TO WHAT EXTENT CAN A SERIOUS GAME ELICIT AND EVALUATE NURSING KNOWLEDGE

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August 2023

I certify that I have read this dissertation and that, in my opinion, it is fully adequate in scope and quality as a dissertation for the degree of Doctor of Philosophy.

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Approved for the Trinity College Dublin Committee on Graduate Studies

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Sinead Impey August 2023

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Dedicated to
Oisin, Finn and my nanny, Florence Devereux

Summary

Background: This research explores to what extent a serious game could elicit and evaluate specialist nursing knowledge. The problem addressed is that not all nursing knowledge is captured in a way that is easy to access outside the border of a community of practice (CoP) or beyond geography or time. While all healthcare knowledge is valuable, this research focuses on nurses' knowledge for several reasons. For instance, approximately 59% of the world's health professionals are nurses (WHO, 2020). Worldwide there are nursing shortages (5.9 million in 2018) (WHO, 2020). Nursing professionals perform many functions, including clinical, educational, research and policy development (NMBI, 2021). Nurses hold a broad knowledge base to perform these functions (NMBI, 2015). Nurses can build a personal knowledge bank as they move from novice to expert (Benner, 1984). In addition to academic and formal training, nurses acquire knowledge in clinical practice from peers, their own clinical and personal experiences and the setting they work in. These settings can range from acute to community, from general to specialist.

The study site described in this thesis is considered a specialist clinical area. Specialisation in healthcare occurs when professionals focus on a specific area or disease, such as oncology. Through this specialisation, a community of practice (CoP) can be formed around the specific area or disease. A CoP describes a "group of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in the area by interacting on an ongoing basis" (Wenger et al., 2002). Specialisation in healthcare presents many benefits, including better patient outcomes and the development of new knowledge (Britnell, 2011). However, in CoPs, knowledge can 'stick to practice' (Wenger et al., 2002), making it challenging to diffuse to the wider organisation. In addition, even though nurses spend a significant amount of their day completing documentation (Fore et al., 2019), there is evidence that not all tasks completed, or care given, are documented or documented fully (De Marinis et al., 2010; Fore et al., 2019; Gunningberg et al., 2008; Paans et al., 2010; Thoroddsen et al., 2013). As nursing accounts for over half the healthcare professionals globally, the role is broad in scope, performed in various healthcare settings and across the human lifespan; managing this knowledge is important.

Problem formulation: Two exploratory studies were undertaken to understand the domain and problem better. Findings from these studies are presented as answers to two questions in this research. Firstly, 'how do nurses currently share their knowledge?' This study included 17 nurse participants from five outpatient settings across two healthcare institutions. Secondly, 'What are the motivations and barriers to online knowledge sharing for nurses?' These studies and relevant literature identified challenges to eliciting nursing knowledge digitally. These challenges were

constructed into a set of problem statements to be used in this research in several ways, including to help identify a suitable solution.

Aim: A review identified two broad approaches – direct and indirect - to eliciting knowledge (Impey et al., 2021). However, no approach was deemed suitable when compared to the problem statements. Some authors identified serious games as a potential knowledge management tool (Ahmed & Sutton, 2017; Allal-Cherif et al., 2016; Allal-Chérif & Makhlouf, 2016; Bayart et al., 2014). However, this was not tested using a nursing cohort, nor was any suitable game found. Therefore, this research aims to design and evaluate a low-fidelity game capable of eliciting and evaluating nursing knowledge so that it can be shared.

Methodology: The game was proposed as a low-fidelity prototype. It is envisioned that learning from the design, implementation and evaluation could be applied to a digital prototype. A digital prototype is beyond the scope of this research. The research adopted an elaborated action design approach (eADR) by Mullarkey and Hevner (2019). This four-stage approach - diagnosis, design, implementation, and evolution - combines action research and design science research. Each stage can be performed in multiple cycles. Movement can be back or forth depending on research needs. Each cycle contains five intervention activities – problem formulation, artefact creation, evaluation, reflection, and formalisation of learning.

Study site and participants: The study site was a specialist Haematology/Oncology department in a large teaching hospital in the Republic of Ireland. The research used three groups of participants - a co-inquiry group, Knowledge Holders and Knowledge Reviewers. The co-inquiry group was established to act as co-creators in the research. This group comprised clinical, educational and informatics specialists (n=7). The clinical members were based at the study site. The game elicited knowledge from Knowledge Holders who were nurses (n=10) based at the study site for less than 18 months. Knowledge Reviewers evaluated this knowledge so it could be reused and were nurses (n=8) based at the study site for more than 18 months. The clinical experts in the co-inquiry group identified 18 months as a probable time to become accustomed to the area but noted this was based on their experience and was a heuristic rather than a definitive time.

Contributions: Five interlinked contributions arise from this research. These relate to design, design knowledge or relating to theory. The design contributions are: (1) a low-fidelity serious knowledge elicitation and evaluation game artefact called The Nurses Knowledge Bank and (2) an adult oncology daycare nursing discharge reference set Ireland (SNOMED CT refset ID 134791000220109). Learning identified through the research process was embedded into the artefacts produced and formalised into design knowledge contributions. These design knowledge contributions are (1) a set of problem statements (linked to the serious game artefact) and (2) a

process for mapping evaluated knowledge to a clinical terminology (linked to the data reference set artefact). Lessons learned relating to the artefact could be managed through the eADR activities, cycles and stages, and then embedding lessons that emerged into the artefacts created. Managing lessons related to using eADR in this research was not as well defined. This thesis introduced an additional eADR stage (Reflections upon eADR) and intervention activity (end-stage reflection) to manage this learning. A discussion on the application of eADR in this research provided a contribution to theory.

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Abbreviations

A	Artefact Creation
ADR	Action Design Research
ANA	American Nurses Association
AR	Action Research
CKB	Control Knowledge Base
CoP	Community of Practice
DIKW	Data-Information-Knowledge-Wisdom
DSR	Design Science Research
E	Evaluation
eADR	Elaborated Action Design Research
ICNP	Classification for Nursing Practice
KB	Knowledge Bank
KM	Knowledge Management
KS	Knowledge Sharing
KT	Knowledge topic
L	Formalisation of Learning
NMBI	Nursing and Midwifery Board of Ireland
P	Problem Formulation/Action Planning
PSSUQ	Post-Study System Usability Questionnaire
PUC	Potential Unintended Consequences
R	Formalisation of Learning
SECI	Socialisation, Externalisation, Combination, Internalisation
SG	Serious Game
SNOMED CT	Systemised Nomenclature of Medicine – Clinical Terms
SOTA	State-of-the-art
SR	Stage Reflection
vCoP	Virtual Community of Practice
WHO	World Health Organisation

Definitions of Key Terms

The following are definitions for some of the commonly used terms in this thesis.

Term	Description
Annotations:	Describes handwritten notes on pre-printed documents such as patient care documents. Can be used to to highlight anomalies in care, act as a reminder, document important information related to the patient or because new knowledge was available that did not have a 'space' to document in the structured nursing notes
Community knowledge	This describes the totality of the knowledge elicited from the elicitation game and captured on the elicitation game board. It is proposed that this community knowledge will be evaluated and developed into a data set that could be shared.
Community of practice (CoP):	Describes a "group of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in the area by interacting on an ongoing basis" (Wenger et al., 2002).
Control Knowledge Base (CKB)	A control knowledge base (CKB) is a pre-existing object that can be used to initiate knowledge collection (Impey et al., 2023). In this research a 'Haematology/Oncology Day care Patient Medication record' document was used.
Data:	"Discrete entities that are described objectively without interpretation" (Graves & Corcoran, 1989).
Explicit knowledge:	This is knowledge that is codifiable and easy to share or document (Nonaka & Takeuchi, 1995).
Gamification:	Describes the application of game elements in a non-game environment or situation (Deterding et al., 2011).
Information:	Defined as "data that are interpreted, organised or structured" (Graves & Corcoran, 1989).
Knowledge	Is defined as information that has been "synthesised so that interrelationships are identified and formalised" (Graves & Corcoran, 1989). It is information that has value, is relevant and can be used to meet a goal (Bixler, 2005).

Term	Description
Knowledge Bank (KB)	The knowledge bank is represented by the elicitation game board. This is an A0 paper poster. Post-its generated during the game are collected onto the game board. This acts as a collection point for all knowledge submitted during the game so that it can be reviewed by knowledge holders post-game.
Knowledge Gatekeeper	Referred to as 'Gatekeeper', this is the role in the game that arbitrates in case of disputes relating to knowledge. The position is held by a subject expert.
Knowledge Holder	Referred to as 'Holder', this is the role in the game that shares knowledge they have accumulated in practice with an avatar during the knowledge elicitation game.
Knowledge management	ISO standard the governs knowledge management systems is ISO30401, notes knowledge management as a 'discipline focused on ways that organization create and use knowledge.' Other authors described it as the systematic, explicit, and deliberate knowledge building, renewal, and application (Wiig, 1997).
Knowledge management activities	No unified description of KM activities (Girard & Girard, 2015), 'creating' and 'sharing' are frequently mentioned.
Knowledge Mapper	The role in the game that is responsible for mapping evaluated knowledge into a clinical terminology so that it can be preserved and shared beyond the game
Knowledge Reviewer	Referred to as 'Reviewer', this is the role in the game that evaluates knowledge elicited during game.
Knowledge Seeker	Referred to as 'Seeker', this is the role in the game that is represented by the avatar in the game, their purpose is to seek knowledge from the Holder.
Knowledge sharing (KS):	The disseminating one's acquired knowledge with other members within one's organisation.
Knowledge submission	Describes the content of the annotated post-it notes submitted to the community knowledge.
Knowledge topic (KT)	Represented as a clinical scenario in this research. The scenario was 'Nursing advice for patients being discharged from the Adult Oncology Day Care setting'. Incorporated into the elicitation game sheet.

Term	Description
Serious games:	Games that are both entertaining and educational (Abt, 1970). Abt (1970)(p.9) noted serious games "have an explicit and carefully thought-out education purpose and are not intended to be played primarily for amusement".
Specialisation:	Specialisation in healthcare occurs when professionals focus on a specific area or disease, such as oncology.
Tacit knowledge:	This is knowledge that is difficult to verbalise and, therefore, document (Nonaka and Takeuchi, 1995), or as (Polanyi, 1966) notes we know more than we can tell.
Trust	The degree to which an individual is confident in the goodwill and reliability of another (Das & Bing-Sheng, 1998). There are a range of levels of trust – from interpersonal to institutional (Ford, 2004).
Unintended consequences:	This describes outcomes of adoption that are neither predicted nor anticipated but are a direct result of a change (Merton, 1936).
Wisdom:	The American Nurses Association describe wisdom as the appropriate application of knowledge to address a problem (ANA, 2022)

Chapters overview

Chapter 1 presents the motivation, research question, objectives, contributions arising from this research, and thesis structure. The research methodology, an elaborated action design research (eADR), is briefly introduced along with how it was applied in this research.

Chapter 2 describes key concepts such as 'nurse', 'knowledge' and 'specialisation in healthcare' that are used throughout this research.

Chapter 3 describes the Elaborated Action Design Research (eADR) approach by Mullarkey and Hevner (2019) that was adopted in this research. The study site and participants are also discussed in this chapter.

Chapter 4 discusses how the eADR approach was applied to this research. The chapter documents three stage – diagnosis, design and implementation. Additional details for these stages are presented in the appendix section.

Chapter 5 presents the final serious game artefact. Along with the game artefact, the chapter also presents the design knowledge contribution that is embedded in the artefact. This knowledge is represented by a set of 10 problem statements. It is proposed that these statements could be useful for people interested in designing serious knowledge elicitation and evaluation games for the nursing domain.

Chapter 6 presents the 'Adult oncology daycare nursing discharge reference set Ireland' (SNOMED CT refset ID 134791000220109). This artefact is comprised of elicited, evaluated, and coded knowledge. The design knowledge contribution for this artefact is in the form of a mapping process that adds codes to evaluated knowledge so that it can be represented in a clinical terminology is discussed.

Chapter 7 presents the collated stage reflections and a discussion on the learning that emerged using the eADR approach in this research. It is envisioned that these learnings, and subsequent list, could be useful for future researchers intending to adopt eADR.

Chapter 8 concludes the thesis. The chapter presents an overview of the research along with a discussion surrounding the extent to which the six research objectives were achieved. Suggested future work and final remarks conclude the chapter.

1 Research overview

This overview presents the motivation, research question, objectives, contributions arising from this research, and thesis structure. The research methodology, an elaborated action design research (eADR), is briefly introduced along with how it was applied in this research.

1.1 Introduction

This research explores to what extent a serious game could elicit and evaluate specialist nursing knowledge. The problem being addressed is that not all nursing knowledge is captured in a way that is easy to access outside the border of a community of practice (CoP) or beyond geography or time. The research aims to design and evaluate a low-fidelity serious game capable of eliciting and evaluating nursing knowledge so that it can be shared. The game's premise is that nurse participants act as preceptors or mentors and share their knowledge with a 'new nurse'. The 'new nurse' is represented by an avatar in the game. The process embedded in the game represents how one-way knowledge is shared in clinical practice. That is between the experienced nurse, represented by the participant, and the new nurse, represented by the avatar. It is proposed that by nurses playing the game, knowledge typically captured in their processes, or the environment could be elicited, evaluated, in the game and shared beyond time and geography. The study site used for this research was a specialist Haematology/Oncology department in a large teaching hospital in the Republic of Ireland. At this site, oncology patients are cared for by specialist healthcare professionals, including staff nurses, clinical nurse specialists and advance nurse practitioners.

The final game design contained two parts - elicitation and evaluation. The elicitation part surrounds a clinical scenario – the discharge of a hypothetical patient from an oncology daycare setting. Participants, called Holders, share their knowledge of a clinical scenario with an avatar in the game. To do this, the Holders annotate post-it notes with relevant knowledge and submit these to the game. These knowledge submissions are assigned to the Holders' avatar, each earning a point. At the end of the game, the winner is the avatar with the most points.

This elicited knowledge was then evaluated in the second part of the game. Nurse participants in the evaluation part are referred to as Reviewers. The Holder and Reviewer roles are held by different nurses in this research. For evaluation, the elicited knowledge is constructed into a set of cards by the author. The content of each card is evaluated, and Reviewers move an allocated number of points across a gameboard. The winner is the Reviewer who reaches the top of the board first or the highest-placed participant at the end of the game time. Three game cycles were conducted with n=10 Holders and n=8 Reviewers. Through gameplay, the elicited and evaluated

knowledge was mapped to two clinical terminologies Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT) and International Classification for Nursing Practice (ICNP). Knowledge mapped to the SNOMED CT terminology was published as a data reference set for an adult oncology discharge task. Mapping knowledge into a clinical terminology allowed it to be shared beyond time and geography.

As the research problem being addressed had characteristics of a wicked problem, a design science research (DSR) methodology was applied. There are many approaches to design science. This research adopted an elaborated action design science research (eADR) approach by Mullarkey and Hevner (2019). This research makes contributions to design, design knowledge and a contribution to theory. The design contribution is in the form of two linked artefacts, a serious game to elicit and evaluate knowledge and a data reference set developed from the evaluated knowledge. The design knowledge arises from the artefacts. These are a set of problem statements used to guide the design of the game and a process for mapping evaluated knowledge to a clinical terminology. Due to the newness of the eADR approach by (Mullarkey & Hevner, 2019), a further theory contribution is also made. This is in the form of a discussion on the application of eADR in this research. To achieve these contributions, eADR incorporates action research (Mullarkey & Hevner, 2019). Therefore, a co-operative inquiry group was formed. This group (n=7) comprised nursing specialists from the study site, nursing educational experts and computer scientists. The role of the co-inquiry group was to act as co-creators throughout the diagnosis, design, implement and evaluation processes. This chapter presents an overview of the research beginning with the motivation for the research, followed by an explanation of the research question and objectives. The chapter discusses the conference papers from this research and the thesis structure.

1.2 Motivation

Even though nurses spend a significant amount of their day completing documentation (Fore et al., 2019), there is evidence that not all tasks completed, or care given, is documented or documented fully (De Marinis et al., 2010; Fore et al., 2019; Gunningberg et al., 2008; Paans et al., 2010; Thoroddsen et al., 2013). This problem was also identified by the author of this thesis from their nursing practice. They observed how expert knowledge generated in specialist clinical units was shared verbally in peer-to-peer interactions. Other knowledge-sharing routes included publications, academic platforms, or the patients' medical records. The reliance, however, on face-to-face sharing presents challenges for organizations in terms of managing this knowledge.

