks have been uncommon, and residents themselves have rarely had access to email or social media. Indeed, technologies sometimes have been perceived to place additional pressures on carers [SCIE, 2010]. In the last 4 years, the situation has begun to change. Initiatives such as the UK Government's *Get Connected* programme have further increased the technological readiness of homes. For the first time, the

foundations for computing technologies to support dementia care in large numbers of residential homes are in place.

Some computing technologies have already been introduced to improve the quality of lives of people with dementia. For example, Wallace et al. [2012] report the use of digital devices designed as furniture pieces to provide notions of home, intimacy and possessions. Whilst evidence suggests that these digital pieces have led to improved communications between carers and residents, we believe that technologies that are designed primarily to support carers in their work can lead to greater enhancements in care quality in residential homes.

However, deciding the forms of computing technologies to support the work of carers remains an open question. Most current commercial systems (e.g. the *Care Management System* from *Ablyss*) are limited to recording and managing resident care notes, normally through desktop computers. Most of these systems offer the like-for-like replacement of paper-based forms with online equivalents, and focus on information management to ensure compliance with regulations. Some of these systems now offer online forms on mobile devices, but exploitation of the affordance of mobile technologies has been limited to real-time, GPS-based panic alerts.

Moreover, these systems provide little explicit support for person-centred care now regarded as essential for effective dementia care. The person-centred care paradigm seeks an individualized approach that recognizes the uniqueness of each resident and understanding the world from the perspective of the person with dementia [Brooker 2007]. It proposes to deliver care based on appreciations of a resident's feelings to learn about each resident, often through reflection-on-action [Schön 1983], i.e. reflections about past care experiences with the resident. New computing technologies have considerable potential to deliver explicit support for person-centred care [Maiden et al. 2013]. In this paper, therefore, we report the instantiation of a descriptive model of computer-supported reflective learning to

inform what we believe to be one of the first uses of software to support person-centred care.

The next two sections of this paper review previous uses of computer technologies in dementia care and introduce the descriptive model of computer-supported reflective learning that was applied to dementia care. Section 4 summarises a pre-design study of care work in residential care, then section 5 describes how an existing mobile software app was adapted to support reflective learning for person-centred care. Section 6 reports results of use of this app by carers in two residential care homes in the United Kingdom. The paper ends with threats to validity and conclusions, from the studies, implications for mobile software to support person-centred care, and concrete designs of a new desktop application and work procedures associated with the use of the application to be evaluated in other residential homes.

2. Related Work

Most reported computer technologies have been developed for people with dementia to interact with directly, for example the pervasive technologies reviewed in Mulvenna & Nugent [2010]. Cowans et al. [2004] reported early work that utilized interactive multimedia to stimulate long-term memory to prompt verbal and non-verbal communication as part of reminiscence therapy for people with dementia. Cahill et al. [2007] makes the case for assistive technologies to make a significant difference to the lives of people with dementia and to their caregivers. These technologies should be delivered at home in a thoughtful, sensitive ethical way to maintain people's independence and improve their quality of life.

Moreover, some technologies have already demonstrated improvements to the quality of lives of people with dementia, as long as core usability problems are resolved [Hanson et al. 2007]. Wallace et al. [2012] describe the use of computing devices designed as furniture pieces to provide notions of home, intimacy and

possessions with which to develop a sense of personhood, and Banks et al. [2013] report work in which older people made personal digital timelines using technologies for memory designed to support creativity and meaning building rather than cues for remembering. Other forms of technology have also been developed. *Ode*, for example, is a fragrance-release system to stimulate appetite among people with dementia who forget to eat – it releases fragrances each day at mealtimes to stimulate reminders [Design Council 2013].

In contrast to these limited successes, there has been very little research into computing technologies for use directly by dementia caregivers. Hayden et al. [2012] reported that caregivers of people with dementia encounter substantial obstacles of access, cost, and time that inhibits their use of computer technologies to education themselves and receive support. Olsson et al. [2012] describe a study that revealed that the use of computing technologies in homes has to meet the needs of the people with dementia and their caregivers. The right technologies used at the right times can be useful, but providing early information about these technologies to people with dementia and their relatives can facilitate joint decision-making about their use. And Powell et al. [2010] reported the challenges perceived by caregivers about the introduction of computing technologies into dementia care – challenges that included the need to balance power and autonomy whilst maximising safety, reduce personal contact and complement rather than replace care activities.

However, at this time, although there is anecdotal evidence of carers using tablet apps for exploring music and places to understand residents, we are unaware of more systematic research to design, implement and evaluate new technologies to support concrete activities needed for person-centred care – technologies that support the carer to understand the world from the perspective of the resident. Developing such an understanding often necessitates learning about the resident, often through reflection about their behaviour and interactions with them. The next section introduces an existing model of computer-supported reflective learning that

we have developed to inform the design of computing technologies that will support such learning.

3. A Model of Computer-Supported Reflective Learning

To support the adaptation of computer technologies to support reflective learning about residents in person-centred care, we applied a descriptive model of cognitive and collaborative activities that take place during reflective learning that computing technologies could support. The model was developed from existing models of reflective learning [e.g. Schön 1983; Boud et al. 1985, Lave 1993] to be a reference model with which to develop computerised support for individuals, teams and organisations. It is reported at length in [Krogstie 2012] and an overview is depicted graphically in Figure 1. Not all of the discrete activities described in the model need to be present in all instances of reflective learning. For example, during reflection-in-action during work, there might not be a conscious decision to reflect, and the framing of reflection might be brief. Furthermore, although the activities are expected to take place in a broad sequence, some activities can be concurrent and repeated.

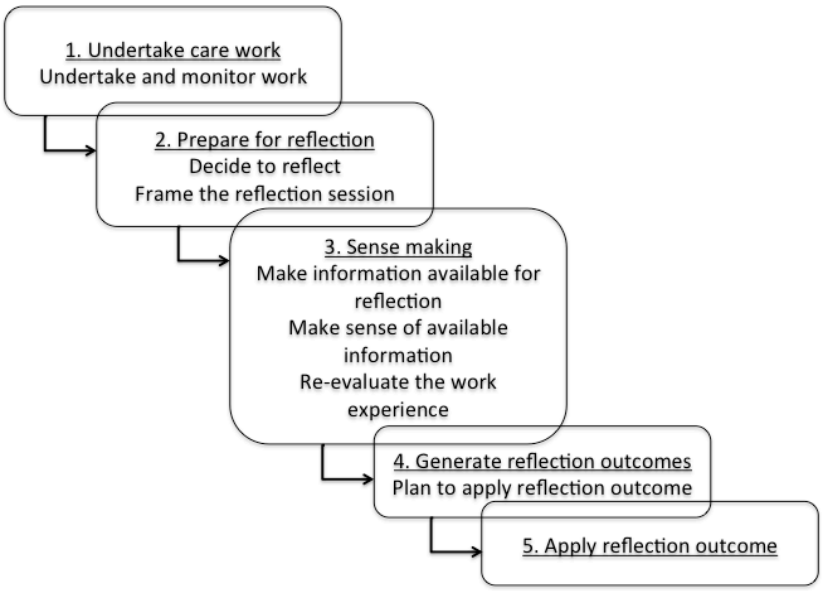


Figure 1. Overview of the Mirror model of Computer-Supported Reflective Learning [Krogstie 2012]

The following sections describe the model's activities applied to reflective learning in dementia care in more detail.

A. Undertake care work: during care work that can facilitate reflective learning, carers are required to document and monitor their own care activities. The monitoring can be both cognitive and automated monitoring. For example, proximity sensors embedded in jewellery based on SocioMetric Badges [Olguin et al. 2009] and worn by carers and residents can automatically monitor social interactions.

B. Prepare for reflection: to initiate reflection, the carer should make a deliberate decision to reflect, often based on the outcomes of work monitoring. For instance, a carer might decide to reflect after experiencing the challenging behaviour of a resident. The carer then frames the reflection session by setting the objective for it, describing who will take part, and making the time and space needed for reflection.

C. Sensing making: the first activities of a reflection session itself are to make information available for reflection. Comparing a care experience with previous ones is an important means by which to do this, so relevant experiences need to be made available. For example, these might be past experiences with a resident to understand the most recent experience. The work experience then needs to be reconstructed using different representations of the data gathered from it, and carers are encouraged to attend to both their rationale thoughts and their emotions during this reconstruction. For example, software can construct an interactive timeline of the resident's recent behaviour to provide the baseline for reflection, or record carer emotions during reflective activities. Carers must also make sense of the information available – what the reconstructed experience means to them in the context of their motivations and objectives, then articulate possible meanings to explain what the experience means to others. For example, carers could use note-

taking software for sharing experiences to explain to others what the violent reaction of a resident means to them.

D. Generate reflection outcomes: the next activities re-evaluate the work experience by framing and critiquing the work experience and reaching a resolution. Framing the re-evaluation requires carers to assess the work experience against success criteria set up for it. These criteria are then used to critique the experience to determine the pros and cons of each alternative candidate resolution using resources made available for the purpose, for example values such as *maintain personal identify* from the *myhomelife* framework [myhomelife 2013]. Carers can then choose one or more resolutions, for example care that reinforce values such as maintaining the resident's personal identity.

E. Apply reflection outcomes: once a resolution is generated and selected, carers can plan to apply the reflection outcome by linking the resolution to the reflected-on work practice, exploring its consequences and sharing the reflection outcome with others. Resolutions need not be applied immediately as changed behaviour, but contribute to an increased readiness to respond in certain ways in certain future situations.

In our work, we have used the current version of the model to provide a reference framework for the types of reflective learning activities that new computing technologies should ideally support. We applied the model to explore different emerging technologies for reflective learning in dementia. For example, we generated new digital solutions to share care data from proximity sensors about interactions with residents based on SocioMetric Badges, and to learn about distressing conversations that can impact negatively on carers' emotional states [Maiden et al. 2013]. However, there has only been limited uptake in residential homes.