While all healthcare knowledge is valuable, this research focuses on nurses' knowledge for several reasons. Approximately 59% of the world's healthcare workforce is made up of nurses. This figure

represents a global workforce of 27.9 million (WHO, 2020). In Ireland, the number of registered nurses is 81,431 (as of 1st June 2022). This figure represents 75,871 nurses currently practicing. Of these, 75,871, 66,471 nurses are patient-facing in their practice (NMBI, 2022). However, there are worldwide shortages of nurses (5.9 million in 2018). Deficits in numbers are not spread evenly worldwide, with low to middle-income countries experiencing the shortage more acutely (WHO, 2020). The nurse's role can be broadly viewed as having clinical, caring, health-promoting, advocacy, educational, research and policy development functions. These functions are performed across the human life cycle and in a range of settings, such as clinical, education, and research (NMBI, 2020, 2021, 2022). It is difficult to know the exact origin of an individual's knowledge. Broadly nurses' knowledge arises from personal and professional experiences and academic settings (Benner, 1984; Benner et al., 1999; Berragan, 1998; Hall, 2005).

Nurses can be based in general or specialist clinical areas. Specialisation in healthcare occurs when professionals focus on a specific area or disease, such as oncology. Through this specialisation, a community of practice (CoP) can be formed around the specific area or disease. A CoP describes a "group of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in the area by interacting on an ongoing basis" (Wenger et al., 2002). Rather than treat knowledge as an object, CoPs are 'living repositories' of knowledge (Wenger et al., 2002). Specialisation in healthcare presents many benefits, such as better patient outcomes and the development of new knowledge (Adibelli et al., 2017; Britnell, 2011). There are many benefits of membership in a CoP. For example, professional development of members and through peer interaction and informal learning, members share their tacit knowledge (Wenger et al., 2002). In terms of managing knowledge, problems are evident. One difficulty is how 'knowledge sticks to practice'. It stays within community boundaries where it is utilised but can be challenging to diffuse to a wider organisation. Knowledge also 'leaks' through practice channels. This describes how knowledge generated within a CoP may not be available to the organisation but could be known by the wider practice community (Wenger et al., 2002). Other challenges to managing specialist nursing knowledge include the tacit nature of knowledge, meaning 'we know more than we can tell' (Polanyi, 1966). As nursing accounts for over half the healthcare professionals globally, managing this knowledge so that it can be preserved mindful of geography and time is important.

1.3 Eliciting knowledge – approaches and challenges

Two exploratory studies were undertaken to understand the approaches and challenges surrounding eliciting knowledge. Each study was conducted to answer a specific question.

Q1: How do nurses currently share their knowledge? (Study 1, n=17)

Q2: What are the challenges and benefits of online knowledge sharing for nurses? (Study 2)

The first exploratory study found that nurses prefer face-to-face knowledge sharing and that they annotate pre-printed care plans when new knowledge emerges or to personalise care plans. Only a small number of participants (n=2) in Study 1 engaged in online knowledge sharing, so a literature review was undertaken to identify challenges and benefits (Study 2). Benefits identified related to the perceived usefulness of online sharing of knowledge. Limitations of sharing knowledge online were related to trust, technology, and time. These studies are described in Chapter 4 and Appendix B.

From these studies, challenges around eliciting and digitally preserving healthcare knowledge were identified. Before data collection began, these challenges were reviewed with the co-inquiry group and participants from the study site to ensure they were relevant to this group. Once they were deemed relevant, these challenges were then transformed into a set of problem statements. This is described in Chapter 4 and Appendix B. These problem statements were used to capture the characteristics of the problem and the domain and also to assess the suitability and effectiveness of any proposed solution.

A review of the current digital approaches to eliciting healthcare knowledge, discussed in Chapter 4 and Appendix B, identified two – direct from experts and indirect from systems such as electronic medical records. No approach was deemed superior. However, from the review process, a few papers retrieved (n=4) noted a potential role for serious games in knowledge management (Ahmed & Sutton, 2017; Allal-Cherif et al., 2016; Allal-Chérif & Makhlouf, 2016; Bayart et al., 2014).

Serious games have are both entertaining and educational (Abt, 1970). The literature describes how serious games are used mainly by nurses for education and training (Bayram & Caliskan, 2019; Tan et al., 2017; Tsai et al., 2015). No suitable serious game was found that could be used to manage nursing knowledge. Therefore, this research aims to explore to what extent a serious game could elicit and evaluate knowledge from nurses based in a specialist clinical area and how this knowledge can be shared outside their CoP. A low-fidelity prototype of a serious knowledge elicitation and evaluation game was developed and evaluated for this research. Using a low-fidelity prototype allowed the research to test the extent to which a serious game could be used in managing nursing knowledge. It is envisioned that learning from the development and evaluation process could be useful in designing and developing a digital version of the game. While a digital game is beyond the scope of this work, in Chapter 5, a discussion on the impact of digitisation and how a digital platform could address the limitations of a low-fidelity prototype is presented.

1.4 Research Question and Objectives

The research question was constructed based on the challenges captured in the exploratory studies and SOTA. This question was distilled into a set of research objectives.

1.4.1 Research Question

The aim of this research was to understand to what extent a specially designed serious game could elicit specialist nursing knowledge so that it could be preserved and shared mindful of geography and time. This aim was developed into the research question:

> *"To what extent can a serious game elicit and evaluate specialist nursing knowledge and preserve this knowledge so that it can be shared outside the community of practice (CoP), beyond time and geography, mindful of known challenges?"*

1.4.2 Research Objectives

The following six research objectives (RO) were identified to address the research question.

- RO1: Identify the challenges related to eliciting and sharing nursing knowledge.
- RO2: Describe current approaches to knowledge elicitation in healthcare.
- RO3: Describe the state-of-the-art surrounding serious games and their use in nursing.
- RO4: Design, implement and evaluate a low-fidelity prototype for a serious game that supports elicitation of domain-specific knowledge mindful of outcomes of RO1.
- RO5: Map elicited and evaluated knowledge arising from gameplay and test it in a real-world scenario, for example, a clinical terminology.
- RO6: Identify the benefits and limitations of an eADR approach as it applies to this research.

1.5 Research methodology

The problem, that not all nursing knowledge generated is captured in a way that is easy to access outside the border of the CoP, displays attributes of a 'wicked' problem. Wicked problems are 'ill-formulated', where information is 'confusing', 'with many stakeholders' often holding antagonistic perspectives Churchman (1967). To address this wicked problem, the research adopted a design science research (DSR) methodology. Design science aims to produce both design artefact(s) and knowledge (Baskerville & Myers, 2015). There are several approaches to DSR. An elaborated action design research (eADR) approach (Mullarkey & Hevner, 2019) was chosen for this research. eADR is a four-stage method – diagnosis, design, implementation, and evolution, see Figure 1.

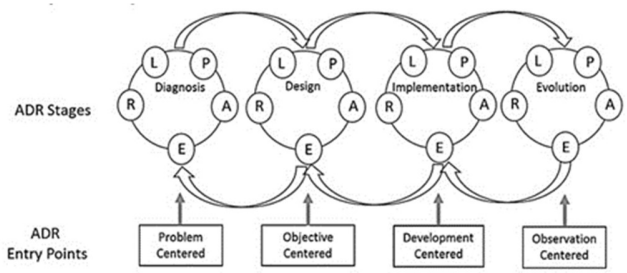


Figure 1 eADR by Mullarkey and Hevner (2019)

eADR combines both action research and design science. A co-inquiry group (n=7) was convened to comply with the action research component. The co-inquiry group included domain experts from the study site, computer scientists and nursing educational experts. As the primary purpose of the serious game being developed was to elicit nursing knowledge, the function of the nursing education experts was to ensure the group understood how nurses learn and share knowledge. The domain experts provided domain knowledge, and the computer scientists brought technological expertise. As noted above, eADR is comprised of four stages. Each stage of the eADR can take several cycles to complete depending on research requirements. Each eADR stage comprises five activities: Problem Formulation/Action Planning (P), Artefact Creation (A), Evaluation (E), Reflection (R), and Formalisation of Learning (L). See Table 1 for the number of cycles performed for each stage.

Table 1 ***Number of cycles performed for each stage***

Stage	**Cycles performed**
Diagnosis	2
Design	2
Implementation	3

In this research, three of the four proposed stages were performed. These were diagnosis, design, and implementation. The diagnosis stage commenced with problem formulation/action planning activities. According to Mullarkey and Hevner (2019), diagnosis is problem centred. The second stage, Design, is objective-centred (Mullarkey & Hevner, 2019). The next stage is implementation and primarily focuses on evaluating the artefact created at the study site. Mullarkey and Hevner (2019) describe this stage as development-centred. The final stage proposed by Mullarkey and Hevner (2019) is Evolution. The purpose of the evolution stage was to monitor for changes to the

problem space and to identify how the serious game might evolve to address potential or actual changes (Mullarkey & Hevner, 2019). Due to time constraints, this stage was not performed in this research. However, during the final implementation stage, the problem statements were reviewed to ensure they were still relevant. No additional statements were identified, and none were removed.

eADR aims to produce both design and design knowledge (Mullarkey & Hevner, 2019). The design is the artefact, and design knowledge can be captured in the artefact. Managing the learning related to the application of eADR in this research presented challenges. The reason for this was that while artefacts were iteratively reviewed and reflected upon throughout the research, learning related to the methodology was captured at the end of the research. To address this, a fifth stage, described as 'Reflection upon eADR', was included in this research. The primary aim of this proposed fifth stage was to provide a space where the learnings surrounding how the eADR approach was applied could be collated and discussed. A reflective activity was introduced to capture these learnings during each eADR stage. This activity was referred to as a 'Stage Reflection' as it was conducted following the completion of each eADR stage. These stage reflections consisted of discussions between the author and their PhD supervisor. The proposed stage, 'Reflection upon eADR', provided a means to formalise the learning that emerged from the stage reflections. An overview of the outputs from each of these five stages performed as part of this research is shown in Table 2. An overview of how eADR approach was applied is shown in Chapter 4.

Table 2 ***Overview of outputs from each eADR stage performed***

Stage	**Outcomes**
Diagnosis	1. Known challenges to eliciting knowledge identified in exploratory studies and literature review, evaluated, and deemed relevant to the study site (see Appendix B and Appendix C, Section 1.2)
Design	1. A knowledge elicitation and evaluation game (see Chapter 5)
Implementation	1. Final knowledge elicitation and evaluation game (see Chapter 5) 2. Final data reference set (see Chapter 6)
Proposed stage: Reflection upon eADR	1. Discussion on the application of eADR in this research. The content of this chapter is based on stage reflections. These are reflections conducted at the end of each stage, focusing on how the eADR was applied during the stage (see Chapter 7)

1.6 Publications arising from this research

The following publications arose from this research. Publications are arranged under the research objective they relate to. Proposed future publications are presented in Chapter 8.

1.6.1 Related to RO 1: Identify challenges related to eliciting and sharing nursing knowledge

The following reference is for a paper that describes the outcome of a research study conducted to understand how nursing knowledge is shared in an outpatient setting (a community of practice, CoP). Five outpatient settings from two healthcare institutions were included in the study (n=17). A full description of this research is provided in Chapter 4 and Appendix B.

- **Impey, S**., Stephens, G. & O'Sullivan, D. (2020) Exploring Factors that Motivate or Inhibit Nurse-to-Nurse Knowledge Sharing in Outpatient Settings. 20th International Conference on Integrated Care, Croatia. (Poster presentation)

The following two papers helped the author to develop an understanding of the challenges related to eliciting and sharing knowledge in a socially distant environment. The research was conducted at a contact tracing centre (CTC) in Ireland. The sample (n=14) were participants at the CTC, from both clinical and non-clinical backgrounds. The first paper provides a description of the information systems, people and support structures deployed at the CTC. The second focuses on the barriers to informal knowledge sharing due to social distance rules.

- **Impey, S,** Wall, P.J., Stephens, G., & Neill, F. (2021) Information Systems, People and Support Structures: A Critical Realist Analysis of a COVID-19 Contact Tracing Centre. Twenty-Seventh Americas Conference on Information Systems, Montreal.
- Wall, P.J., Neill, F, Stephens, G., & **Impey, S.** (2020) Limitations to informal knowledge sharing in a contact tracing centre (CTC) – implications for knowledge management. Joint Public Health Annual Conference. (Poster presentation)

The author was invited to take part in an international expert panel on the topic of Responsible Uses of Technology and Health Data During Times of Crisis. The author was able to draw from nursing, health informatics and experience of a contact tracing centre.

- Stephens, G., **Impey, S.,** Wall, P.J. & Neill, F. (2020) Responsible uses of technology and health data during times of crisis. The Future of Privacy Forum, in collaboration with the National Science Foundation, Duke Sanford School of Public Policy, and Intel Corporation, presents Privacy & Pandemics: Responsible Uses of Technology and Health Data During Times of Crisis -- An International Tech and Data Conference. (Expert Panel).

1.6.2 Related to RO 2: Describe current approaches to knowledge elicitation in healthcare

This paper was presented at the 23rd International Conference on Health Informatics and Health Information Management. The review was performed for an earlier project to develop a knowledge elicitation method, the WICKED method (Impey et al., 2023). This review identified two main approaches to knowledge elicitation – direct and indirect (Impey et al., 2021). Direct knowledge capture describes a process whereby knowledge is taken directly from subject experts (Torshizi et al., 2014). Indirect approaches rely on extracting new knowledge from previously captured data from various digital sources, including medical records, using artificial intelligence techniques. A description of this research is provided in Chapter 4 and Appendix B.

- **Impey, S.,** Stephens, G and O'Sullivan, D. (2021) Capturing Healthcare Expert's Knowledge Digitally – a Scoping Review of Current Approaches. ICHIHIM 2021: 23rd International Conference on Health Informatics and Health Information Management. London, United Kingdom (Poster presentation).

1.6.3 Related to RO 5: Map elicited and evaluated knowledge arising from gameplay and test it in a real-world scenario, for example, a clinical terminology

A poster presentation has been accepted to the International Council of Nurses Congress, 1-5 July 2023. The title is 'Mapping nurses' knowledge generated from a serious knowledge elicitation game to ICNP©'. The purpose of this research is to describe the process used to map validated knowledge to the International Classification for Nursing Practice (ICNP). The paper was co-authored by Gaye Stephens, Trinity College Dublin and Dr Ciara White, Centre for eIntegrated Care (CeIC), School of Nursing, Psychotherapy and Community Health, Dublin City University, Ireland. A full description of this research is provided in Chapters 4, 6 and Appendix D.

1.7 Impact to date

In addition to these publications, this thesis has made a number of impacts. These are described here:

1.7.1 Committee of Games and Learning Alliance conference

The author has been invited to act as a member of the Program Committee of Games and Learning Alliance conference (GALA Conf 2023). This will be held in Dublin, Ireland, November 29 – December 1, 2023. https://conf.seriousgamessociety.org/

1.7.2 Micro-credential in Digital Health: using technology in modern healthcare

Along with members from the School of Nursing and Midwifery and the School of Computers and Statistics, the author has been approved by Trinity College Dublin (TCD) for funding to develop and deliver a micro-credential. This micro-credential is a 12-week module on the topic of using technology in modern healthcare. It aims to give learners a fundamental understanding of the benefits and challenges of digital health systems used in healthcare. I have been able to incorporate topics researched in this thesis, data, information, knowledge and wisdom, serious games, and knowledge management, into the content. This provides the author with a way to share their research with a wider audience.

1.7.3 Group memberships

Through their research, the author has become a member of the SNOMED CT working group and ICNP Editorial Board. These groups are concerned with prompting the use and awareness of specific clinical terminology.

1.7.4 Contributor

The author contributed to the content of the Digital Health Module developed by The European Patients' Academy on Therapeutic Innovation (EUPATI). This is a multi-stakeholder public-private partnership originally launched by the IMI-EUPATI project (2012-2017) and hosted by the European Patients' Forum (EPF) from 2017 to 2020. Their contribution focused on the concepts of data, information, knowledge and wisdom in health technologies (learning.eupati.eu/local/coursecatalogue/index.php?categoryid=14).

1.8 Proposed publishing plan

The future publishing strategy includes exploring ways to disseminate research relating to the serious game.

Proposed paper 1: How do nurses use serious games? The author hopes to submit the state-of-the-art to the conference on Serious Games 2023: Serious Games and Serious Stories, Trinity College Dublin, Ireland, 26-27 October 2023.

Proposed paper 2: Design, implementation and evaluation of a serious knowledge elicitation and evaluation game for nurses – the nurses' knowledge bank. The author hopes to submit a paper

describing the final serious knowledge elicitation and evaluation game to the Committee of Games and Learning Alliance conference (GALA Conf 2023). This will be held in Dublin, Ireland, November 29 – December 1, 2023. https://conf.seriousgamessociety.org.

1.9 Research contributions

Five interlinked contributions arise from this research. These are categorised as relating to design, design knowledge or relating to theory. These are shown in Table 3 and described in Chapters 5, 6, 7.