4. A Pre-Design Study

The effective uptake of computer-based technologies in residential homes has proved challenging. Muller et al. [2012], for example, report that parachuting in existing technologies into residential homes is unlikely to be effective. Instead, new designs need to be framed by important socio-technical themes such as sociality and trust. For these reasons, we undertook a pre-design study in one pilot home to determine how best to deliver digital technologies to carers in residential homes.

We undertook the study in the dementia care wing of one residential home in the United Kingdom rated as good by the UK's Care Quality Commission. Each resident in the wing had a private room and access to a large day room divided into smaller spaces through the use of screens and chairs. Carers encouraged the residents to move to the day room each day as it was seen as beneficial to their care, compared with remaining in their private rooms. To encourage a sense of homeliness, both residents and carers were free to wander in and out of any room, and doors were only closed when confidential matters are being discussed. There was very little space available for carers could meet and in which to install equipment and objects such as desktop computers and noticeboards.

We observed regular care work that supported the expected everyday activities of residents, such as getting up in the morning, having lunch, and bathing. At the start of each shift, nurses gave each carer a worksheet for the group of five residents they are to look after each day to record information about these activities, before transferring this information to the care management system via the desktop computers at the end of each shift in order for carers to share notes and learn from. As a consequence, carers only recorded a small number of care notes about each resident each day. Electronic care notes were printed out from the care management system and made available in each resident's room, and carers shared information about resident preferences on papers notes such as the one on the tea trolley about how much milk and sugar each resident likes, or on the kitchen notice

board about dietary preferences. However, breakdowns in this process often occurred. There were only two such computers in the wing, and carers had to queue to use them. Carers also reported difficulties to enter information into the care management system, and the home's managers were unsatisfied with the quality of the recorded information.

To conclude, the study revealed the physical and mobile nature of most care work, and the absence of space to locate new fixed-placed technologies. In terms of the activities described in the model of computer-supported reflective learning, in-situ cognitive monitoring of care work was very limited, and there was no systematic support for reflective learning. Triggers to reflect were ad hoc, retrieving relating care experiences was difficult due to the lack of available desktop computers, and no explicit criteria were made available for re-evaluating experiences. Therefore, to overcome these constraints, we explored replacing the desktop computer with mobile devices that would support carers to record care notes, and providing explicit support for reflective learning activities in-situ throughout care shifts.

To formatively evaluate these design ideas, we selected and adapted an existing mobile software app to support reflective learning to deliver more person-centred care. Our aim was to undertake a first exploratory investigation of the use of mobile apps to support reflective learning about people with dementia. This app and its adaptation are described in the next section.

5. The Yammer App

To deliver quickly a reliable and cost-effective prototype with which to investigate how carers might use mobile devices and apps to undertake reflective learning, we adapted the Yammer enterprise micro-blogging mobile iPhone app. This decision was motivated by an earlier investigation during another pre-design study. For one week, we replaced the paper notes of carers in a residential home with mobile iPod Touch devices running commercial apps that could support what is done with the

paper notes, for example with a social media app to capture and share observations about residents [Karlsen et al. 2011]. The pilot was successful in that the carers carried the devices and used the apps throughout the week.

Yammer [2013] is an enterprise micro-blogging app that we installed on mobile iPod Touch devices. Carers were expected to record care notes about each resident in situ during care shifts and communicate these notes with other carers using a private and encrypted network in real-time. Functions on the mobile client with which to post messages, tag them to enable viewing, searching, alerting, and adding comments to previous posts were used to capture, share and reflect on care notes. Figure 2 depicts some typical uses of the Yammer app to document and reflect on recorded care notes. The left-hand side shows how a carer can enter a care note into the app using the standard device keyboard. The middle of the Figure demonstrates the use of a search function to retrieve all resident care notes with the term '*fluid*'. And the right-hand side depicts a stream of sequential care notes around a resident, with replies from other carers, with which to reconstruct the care experience and articulate meaning to the care of one resident.

Figure 2. Uses of the Yammer app adapted for care note recording and reflective learning. The left-hand image depicts how a carer can enter a care note in-situ using the keyboard and, if suitable, the Siri speech recognition feature. The middle image depicts the results of a search of care notes containing the term 'fliud'. The right-hand

image depicts a browse-able sequence of contextualised care notes about one resident, including features to reply to existing notes to annotate them and alert other carers in the network of important notes.

Features of the app to support that were designed to support most carer activities described in the computer-supported model of reflective learning are described in Table 1. Some of these activities were not supported explicitly by the app features. Different work events, such as starting or ending a care shift, or encountering a challenging behaviour by a resident, might trigger a decision to reflect using the app, and explicit criteria with which to re-evaluate an experience were assumed to be part of the care processes adopted in different residential homes.

Reflection model activity	**Yammer feature**
Monitor work	Record care notes in situ at the time that care delivered
Decide to reflect	*No explicit support*
Frame the reflection session	Define search queries to retrieve previous care experiences documented in notes about residents, then select the one or more notes to reflect about
Make related experience available	Directly browse all previous care notes about the resident from all carers
Reconstruct experience	Read back one or more care notes to reconstruct the past care experience. Notify other carers of selected care notes
Understand meaning	Each care note is presented in context of the feed of related care notes about the resident
Articulate meaning	Reply to a care note to add more meaning to that note
Frame the re-evaluation	*No explicit support*
Critique experience	*No explicit support*
Reach a resolution	Document or more new care notes that record the resolution to be applied for the resident

Table 1. Designed use of Yammer app features, and related work redesigns, to support reflective learning activities described in the model of computer-supported reflective learning.

Unlike in hospital settings, in which mobile devices have been used extensively by trained medical staff (e.g. [Ammenwerth et al. 2000], others), we were unaware of evaluations either of the use of mobile devices by carers on shift in residential homes, or of software designed to provide explicit support for person-centred care based on reflective learning by carers about the residents in their care. Therefore,

we used the Yammer app implemented on mobile iPod Touch devices to undertake a first, formative investigation to determine further whether carers would carry and use mobile computing technologies through their care shifts, the styles of care notes that are documented on mobile devices, and whether the app as configured could result in more reflective learning about residents in their care. We deployed the devices and app as prototypes in evaluations undertaken in two residential homes independent of the two homes used in the predesign studies, both in the United Kingdom. The next section describes the method and results from these evaluations.

6. Formative Evaluations in 2 Residential Homes

We sought to undertake evaluations that would provide sufficient evidence for reflective learning about residents over a sufficient period of time. Therefore, the evaluation periods in the two residential homes lasted for 56 days and 40 days respectively. Prior to the start of each evaluation, we undertook technical work to ensure that each home's broadband wireless network was reliable and could be connected to by the iPod Touch devices in all resident rooms and lounges.

6.1 Evaluation Method

At the start of each evaluation, all participating carers in each residential home, all of whom had volunteered to participate, were given a configured iPod Touch for their individual use over the evaluation period. The carers could contact a help desk manned by the researchers throughout the period. Each device was locked but provided the carers with access to the adapted Yammer app, a second bespoke app called *Carer* [Zachos et al. 2013a] that was developed to support carers creatively resolve challenging behaviours exhibited by residents, and other apps that come as standard on the iPod Touch, for example to take photographs and record audio-notes. All carers received face-to-face training in how to use the device and apps

before the evaluation started. A half-day workshop was held at the residential home to allow them to experiment with all app features.

Due to the durations and nature of each evaluation, the researchers could not be present to collect data from carers throughout. Therefore, the primary source of evaluation data was the care notes about residents entered into the app during the evaluation. The other major sources of data were a focus group with the carers held at the end of each evaluation period, and telephone/email exchanges between the carers and helpdesk during each evaluation to resolve emerging technical problems. Each focus group was audio recorded, transcribed and analyzed in-depth using predefined themes generated from analysis of care notes used during the evaluation period.

After the evaluation, two analyses were applied to the recorded care notes. The first was of the totals and frequencies of care notes documented by the carers in each evaluation. The second was a content analysis of the recorded care notes. An experienced analyst who worked for the Registered Nursing Home Association categorized each care note as:

- A care note that reports observable information about a resident;
- A care note that reports carer inferences about a resident;
- A care note that reports both observable information and carer inferences about a resident.

Carer inferences about a resident were treated as documented evidence of potential reflective learning. The analyst applied the concrete rules described in Table 2 to categorize each care note into one of these 3 categories.

A care note that communicates observable information about a resident, which can be: • A description of a resident's observed regular behaviour, for example *sits to watch television in his room*, or *eating most of her lunch in the dining room;* • A description of a resident's regular states based on direct observations of the resident, for example *calm*, *happy*, and *withdrawn*; • A description of a resident's observed challenging behaviour, i.e. "culturally abnormal behaviour(s) of such an intensity, frequency or duration that the physical safety of the person or others is likely to be placed in serious jeopardy, or behaviour which is likely to seriously limit use of, or result in the person being denied access to, ordinary community facilities" [ref]. Examples of observed challenging behaviours are *refusing to take medication*, and *shouting violently at other residents*; • A description of one or more observed and/or reported carer responses to observed challenging behaviours, for example *asked another carer to provide the medication*, *and gently moved the resident into another room away from the other residents*; • A description of one or more observed and/or reported carer interventions into a resident's regular care, for example *helped to eat lunch*, and *rearranged pillows in lounge chair*; • Observed and/or reported relevant carer behaviour that does not include interactions with residents. Examples of such behaviour include *consulting with the supervisor* and *talking to the relatives of the resident*.
A care note that reports carer inferences about a resident, which can be: • A description of an attribution to meaning of resident's behaviour, state or condition that could not be observed, for example *suspect personal insecurities underlie this behaviour* and *appears not to enjoy gardening activities*; • A description of a proposed resolution to a monitoring situation or encountered challenging behaviour, for example *recommend the removal of the reasons for personal insecurities during lunchtimes* and *suggest that the resident walks in the garden rather than undertake gardening activities*; • A description of an explicit inference made about the resident, for example *the resident is not always asleep when she appears to be* and *I believe that she has an allergic reaction to this foodstuff*.

Table 2. Categorization rules applied to each recorded care record to determine whether it contained observable information about a resident, carer inferences about a resident, or both.

We analyzed the counted and categorized care notes to investigate the following 4 related research questions. The care note categories were derived from the descriptive model of behavior during computer-supported reflective learning reported in Section 3 that the mobile devices and apps were intended to support. The first question was posed to investigate the feasibility of the use of mobile technologies and apps in care work:

RQ1 Did carers carry their mobile device and use the app during care shifts?

The setting of the second and third research questions assumed a positive answer to the first question. We set the second and third research questions to explore whether mobile app use led to the quantitative changes in the volume and/or frequency of care notes recorded in situ, related to the *monitor work* activity described in the reflection model described in Table 1:

RQ2 Did carers who used the app record care notes more frequently than with the existing manual procedures and care management systems in their homes?

RQ3 Did carers who used the mobile app record more complete care notes than with the existing manual procedures and care management systems in their homes?

The fourth research question also assumed a positive answer to the first and/or second and third research questions. We set the question to explore whether use of the mobile device and app might have led to increased reflective learning by carers. The question was framed to analyze documented care notes resulting from the *reach a resolution* activity described in the reflection model described in Table 1:

RQ4 Did carers who used the mobile app record more evidence of reflective learning about individual residents than with the existing manual procedures and care management systems in their homes?

Direct evidence of increases in reflections about residents recorded in the app would provide first, albeit indirect evidence of other reflection activities described in the reflection model – activities such as making related activities available, understanding meaning and articulating meaning.

6.2. The Evaluation at Home A

The evaluation at home A took place consecutively over a period of 56 consecutive days. The home did not specialize in dementia care, but was home to a range of residents of different ages, a minority of whom had milder forms of dementia. Most

of the residents in the home had none or were in the early stages of dementia. The evaluation was undertaken by 3 nurses and 4 care assistants who worked in the home. All had come to the UK to work in the care sector, English was their second language, and all but one owned and used a smartphone. In these regards we considered them to be typical of residential carers in the UK. The evaluation was in two parts.

In the first 28 days we collected resident care notes produced using the current process to provide a baseline for the introduction of the devices and app. Although the home had 49 residents, we chose to focus on just 8 residents in the care of the 3 nurses and 4 care assistants so that we could undertake a direct comparison between the care notes for these residents before and after the introduction of the devices. Only one of these 8 residents had early-stage dementia. The current care note recording process in the home was a manual one that did not make use of any computing technologies. A large paper file of care note records was compiled over time about each resident. The normal practice was for care assistants to complete a daily tick-box task list to record the basic care that was provided. Any further information was then recorded by the nurses on an assessment form composed of the simple tick-box checklist and a variation form on which to record extra information.

In the second 28 days we collected the resident care notes for the same 8 residents documented by the same carers using the iPod Touch devices and app. The device running the app was made available to each of the 3 nurses and 4 care assistants for use throughout the period. To ensure that the care notes recorded using the app were added to the resident care files, we developed a simple automated routine to produce printouts of the care records onto paper in a form similar to the current assessment forms via a printer in the home. The nurses then simply inserted the printed forms into residents' care files.

An overview of the quantitative analysis of the care notes documented for the 8 residents during the 56 days is reported in Table 3. During the first 28 days, a total of 47 care notes were recorded for the 8 residents using the current manual system, and the average length of each care note was 27 words. The focus group revealed that these care notes were made by the 3 participating nurses but not the 4 care assistants because such work in the current system was only the responsibility of the nurses. Most of the care notes (43 of the 47) were made about just one resident. No care notes were recorded for 3 of the residents and just 1 care note each was recorded for the remaining 4 residents. The content analysis of the 47 care notes revealed that the nurses had only recorded observable resident information, and there was no evidence of carer inferences about residents that might be indicative of reflective learning.

	Contributors	Number of care notes recorded	Average word length of each care note	Number of care notes containing inferences about a resident
During first 28 days	3 Nurses	47	27	0
During second 28 days	3 nurses, 4 care assistants	86	48	13

Table 3: Comparison of care notes recorded for the 8 target residents in home A for 28 days before and after the introduction of the iPod Touch devices and apps

During the second 28-day period, all of the nurses and care assistants used the devices and apps when on shift throughout the period. A total of 86 care notes were recorded during the second 28 days using the redesigned work responsibilities and iPod Touch devices, and the average length of each care note was 48 words. Each nurse and carer entered up to 5 care notes a day, and the average was 2.5 care notes per day, although it should be noted that not all nurses and care assistants were on shift each day. A comparison of the care notes recorded in the two 28-day periods revealed a 74% increase in the number of recorded notes and a 77% increase in the number of words recorded per note with the device and app,

although the number of carers available to enter care notes did increase by 133%. Comments made during the focus group revealed that the carers found the devices easy to carry during their shifts. They enjoyed using the devices and had fun using other apps such as YouTube, iTunes and iPhoto outside of their shifts for leisure purposes. However, compared with the previous practice in which the nurse asked them verbally for information about each resident, the care assistants sometimes found it disruptive to find the time to enter the care notes into the app.

The recorded increases in the volume and frequency of care notes documented using the app happened in spite of a problem that emerged with the home's technical infrastructure in the second week. The problem led an Internet connection failure that took 3 days to correct, and it undermined confidence in the devices during a period when the senior nurse – the champion – was on leave. Several of the care assistants stated that they believed that the Internet connection failure that arose was their fault, resulting in a breakage of the app, and they did not want to repeat this perceived mistake. The return of the champion in the final week was instrumental in restoring confidence in the devices.

In contrast to the first 28 days, the nurses and care assistants used the app to document care notes about all 8 residents, and a total of between 2 and 19 care notes about each individual resident in the period. Moreover, almost one-third of the care notes documented some form of challenging behavior of the resident – typically but not always verbal and/or physical abuse of the carer(s). Furthermore, in two cases, the senior nurse documented care notes as direct responses to notes about challenging behaviours entered previously by care assistants. In one of these cases, the care assistant asked a direct question to the senior nurse, and the senior nurse responded. In the second, the senior nurse provided unsolicited guidance to manage the challenging behaviour of a resident, which the care assistant agreed to adopt. Both sets of responses were made within 3 hours of the care note recording of the challenging behaviour, indicating that, although the senior nurse and care assistant were on shift in different parts of the care home at the same time,

communication between them was facilitated by use of the app. In the focus group, the senior nurse expressed pleasure at the increased communication between carers from app use, which in his opinion arose because the app was simple for everyone to use.

The focus group also revealed that the nurses were surprised at the care assistant capabilities to document care notes, and praised their work. Indeed, the improved care notes enabled the nurses to be better informed about the residents, in spite that all had come to the UK to work in the care sector with English as their second language, for example from care assistant 1:

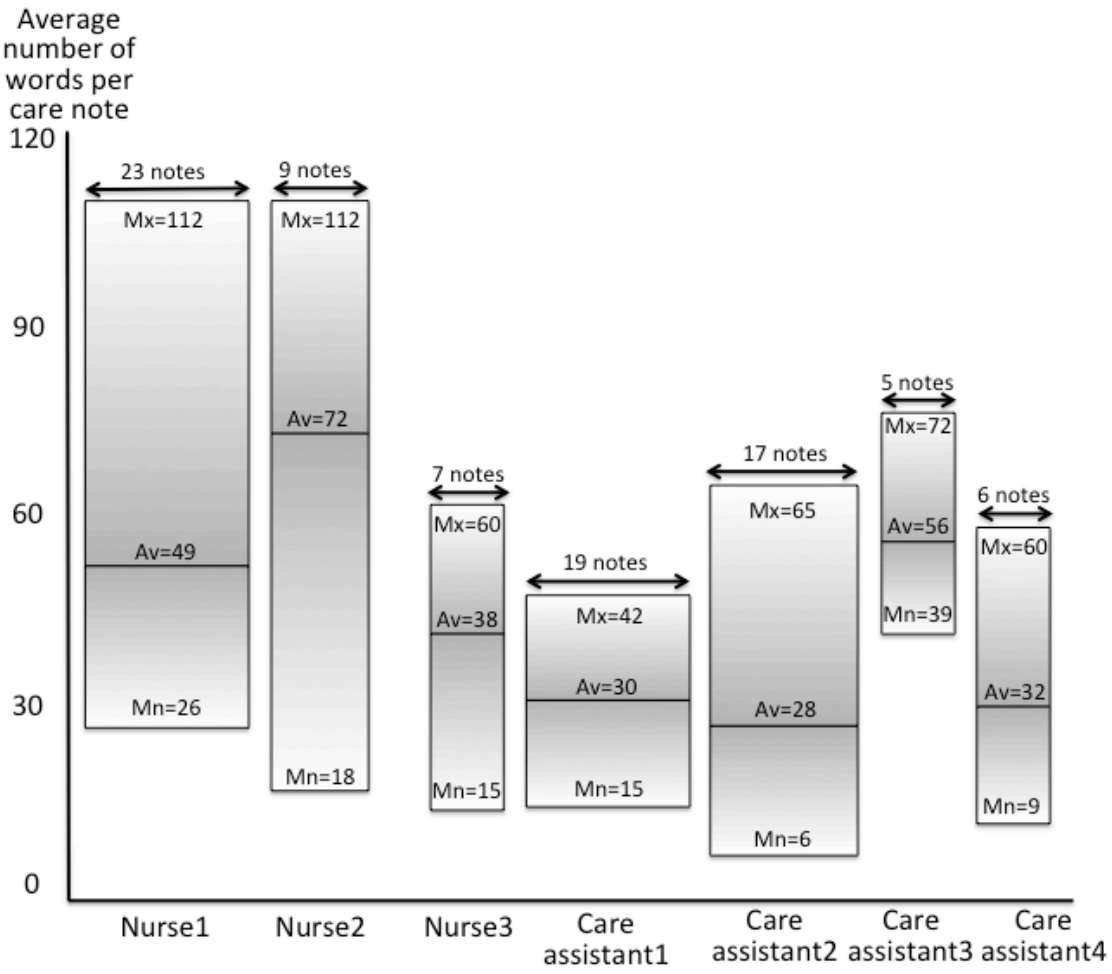
"The resident was very sleepy and started to fight when we washed him. We reassured and gave him cup of coffee. Afterwards he seems bit brighter than before and we managed to bring him to dining room."