Table 3 Contributions arising from this research

Type	**Contribution**
Design Contributions	1. Low-fidelity serious knowledge elicitation and evaluation game artefact called The Nurses Knowledge Bank (The final serious game contribution is presented in Chapter 5) 2. A data reference set for an adult oncology day care setting (The final data reference set is presented in Chapter 6)
Design knowledge Contributions	In the case of this research, knowledge embedded in the artefacts are: 1. Problem statements for future game developers for a nursing cohort (linked to the artefact: serious game) (The final set of problem statements are presented in Appendix C) 2. A process for mapping evaluated knowledge to a clinical terminology (linked to the artefact: data reference set) (The mapping process is described in Chapter 6, Section 6.6)
Theory Contribution	The theory contribution is a proposed additional eADR stage and intervention activity. The proposed stage is referred to as a 'Reflection upon eADR', and the activity is referred to as stage reflection. These proposed stage reflections were an additional activity performed during the eADR processes (Chapter 7)

Although presented as individual contributions, their design and development were linked. For example, to explore to what extent the serious game was capable of eliciting and evaluating knowledge, the outputs from the game were tested in a real-world scenario. This scenario describes the mapping of the evaluated knowledge to a clinical terminology. Whereas designing and developing the artefacts using eADR enabled the author to understand the benefits and limitations

of the approach as it applied to this research. It is hoped that the latter contribution could be helpful to future researchers applying an eADR approach to develop serious games. The following text describes the artefacts in greater detail.

1.9.1 Design contributions

From the literature, games in the nursing domain surrounded their use in education and training (Bayram & Caliskan, 2019; Tan et al., 2017; Tsai et al., 2015). In this research, a low-fidelity prototype (paper-based) for a scenario-based game was designed, implemented, and evaluated. All illustration of the final game flow is presented in Chapter 5, Section 5.3. This presents a contribution to the field of serious games building on work by authors such as Abt (1970) and, more recently, Dörner et al. (2016) and Deterding et al. (2011) to extend our understanding of serious games beyond education and entertainment into potential knowledge management tools for the nursing domain. See Chapter 5 for a full description of the serious game contribution. Figure 12 shows the final game produced. The game has two parts – a knowledge elicitation part and then an evaluation of the (elicited) knowledge part. The elicitation part was designed in the first design cycle (see Appendix C, Section 1.1) and the evaluation part was added in the second design cycle (see Appendix C, Section 1.2).

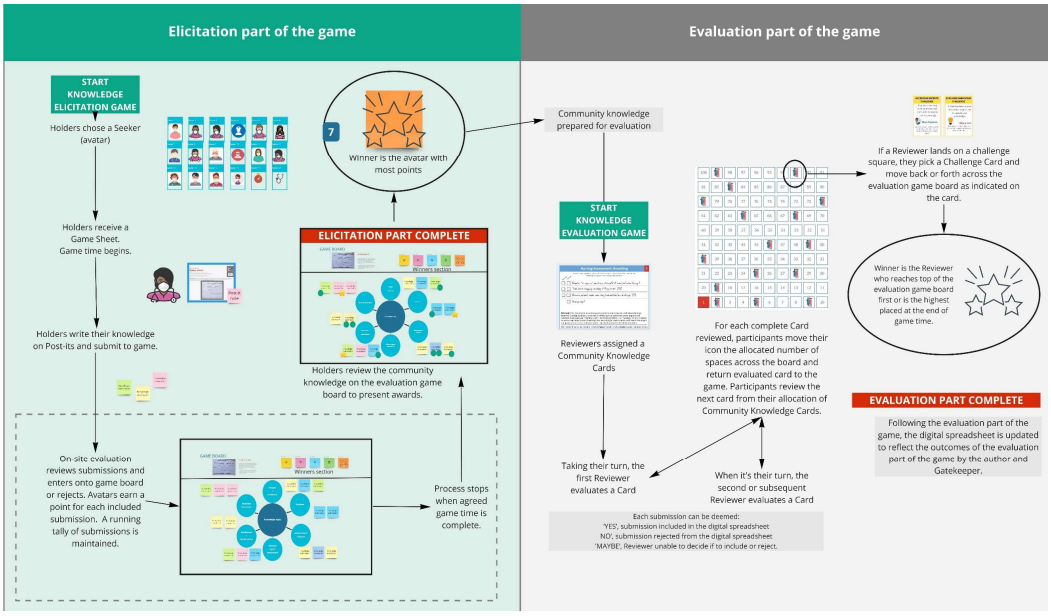


Figure 2 Final knowledge elicitation and evaluation game flow

It is envisioned that a serious game deployed at a single study site could potentially elicit and evaluate nursing knowledge. However, the game did not provide a way to share this knowledge

beyond the border of the study site. Therefore, the knowledge elicited and evaluated was mapped to two clinical terminologies. In this research, two clinical terminologies were used – Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT) and International Classification for Nursing Practice (ICNP). A standardised clinical terminology is a "compilation of terms used in the clinical assessment, management and care of patients, which includes agreed definitions that adequately represent the knowledge behind these terms and link with a standardized coding and classification system" (WHO, 2006). The potential benefits of adopting a standardized language include improved communication and patient care along with interoperability, knowledge generation (Fennelly et al., 2021) and articulating nursing (Strudwick & Hardiker, 2016). Terminologies can enable nurses, indeed all healthcare professionals, to document and share knowledge across digital platforms. Evaluated knowledge elicited during gameplay was mapped to a clinical terminology - 'Adult oncology daycare nursing discharge reference set Ireland' (SNOMED CT refset ID 134791000220109). This contribution, it is proposed, could be useful for knowledge managers concerned with the nursing domain. The mapping process and contribution is fully discussed in Chapters 6, Section 6.6.

1.9.2 Design knowledge contributions

A set of 10 problem statements used to guide the design of the game artefact constitute a contribution to design knowledge. These problems can be divided into three broad groups. These are related to knowledge. For example, problem statement 1 notes, "The solution should be capable of eliciting tacit knowledge". This statement acknowledges that not all knowledge is explicit or easily codifiable, citing the work of (Polanyi, 1966). The second group of statements are related to the nursing domain. An example in this group is problem statement 7, which notes, "The solution should be capable of accessing subject experts". This statement acknowledges the difficulty accessing experts and cites the work of Ericsson (2016), who notes non-experts often rely on 'peer-nominations'. The final group related to the potential for any solution to create potential unintended consequences (PUC). These could arise as deploying any solution to a context that could impact another element not initially considered. For instance, problem statement 3 describes, "There is potential for unknown socio-technical challenges linked to the study site to present additional challenges for the solution. Therefore, the researcher should hold a thorough understanding of the study site". The concept of unintended consequences draws from the work of Merton (1936). While this thesis does not purport to build on these theories, rather the purpose of this list is to highlight their importance to game designers. See Chapters 5 for the final game contribution and Appendix C for a full description of the problem statements. In relation to the data reference set, a process for mapping evaluated knowledge to clinical terminology was

developed. The purpose of this process was to help nurses map their own knowledge to clinical terminology so that it could be preserved. This contribution aims to add to mapping processes, such as Block et al. (2021) and the wider discussions around clinical terminologies (Fennelly et al., 2021; Randell et al., 2021). See Chapters 6 for a full description of the data reference set. Section 6.6 describes the mapping process. The design and design knowledge contributions emerged from the eADR stages and cycles. Figure 3 shows the application of eADR, as described by Mullarkey and Hevner (2019) in this research. This comprises of diagnosis stage (2 cycles), design stage (2 cycles) and implementation stage (3 cycles). Further discussed in Chapter 4.

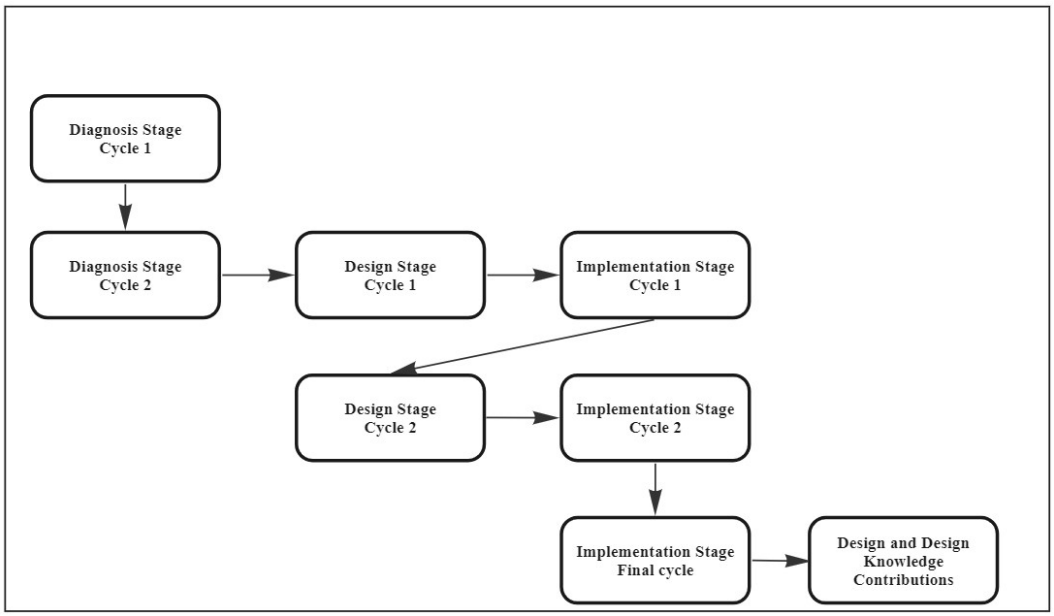


Figure 3 The application of eADR, as described by Mularkey and Hevner (2019) in this research.

1.9.3 Theory contribution

Mullarkey and Hevner (2019) noted that an important direction for the eADR approach is to include design theory development. The final contribution, it is proposed, could be useful to other researchers who wish to adopt an eADR approach to produce both design artefacts and develop design theory. This proposed benefit arises from the additional stage and additional reflection activity. Combined, these provide researchers with an activity to capture learning related to the application of eADR within each stage. Along with a separate stage to collect and formalise these learnings. This contribution aims to add to this discussion and builds on the work of authors such as Hevner et al. (2004), Sein et al. (2011) and, specifically, Mullarkey and Hevner (2019). See Chapter 7 for a full description of the theory contribution. The additional reflection stages are

shown in Figure 4 and how these link to the eADR stages proposed by Mullarkey and Hevner (2019).

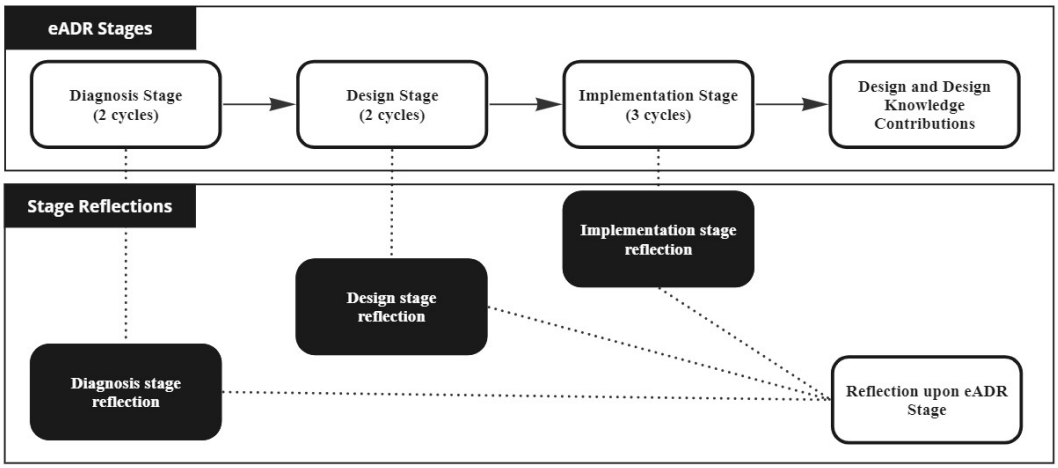


Figure 4 The additional reflection stages identified in this research

1.10 Thesis structure

The initial chapters in this thesis introduce the research, the domain, and the challenges this work aims to address. In the middle part of the thesis, the design, implementation, and evaluation of the three contributions using the eADR approach are presented. These three contributions are interrelated. An eADR approach was used to design, implement, and evaluate the game. The game produced evaluated knowledge that could be mapped to clinical terminology, while reflecting on the whole process produced a discussion on the application of the eADR approach. This interrelatedness, while required to achieve the contributions, presented challenges for structuring the thesis. This challenge arose as movement throughout the four eADR stages was backwards as well as forward and took eight cycles in total to complete. To present a full and true account of the research, the thesis structure followed these cycles. When subsequent cycles of an eADR stage were performed, these were presented together. The final contributions are presented in three individual chapters following a discussion on the eADR stages. This structure is presented in Table 4, along with a description of each chapter and a link to the research objectives.

Table 4 ***Structure of PhD***

Chapter	Purpose of chapter	RO
2. Key concepts	To describes the key concepts used in this research, including what is a nurse, specialisation in healthcare and the distinction between data, information, knowledge and wisdom.	-
2. Methodology	To describe the methodology used – an elaborated action design research (eADR) as described by Mullarkey and Hevner (2019).	-
3. Application of eADR	To presents an overview of the research journey using the eADR approach - from initial problem formulation in the diagnosis stage to the final implementation cycle.	RO1, RO2, RO3, RO4, RO5
5. Contribution 1	In this chapter, the final serious game artefact is described. The iterative design process is presented in Chapter 4 and Appendices A-D.	RO4
6. Contribution 2	In this chapter, the final data reference set is presented. How the specialist nursing knowledge was elicited, prepared and evaluated is presented in Appendices D and F.	RO5
7. Contribution 3	This chapter presents the lessons learned during around the application of eADR in this research. The stage reflections, that the lessons learned, are presented in Appendix E.	RO6

1.11 Conclusion

The problem addressed is that not all nursing knowledge is captured in a way that is easy to access outside the border of a CoP or beyond geography or time. This chapter highlighted why this was an important problem to address, given the prevalence of nurses in healthcare and the scope of their role. To address this problem, a solution in the form of a serious game was proposed. The chapter provided an overview of the research, including the problem statement, motivation and chosen research methodology. The main contributions arising from this work were described. These are the serious knowledge elicitation game (for nurses) and a data reference set. While the methodology used, DSR is well established, the specific eADR approach is relatively new (published in 2019). Therefore, a further contribution is a discussion based on the learning accumulated through the application of the eADR in this research. The next chapter describes the key concepts used in this research. These concepts include what is a nurse, specialisation in healthcare

2 Key Concepts

This chapter describes the key concepts used in this research. These concepts include what is a nurse, specialisation in healthcare and the distinction between data, information, knowledge and wisdom. The purpose of this chapter is to present an understanding of these terms.

2.1 Introduction

The purpose of this chapter is to described key concepts used in this research. To identify the most appropriate, the research question was reviewed, and concepts extracted: *"To what extent can a serious game elicit specialist nursing knowledge and preserve this knowledge so that it can be shared outside the community of practice, beyond time and geography, mindful of known challenges?"*

Key concepts discussed in this chapter include what is a nurse (see Section 2.2) and specialization in healthcare and communities of practice (see Section 2.3). The data, information, knowledge wisdom (DIKW) hierarchy was used as a means of distinguishing between what is knowledge and what is not knowledge (see Section 2.4). This discussion references the work of Ackoff (1989), Graves and Corcoran (1989) and Blum (1986). The chapter also reviews dimensions of knowledge, specifically tacit. While explicit knowledge is easily codifiable, tacit is described by Polanyi (1966) as 'we know more than we can tell'. How tacit knowledge is converted to explicit knowledge is described using the SECI model by Nonaka and Takeuchi (1995). The initials 'SECI' represent socialization, externalization, combination, and internalization (see Section 2.5). Annotations, including handwritten notes on pre-printed documents are identified as a way nurses share their knowledge. These are discussed in Section 2.7. The chapter also introduces the concepts of serious games (see Section 2.8) and clinical terminologies (see Section 2.9). Table 5 shows the part of the research question each concept is relevant to. The table also shown the relevant section(s). While some parts of the question can be represented by a single concept for example serious games, others encompass multiple concepts, for example, to discuss specialist nursing knowledge an understanding of what is a nurse, specialization in healthcare and annotations is provided. The chapter each concept is linked to is also provided in the table. One omission is the reference in the research question to "… mindful of known challenges". While the tacit aspect of knowledge was identified as a challenge, this was not the only one. In total 10 known challenges were identified. These were identified through two exploratory studies, relevant literature and discussions with the study site. The final set of challenges are discussed in Appendix D.

Table 5 How key concepts described are linked to the research question

Section of research question	Key concept	Chapter
"…serious game…"	Serious games (see Section 2.8)	The final game is presented in Chapter 5
"…elicit…", "…preserve…"	Knowledge management (see Section 2.6)	
"…specialist nursing knowledge…"	What is a nurse (see Section 2.2), Specialisation in healthcare (see Section 2.3) and Annotations (see Section 2.7)	
"… shared outside the community of practice, beyond time and geography…"	Clinical terminologies (see Section 2.9)	The final data set is presented in Chapter 6
"… mindful of known challenges"	Tacit knowledge to explicit knowledge (see Chapter 2, Section 2.4)	The final set of challenges is presented in Appendix C, section 1.2

2.2 What is a nurse?

Approximately 59% of the world's health professionals are nurses (WHO, 2020). However, nursing is difficult to define as it is not an internationally classified occupational group (WHO, 2020). As a unified definition is unavailable, this research explores what a nurse does. This is discussed below using literature from the Nursing and Midwifery Board of Ireland: Code of Professional Conduct and Ethics for Registered Nurses and Registered Midwives (NMBI, 2021), American Nurses Association (ANA): Scope and Standards (2021) and World Health Organisation: State of the World's Nursing (WHO, 2020).

"Nursing integrates the art and science of caring and focuses on the protection, promotion, and optimization of health and human functioning; prevention of illness and injury; facilitation of healing; and alleviation of suffering through compassionate presence. Nursing is the diagnosis and treatment of human responses and advocacy in the care of individuals, families, groups, communities, and populations in recognition of the connection of all humanity" (ANA, 2021).

"Nursing encompasses autonomous and collaborative care of individuals of all ages, families, groups and communities, sick or well and in all settings; it includes the promotion of health, the prevention of illness, and the care of ill, disabled and dying people. Additional key nursing roles include advocacy, promotion of a safe environment, participation in patient and health services management, shaping health policy, education, and research. Nurses provide a wide variety of health care services for people in all health care settings, from tertiary hospitals to health posts in remote communities" (WHO, 2020).

While the Code of Professional Conduct and Ethics for Registered Nurses and Registered Midwives (NMBI, 2021) does not provide a concise description of role nursing, it does provide five principles that govern the provision of patient care. These are:

1. Principle 1 Respect for the dignity of the person
2. Principle 2 Professional responsibility and accountability
3. Principle 3 Quality of practice
4. Principle 4 Trust and confidentiality
5. Principle 5 Collaboration with others

Using these descriptions and principles, the nurse's role can be broadly viewed as having clinical, caring, health-promoting, advocacy, educational, research and policy development functions. These functions are performed across the life cycle and in various healthcare settings. For example, clinical, education, research, administration, and management (NMBI, 2021) and in a variety of roles, such as staff nurses, advanced nurse practitioners, clinical nurse specialists, clinical nurse managers, directors of nursing, clinical nurse tutors and research nurses. This description or the variety of the nurse's role is not to be viewed as an exhaustive account, but it is used here to demonstrate the diversity of nursing. Common to all is that to perform this range of roles, nurses require knowledge. As nursing accounts for over half the healthcare professionals globally, managing this knowledge in their real-world work contexts is important.

2.3 Specialisation in healthcare

Specialisation in healthcare occurs when professionals focus on a specific area or disease, such as oncology. Through this specialisation, a community of practice (CoP) can be formed around the specific area or disease. A CoP describes a "group of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in the area by interacting on an ongoing basis" (Wenger et al., 2002). CoPs promote collaborative work

practices, shared problem solving and ubiquitous knowledge sharing. (Fingrut et al., 2018; Huckson & Davies, 2007; Pyrko et al., 2017). Rather than treat knowledge as an object, CoPs are 'living repositories' of knowledge (Wenger et al., 2002).

Specialisation in healthcare presents many benefits for patients. These include better patient outcomes and the development of new knowledge (Britnell, 2011). A study by Adibelli et al. (2017) described how respondents (nurses) identified benefits of specialisation, such as the positive effect on nursing as a profession and service quality improvements. In addition to these benefits, Wenger et al. (2002) note there are many benefits of membership in a CoP. For example, the professional development of members and through peer interaction and informal learning, members share their tacit knowledge.

However, problems are also evident. One difficulty discussed by Wenger et al. (2002) is how 'knowledge sticks to practice' (Wenger et al. 2002, p. 151). It stays within community boundaries where it is utilised but can be challenging to diffuse to a wider organisation. However, knowledge also 'leaks' through practice channels (Wenger et al., 2002). This describes how knowledge generated within a CoP may not be available to the organisation, but it could be known by the wider practice community. Highlighting the importance of communities of practice, Davenport (1998) discusses the 'localness of knowledge'. By this Davenport (1998) discusses how individuals learn from those they are physically close to, for instance, within their organisation. Part of why this learning occurs is that individuals trust those they know. Or at least they can assess if another can be trusted. Furthermore, people can be members of many CoPs, and there is potential for knowledge to be generated in one CoP and shared in another. This is illustrated in Figure 5.

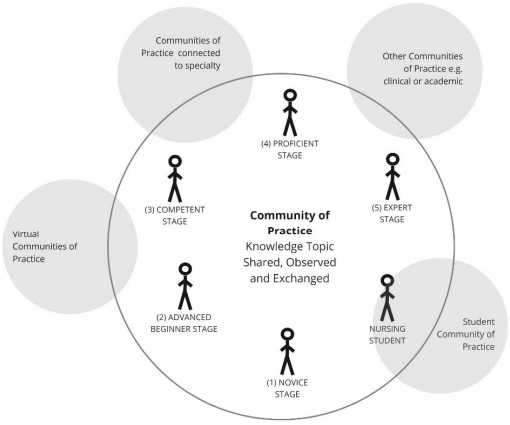


Figure 5 Potential membership overlap between specialist CoP and other CoPs

This figure was developed based on participants' responses from the first exploratory study undertaken for this thesis research (see Appendix B). The purpose of the figure is to illustrate how individuals can be members of multiple CoPs. The CoP at the centre of the illustration represents the specialist unit where participants were based. The CoPs on the peripheries of the illustration represent the additional groups a participant could be a member of. However, this representation can shift depending on the participant's perspective, and a peripheral CoP could move to the centre. The potential skill mix of a CoP is represented using Benner (1984) Novice to Expert model. This model describes the evolution of nurses as they move from novices to experts. Novices are perceived as group members who cannot apply discretionary judgement. Experts are at the other end of the scale and possess an intuitive sense of a situation. Nurses move through three levels to move from one end of the scale to the other. These levels are advanced beginners, competent and proficient. The model is based on the Dreyfus Model of Skill Acquisition (Dreyfus & Dreyfus, 1988). While this helps to demonstrate the potential range of nursing skills available within a CoP, the model is not without its critics. For example, Gardner (2012) notes that in Benner's interpretation, experts are not merely unable to recall the rules they work by but are less efficient if they work by rules.

> *"…according to Benner, if experts are forced to practice by the book, according to established research- and theory-based procedures, their performance actually deteriorates." Gardner (2012, p339).*

In addition, the model provides a way of talking about the potential transition that occurs as nurses move through their careers. There is an expectation, however, that all nurses achieve expert status. Rather than offering support for or critique of the model, the model was used in this thesis to demonstrate the potential diversity of skills within a nursing CoP.

2.4 Data, information, knowledge, and wisdom (DIKW)

Many definitions of knowledge exist. To avoid confusion, the concepts of data, information, knowledge, and wisdom (DIKW) as core concepts within clinical information systems are adopted in this research. A practical way to describe knowledge is in the context of the data-information-knowledge-wisdom (DIKW) framework proposed by Ackoff (1989). This framework describes four individual concepts of data, information, knowledge and wisdom. Although the terms are often used interchangeably, this thesis will discuss these concepts individually, along with providing examples relating to nursing.

The concepts of data, information and knowledge and their applicability to clinical information systems (CIS) are generally attributed to the work of Blum (1986). Blum's (1986) work presents

a way to understand CIS by the objects the system processes – namely data, information, and knowledge. Building on Blum's work, Graves and Corcoran (1989), in their seminal paper on nursing informatics, note that **data** is "discrete entities that are described objectively without interpretation". **Information** is "data that are interpreted, organised or structured". **Knowledge** is information that has been "synthesised so that interrelationships are identified and formalised". These are described here in more detail and are followed by a discussion on the introduction of 'wisdom' into the hierarchy by authors such as Ackoff (1989).

2.4.1 Data/information

The first concept – data - consists of basic facts or values. On their own, they have no further meaning (Ackoff, 1989). An example of data would be the number '80'. Data are discreet entities that cannot be interpreted on their own but need 'information' to make sense. Information, therefore, is a collection of facts organised to give data value and meaning (Hoppe et al., 2011). According to Ackoff (1989), information can be captured in questions surrounding: 'who', 'what', 'when', 'where,' and 'how many'. For example, if we add that '80' is the patient's resting heart rate (beats per minute, bpm). This allows the nurse to understand the value of the data. Data on its own is meaningless, but when paired with the correct information, it can be interpreted.

2.4.2 Knowledge

There are many definitions of knowledge. For example, Davenport et al. (1998) describe knowledge as "information combined with experience, context, interpretation, and reflection". Bixler (2005) describes knowledge as information that has value, is relevant and can be used to meet a goal. Whereas professional knowledge, described by Eraut (1994), is an umbrella term that represents a range of different forms of knowledge – procedural, propositional, practical, tacit, skills and know-how. Personal knowledge, according to Polanyi (1958) is grounded in the experiences of the individual. While there are many aspects to the nurse's role, central is the art and science of caring (ANA, 2021). This care is not limited to individual patients but also to families, communities, and populations. In order to provide this care, nurses need to hold a broad knowledge base which includes biological, psychological or spiritual, but also social, emotional and cultural (NMBI, 2015). Nurses hold multiple ways of knowing that integrate both art and science (ANA, 2021). In seminal work, Carper (1978) describes four fundamental patterns of knowing in nursing. These are empirics, esthetics, personal knowledge, and ethics. Empirics describes the science of nursing or its theoretical foundation. Whereas esthetics builds on empirics and is the art of nursing or, as Rogers (1992) notes, "creative use of this knowledge" (Rogers, 1992, p.29). Personal knowledge in nursing, according to Carper (1978), refers to nurses

understanding themselves in order to empathise with their patients. Whereas personal knowledge, as described by Eraut (2004), is described as what individuals bring to situations that enable them to think, interact and perform. The final pattern is ethics. According to Carper (1978), ethics goes beyond adherence to a prescribed ethical framework and understanding right from wrong. Rather it includes the choices and actions that underpin nurses' decisions around their care. Rather than four distinct types of knowledge, Carper (1978) proposed these fundamental patterns as a way to understand nursing knowledge holistically and its application to practice.

Knowledge represents the awareness and understanding of information and the ways it can be made useful to support a task or make a decision. It is "information connected by some relations" (Hoppe et al., 2011) or the answer to 'how-to' questions (Ackoff, 1989). For example, knowing that the patient is a 45-year-old male and also knowing that a resting heart rate of 40 beats per minute is outside of the normal range for an adult male, knowledge built over the nurse's career allows them to identify 'how to' manage or identify the appropriate action for a situation.

2.4.3 Wisdom

Knowing how to apply this knowledge describes another concept, 'wisdom'. Although Blum (1986) nor Graves and Corcoran (1989) did not include the concept of 'wisdom', other authors do (Ackoff, 1989; Matney et al., 2011; Nelson, 2018, 2020). Therefore, we will include this concept here. The ANA (2022) describe **wisdom** as the appropriate use of knowledge to manage and solve human problems. Ackoff (1989) notes wisdom is central to the exercise of judgement. These descriptions link wisdom to action. Therefore, going back to the earlier heart rate example, the application of wisdom would involve the healthcare practitioner taking appropriate clinical action (or no action, as the case may be).

This final component, wisdom, requires a judgement of knowledge and action (Ackoff, 1989). Bickford (2015) notes wisdom is "the appropriate use of knowledge to manage and solve human problems." Going back to the example, aggregated experiences developed over a career allows the nurse to consider courses of action (for a heart rate of 80 bpm) and chose one they consider to be the most suitable. Through this action, nurses are applying their clinical judgement to identify the most appropriate course of action for a situation. Standing (2017) describes clinical judgement as "informed opinion (using intuition, reflection and critical thinking) that relates observation and assessment of patients to identifying and evaluating alternative nursing options" (Standing, 2017, p. 7). Nurses acquire clinical judgement through evidence and experience and by aligning these with patient preferences (Standing, 2017).

While capturing data and information is relatively easy, knowledge is more complex, and wisdom presents further challenges (Nelson, 2018). One potential reason for this is that data, such as symbols (such as numbers) and information (instructions), are more easily codified. Knowledge

and wisdom, on the other hand, have tacit dimensions that are more difficult to reproduce. Referring to tacit knowledge, (Polanyi, 1966) noted that we "know more than we can tell".

Data, information, knowledge and wisdom are often presented as a pyramid with data at the bottom and wisdom at the top and referred to as the DIKW hierarchy. Although this categorisation allows users to distinguish between individual concepts, the hierarchy is not without its limitations or critiques. For instance, Blum (1986) noted that data, information, and knowledge should not be viewed in isolation. Instead, they see the progression from data to information to knowledge as one of increasing complexity. Other critiques include whether wisdom should be included in the hierarchy at all (Rowley, 2007). Whereas Frické (2009) cautions against the notion that data will, at some point, turn into information (or information into knowledge). Regardless of these limitations or critiques, the DIKW hierarchy presents a way to broadly, if not a somewhat simplistic way, understand clinical information systems based on the type of objects it processes. For instance, data and information (information systems), knowledge (decision-support systems) and wisdom (expert system) (Nelson, 2020).

2.5 Tacit knowledge to explicit knowledge

To fully understand 'knowledge', further investigation of its tacit and explicit dimensions is required. At its simplest, explicit knowledge is knowledge that is codifiable and easy to share or document. Comparatively, tacit knowledge is difficult to verbalise and, therefore, document (Nonaka & Takeuchi, 1995). As Polanyi (1966) notes, referring to tacit knowledge, 'we know more than we can tell'. One way that tacit knowledge is built is through experience (Nonaka & Takeuchi, 1995). Wenger et al. (2002) discuss how tacit knowledge is shared in a community of practice (CoP) through interaction between members using informal learning processes, such as storytelling or members conversations. According to Davenport et al. (1998) tacit knowledge transfer requires close proximity between the individuals. While capturing codifiable and explicit knowledge is less challenging for knowledge managers, tacit, on the other hand, is a more complex undertaking. Nonaka and Takeuchi (1995) argue that our tacit stock reflects, not only our experiences, but also understanding of the context to which we apply it. Schön (1991) notes that knowledge is not merely created through observation but requires the learner to reflect and act on the experience. A similar sentiment was raised by Eraut (2004) who noted that tacit knowledge "does not arise only from the implicit acquisition of knowledge but also from the implicit processing of knowledge."

Separating knowledge into two distinct dimensions (tacit or explicit) can be problematic as what one person might understand tacitly, another may know explicitly (Nonaka & Takeuchi, 1995). For these reasons, it is probably best to understand knowledge as being on a dynamic continuum

between tacit and explicit. Furthermore, while we can separate data (discrete entity) from information (additional facts to describe the data) without difficulty, the distinction between knowledge and wisdom in clinical practice is blurred. Both are vital to clinical judgement, and both have tacit and explicit components. This research focuses on knowledge as being an essential component of nurses' wisdom and clinical judgment. As such, the term 'knowledge' will be used to represent the knowledge-wisdom continuum in this research.

To understand how tacit could be converted to explicit and vice versa, the research for this thesis applies the model of knowledge conversion by Nonaka and Takeuchi (1995). This is referred to as the SECI model and it proposes that the generation of new organizational knowledge is a result of the ongoing interaction between the tacit and explicit of the individuals and groups with the organisation. The model encompasses four modes of knowledge conversion that are arranged in a 'knowledge spiral' formation (see Figure 6).