And from care assistant 2:

"The resident had a very good supper and appeared to be in good mood, he was talking, even make a joke with staff, he was cooperative when we assisted him to go to bed."

A more thorough analysis of the volume of all 86 care notes and the average, minimum and maximum number of words in each revealed individual differences between the care notes provided by these nurses and care assistants, as depicted graphically in Figure 3. The senior and one other nurse documented the longest care notes, while 3 of the 4 care assistants documented, on average, shorter care notes. Two of the nurses and 2 of the care assistants documented fewer care notes than the others.

Figure 3. The number and average, minimum and maximum number of words in care notes produced by each individual nurse and care assistant



The content analysis of the notes entered per nurse and care assistant revealed possible explanations for these quantitative differences, and summaries of the note styles adopted by each individual nurse and care assistant are reported in Table 4. It revealed that the nurses and care assistants documented individual care notes to cover different time periods. Some focused more on reporting the resident behaviour and state, while others documented more of the care given to residents. Although care assistant 3 entered fewer care notes, each care note was more complete because it also documented the effect of care actions on the resident. Nurse 1 also entered fewer care notes, but most of the notes were entered during the night shift when there is less resident activity, and this shift pattern might explain why the care notes often covered the actions and state of a resident across long periods.

Nurse/ Care assistant	**Care note content and form**	**Example care note**
Nurse 1, the senior nurse	The care notes described the actions and events related to the resident, with summaries of responses made by the carers	*resident appeared to be uncooperative when assisted with wash. She has been swearing and passing racial comments. She was reassured frequently during the care to calm her down. She got settled after wash and managed to eat her lunch.*
Nurse 2	Longer care notes that described the actions of both the resident and carers, often summarising the care given across a whole shift.	*The resident refused to take her night medication and asked me to leave her alone. I went to her room several times to encourage her to have the tablets. Despite the encouragements she continued to refuse to take them. However, after sometime she started have the symptoms of her disease and called for help. I could use that opportunity to explain the importance of taking medication correctly and she accepted to take them. As a result, she could sleep well without any disturbances.*
Nurse 3	Shorter care notes that described the resident's state, with occasional descriptions of care responses to challenging behaviours	*the resident was very aggressive this evening when she was assisted to bed, very uncooperative and very bad racist comments. I tried to reassure her that we were trying to help but she refused all help so we left her alone for sometime to let her settle, then after a few minutes we offered assistance and she agreed to be helped.*
Care assistant 1	Shorter care notes that described the actions of residents and carers	*The resident was very sleepy and started to fight when we washed him. We reassured and gave him cup of coffee. Afterwards he seems bit brighter than before and we managed to bring him to dining room.*
Care assistant 2	Shorter care notes that often described the food and drink intake, followed by observations about the resident's mood	*The resident had very good lunch, he starts shouting when he is in bed for a short rest after lunch.*
Care assistant 3	Longer care that	*The resident positively took her fluid &*

	described care actions then the effect of these actions on the resident	*chocolate when charted with her about her horse & her riding in her past. She seems to like drinking more when explain to her how importance the fluid to her body.*
Care assistant 4	Shorter care notes that documented the resident's state, and some descriptions of care response to challenging behaviours.	*during night rounds helped the resident to change her pad but she started shouting, I reassured her that we were helping her to be comfortable she calmed down and let us hangs her pad. She later settled down to sleep. Regular check done to ensure comfort and safety.*

Table 4. Analysis and examples of the style of care note documented using the app by each nurse and care assistant

Moreover, 13 of the 86 care notes were categorized as containing carer inferences. An example of a care note that contained an inference about a resident's behaviour was:

"*The resident appeared to be very happy and talkative when we mentioned about his love story between him and his wife*".

And an example of a care note that contained a more explicit inference about a resident was:

"*The resident refused to eat her breakfast and told the staff to go away. The tray was left beside her. After half an hour when she was visited again she was found to be eating by herself. It seems that she does not like the staff to help her with feeding. If the food is cut for her and make it easy for her to feed herself. It might be a solution to the issue of not eating well*."

One possible reason for this limited increase in reflective learning with the app was revealed during the focus group. The care assistants reported deliberately seeking out content to document beyond routine observations about each resident, such as observations about resident moods and descriptions of challenging behaviours.

Indeed, use of the app appeared to provide a social motivation for the care assistants to report more complete and reflective care notes. The focus group also revealed that the increased communication between carers through the app might have increased reflective learning, as carers reported reflecting on resident behaviour after reading care notes entered by others. During the focus group, the senior nurse reported that it was useful to be able to look at the stream of care notes when not at work to know what to expect when he arrived on shift. Some of the carers reported similar behaviour, although others were uncomfortable with working outside of their shift times.

To conclude, the nurses and the care assistants in home A carried the devices and used the app during their shifts throughout the evaluation. There was an observed increase in the number of care notes recorded, and this appears to have been caused, first, by the app enabling the care assistants to record notes, and second by their motivation to be more complete and reflective. Indeed, the focus group revealed that the carers would have been preferred the app to record care notes for all 49 residents in the home – in this sense the evaluation was too limiting. This use of the app by care assistants as well as nurses led to more complete recording about all of the residents, unlike the focus on one 8 resident before the devices were introduced. Moreover, there was evidence of increased reflective learning in the care notes recorded with the app, in part due to app features but also to increased social communication between the carers through the app. That said, individual differences in nurse and care assistant use of the app were identified, indicating different focuses and styles of care note recording that were adopted when free-form care note recording was made available to the carers.

6.3. The Evaluation at Home B

Unlike home A, home B was an acknowledged quality provider that specialized in dementia care, with greater emphasis on care note recording as part of person-

centred care. We were interested to explore whether introduction of the app could result in similar increases in care note recording and reflective learning in such a home.

The formative evaluation at home B took place consecutively over a period of 40 days during which we collected data about the care practices and recorded care notes for selected residents by the carers using the mobile devices. In contrast to home A, no care notes about the residents from the period before the introduction of the devices were available to the researchers. Seven devices running apps were made available to 7 carers in the home for constant use over the period. All of the carers worked in one wing of the home and cared for all of the 8 older people with medium levels of dementia who resided in the wing, thereby overcoming one limitation revealed in home A when the carers needed to use both the device and the manual process to record resident care notes during shifts. All of the carers were UK citizens and English their first language. Again, we considered them to be typical of residential care workers in the UK.

The current care recording process at home B used a computer-based care management system. Carers used one laptop computer provided in the wing to enter care notes directly into the system via an electronic form to which the carers transferred simple handwritten notes. The care notes were usually entered into the system at the end of shifts or when opportunity arose – although often, the carer would need to open the laptop, log on to it and launch the system in order to enter care notes. Interviews with the carers revealed that, as discovered in the first pre-design study, this sometimes created a bottleneck as several carers would be waiting to use the same laptop at the end of shifts, and carers often had to stay behind after shifts to enter care notes. During the evaluation we were unable to fully automate the transfer of care notes about each resident from the app to the care management system. Therefore, we designed a semi-automated solution that required an administrator who was independent of the evaluation to guide the

transfer of care notes to the correct resident records in the care management system.

The results revealed that, as in home A, all of the carers used the devices and apps when on shift throughout the period. Comments made during the focus group revealed that, once the carers had become familiar with the devices, the use of the app on the iPod Touches was faster and more convenient than using the laptops to record care notes, for example:

"*... as time went on I found it was really fast [to use Yammer], a lot faster than the laptop. A lot faster to load, you weren't waiting about for computers. I could get the resident downstairs, then sit in their bedroom and do my report*" and

"*... we were able to get the reports on quicker because we didn't have to wait for the laptop*".

An overview of the quantitative analysis of the care notes documented for the 8 residents is shown in Table 5. All 7 carers successfully used the devices and app throughout the evaluation period. They posted a total of 749 care notes, at an average of 18 care notes per day. There was an average of 60 words per care note with two-thirds of these care notes being between 18 and 103 words in length.

	Contributors	Number of care notes recorded	Average word length of each care note	Number of care notes containing information about challenging behaviours	Number of observations containing carer inferences about a resident
During 40 days	7 carers	749	60	124	20

Table 5: Quantitative data about care notes recorded for the 8 target residents in home B for 40 days after the introduction of the iPod Touch devices and Yammer app

Of these 749 care notes, 25 (3.3%) were direct responses to notes entered previously by other care coordinators and assistants. However, unlike in home A, the content analysis of these notes revealed no purposeful use of care note threads. At the start of the evaluation, three of the care coordinators and assistants made a total of 5 dummy responses to practice use of the response feature, and the remaining 20 care note responses appeared to be used in error by one care assistant, instead of entering a new care note. Moreover, each of these 20 notes had no relationship to the care note to which it responded, and most were about a different resident.

A more thorough analysis of the volume of the 749 care notes and the average, minimum and maximum number of words in each revealed individual differences between the care notes documented by each care assistant and coordinator, as depicted graphically in Figure 4. The 4 care assistants each documented more care notes and care notes with more words on average than the 3 care coordinators – the care assistants 1 and 2 documented over 10 times the number of care notes as care coordinators 2 and 3. Compared to the care notes documented in home A, the average numbers of words per care note entered by each care assistant were equivalent, however the maximum numbers of care note words documented in home B were higher (436 words from care assistant 3 and 281 words from care assistant 2), indicating more complete care note recording in home B in response to some care situations such as the reporting of challenging behaviours.

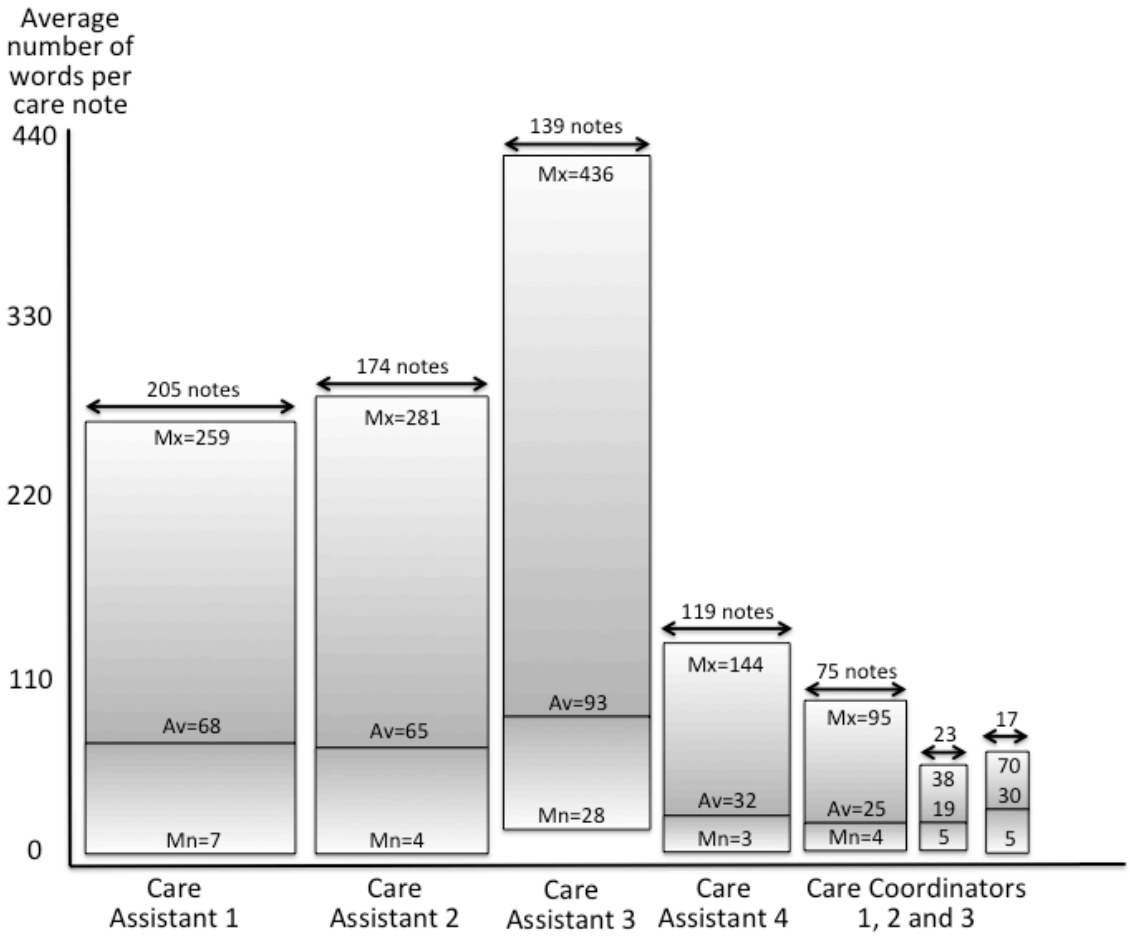


Figure 4. The number and average, minimum and maximum number of words in care notes by each individual care assistant and coordinator

The content analysis of the notes entered by each individual care coordinator and assistant again revealed possible explanations for these quantitative differences, as reported in Table 6. The analysis indicated that the nurses and care assistants documented individual care notes to cover different time periods, and the care assistants provided more detailed care notes than the care coordinators, especially in response to encountered challenging behaviours by residents. Indeed, some of the care assistants documented the concrete resident behaviours and verbal abuse directed at them during an episode of challenging behaviour at a level of detail that was not identified in the care notes from home A. Some of the care coordinators and assistants also documented quantitative information such as the resident's weight, and some the care assistants often documented repeating phrases, such as

'*incontinent with urine'* in multiple care notes for the same resident, in spite of the freeform care note format.

Care assistant/ coordinator	**Care note content and form**	**Example care note**
Care assistant 1	Each care note typically covered a period of 2-3 hours of care for one resident, and was well written. with good grammar. The care assistant tended to use the same expressions to describe many residents, but will precise resident quotes to report resident utterances. One short care note just reported a resident's weight, while other notes provided very detailed descriptions of challenging behaviours. Finally some care notes were incomplete, indicating that the care assistant pressed the *Send* button before completing the note. Many care notes recorded the timings of care event.	*[resident] was heavily incontinent of urine this morning and passed urine on the toilet. She has received assistance with her personal care and has had a good wash. Received full assistance with getting dressed. Verbal and physically hostile thought care; Elizabeth continually attempted to strike me with a closed fist and was grabbing hold of me by my Tshirt and shorts. She was also screaming "no, you dirty bugger" and "get away". Verbal reassurance given but with No effect. Refused to come downstairs to the snug with my assistance at 1000hrs. Consequently I assisted [resident] to sit in her chair in her room and asked c/a Kelly warren to take over.*
Care assistant 2	Each care note typically covered a period of 3-4 hours of care given to one resident. Most reported the state and actions of the resident, and each first sentence was an explicit statement about the resident's state. Each care note was well written. Each care note also included a lot of timing information, describing when residents acted and received care. Some care notes also documented explicit insults made by a resident.	*07.10-10.25hrs. [resident] as received 1;1 support throughout. [resident] has displayed agitation and been repetitive in mood stating he wants to go home. [resident] has engaged in brass cleaning, washing pots and looked at the newspaper briefly. [resident] visited the sweet shop and repeated to me the choices I gave to him. [resident] was verbally aggressive as we walked around the garden. I assisted him to his room. He was doubly incontinent and*

		continued to open his bowels on his toilet. [resident] then climbed into bed. Sensor on. Tv on.
Care assistant 3	Each care note provided a detailed description of the resident's state, and the physical actions undertaken for that resident over a longer, explicitly stated time period. Many care notes used standard phrases that repeated across residents. The care notes had numerous typos, mainly of which appear to have occurred due to use of the auto-correct feature on the mobile devices.	*[resident] got up at 8.15 this morning. She was incontinent of urine in bed and assisted with a good wash. [resident] was very quiet during personal care, only nodding on occasion as I was speaking to her. She was grabbing on to bedding whilst I was assisting her to dress on the bed. She was given lots of reasuarnce. [resident]'s feet were a little swollen so I have not pulled her socks up high. The wound on the top of her left arms is drying but was wrapping and the small one under Neath was weeping slightly. Flamazine and active heal were applied the wound on her right arms required soaking off. It is also slightly yellow and wearing dressing applied. [resident] was assisted to the snug for breakfast.*
Care assistant 4	These care notes were shorter, and appeared to cover shorter time periods that the notes made by the other assistants. Many of the care notes stated the time that resident arose in the morning, then described their state, and reported the care actions applied to that resident, rather than the behaviour of the resident. The care notes were written in less complete sentences.	*[resident] got up at 09.15,incontinent of urine in bed,given a good wash and cavil on cream applied to groins,[resident] was grabbing my wrist during all personal care and when given a shave Ron stated to get more agitated so I stopper shaving him, when I took him to the snug I put a apron on him and he started to pull it off so I sat him on his own for a while to calm down, lots of reassurance given with little effect.*
Care coordinator 1	Most of these care notes were expressed as single, well	*[resident] was taken to bed at 2210 he was very cooperative*

	written sentences that described the resident's state and behaviour. Some of these sentences were short.	*he was incontinent of urine all personal care given he remained in a good mood during the night but he kept putting his legs over the side of the bed*
Care coordinator 2	Most of the care notes were short, and reported quantified information such as times and the BM. Most reported both the state of the resident and the care given to the resident.	*[resident] e BM at 01.00 was 4.6 she was given biscuits and milk with singer in BM checked again at 01.30 it was 6.1.*
Care coordinator 3	Most of the care notes contain information about timings, and described the resident's state and the resident's reactions to the care given.	*[resident] was assisted to bed at 17.45 at his request he transferred really well using his Zimmer frame and moving belt good wash given and settled watching his tele*

Table 6. Analysis and examples of the style of care note documented using the app by each care assistant and coordinator – [resident] replaces the resident names in the care note examples, to ensure anonymity

We again applied the content analysis to the 749 recorded care notes. Only 20 of the 749 (2.6%) care notes contained evidence of carer inference about the resident. This was surprising because of both the management focus on person-centred care in the home and the challenging behaviours reported in 124 different care notes – such behaviours were expected to trigger reflective learning. A detailed analysis of the 20 care notes revealed that different forms of reflective learning were recorded. Some described inferred reasons for resident behaviour, such as a resident appearing to be in a different reality, while others reported the success of a resolution to such behaviour, for example sitting at the side of the bed and providing verbal reassurance to successfully reduce physical aggression:

"[resident] was heavily incontinent of urine this morning. He has received assistance with his personal care and has had a good wash. Physically resistive at times, grabbing me by the wrists and forearms. Verbal reassurance given with effect and these behaviours ceased promptly…."

Others report the consequences of failing to provide reassurance at other times, for example:

"[resident] was assisted to bed at 1710 hrs as she had regurgitated. [resident] was given a full body wash and was assisted into her nightclothes. Resistive on occasion shouting "no" and grabbing me by the wrists and forearms. Verbal reassurance given with little effect; I also began singing "daisy daisy" in an attempt to reduce her level of agitation but again this had no effect. I have asked RGN [nurse] to examine [resident's] upper left shin and knee area as there appears to be three circular sores evident."

Some of the carers also recorded reflections about possible causes of behaviour, for example one resident who appeared to take fright each time a door was closed loudly, and another whose physical ailments were possible contributions to his behaviour, for example:

"When [resident] was assisted with personal care this after noon he displayed aggression grabbing and holding on to the stand aid and wouldn't let go so had to transfer [resident] still holding on to the stand aid so he didn't get more frustrated I think he had shown signs of challenging behaviour due to the fact he had been incontinent of urine".