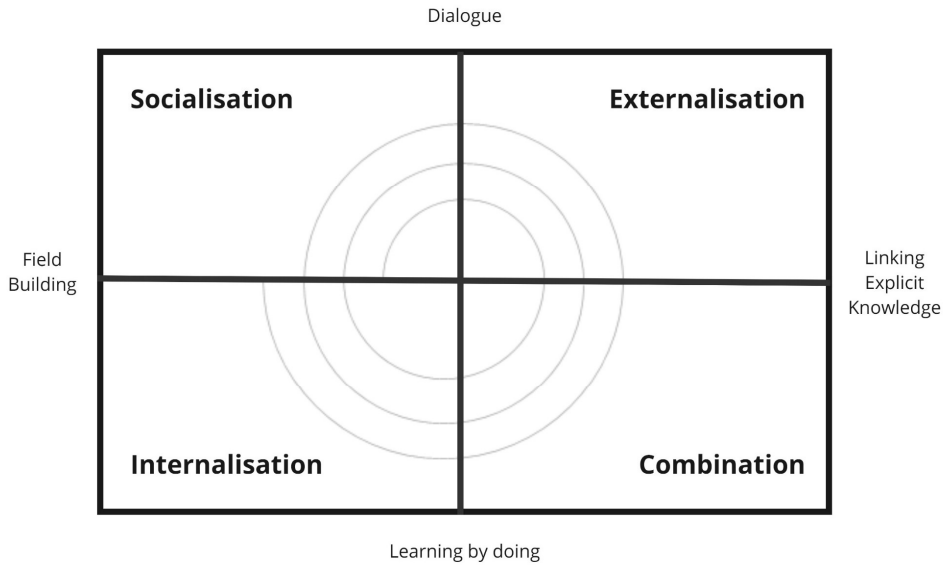


Figure 6 Diagram of the Knowledge Spiral reproduced from The Knowledge-Creating Company Nonaka and Takeuchi (1995)

The SECI model has been used in serious games in knowledge management research previously (Allal-Cherif et al., 2016; Allal-Chérif & Makhlouf, 2016; Bayart et al., 2014). These papers are discussed in the literature review chapter. Each mode represents a letter in the title 'SECI', these are:

- Socialisation: from tacit to tacit
- Externalisation: from tacit to explicit
- Combination: from explicit to explicit

- Internalisation: from explicit to tacit

The following text uses the SECI process to describe how nursing knowledge could potentially be converted into organizational knowledge by describing each of the four concepts and providing examples from clinical practice.

2.5.1 Socialisation (tacit to tacit)

Socialisation describes how an individual can acquire the tacit knowledge of another without the use of language through 'observation, imitation and practice' (Nonaka & Takeuchi, 1995). Central to socialization is that the stakeholders are involved in a shared experience. Nonaka and Takeuchi (1995) describe the apprentice/mentor relationship as an example of the socialization of knowledge conversion. There are many ways in which nurses acquire and build their knowledge. For example, personal experience, in the academic setting and through clinical practice experiences. One-way nurses learn in clinical practice is through modelling. Modelling describes how individuals can learn by observing and copying others. And by observing the outcomes of the behaviour of others. The concept of modelling sits within a social cognitive theory described by psychologist Albert Bandura (1925-1921). In Bandura's now famous Bobo doll experiments, children watch a video of adults attacking the Bobo doll. Bandura observed the participants copy the behaviour in the video (Bandura, 1965). This highlights the importance of the preceptor/preceptee relationship that occurs in the nursing domain. Preceptorship describes a form of situated learning that occurs through participation in monitored in clinical practice of student nurses (Nielsen et al., 2017). According to the (NMBI, 2020) preceptors as the primary teacher in the clinical area, receive training for the role (which must be updated every two years). Qualified nurses, assigned to the preceptor role, maintain their clinical duties but also help student nurses transition into the discipline (Quek & Shorey, 2018). Preceptors plan and monitor the students learning and progress, demonstrate best practices and share their clinical experiences (NMBI, 2020). Knowledge sharing (KS) is the "behaviour of disseminating one's acquired knowledge with other members within one's organisation" (Ryu et al., 2003)(p. 113). KS has been highlighted as critical to knowledge management (Nonaka & Takeuchi, 1995). In a study by McLeod et al. (2021) not only was this model of supervision well received by students but also helped them develop a 'Sense of Belonging'. In addition to these formal roles, learning can also be informal. Not discussing nursing specifically, Eraut (2004) recognises the benefits of learning from other people.

2.5.2 Externalisation (tacit to explicit)

Externalisation describes how this tacit knowledge can be verbalized (by converting to explicit), it is the formalization of the tacit knowledge captured (during socialization) into an individual's conceptual model (Nonaka & Takeuchi, 1995). To extract and transform tacit to explicit knowledge individuals can use reflection to apply these conceptual models to context. Reflection is "the practice by which professionals become aware of their implicit knowledgebase and learn from their experience"(Schön, 1991). Reflection can be a sole or group endeavor and be in written or discussion form (Bjerkvik & Hilli, 2019; Contreras et al., 2020). While protected time for reflection is provided to students in the clinical environment (NMBI, 2020), reflection and professional development are ongoing through the nurses career (NMBI, 2021). A detailed discussion on models of reflection, although interesting, is considered beyond this research other than to note that there are many models of reflection. For examples see (Gibbs, 1988; Rolfe et al., 2001). Each provide guidance on how to approach reflection, for instance, Schön (1991) in their book The Reflective Practitioner describes two approaches. These are 'reflection in action' and 'reflection on action'. Reflection in action occurs when an individual reflects when something is happening. Whereas reflection on action occurs after the event has occurred. Nonaka and Takeuchi (1995) describe concept creation as an output of externalization. They also note that as tacit is converted into explicit concepts in the externalization, this mode is key to creating knowledge.

2.5.3 Combination (explicit to explicit)

In the first two modes it was discussed how tacit knowledge is shared and then transferred into explicit knowledge. In the third mode, combination, this explicit knowledge is combined with concepts from a range of other knowledge systems, for instance, documents or meetings, to form new bodies of explicit knowledge (Nonaka & Takeuchi, 1995).

2.5.4 Internalisation (explicit to tacit)

The final mode discussed is internalization. This is the 'embodying explicit knowledge into tacit' (Nonaka & Takeuchi, 1995)(p69). This process occurs when knowledge gathered through socialization, externalization and combination is assimilated into an individual tacit body of knowledge. Nonaka and Takeuchi (1995)(p69) note this process is closely linked to 'learning by doing'. However, it notes that internalization can occur without having to 're-experience' another's experience but can occur through reviewing accounts of an event. Although presented as the final phase, the total SECI model should be seen as a continuous process between tacit and explicit knowledge that produces new knowledge (Nonaka & Takeuchi, 1995).

2.6 Knowledge management

The ISO standard the governs knowledge management systems is ISO30401. In this standard, knowledge management is described as a 'discipline focused on ways that organization create and use knowledge.' Whereas, Wiig (1997) describes knowledge management as systematic, explicit, and deliberate knowledge building, renewal, and application. There are differences among authors regarding what activities are accomplished under 'knowledge management' (KM) (Girard & Girard, 2015). Based on an analysis of KM definitions from 23 domains, Girard and Girard (2015) cite 'creating' and 'sharing' as frequently mentioned KM activities. Nonaka and Takeuchi (1995) describe knowledge creation as learning that occurs from others that are then internalised by the individual. Rather than knowledge creation, the aim of this thesis was to elicit knowledge that had been created in clinical practice and facilitate the sharing of this knowledge. While many definitions of knowledge sharing exist, Akhavan and Mahdi Hosseini (2015) note that a common theme is the transfer of knowledge from "one person or group to another person or group". For knowledge to be shared meaningfully, it needs to be evaluated to ensure its accuracy and relevance. In this thesis, managing knowledge focuses on elicitation, evaluating and sharing.

2.7 Annotations

A study conducted as part of the diagnosis cycle (see Appendix B, Section 1.1) identified that nurses share knowledge in a predominately oral world, both within and with those outside the unit. While this method makes knowledge capture difficult, it was preferred by participants as it was considered easy and allowed for 'back and forth' communication. Complicating knowledge capture was that knowledge was also found to be embedded in the clinical environment, such as posters, signs, placement of equipment and embodied in staff, such as knowledge passed from other staff members.

Another way to share, and subsequently capture, knowledge discussed by participants was through annotations in patient documentation. Annotations (handwritten notes on patient documents) were used by participants to highlight anomalies in care, act as a reminder, document important information related to the patient or because new knowledge was available that did not have a 'space' to document in the structured nursing notes. Annotations allowed nurses to update documents, including patient care plans or patient information leaflets, as new evidence became available and in between the formal document being reviewed and reprinted. Participants discussed how awareness of potential annotations are shared among members of the CoP, increase

with clinical exposure, and accumulate throughout the nurse's career. Due to patient privacy restrictions, the study was unable to collect examples of annotations.

To provide an example, pictures denoting annotations are used in this research from an exhibition in Marsh's Library, Dublin. Permission to show pictures was granted by Marsh's Library. The first picture shows a medical book (Johannes Scultetus, Armamentarium chiurgicum, Amsterdam, 1662). The reader has crossed out one of the instruments illustrated and given suggestions for replacement instruments and included accompanying notes. The second picture shows text from a book titled Chronicles of England (London, 1503). Every instance of the word 'Pope' crossed out. This occurred as the book was printed before England broke away from Rome but was still used post-1530. See Figure 7.

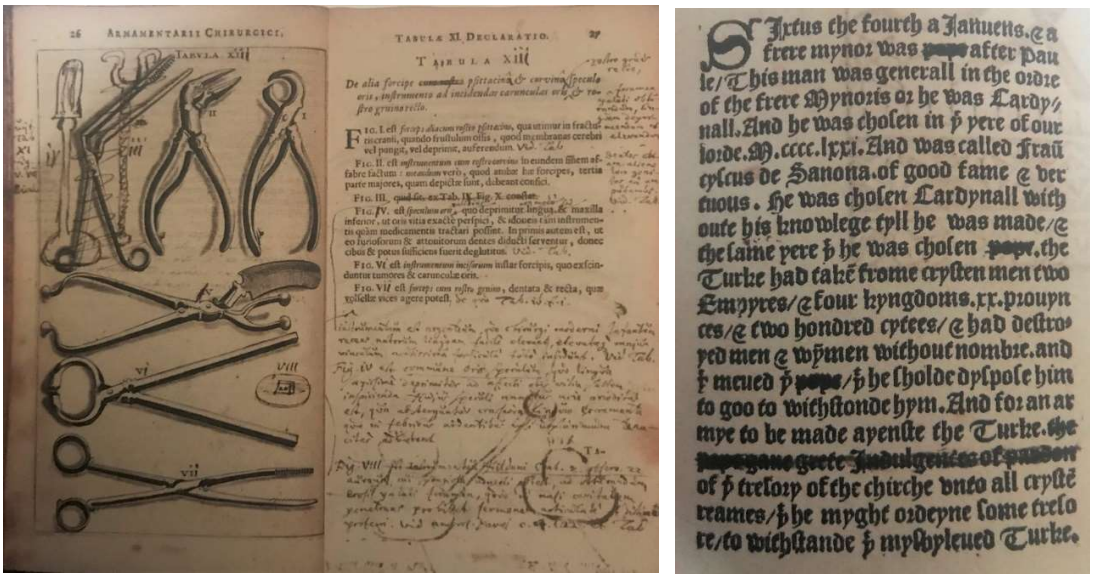


Figure 7 Photo credit Marsh's Library, Dublin

According to participants, awareness of potential annotations is shared among members of the CoP and built throughout the nurse's career. While annotations could be stored in the patient's record, they are not easy to access outside the CoP. One answer to increasing nursing knowledge captured could be through participation in online knowledge sharing platforms. However, participants described barriers to online knowledge sharing, such as lack of credibility, trust and time limitations.

2.8 Serious Games (Linked to Contribution 1)

An output from the diagnosis stage was that serious games could have the potential role in knowledge elicitation (see Appendix B). The term, **serious games**, is attributed to Clark C. Abt 1970. Serious games "have an explicit and carefully thought-out education purpose and are not intended to be played primarily for amusement" (Abt, 1970, p.9). A later description by Michael and Chen (2005) notes a serious game is a "game in which education (in its various forms) is the primary goal, rather than entertainment". Although this does not mean that serious games are not fun or played for amusement (Abt, 1970). While all games could be capable of being both educational and entertainment. The distinction between games and serious games lie in what is the primary purpose of the game i.e., entertainment then education or vice versa.

While Abt (1970) did not categories serious games as digital, more recent authors have. For instance, Stokes (2005) notes that serious games increasingly denote digital games where the 'primary goal goes beyond entertainment to education, outreach or training'. More recent definitions, such as Dörner et al. (2016) highlight how current technological advances and new mediums are often explored as a potential learning platform, using the introduction of television and education shows as an example. They propose the following definition: a serious game is a "digital game created with the intention to entertain and to achieve at least on additional goal (e.g. learning or health) (Dorner et al. 2016, p. 3). Dorner et al. (2016, p. 3) describes these additional goals as 'characterising goals'. Examples of these goals include 'exergames' where the goal is to increase users' activity. These labels are useful way to categorise the myriad of games within the serious game field. The final serious game is discussed in Chapter 5.

2.9 Clinical terminologies (Linked to Contribution 2)

While serious games could potentially elicit knowledge, to be able to share this knowledge beyond the border of the study site, it needed to be mapped to a clinical terminology. Along with describing and representing nursing (ISO18104:2014), a standardised nursing language also allows nursing data to be collated from various sources and used for patient care, quality improvements, research and influencing policy. For example, a study by Sanson et al. (2019) found that nursing diagnosis can be used to predict hospital mortality. The authors highlight that it is important, therefore, to include standardized nursing data in electronic records (Sanson et al., 2019). Considering that approximately 59% of the world's healthcare professionals are nursing, this represents a substantial amount of healthcare data.

An ISO standard relative to a nursing standardized language is the ISO 18104:2014. This health informatics standard describes 'Categorial structures for representation of nursing practice in

terminological systems'. At the time this thesis is being prepared, a replacement to this standard is in currently in the enquiry stage (stage 40.6). This replacement is the ISO/DIS 18104, as it is available publicly, the thesis will refer to the ISO 18104:2014 standard. The primary aim of the standard is to support interoperability between systems with respect to nursing diagnosis and actions.

Two terminologies were used in this research – SNOMED CT and ICNP. While one is a broad clinical reference terminology (SNOMED CT), the other provides more granularity needed to capture nursing work (ICNP). While there are several terminologies available, this thesis does not intend to identify one as superior. Rather they are used in this research as a means of demonstrating that for nursing knowledge to be capable of sharing beyond the community of practice (origin) and preserved beyond time and geography, knowledge used must be mapped into a standardized form. Standardised terminologies support this goal. To move from elicited, evaluated, and validated knowledge into a format capable of being shared, that is as a coded data reference set, knowledge needs to be mapped to a clinical terminology. It is important, therefore, that terminologies represent the full breath of nursing knowledge. However, not all knowledge elicited was capable of being represented in either standardized terminology used as suitable matches were not always found. Focusing on SNOMED CT the matches identified following the mapping process were developed into a refset for an 'Adult oncology daycare nursing discharge reference set Ireland' (SNOMED CT refset ID 134791000220109). This refset contains n=107 concepts. This demonstrates that knowledge elicited and evaluated during the game and validated by a subject expert can be capable of sharing to some degree. The degree to which this sharing is facilitated beyond time and geography is reliant on standardized terminologies representing nurses work. The final data set is discussed in Chapter 6.

2.10 Conclusion

This chapter described key concepts used in this research. These included what is a nurse, specialisation in healthcare and the distinction between data, information, knowledge and wisdom. The purpose of this chapter was to present an understanding of these terms and how they will be used in this research. To identify the most appropriate concepts, the research question was reviewed: *"To what extent can a serious game elicit specialist nursing knowledge and preserve this knowledge so that it can be shared outside the community of practice, beyond time and geography, mindful of known challenges?"* Concepts were identified and descried in this chapter. The next chapter describes the methodology used in this research, an elaborated action design research (eADR) by Mullarkey and Hevner (2019). This includes a discussion on design science research (DSR) and how it is linked to eADR.

3 Methodology

The Elaborated Action Design Research (eADR) approach by Mullarkey and Hevner (2019) was adopted in this research and is discussed in this chapter. The study site, along with a discussion about the relationship of eADR to design science methodologies, the rational for choosing the eADR approach and how eADR was applied in this research are also discussed.

3.1 Introduction

Nursing, as a professional body, is dynamic; nurses hold a collection of evolving clinical skills and have a broad knowledge base within a variety of roles and responsibilities. Eliciting nursing knowledge is, therefore, complex. In fact, it is a 'wicked problem'. Referencing Prof Horst Rittel, Churchman (1967) notes that a wicked problem is one that is 'ill-formulated', information is 'confusing', and there are many stakeholders' often holding antagonistic perspectives. Without careful consideration of the problem, solutions to wicked problems risk being 'worse than the symptoms' (Churchman, 1967). To address this wicked problem of eliciting and evaluating nursing knowledge, a serious game was proposed. As no appropriate game was found in the literature, the purpose of this research was to design, implement and evaluate a low-fidelity prototype of a serious game capable of eliciting and evaluating nursing knowledge. The research used an elaborated action design research (eADR) (Mullarkey & Hevner, 2019) approach. This is a four-stage iterative approach with roots in Design Science Research (DSR). The eADR approach is used to produce relevant artefacts and generate knowledge about the artefact (Mullarkey & Hevner, 2019). This chapter describes the eADR approach in detail, starting with an overview of DSR (see Section 3.3) and how they are linked. A description of the study site, research participants and recruitment methods are also included (see Section 3.7).