Even though no evidence in these care notes was captured of references to the resident's past that you might associate with person-centred care, comments made by the carers during the focus group did reveal some evidence of learning by them. The carers on night shift reported use of the app on the device at their own homes before coming on shift, and found it useful to be able to view the residents' mood and behaviour during the day to prepare for what to expect for the night shift:

"I only used it [the Yammer App] at home, I'm working on nights, so I could read what had happened during the day, because it [care notes] did a lot of the time get on on the same day. And then I read it and then put mine [care notes] back on in the morning. And the Internet was much quicker at home as well".

Similarly, one carer who was on holiday for one week of the evaluation period reported that she had used the app at her own home before returning to work to update herself with what had happened over the week. By doing this she reduced the amount of time needed from the team to update her on the week once at work:

"I was on annual leave for a week halfway through having them [the devices] and all that week I could read exactly what was going off in that week. So when I came back I felt like I knew what had happened. So it was good for that respect, as I didn't need a week's worth of handover because I could see throughout the week how everybody had been".

As with the evaluation at home A, the carers reported that they used the app and devices to make care notes outside of work or on breaks:

"*To start with I thought the [iPod] was dead slow. They are really tiny keys aren't they [iPod keyboard], you're pressing one and it was pressing the one next to it, but as time went on I found that it was really fast, a lot faster than the laptop. A lot faster to load, you weren't waiting about for computers . I could get the resident downstairs, then sit in their bedroom and do my report. Nobody was seeing me do it, there was no residents or anything there. Very rare I was sat in the lounge actually doing it*".

"*The majority of the time I did mine [writing care notes] on my break*".

At least two of the carers reported that they used the devices at their own homes to make care notes when they had not had time during the shift to complete their reports. However, this was reported as a negative outcome by the senior nurse as

not all the information from the day was then available at the time of the shift handover, and some carers felt that writing care notes on breaks or at home was unwelcome.

To conclude, like in home A, the carers in home B carried the devices and used the app during their shifts throughout the evaluation. Indeed, carers chose to use the app outside of shifts to record care notes and learn about resident behaviour. The care assistants and care coordinators produced different styles and lengths of care notes. Under some circumstances, the carers produced substantial more detailed care notes, which can be explained by the home's specialization in dementia care and the care assistant's familiarity with documenting digital care notes in the existing computer-based care management system. However, the recorded care notes still revealed limited evidence of reflective learning, and the learning that was reported described problems and causes were primarily related to challenging behaviour.

7. Research Questions Revisited

We used the results from the evaluations in both homes to seek a first answer to each of the four research questions. The initial answer to the first question RQ1 was '*yes*', the carers did carry their mobile device and use the app during their care shifts. Indeed, we received no reports from carers of any significant problems carrying or using the devices during shifts in either home, although use of the app led to the need to change working practices in both. Furthermore, some of the carers carried the devices outside of their shifts, and combined use of the app off shift with use of other apps for leisure purposes.

The answer to the second question RQ2, whether carers who used the app recorded care notes more frequently than with the manual procedures, was less definite, but we responded with a tentative '*yes*' for the one home that a direct comparison can

be made for. The carers in home A who used the app did record care notes more frequently than with the existing manual procedures. However, the reasons for this increase in app use were not consistent with the descriptive model of computer-supported reflective learning that was reported in Section 3. Instead, the increase in app use arose in part because of an increase in the number of carers – care assistants as well as nurses – who entered the care notes through the provision of the mobile technologies. Of course, changing to the home's manual processes so that care assistants could have documented care notes might also have increased the frequency of care note recording. However, both the care assistant's desire to use the app and the simple access that it gave to exemplar care notes already entered by nurses motivated carers so that care notes were recorded about more residents than with the manual system.

The answer to the third question RQ3, whether carers who used the mobile app record more complete care notes than with existing manual procedures, was also a tentative '*yes*', based on results from carers for the one home that a direct comparison can be made for. The carers in home A with the app did record more complete care notes than with the existing manual procedures. The number of words in the care notes entered with the app was almost double the number entered without it. We were not able to make this comparison during the evaluation in home B. However, there was no evidence that the completeness of recorded care notes had been reduced, and the carers did report that they were able to find more time to document care notes because of the increased flexibility in work made possible by the mobile devices. Furthermore, it is important to note the differences in the care note volume and content recorded by different carers, indicating the effect of individual care behaviour on the completeness of care notes.

Finally, the answer to RQ4 was '*no*'. Whilst the carers with the mobile app in home A exhibited more evidence of reflective learning about individual residents than with the existing manual procedures, there was limited evidence of reflective learning in

the care notes recorded using the app in home B, in spite of its greater specialism in person-centred care and its support for reflective learning. That said, the focus groups in both homes revealed that the carers used the app to learn about the state of residents when on shift. These results suggest the need for more effective app support for reflective learning activities such as *reconstructing experiences* and *articulating meeting* – new support that is described later in the paper.

7.1 Possible Threats to Validity of Results

Of course, these results are open to different possible threats to their validity. Threats to conclusion validity were concerned with issues that affected our ability to draw correct conclusions about the relations between the treatment and outcome [Wohlin et al. 2000]. The one obvious threat to the conclusions validity of the evaluations was that not all reflective learning by the carers triggered by app use was not recorded in resident care notes – the app might also have triggered reflective learning that was shared and/or only communicated verbally to other carers. That said, the focus group did not reveal any systematic evidence of such communicated learning, and the carers were well schooled in the importance of recorded complete care notes.

Threats to the internal validity of the study were influences that could have affected independent variables related to causality [Wohlin et al. 2000]. One such influence was the provision of the *Carer* app [Zachos et al. 2013a] to support creative thinking about challenging behaviours of residents on the same devices to the same carers. In home B, the carers rejected use of the app after 9 of the 40 days, so it did not appear to pose a threat to results validity. In home A, however, the carers did use the *Carer* app throughout the second 28 days, generated and reflected on 14 separate ideas and used these ideas to generate at least one major change to resident care [Zachos et al. 2013b]. It is possible that some evidence of reflective learning in home A might have been captured in the *Carer* app, although there was limited use of that app by most carers. The one other obvious threat to internal

validity was the influence of established care models in operation, especially in home B that had successfully already implemented a model of person-centred care that stressed intimate understanding of each resident – an understanding which might have undermined the need for further reflective learning by carers.

Threats to the external validity were conditions that limited our ability to generalize the results of the two evaluations more widely [Wohlin et al. 2000], and the threats to this exploratory investigation were numerous. It only took place in two homes with only a small number of the available carers, and the carers who did take part volunteered to use the new technologies. There was no attempt to ensure the representativeness of the homes for the sector.

Finally, construct validity concerns generalizing the results from the evaluation of the concepts or theories behind the study, namely the descriptive model of computer-supported reflective learning [Wohlin et al. 2000] and the adapted Yammer app. The results from the two evaluations provide no direct evidence to support the model, and we make no claims for it. In contrast, we can make some very tentative claims for the device and app – carers who volunteered to use it were able to effectively and record and read care notes. Indeed, the carers were excited to have the devices and some in both homes were reluctant to return them at the end of the evaluations.

Overall, these validity threats reveal the extent of the challenges that researchers face to evaluate the use of software apps and activities such as reflective learning in residential care settings. The nature of the work in such settings – mobile, 24 hours-per-day, and often private – means that evaluation techniques such as observations, focus groups and usability studies that are often used to evaluate software use cannot be used in this context. Indeed, the lack of direct observer access to most work that the software use support means that direct evidence of phenomena such as reflective learning cannot be captured, and researchers are often reliant on indirect evidence of the occurrence of such phenomena, such as documented

outcomes and retrospective verbal reports. Uptake of the software is also impacted by wider socio-technical themes such as peer recognition and trust [Muller et al. 2012], as we discuss in the remainder of the paper.

8. Conclusions, Discussion and Future App Development

Results from both homes suggest that carers used app features to support some but not all reflective learning activities described in the model of computer-supported reflective learning introduced in section 3. The carers increased the volume and content of recorded care notes, and found more time to undertake *work monitoring* activities. The carers also read existing resident care notes entered by other carers in a timeline form to learn more about selected residents. However, the recorded care notes revealed no evidence of other reflection activities described in the model of computer-supported reflected learning activities, from *reconstructing experiences* and *understanding its meaning*, to *reframing* and *critiquing each previous experience*. The results indicate that the carers in the evaluations exhibited *reflection-in-action* rather than *reflection-on-action* as defined by Schön [1983].

From these results, one conclusion that we drew was that new software and related work procedures are needed to support more of reflective learning activities described in the model of computer-supported reflective learning. Various software redesign alternatives were considered to support more reflective learning activities. One solution was to continue to use the Yammer to support care note recording, reading and sharing during the *monitoring work* activity, but to export these care note records to a separate new desktop application to support other activities described in the model of computer-supported reflective learning. The use of a separate application would have required each carer to make an explicit decision to reflect after monitoring, a decision that is part of an activity to prepare for reflection described in the model of computer-supported reflective learning. The design of a desktop rather than mobile application represented the realization that reflection

would be structured and team-based, rather than frequent and undertaken by individual carers. At the same time, we sought to reduce the variability between care notes documented by different carers with more explicit prompts in the Yammer app to collect and structure care notes, without resorting to a tick box approach to care note recording. Therefore, a new desktop software application was designed and implemented to support more explicit reflection using the captured care notes. The web application was designed to run on both mobile and desktop devices, and developed in HTML5, Javascript and PHP, and uses the Yammer API to retrieve data from the Yammer Network.

The new desktop application will provide new opportunities to support more effectively some of the other reflective learning activities that are described in the model. For example, to make a related experience available for reflection, a carer can use the application to search, browse and read care note records about different residents, an activity that is rendered easier than with the mobile app by the larger desktop screen size. Figure 5 depicts a screenshot of a carer browsing care notes belonging to different residents in their care using the new desktop application.

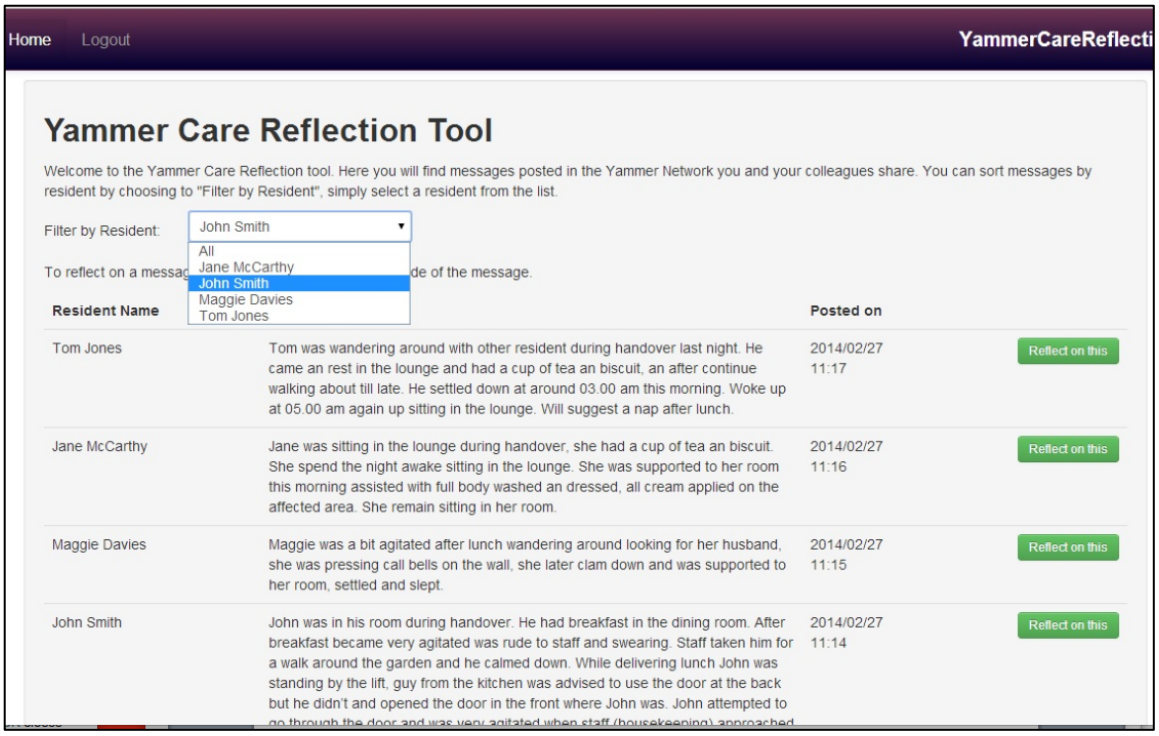


Figure 5. The desktop application support for carers to search, browse and read care notes in order to make related experiences available for reflection

A carer can then use the desktop application to provide more support with which to reconstruct the experience prior to reflection about it than is currently provided by the mobile app. For example, the carer is able to group different care notes to reconstruct a single care experience, as well as link to elements of the resident's past using the related Digital Life History app [Maiden et al. 2012]. Figure 6 depicts another screenshot from the desktop application, in which a carer can select related care notes about one resident to reconstruct a relevant past experience that will be the focus for reflection. The carer can then view each care note in the context of other care notes, for example the agitation of John in the second care note listed in Figure 6 can be better understood in the context of John's behaviour before and after this episode, to guide meaningful reconstruction of a relevant care experience.

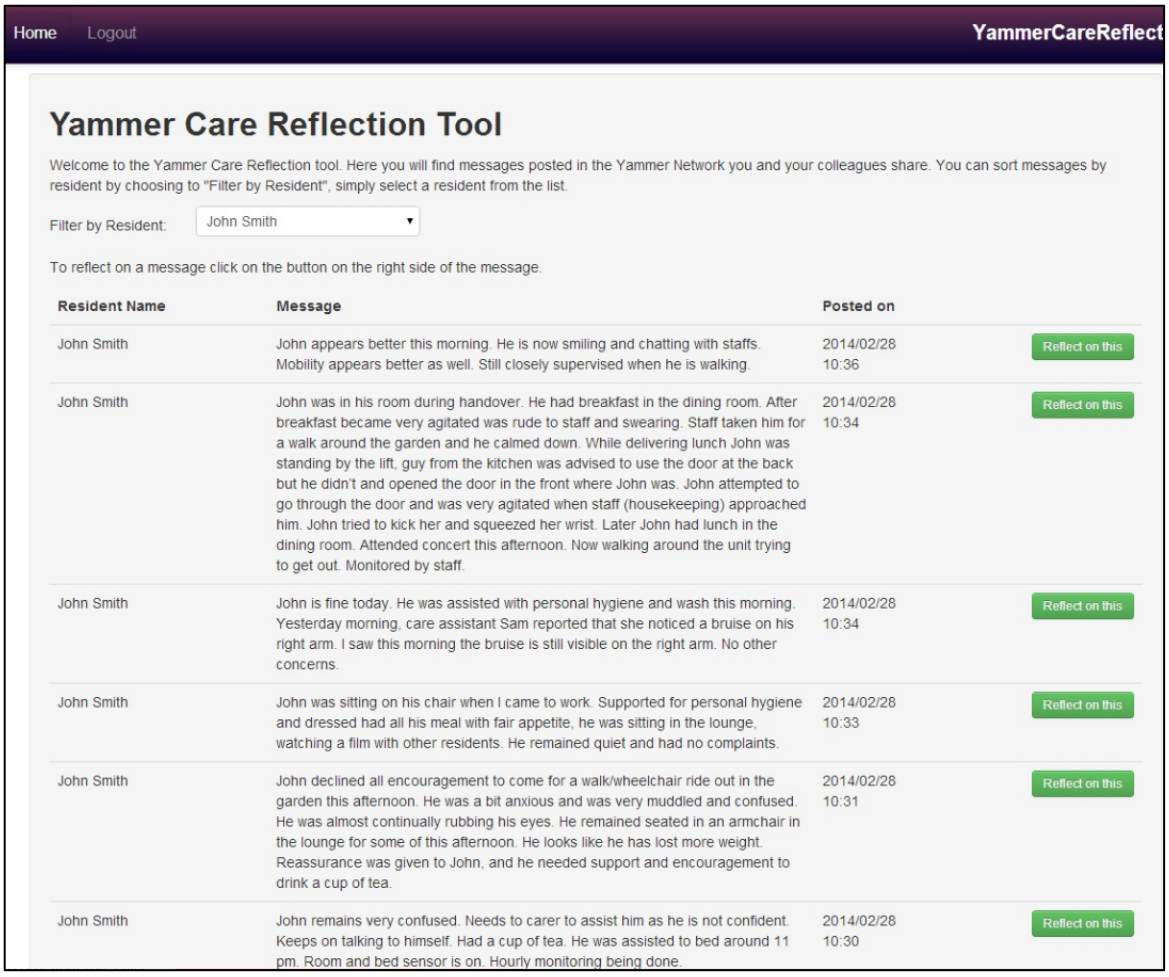


Figure 6. The desktop application support for carers to reconstruct from existing care notes to enable reflection to take place

Later, in the same reflection session, the desktop application provides simple guidance to understand meaning in the care experience reconstructed through the selected care notes. To do this, the application was designed to provide simple prompts such as *What sort of day was this for the resident?* and *Why was this?* In response to these prompts, the desktop application enables the carer to articulate new meaning to the past care experience, in the form of possible explanations for the experienced behavior. Figure 7 shows a response from one carer about what sort of day the resident had had, and possible reasons for it. In the example response, the carer seeks to understand possible reasons for the agitation that John is reported to have demonstrated in the care note.

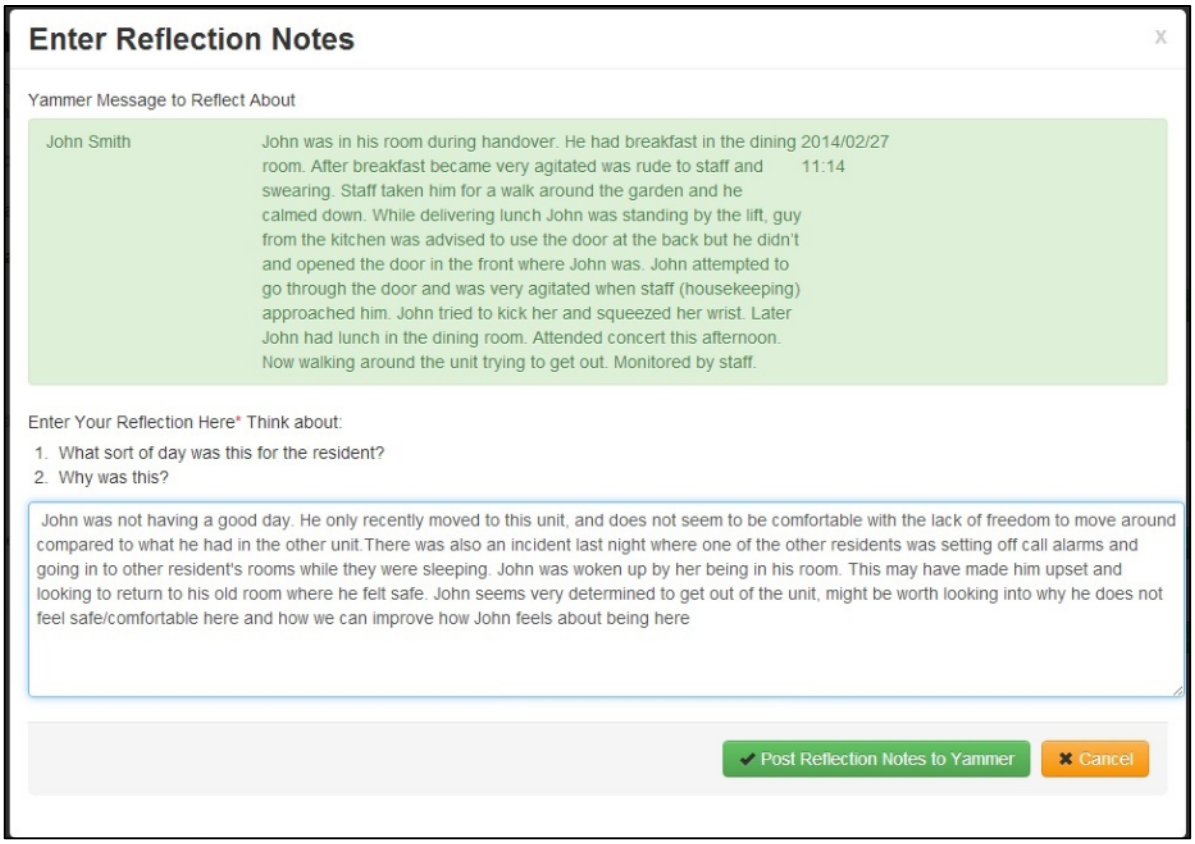


Figure 7. The desktop application support for carers to articulate meaning about the care notes that were reconstructed for reflection.