3.2 Artefacts

This research produced two design artefacts. The first is a low-fidelity serious knowledge and elicitation game. To evaluate the utility of the game, knowledge generated during game play was collated into a digital spreadsheet and evaluated. This spreadsheet represented an early version of the second artefact, which was an adult oncology daycare nursing discharge data reference set. To develop this data reference set, the evaluated knowledge was mapped to a clinical terminology. Two terminologies were used. The first, Systematized Nomenclature of Medicine - Clinical Terms (SNOMED CT), was chosen as it was a nationally recommended terminology (HIQA, 2014). The second, the International Classification for Nursing Practice (ICNP), was chosen as it is nursing specific, is represented in SNOMED CT, but is also available to nursing groups free of charge.

Both the game artefact and data set represent a design contribution. Learnings that occurred during the research process were applied iteratively to the design artefacts. As such, these design artefacts embody these lessons. Learning from the development of the artefacts is identified as design knowledge. From the game, a set of 10 problem statements used to guide the design of the game artefact constitute a contribution to design knowledge. In relation to the data reference set, a process of mapping the evaluated knowledge was identified and constitutes a second contribution to design knowledge. The final game artefact and data reference set artefact is presented in Chapters 5 and 6, respectively. To design, implement and evaluate these artefacts, a research methodology was identified. This is discussed in this chapter.

3.3 Design Science Research (DSR)

Design science research (DSR) emerged in the 1990s as a means to address the relevance versus rigour discussion that surrounded information system research (Baskerville et al., 2018) as a problem-solving paradigm with roots in pragmatism (Hevner et al., 2004). DSR addresses the relevance questions through the design and development of artefacts. Or as (Wieringa, 2014)(p.3) notes, "the design and investigation of artefacts in context". Baskerville et al. (2018) highlight how the goal of the science component of DSR is to grow descriptive knowledge about the natural world, including human behaviour, through the application of rigorous research methods. In turn, the design component of DSR produces prescriptive knowledge. The goal of DSR is to grow this prescriptive knowledge through the design of purposeful artefacts. That is, artefacts that are designed to address a relevant problem. Baskerville et al. (2018) describe how the design and science components evolve over time; changes in one component can lead to changes in the other. This relationship is shown in Figure 8.

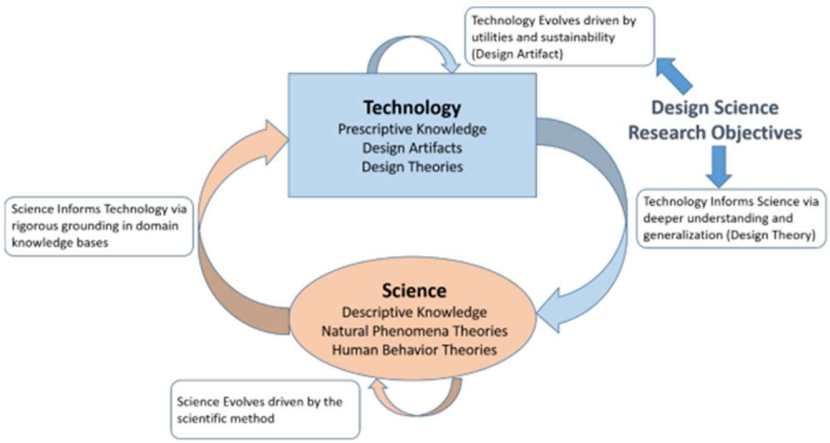


Figure 8 Technology and science relationship described by Baskerville et al. (2015). Illustration from Baskerville et al. (2018)

As discussed, DSR produces design and scientific knowledge. Design knowledge is embedded in the artefact. Artefacts can be thought of as "constructs, models, methods and instantiations" (March & Smith, 1995). According to Hevner et al. (2004), artefacts define ideas and capabilities, thereby facilitating the analysis of technology in context. Baskerville et al. (2015) note knowledge is created by analysing a design problem and then synthesising the knowledge generated from applying the solution. However, Baskerville et al. (2015) cautions that antagonism can exist between the focus on designing artefacts and the drive to acquire new knowledge. Authors such as Nunamaker Jr et al. (1990) support a view of DSR as one of prioritising design where the primary output is the artefacts. Whereas other authors, according to Baskerville et al. (2015), view DSR as primarily concerned with generating scientific knowledge in the theories generated through the design and implementation of an artefact. This is summarised by noting that theoretical goals often promote descriptive research, such as knowledge generation. Prescriptive research, such as artefact development, is more pragmatic (Baskerville et al., 2015). This thesis aims to generate prescriptive research in the form of two artefacts, a serious game, and a data reference set. But also, descriptive research in the form of problem statements that should be addressed by the game design and a process describing how evaluated knowledge could be mapped to a clinical terminology.

3.3.1 Design-Science Research Guidelines

A DSR methodology incorporates 'rigorous methods across the design, development and evaluation of the artefact(s)' (Hevner et al., 2004). DSR projects can comprise many research methods, so they can be difficult to assign to a single research type. For instance, a project can be seen as part case study, part ethnography and part action design. This 'methodological hodgepodge' can present challenges when demonstrating rigour or reporting findings (Baskerville et al., 2015). Baskerville et al. (2015, p.542) describe this perfectly in the following quote:

> *"It (DSR) is a study that does not fit squarely into any of our existing research pigeonholes but, from appearances, might fit partly into all of them. For the researcher, reporting the findings of this seeming hodgepodge is challenging."*

Furthermore, a perfect solution may not be found as wicked problems have a 'no stopping rule'(Churchman, 1967). DSR supports not just problem-solving but 'problem improving' Vaishnavi and Kuechler (2008). To ensure DSR is a suitable methodology, Hevner et al. (2004) describe seven research guidelines to assist researchers. These guidelines and how they apply to the research presented in this thesis are outlined in Table 6. Additional methodologies/frameworks incorporated as per Guideline 5 (Research Rigor) as outlined in Table 7.

Table 6 Design-Science Research Guidelines (Hevner et al., 2004)

DSR Guideline	Description	Application to the Thesis research
1: Design as an Artifact	States that DSR must produce a viable artefact in the form of a construct, a model, a method, or an instantiation.	The two artefacts produced are the Game artefact and the Data reference set (see Chapters 11, 12).
2: Problem Relevance	States that DSR must develop a solution relevant to the study site.	Worldwide nurse shortages and the impact on knowledge management (see Chapter 3).
3: Design Evaluation	States that the utility, quality, and efficacy of the contributions are rigorously evaluated.	Artefact 1: Low-fidelity serious game prototype evaluated through post-game participant survey and group discussion. Artefact 2: Knowledge elicited was evaluated by subject experts and participants during implementation stages.
4: Research Contributions	States that to be considered a DSR study, there must be clear contributions arising from the research.	1. Contribution 1: design knowledge (game, data reference set), Chapters 5 and 6. 2. Contribution 2: design knowledge (known set of problem statements around eliciting nursing knowledge (see Appendix C) and knowledge mapping process. Chapter 6 3. Contribution 3: theory (a discussion of how eADR was applied to this research). Chapter 7.
5: Research Rigor	States DSR incorporates rigorous methods across design, development, evaluation of artefact(s).	Appropriate methodologies or frameworks were adopted at relevant times during the process. These are

		shown in a separate table (see Table 7 below).
6: Design as a Search Process	States that DSR projects utilise available means and are mindful of limitations in the problem environment to make improvements.	The game was deployed in practice for three cycles (see Appendix D).
7: Communication of Research	States that DSR projects have explicit practices for sharing contributions.	A number of publications have arisen from this work (see Chapter 1).

Table 7 Additional methodologies/frameworks incorporated as per Guideline 5: Research Rigor

Where used	**Methodology/framework details**
Stage: Diagnosis	SECI model of knowledge conversion by Nonaka and Takeuchi (1995) (see Chapter 3) to understand how knowledge could be transformed from tacit to explicit.
Stage: Design	To design the game, the framework developed by Verschueren et al. (2019) was adopted (see Appendix C, Sections 1.1 and 1.4).
Stage: Implementation	Framework by Braun and Clarke (2006) to thematically analysis data collected during a number of events such as group discussions post game play (implementation stage). See Appendix D, Section 1.1.
Stage: Reflection upon eADR	Rolfe (1997) Model of Reflection was used throughout each eADR stage as a reflection tool and also the final stage performed, the proposed Reflection upon eADR.

3.3.2 DSR Knowledge moments

Understanding where DSR outputs fit allows IS researchers to categorize their outputs and findings (Hevner et al., 2004). As mentioned above, Baskerville et al. (2015) caution that design science can be a 'methodological hodgepodge'. As well as its reliance on additional research methods, this methodological hodgepodge arises from the duality of the knowledge goals of design science. That is, on the one hand, design knowledge can be influenced by elements such as the context or influenced by the designer and their experience. Design knowledge can also evolve and can rely on abstracting from other theories or experiences for a specific context or design problem. Baskerville et al. (2015) discuss the concept of 'knowledge goals'. These are goals that relate to either the design or design or theoretical knowledge. For instance, Baskerville et al.

(2015) note that design goals *apply* knowledge, whereas science goals *extend* knowledge. To map the journey toward the goal, Baskerville et al. (2015) describe knowledge moments.

Although borrowed from a knowledge management domain, Baskerville et al. (2015) define knowledge moments as "a unity of knowledge processing, triggered by a specific need for knowledge and addressed by the specific delivery of the knowledge in a manner that is aligned with a given context." (Baskerville et al. 2015, p. 552). Knowledge moments reflect the needs of the design researcher at a specific time in the development process. Knowledge moments can be mapped onto the genre of inquiry framework for design-science studies to demonstrate their status and, if appropriate, their evolution to another genre.

Another way to view this duality is via the concepts of nomothetic and idiographic. Each concept refers to the scope of the knowledge generated – case specific or generalisable. The concepts of nomothetic and idiographic arise from the work of Wilhelm Windelband (1848-1915) and Gordon Allport (1897-1967) (Lamiell, 1998). For instance, nomothetic refers to the development of general theories that address a class of problems. Idiographic is much more focused on the scope and is concerned with producing knowledge related to a specific case. Furthermore, while modes of inquiry exist, including positivism or interpretivism, the difficultly with design science, according to Baskerville et al. (2015), is that design science fits into all in some fashion but does not belong to a specific paradigm completely. To help arrange contributions, Baskerville et al. (2015) describe four genres of inquiry in design science studies. While presented as four distinct categories, Baskerville et al. (2015) submit that the borders are not hard but rather soft. Regardless, they present a way to understand the contributions arising from a design-science methodology. Using these categorisations can help manage the potential 'methodological hodgepodge' described by Baskerville et al. (2015). The four categories are noted below and are shown in Figure 9:

- Nomothetic Design (ND): describes general knowledge that can be applied to a class of problems.
- Nomothetic Science (NS): describes knowledge that can be generalisable about the natural world and how it interacts with the designed artefact.
- Idiographic Design (ID): describes knowledge that is relevant to a specific case and validated through its (the artefacts) use in the specific context.
- Idiographic Science (IS): describes knowledge that explains an artefact in a specific context.

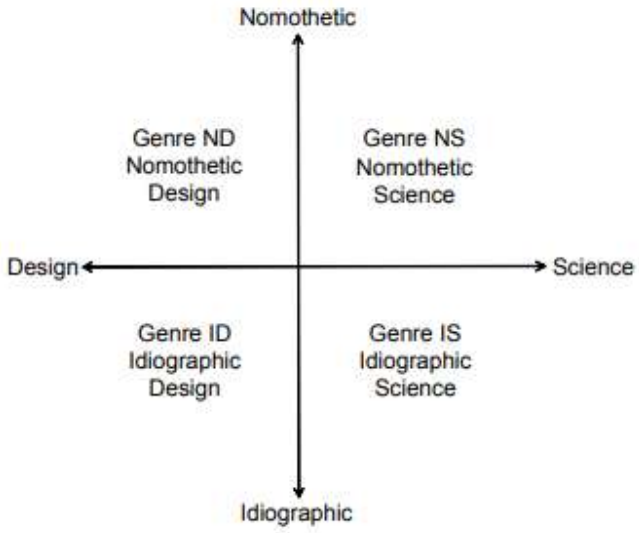


Figure 9 Genres of Inquiry Framework for Design-Science Studies by Baskerville et al. (2015)

A DSR research project can produce a number of artefacts across the sections of the framework. Artefacts can initially originate in one genre and evolve over the course of the process into another genre. For example, knowledge generated to develop an artefact can originate in an idiographic design. This artefact is context specific. Over time, the knowledge generated by the artefact (or represented in the artefact) can evolve into nomothetic design (ND) knowledge. This ND knowledge is then applicable to a general class of design problems. Movement from idiographic to nomothetic can be likened to moving from a site-specific problem to a general class of problems. Categorising the type of knowledge that is being produced from design-science research is important if future designers are to avoid 'reinventing the wheel'. Rather, these categorisations help future DS researchers build upon the current state of the art for a given class of problems or problems. Mapping this knowledge is, therefore, important. Returning to the framework by Baskerville et al. (2015) surrounding the genres of inquiry framework for design-science studies, mappings proposed for the contributions arising from this research are shown in Figure 10.

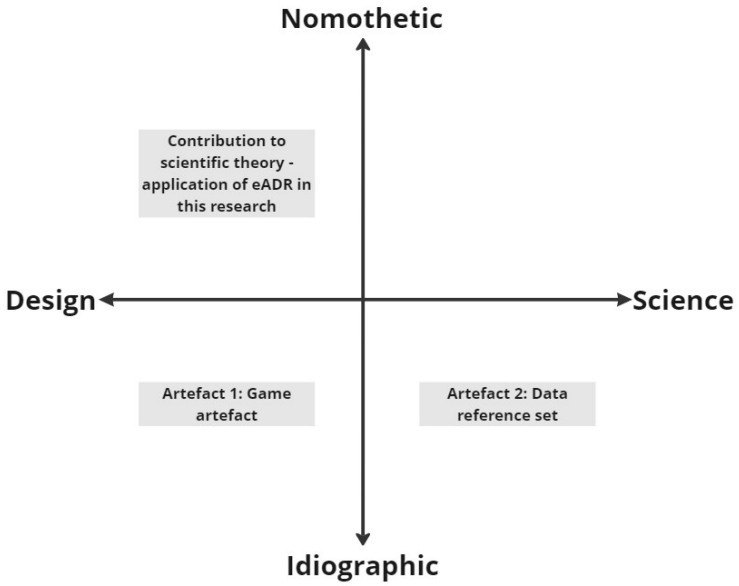


Figure 10 Contributions arising from this research

The game artefact was designed and evaluated at a single site and therefore is considered idiographic. That is related to a specific case (the study site). While the knowledge artefact is broader in scope to nurses based in the wider oncology setting, due to the nature of the content, its scope is still limited. A third artefact is in the form of a discussion on the application of eADR during this thesis research. It is envisioned that these could be useful for a wider nursing audience that is interested in designing serious knowledge elicitation games for their clinical area. This artefact is therefore considered nomothetic or knowledge relating to a general class of problems. In this case, the class of problem is managing nursing knowledge.

Following this review, DSR was identified as a suitable methodology for this research. It was primarily chosen as it proposes that through the design and evaluation of a research artefact, knowledge can be generated that can have design and scientific benefits beyond the initial project (Hevner et al., 2004). DSR emerged in the early 1990s and has since undergone a number of developments (Hevner et al., 2004; Pfeffers et al., 2006). These developments include linking DSR to another approach, for example, action design research (ADR) described in Sein et al. (2011) or design ethnography (Baskerville & Myers, 2015). Action design research (ADR) combines action research and design science research (Sein et al., 2011). Central to action research is the development of scientific knowledge while simultaneously attempting to solve a problem (Bradbury & Reason, 2003; Coghlan, 2019; Collatto et al., 2018; Susman & Evered, 1978). For

this research, the author considered two approaches arising from a design science methodology. These are action design research (ADR) described in Sein et al. (2011) and elaborated action design research (eADR) described by Mullarkey and Hevner (2019). While both approaches adopt action research into design science methods, there are some differences between them. The following text describes ADR and eADR approaches with a view to justifying its inclusion in this research.

3.4 Action design research (ADR)

Action design research (ADR) combines two distinct approaches – action research and design science (Sein et al., 2011). The purpose of ADR is to seek design knowledge through the development of an artefact. ADR engages participants as co-creators in the research to solve a practical and relevant practice problem. The practice problem identified is that accumulated nursing knowledge is not always captured so that it can be preserved. ADR, as described by Sein et al. (2011), is shown in Figure 11.