We will also recommend that related work procedures will also be redesigned to support use of the desktop application in care homes in regular, structured reflection sessions. During shift meetings, carers will be encouraged, under guidance from the shift leader, to reflect about individual residents. The desktop application will be used to prepare for the meeting, guide reflection during it, then record the results of reflection after it.

Another implication from the conclusions from the evaluation is for future software use to be framed by important socio-technical themes to ensure its uptake, as reported in [Muller et al. 2012]. Our evaluation results revealed several important themes that warrant highlighting. One is the professional recognition from their

peers that increased carer motivation to use the mobile app. The app enables carers to have their work and expertise explicitly recognized by their peers, and as a consequence motivated their care note recording. Future app use should afford peer recognition. A related socio-technical theme is communication. Future software should support increased asynchronous communication between carers to increase mutual sharing and learning about residents. A third important theme was the awareness of resident wellbeing – using the app outside of shifts to remain aware of resident health and wellbeing. Future app use should increase carer awareness of resident wellbeing.

The final socio-technical theme is an increase in trust, not just between carers and between residents and carers, but with relatives who visit homes. During the evaluation at home B, visiting relatives perceived the iPod Touch devices as mobile phones, and complained to the home manager. The carers, in turn, felt uncomfortable about using the devices in the lounge, and preferred to make care notes away from the lounge, though during the day it could sometimes be difficult to leave the lounge to post care notes. This had not been an issue with the laptops as family members were used to seeing these in use by carers. Mobile technologies associated with leisure raise new trust issues to overcome.

Finally, we believe that our results and conclusions can offer new baseline evidence about the use of mobile devices, apps and desktop applications in residential care that other researchers can build upon. We intend to evaluate this redesigned computer-based support for reflective learning in the near future in larger-scale evaluations with other apps such as the *Digital Life History* and *Carer*. Indeed, the potential for data fusions from different sources to support more effective reflective learning is one that we actively pursue.

Acknowledgements

The research reported in this paper is supported by the EU-funded MIRROR integrated project 257617, 2010-1.

References

Ammenwerth E., Buchauer A., Bludau B., Haux R., 2000, 'Mobile Information and Communication Tools in the Hospital', International Journal of Medical Informatics 57(1), January 2000, 21-40.

All-Party Parliamentary Group on Dementia, 2009, 'Prepared to care: Challenging the dementia skills gap', June 2009.

Thiry E., Lindley S., Banks R. & Regan T., 2013, 'Authoring personal histories: Exploring the timeline as a framework for meaning making', Proceedings 2013 SIGCHI conference on Human Factors in computing systems (CHI 2013), ACM, April 2013, 1619-1628.

Boud, D., Keogh, R., and Walker, D., 1985, 'Promoting reflection Experience into Learning', Routledge Falmer, 18-40.

Brooker, D., 2007, 'Person-centred dementia care: Making Services Better, Bradford Dementia Group Good Practice Guides. Jessica Kingsley Publishers London and Philadephia.

Cahill S., Macijauskiene J., Nygard A-M., Kaulkner J-P. & Hagen I., 2007, 'Technology in Dementia Care', Technology and Disability 19, 55-60.

Cowans G., Campbell J., Alm N., Dye R., Astell A. & Ellis M., 2004, 'Designing a Multimedia Conversation Aid for Reminiscence Therapy in Dementia Care Environments', Proceeding CHI'04 Extended Abstracts on Human Factors in Computing Systems, ACM New York, NY, USA, 825-836.

U.K. Department of Health, 2012, 'Caring for Our Future: Reforming Care and Support', presented to Parliament by the Secretary of State for Health by Command

of Her Majesty, July 2012; https://www.gov.uk/government/publications/caring-for-our-future-reforming-care-and-support

Design Council, 2013, http://www.designcouncil.org.uk/our-work/challenges/Health/Living-well-with-Dementia1/Solutions1/ode/, accessed 12th August 2013

Graham, N. and Warner, J., 2012, 'Understanding Alzheimer's Disease and Other Dementias', British Medical Association, Family Doctor Books, Poole, Dorset, U.K., 2009.

Hanson E., Magnusson L., Arvidsson H., Claesson A., Keady J. & Nolan M., 2007, 'Working together with persons with early stage dementia and their family members to design a user-friendly technology-based support service', Dementia 6(3), 411-434.

Hayden L. J., Glynn S. M., Hahn T. J., Randall F. & Randolph E., 2012, The use of internet technology for psychoeducation and support with dementia caregivers', Psychological Services 9(2), 215-8.

Help The Aged, 2007, 'My Home Life: Quality of Life In Care Homes; A Review of the Literature London. [online] http://myhomelifemovement.org/downloads/mhl_review.pdf [Accessed 5 January 2011]

Karlsen K., Zachos, Z., Maiden N.A.M., Jones S, Turner I., Rose M. and Pudney K., 2011, 'Supporting Reflection and Creative Thinking by Carers of Older People with Dementia', Proceedings 1st International Workshop on Pervasive Care for People with Dementia and their Carers, Dublin, Ireland, May 2011.

Krogstie B., 2012, 'Deliverable D1.4 MIRROR Model of Computer Supported Reflective Learning', available at http://www.mirror-project.eu/showroom-a-publications/deliverables.

Lave, J., 1993, 'The practice of learning. Understanding Practice: Perspectives on Activity and Context', S. Chaiklin and J. Lave. Cambridge, Cambridge University Press: 20.

Maiden N.A.M., D'Souza S., Jones S., Muller L., Panesse L., Pitts K., Prilla M., Pudney K., Rose M., Turner I. & Zachos K., 2013, 'Computing Technologies for Reflective and Creative Care for People with Dementia', Communications of the ACM 56(11), 60-67.

Muller C., Neufeldt C., Randall D. & Wulf V., 2012, 'ICT-Development in Residential Care Settings: Sensitizing Design to the Life Circumstances of the Residents of a Care Home', Proceedings CHI'2012 Conference, ACM Press, 2639-2648

Mulvenna, M. D. & Nugent, C. D., 2010, 'Supporting people with dementia using pervasive health technologies', (1 Edition ed.). London: Springer.

My Home Life Movement, 2013, http://myhomelife.org.uk.

Olguin D., Gloor P.A. & Pentland A., 'Capturing Individual and Group Behavior with Wearable Sensors. Human Behavior Modelling', AAAI Spring Symposium. Palo Alto, CA. March 2009.

Olsson A., Engström M., Skovdahl K. & Lampic C., 2012, 'My, your and our needs for safety and security: Relatives' reflections on using information and communication technology in dementia care', Scandinavian Journal of Caring Sciences 26(1), 104-12.

Powell J., Gunn L., Lowe P., Sheehan B., Griffiths F., & Clarke A., 2010, 'New networked technologies and carers of people with dementia: An interview study', Ageing and Society / Volume 30 / Issue 06 / August 2010, 1073-1088.

Santi P., 2013, 'Mieux Vieillir avec le Numérique', Le Monde, http://www.lemonde.fr/sciences/article/2013/08/26/la-revolution-numerique_3466651_1650684.html

Schön, D., 1983, 'The Reflective Practitioner', Basic Books, Inc.

SCIE 2010, 'E-Readiness in the Social Care Sector for SCIE: Final report', Social Care Institute for Excellence', January 2010.

Sugihara T., Fujinami T., Phaal R,, Ikawa Y., 2013, 'A technology roadmap of assistive technologies for dementia care in Japan', Dementia In Press.

Wallace J., Thieme A., Schofield G. & Oliver P., 2012, Enabling Self, Intimacy and a Sense of Home in Dementia: An Enquiry into Design in a Hospital Setting', Proceedings CHI'2012 Conference, ACM Press, 2629-2638.

Wimo A. & Prince M., 2010, 'World Alzheimer Report 2010: The Global Economic impact of Dementia, http://www.alz.co.uk/research/worldreport/.

Wohlin C. Runeson P., Host M., Ohlsson M.C., Regnell B. & Wesslen A., 2000, 'Experimentation in Software Engineering: An Introduction', Kluwer Academic Publishers, Boston/Dordrecht/London.

Wortmann M. & Fletcher S., 2013, 'World Alzheimer Report 2013: Journey of Caring', http://www.alz.co.uk/research/WorldAlzheimerReport2013.pdf

Yammer, 2013, 'Yammer', available at http://en.wikipedia.org/wiki/Yammer, available August 14th 2013.

Zachos K., Maiden N.A.M., Pitts K., Jones S., Turner I., Rose M., Pudney K. & MacManus J., 2013a, 'Digital Creativity in Dementia Care Support', International Journal of Creative Computing 1(1), 35-56.

Zachos K., Maiden N.A.M., Pitts K., Jones S., Turner I., Rose M., Pudney K. & MacManus J., 2013b, 'A Software App to Support Creativity in Dementia Care', Proceedings 9th ACM Creativity and Cognition Conference, 124-131.