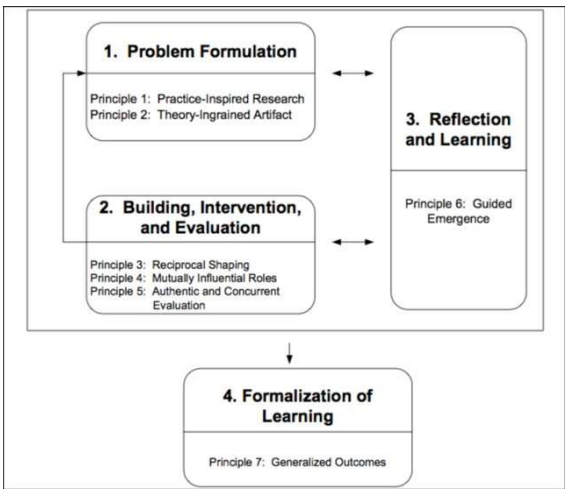


Figure 11 ADR by Sein et al. 2011

3.4.1 ADR Principles

As demonstrated in Figure 8, ADR comprises four stages: (1) problem formulation, (2) Building, Intervention and Evaluation, (3) Reflection and learning and (4) Formalisation of learning. The first three stages performed iteratively, are primarily concerned with identifying and addressing a problem. The final stage is focused on developing and formalising learning outcomes. In addition to these stages, ADR prescribes seven principles that guide the process. For example, the research must address a real-world problem (Principle 1 – Practice-Inspired Research), or that artefact creation and evaluation are informed by existing theories (Principle 2 – Theory-Ingrained Artefact**).** These principles are shown in Table 8.

Table 8 Overview of explanation and application of principles (Sein et al. 2011)

ADR Principle	**Description**
Principle 1 – Practice-Inspired Research	The research addresses a real-world problem, where outcomes can be used as knowledge-creating opportunities for a class of problems.
Principle 2 – Theory-Ingrained Artefact	Existing theories inform artefact creation and evaluation
Principle 3 – Reciprocal Shaping	Emphasises the influence between artefact and domain and how an iterative approach to design will shape the form of the final artefact.
Principle 4 – Mutually Influential Roles	Describes how co-creators share their specialist knowledge with group members.
Principle 5 – Authentic and Concurrent Evaluation	Evaluation during the early stages is at a higher level of abstraction, whereas later evaluation is more focused on artefact utility.
Principle 6 – Guided Emergence	States that the design of the final artefact, although based on the preliminary design, is shaped by factors including the context and users. This principle is linked to number 6.
Principle 7 – Generalised Outcomes	States the importance of applying knowledge acquired (during the process) not just to the project but to the class of the problem.

An early knowledge elicitation method (the WICKED method) developed by the researcher (author of this thesis) adopted an ADR approach (Impey et al., 2023). This knowledge elicitation method was used as an initial starting point for serious game design. This is discussed in detail in Appendix C.

3.5 Elaborated Action Design Research (eADR)

Elaborated Action Design Research (eADR), described by Mullarkey and Hevner (2019), extends the work on ADR by Sein et al. (2011). Both aim to combine action research with design science to produce relevant artefacts and design knowledge. The main difference between ADR (Sein et al., 2011) and eADR (Mullarkey & Hevner, 2019) is the latter provides multiple entry points into the research. Mullarkey and Hevner (2019) propose that multiple entry points allow researchers to consider topics, such as proposed research outcomes, and align these with a starting point that may not necessarily be the first stage of the approach. In total, eADR has four intervention stages – diagnosis, design, implementation, and evolution. Both the ADR and eADR propose ongoing reflection. However, unlike the method proposed by Sein et al. (2011), in the eADR approach by Mullarkey and Hevner (2019), evaluation is conducted throughout all cycles rather than as a separate section (ADR Stage 2). Formalisation of learning is also ubiquitous throughout the eADR process, unlike ADR, where it is represented by a separate stage (ADR Stage 4). While the eADR methodology includes the seven principles described by Sein et al. (2011), Mullarkey and Hevner (2019) add another principle: Abstraction. According to Mullarkey and Hevner (2019) the additional abstraction principle facilitates different levels of artefacts to be created across the research. Each artefact produced, then is an abstraction at a suitable level to address the stage problem (Mullarkey and Hevner, 2019). For example, the initial game artefact encompassed an elicitation part only. This evolved into an elicitation and evaluation game for the final artefact. The data reference set in the initial stages was presented as a digital spreadsheet.

eADR consists of four stages: Diagnosis, Design, Implementation and Evolution. Each stage of the eADR method has a different focus. For instance, stage 1 (diagnosis) is problem centred. Stage 2 (design) is objective-centred, and stage 3 (implementation) is development centred. Stage 4 (evolution) is observation centred and concerned with reviewing the artefacts in context and over time. Multiple cycles of these stages can be performed depending on the research needs (Mullarkey & Hevner, 2019). Each cycle consists of five activities. These are problem/formulation/action planning (P), artefact creation (A), evaluation (E), formalisation of learning (L), and reflection (R). The eADR, as described by Mullarkey and Hevner (2019), is shown in Figure 12. How the eADR approach was applied in this research is described in Chapter 4.

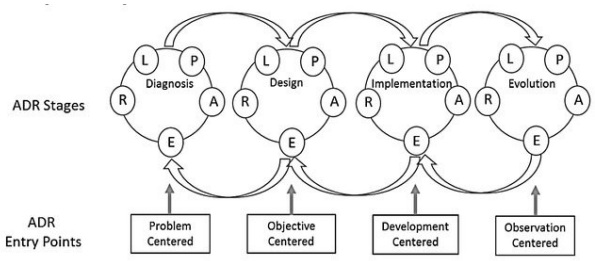


Figure 12 eADR by Mullarkey and Hevner (2019)

3.5.1 eADR Stages

While eADR describes four stages, only three were performed in this research. These were diagnosis, design and implementation. Multiple cycles of the stages were performed. The number of cycles performed for each stage is shown in Table 9.

Table 9 Number of cycles of each stage performed

Stage	**Cycles performed**
Diagnosis	2
Design	2
Implementation	3
Evolution	0

The following text describes the stages and activities performed in this research in detail.

3.5.1.1 Stage 1: Diagnosis

The diagnosis stage is problem-centred and is concerned with understanding the problem and problem space (Mullarkey & Hevner, 2019). According to Mullarkey and Hevner (2019), during the diagnosis stage, the problem is explored, and a potential solution is identified. In this stage, the researcher and co-inquiry group, including members from the study site, developed a shared understanding of the domain and the organisation and formulated the problem. Challenges to eliciting knowledge identified in earlier exploratory studies were discussed with the co-inquiry group and evaluated by participants at the study site. From these challenges, a set of problem statements were extracted. Two cycles of the diagnosis stage were conducted for this research (see Chapter 4 and Appendix B).

3.5.1.2 Stage 2: Design

The design stage is objective-centred and is concerned with exploring and identifying solutions (Mullarkey & Hevner, 2019). The second stage surrounds the designs of the proposed artefact. This stage produced the initial game artefact. The initial game design was based on a knowledge elicitation method developed by the researcher (Impey et al., 2023). The design was evaluated during a pilot study to ensure it was suitable for implementation at the study site. Two cycles of the design stage were conducted for this research (see Chapter 4 and Appendix C).

3.5.1.3 Stage 3: Implementation

The next stage is implementation which primarily focuses on evaluating the artefact created and reflecting on its utility to the study site. Mullarkey and Hevner (2019) describe this stage as development-centred. During the implementation stage, the game was updated based on user feedback. Knowledge was elicited and evaluated during this stage. Three cycles of the implementation stage were conducted for this research (see Chapter 4 and Appendix D).

3.5.1.4 Stage 4: eADR Evolution

The final stage proposed by Mullarkey and Hevner (2019) is Evolution. This stage primarily focuses on ongoing evaluation and reflection of the artefact in situ. In this sense, the stage is observation-centred (Mullarkey & Hevner, 2019). Although this stage was not conducted during this research, it is included here to fully discuss the eADR approach. Mullarkey and Hevner (2019) propose that during this eADR stage, the artefact is further reviewed at the study site to understand how the context impacts the ongoing artefact development. The evolution stage also aims to understand how the artefact impacts the context over time. Due to time constraints, this stage was not performed in this research. However, during the final implementation stage, the problem statements were reviewed to ensure they were still relevant. No additional statements were identified, or none were removed.

3.5.1.5 Proposed stage 5: Reflection upon eADR

Although not part of the stages proposed by Mullarkey and Hevner (2019), a fifth stage was identified in this research. A description of this stage is included in the section to give a full account of the stages performed. The artefact was designed, implemented and evaluated in the first three stages. Design knowledge generated during these processes is embedded in the artefact. It was found that learning related to applying an eADR approach had no explicit place within the stages. A fifth stage, Reflection upon eADR, was included to address this. Adding a further stage prompted the inclusion of a further activity for each stage. This additional activity is referred to

as a stage reflection. See Chapter 7 for a full discussion on stage 5: Reflection upon eADR. The stage reflections are also presented in Appendix E.

The eADR stages performed in this research, with the additional stage reflection, are shown in Figure 13.

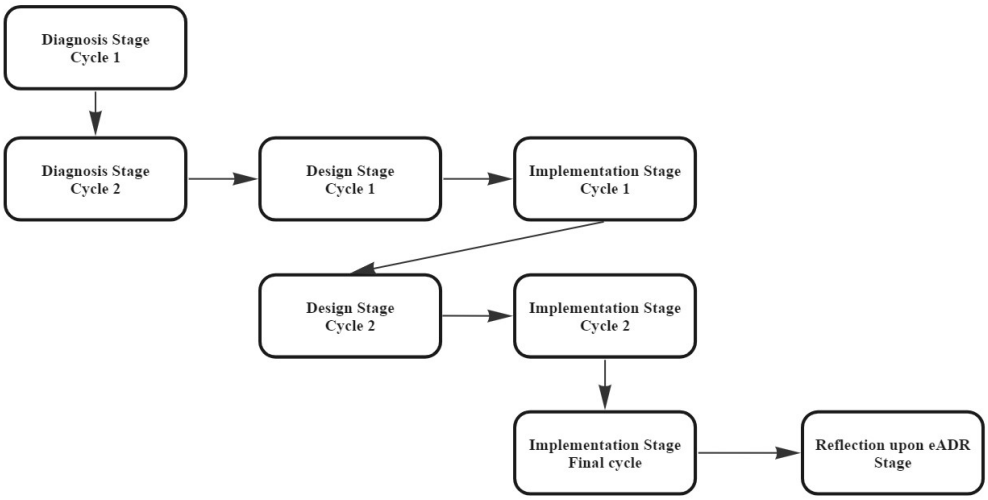


Figure 13 Stages from the eADR approach (Mullarkey & Hevner, 2019) performed in this research including the proposed stage, 'Reflection upon eADR.'

An overview of the outputs from each of these five stages is shown in Table 10.

Table 10 Number of cycles of each stage performed

Stage	**Outcome**
Diagnosis	Known challenges to eliciting knowledge identified in exploratory studies and review of the literature, evaluated and deemed relevant to the study site.
Design	Serious games are identified as a potential solution. Design framework identified.
Implementation	The initial design of the serious game The final design of the serious game and data reference set
Evolution	Not performed
Reflection upon eADR	Discussion on the application of eADR in this research.

3.5.2 eADR Activities

Each stage of the eADR process comprises five intervention activities (Mullarkey & Hevner, 2019). These are Problem Formulation/Action Planning (P), Artefact Creation (A), Evaluation (E), Reflection (R), and Formalisation of Learning (L). Related to the proposed new stage (Reflection upon eADR), a sixth activity was also proposed – Stage Reflection. These are described in the following text.

3.5.2.1 Activity: Problem Formulation/Action Planning (P)

According to Mullarkey and Hevner (2019), problems are formulated by reviewing the learning from previous stages. In this research, problems were developed based on outcomes from the previous stage and supported by the literature. Actions were considered by the co-inquiry group that could address these problems. Actions could include amending the artefact and performing a further evaluation. Through artefact creation and evaluation, problems are modified and addressed in subsequent stages (Mullarkey & Hevner, 2019).

3.5.2.2 Activity: Artefact Creation (A)

Artefacts are created to address the problem formulated. Artefact creation is an important part of design science research (Mullarkey & Hevner, 2019). Throughout the creation process, the abstract nature of the artefact created will develop. For instance, Mullarkey and Hevner (2019) describe an artefact developed during the diagnosis stage could be a concept, and the design stage could produce a model or method. Later stages, such as implementation, could produce a system that is further evolved during the evolution stage (Mullarkey & Hevner, 2019).

3.5.2.3 Activity: Evaluation (E)

The eADR process has roots in action design research (ADR). A central component of ADR is to build, implement and evaluate a relevant artefact (Sein et al., 2011). Building and implementing in eADR are presented as individual stages (design and implementation, respectively), whereas evaluation is the activity of all stages. The purpose of the evaluation is to ensure artefacts created meet their intended purpose.

3.5.2.4 Activity: Formalisation of Learning (L)

Based on the learning from each cycle, the researcher can initiate another cycle or move the process forward to the next stage. In this research, learning captured throughout was formalised into a set of problem statements and updated use cases. The updated use case reflected changes to the serious game. These changes were evaluated in the subsequent stage.

3.5.2.5 Activity: Reflection (R)

In the eADR activities, Mullarkey and Hevner (2019) propose a reflection activity that is performed in every stage. The purpose of reflection is to identify learnings that can be incorporated into the developing artefact. In this research, reflection was a continuous process throughout each stage.

3.5.2.6 Activity: Proposed Stage Reflection (SR)

In this research, a second reflection activity was also performed. The stage reflection is focused on identifying learning around how the eADR was applied in this research. These stage reflections were collated and presented as a discussion in the proposed new eADR stage, 'Reflections on eADR'. The purpose of presenting reflection as two activities was to make explicit both their purposes, that is, artefact development and theory development.

3.5.3 eADR Principles applied to this research

Across the stages, eADR incorporates the seven ADR principles described by Sein et al. (2011). An additional principle in eADR, called abstraction, was introduced by Mullarkey and Hevner (2019). This principle allows for versions of the artefact to be introduced at during development, each relevant to the stage it is created, rather than a completed artefact produced at the end of the study. How the eADR principles were applied to the research for this thesis is shown in Table 11.

Table 11 Principles by Sein et al. (2011) and Mullarkey and Hevner (2019) to this research

eADR Principle	**Application to Thesis Research**
1 – Practice-Inspired Research	The real-world problem addressed by this research was that not all nursing knowledge created within a CoP is captured in an easily accessible format.
2 – Theory-Ingrained Artefact	Including SECI model of knowledge conversion (Nonaka & Takeuchi, 1995).
3 – Reciprocal Shaping	During the implementation stage at the study site, the game artefact and data reference set emerged iteratively. This was guided by feedback around how the game should be modified to suit participants at the study site and what allowances were possible to facilitate the game.

4 – Mutually Influential Roles	Clinical group members brought domain knowledge; computer science members held design and technical knowledge, and nursing educational specialists were able to highlight how nurses build and share knowledge.
5 – Authentic and Concurrent Evaluation	Continuous evaluation of the game and data reference set occurred during each stage by participants with varying levels of expertise - from novice players to domain experts.
6 – Guided Emergence	To ensure the game artefact and data reference set were relevant and usable, they were designed iteratively so that the initial design evolved based on continuous evaluation during the process.
7 – Generalised Outcomes	Managing clinical knowledge was deemed an important problem to address with implications beyond this research and study site.
8 - Abstraction	The final artefacts that emerged from this research arose from earlier iterations. Each iteration was relevant to the stage it was created and evaluated in. For example, this data reference set evolved from the earlier digital spreadsheet containing evaluated knowledge.

3.6 How AR was incorporated into eADR in this research

As discussed, eADR combines Action Research (AR) and Design Science Research (DSR). While the discussion so far has mainly explored the design science influences. This section describes how AR was incorporated into eADR in this research. Central to AR is the action research cycle. These iterative cycles comprise four steps. These steps are constructing, planning action, taking action and evaluating action (Coghlan, 2019). In this research, these steps were consumed into the five activities performed during each eADR stage. For instance, the first step, 'constructing,' describes a process where stakeholders engage in discussions to identify and understand the research problem (Coghlan, 2019). In this research, problems were identified and addressed, and new issues emerged. These actions were performed during the problem formulation/action planning (P) activities that occurred throughout all the eADR stages, as described by Mullarkey and Hevner (2019). The next step in the research cycle, as discussed by Coghlan (2019), is planning action. This step is concerned with identifying actions that could address problems found in the 'constructing' step. Again, this was also evident in the problem formulation/action planning (P) activities (Mullarkey & Hevner, 2019).

The third step is ‘taking action’. Coghlan (2019) describes this step as one where actions identified are implemented. Action in this research was the creation of the artefact (A) activity (Mullarkey & Hevner, 2019). The final ‘Evaluating action’ step discussed by Coghlan (2019) was performed during Mullarkey and Hevner (2019) proposed ‘Evaluation’ activity. The evaluating action, as discussed by Coghlan (2019), provides researchers with an opportunity to examine and consider both the intended and unintended outcomes of taking action. In this research, evaluation was an activity such as participants reviewing the artefact and taking part in a group discussion.

Reflection on learning happens alongside the four prescribed steps (Coghlan, 2019) as it is not explicitly identified. Whereas Mullarkey and Hevner (2019). eADR approach reflection is a designated activity. In this research, reflection was both continuous to identify learning as it occurred and could be incorporated into the artefact and as a distinct step at the end of each stage. The stage reflection focused on how the eADR approach applied to the research. This latter reflection is further discussed in Chapter 7. An activity not explicitly represented in the AR steps but described by Mullarkey and Hevner (2019) was the formalisation of learning. This activity provided an opportunity to consider the learning that occurred during the specific eADR stage and move the research forward or back, depending on the outcome.

3.7 Study site and participants

The following text describes the study site and research participants, including recruitment.

3.7.1 Study site

The study site is a specialist Haematology/Oncology department in a large teaching hospital in the Republic of Ireland. The study site represents a community of practice (CoP) specializing in managing the care needs of Haematology/Oncology patients. A CoP describes a “group of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in the area by interacting on an ongoing basis” (Wenger et al., 2002). At the time of the study, specialist oncology nurses used a ‘Haematology/Oncology Day care Patient Medication Record Sheet’ to discuss medication during discharge. This sheet includes topics such as medication time and type. Nurses annotated the sheet with hand-written notes as a means to personalize it for the patient. On discharge, this completed sheet is given to the patient, and they bring it to all their subsequent appointments. This document, developed in 2005, is focused on patient medication, including dose, scheduling, and a section for any special instructions. However, the discharge discussion goes beyond medication. Nurses discharging patients from day care units must consider individual patient presentations and treatments given to tailor their nursing assessment and plan. Potential content of an assessment, discharge process and systems

involved is shared among nurses working at the study site. Topics include how a patient should manage a medical emergency at home and how to contact the unit if they have any queries.

3.7.2 Participants

As noted, ADR and eADR combine design science and action research (Hevner et al., 2004; Mullarkey & Hevner, 2019; Sein et al., 2011). As part of an action research (AR) approach, a co-inquiry group was convened for this research. According to Coghlan (2019), co-inquiry groups are 'collaborative democratic partnerships' (Coghlan, 2019, p. 6). In total, the co-inquiry group had n=11 members. They represented nursing education (n=2), clinical experts (n=7) and health informatics specialists (n=2). The nursing education members had previously engaged with the study site to develop nursing education pathways and had combined 30 years of experience. Clinical experts were senior nurses based at the study site from the study site and had over 80 years of combined nursing experience. A member of the clinical expert's group was also the principle investigator (PI) of the research. Their primary function was to oversee the research. Including a PI was a requirement of the ethics application at the site. The health informatics specialists group members were the author of the thesis and the thesis supervisor. The purpose of the co-inquiry group meetings was to allow members to reflect on their own experiences in relation to a particular research problem or aspect of the research. Coghlan (2019) describes that through these discussions' new ways of thinking about the problem can emerge. Due to scheduling conflicts, not all co-inquiry group meetings had full attendance. It was agreed that a minimum of four individuals was required for a quorum. This number was made up of one member of the education group and one from the clinical group, and all meetings would be attended by the author of the thesis and the PI. The author's function was to introduce and moderate the meeting. The PI's function was to ensure any data collected accurately captured the perspectives of the group members. If the quorum was not met, a second meeting was arranged.

In addition to the co-inquiry group, two other groups of participants participated in this research. These are Holders and Reviewers. The primary purpose of the Holders group was to share their knowledge of the game. In total, n=10 Holders took part in this research. The primary purpose of the Reviewer group was to evaluate the elicited knowledge captured during the game. In total, n=8 Reviewers took part in this research. Membership of the Holders group was limited to new nurses based at the site for less than 18 months. Whereas Reviewers were nurses based at the site for over 18 months. Due to the specialism at the site, the clinical experts in the co-inquiry group identified 18 months as a probable time to become accustomed to the area. But noted this was based on their experience and was a heuristic rather than a definitive time. A more robust way to identify

a ‘new nurse’ was not found in the literature. Therefore, 18 months was taken as a benchmark for this research.

During all participant meetings, paper notes were taken by the researcher. No data collected was attributed to any individual member. As groups met in person, the information captured could not be considered anonymous. These notes were transcribed to a Microsoft document and discussed with the PI to ensure they accurately represented the group's feedback. No patient specific data was used in this research. If mentioned, any patient details were not captured in the researcher's notes. Where relevant, the group, focus and length of meeting, and the number of attending participants are documented throughout the research. The total research process went from October 2021 to September 2022. The research was performed during the recent Covid-19 pandemic. This limited access to healthcare professionals, but the study site was very open to the study and access was permitted but limited to their ongoing education sessions.

3.7.3 Participant recruitment

The participants of the co-inquiry group were recruited via snowball sampling. Snowball sampling, a form of convenience sampling, refers to a type of non-probability sampling where participants are chosen due to ease of access and at the recommendation of others (Gerrish & Lacey, 2010). A deficit of this type of sampling is the under or over-representation bias (Gerrish & Lacey, 2010). This describes a situation where participants who hold strong opinions on the study topic might be more receptive to being included in the research. The research was presented to the study site, and participant information leaflets were circulated. Interested participants for the knowledge holders and reviewers group contacted the researcher directly via email to take part. No data was collected before consent forms were signed.

3.8 Ethics application

Before any data collection related to any of the research studies for this thesis commenced, ethical approval was obtained from both the healthcare organization and the School of Computer Science and Statistics – ‘SJH/TUH Joint Research Ethics Committee Project ID: 0541’, ‘St. James’s Hospital Research and Innovation Approval reference 7233’ and ‘School of Computers and Statistics application number 20220207’.

3.9 Conclusion

This chapter discussed the methodology used for the research of this thesis, namely the elaborated Action Design Research (eADR) methodology. As proposed by Mullarkey and Hevner (2019), eADR is a four-stage approach. Each stage is comprised of five activities. These activities include

an evaluation. Unlike other design science approaches, such as action design research (ADR) (Sein et al., 2011), in eADR, evaluation is continuous throughout the process and not a separate stage. However, similar to ADR, an eADR approach is a type of design science methodology. Design science methodologies propose that through the design and evaluation of design artefacts, scientific knowledge can be developed (Baskerville et al., 2015; Hevner et al., 2004). This thesis focuses on two design knowledge artefacts – a serious game and a data reference set. These artefacts are interrelated. The game was needed to access the knowledge, and the knowledge was validated knowledge by means of evaluating the game. A methodology knowledge contribution has also resulted from the application of the methodology, in particular, in a discussion of how the eADR approach was applied to the research undertaken for this thesis. In the next chapter, how eADR was applied in this research is discussed.

4 Application of eADR

This chapter presents an overview of the research journey from initial problem formulation to the final implementation cycle. Rather than a detailed description of each cycle, the chapter focuses on providing an overview of the processes used, and how the research moved throughout the stages.

4.1 Introduction

As discussed in Chapter 3, the approach adopted in this research was an elaborated action design research. This research aims to produce both an artefact and knowledge. To apply this approach, researchers apply cycles of each of the proposed stages. The number of cycles performed is dictated by the needs of the research. Within each cycle, the approach proposed five activities that should be performed. While this approach provides guidance on producing both an artefact and knowledge (related to the artefact), its iterative nature combined with multiple cycles and activities can make documenting and reporting the research challenging. The aim of this chapter, therefore, is to present an overview of the research process as a means of helping the reader understand the journey from problem statement to research contributions. A full description of the contributions is provided in subsequent chapters (see Chapters 5, 6,7). Additional details of the processes used are also included in the Appendices B-D. Each appendix is linked to a specific eADR cycle performed.

eADR consists of four stages: Diagnosis, Design, Implementation and Evolution. Each stage of the eADR method has a different focus. For instance, stage 1 (diagnosis) is problem centred. Stage 2 (design) is objective-centred, and stage 3 (implementation) is development centred. Stage 4 (evolution) is observation centred and concerned with reviewing the artefacts in context and over time. The Evolution stage is observation-centered and surrounds monitoring any changes to the problem environment and considering how subsequent designs could evolve to meet these changes (Mullarkey & Hevner, 2019). This stage was not performed in this research due to time constraints. Multiple cycles of these stages can be performed depending on the research needs (Mullarkey & Hevner, 2019). Each cycle consists of five activities. These are problem/formulation/action planning (P), artefact creation (A), evaluation (E), formalisation of learning (L), and reflection (R). The rest of this chapter provides an overview of the eADR stages and cycles performed in this research. Each section deals with a separate cycle and provides a reference to an Appendix where a more detail account of the stage can be found.

There are three contributions arising from these cycles. These are:

- Contribution 1: a serious knowledge elicitation and evaluation game (see Chapter 5)

- Contribution 2: data reference set for an oncology day care setting (see Chapter 6)
- Contribution 3: a discussion surrounding how eADR was applied in this research (see Chapter 7)

4.2 eADR Diagnosis stage - Cycle 1

The first diagnosis cycle is concerned with understanding the problem and the domain. The activities undertaken in this cycle are shown in Table 12. A full description of the research undertaken during this cycle is presented in Appendix B, Sections 1.1 and 1.2.

Table 12 Diagnosis cycle 1

Problem Formulation/Action Planning (P)	Initial review of literature/exploratory studies
Artefact Creation (A)	Challenges need to be evaluated through discussions with co-inquiry group and constructed into an agreed list. This agreed list of evaluated challenges represents the artefact generated from the first cycle. See Appendix C, Section 1.2.
Evaluation (E)	The artefact was evaluated through discussion with participants from the study site (n=18). Following this discussion, the challenges were deemed relevant to the study site.
Reflection (R)	Ongoing reflection of the artefact occurred throughout the first cycle via discussion with participants. Learning that arose was incorporated into the artefact during the cycle.
Formalisation of Learning (L)	Learning that occurred throughout the cycle was formalised into a set of problem statements through discussions with the co-inquiry group in the form of a set of evaluated problem statements.

A previous chapter (see chapter 2) presented key concepts, such as 'nurse' and 'knowledge'. While exploring the literature related to these were useful to establish an understanding of the terms, it did not fully explore challenges to eliciting nursing knowledge. Therefore, during the first diagnosis cycle two exploratory studies were undertaken. These studies were:

- Study 1: Exploring Factors that Motivate or Inhibit Nurse-to-Nurse Knowledge Sharing in Outpatient Settings (N=17 nurses from five outpatient departments) (see Appendix B, Section 1.1).

- Study 2: Literature review of factors that motivate or inhibit participation in online nurse-to-nurse virtual communities of practice (see Appendix B, Section 1.2).

The purpose of these studies was to better understand challenges that any potential solution should address. These exploratory studies were not limited to the study site. Multiple studies were undertaken for two reasons. Firstly, as the author of this thesis is a registered nurse, and their perspective of nursing is limited to their experience, it was considered that exploring several sites was prudent to minimize the risk of researcher bias. Secondly, no single study provided a comprehensive account of the challenges to knowledge sharing amongst nurses or potential knowledge sharing solutions. For example, the first study (Exploring Factors that Motivate or Inhibit Nurse-to-Nurse Knowledge Sharing in Outpatient Settings) provided a general overview of nursing knowledge sharing behaviours so to identify what motivates or inhibits knowledge capturing, sharing, reusing, and storing. However, only 2 participants in the first study engaged in online knowledge sharing, and when this occurred it was in a closed online community where members had prior relationships. As a result, a review of the literature (Literature review of factors that motivate or inhibit participation in online nurse-to-nurse virtual communities of practice) was conducted to become more familiar with these barriers. In total 8 challenges were identified during the diagnosis stage, including tacit aspects of knowledge and the busyness of the clinical environment. The challenges were transformed into a set of problem statements through co-inquiry group discussions. The final list of challenges and problem statements are shown in Appendix C, Section 1.3. Once the problem was understood, the research focused on finding an appropriate solution. This is discussed in the second diagnosis cycle. To identify an appropriate solution, the challenges identified (in diagnosis cycle 1) were used as a guide.

4.3 eADR Diagnosis stage - Cycle 2

Once cycle 1 was complete, cycle 2 commenced. The second cycle of the diagnosis stage was concerned with identifying a proposed solution that could address the challenges and problem statements identified in cycle 1. A previous study (Impey et al., 2021) explored how healthcare knowledge was elicited digitally. From this review no approach was deemed superior. See Appendix 7 for an overview of this research. Although no approach to eliciting knowledge was identified, a small number of papers retrieved highlighted a potential role for serious games in knowledge management (Ahmed & Sutton, 2017; Allal-Cherif et al., 2016; Allal-Chérif & Makhlouf, 2016; Bayart et al., 2014). To explore this further, a review of the literature on the concept of serious games was performed. A full description of the research undertaken during this cycle is presented in Appendix B, Sections 1.3 and 1.4. How the eADR activities were applied in the second cycle is outlined in Table 13.

Table 13 Diagnosis cycle 2

Problem Formulation/Action Planning (P)	It was unclear how a serious game could be applied to address the problem statements identified in the first cycle.
Artefact Creation (A)	The artefact in this cycle was a list created to highlight how the concept of serious games could be applied in this research to address the problem statements based on co-inquiry group review. See Appendix C, Section 1.2.
Evaluation (E)	The artefact was evaluated through discussions with the study site. The purpose of this evaluation was to reach agreement on whether serious games could be a potential solution in this research.
Reflection (R)	Similar to the first cycle, the reflection focused on artefact creation throughout the cycle.
Formalisation of Learning (L)	Use cases for a serious game.

The main finding from the SoTA was that while serious games were used in nursing, this was primarily around education and training. While it was noted that serious games could potentially have a role in managing knowledge (Ahmed & Sutton, 2017; Allal-Cherif et al., 2016; Allal-Chérif & Makhlouf, 2016; Bayart et al., 2014), this was not explored in a nursing cohort. A list of how a serious game could address the challenges and problem statements identified in the first cycle was constructed. This is shown in Appendix 13. In addition to identifying serious games as a potential solution, during the diagnosis cycles four groups were identified as directly relevant to knowledge elicitation in this research. These are (1) clinical experts based at the study site, (2) nurses based at the study site less than 18 months, (3) nurses based at the study site more than 18 months and (4) co-inquiry group members from the study site who were subject experts. It was proposed that nurses from group 2 could share the knowledge they acquire from clinical experts based at the study site (group 1) with the game. In this research, this group is referred to as Holders. Group 3, nurses based at the study site more than 18 months were deemed to be experienced and could therefore evaluate the knowledge elicited. In this research, this group is referred to as Reviewers. In addition to co-creating the solution and providing clinical and educational, and technical expertise to the research, Group 4 also have a role in evaluating the elicited knowledge. If any queries relating to elicited or evaluated knowledge occurred, the co-inquiry group could act as an arbiter.

4.4 eADR Design Stage - Cycle 1

As no suitable game was identified during the diagnosis cycle, this stage is concerned with design and evaluation of a game capable of eliciting nursing knowledge. The activities performed during this cycle are shown in Table 14. A detailed account of the first design cycle is provided in Appendix C, Section 1.1 and 1.2

Table 14 Design cycle 1

Problem Formulation/Action Planning (P)	No suitable serious game identified in the literature that could be implemented in this research. The purpose of this stage is to design the 1st iteration of a serious knowledge elicitation game and an evaluation process.
Artefact Creation (A)	1st iteration of serious knowledge elicitation game and associated evaluation process (see Appendix C, Section 1.1 and 1.2).
Evaluation (E)	Pilot study n=3 (see Appendix C, Sub-Section 1.1.4).
Reflection (R)	Ongoing reflection focused on the designing the artefact. Lessons learned were incorporated into the artefact (see Appendix D).
Formalisation of Learning (L)	• Updated and categorised set of problem statements, see Appendix C, Section 1.2. • Updated set of use cases to capture learning that occurred during the design cycle 1, see Appendix C, Section 1.2.

The initial design adopted a knowledge elicitation method, the WICKED method, (Impey et al., 2023) as a starting point. The inclusion of this method introduced two additional challenges (then problem statements) to eliciting knowledge. These challenges surround the skills of researcher and ceasing knowledge collection. To design the game, the framework developed by Verschueren et al. (2019) was used. This 5-stage framework had been used previously for designing serious games for healthcare. For instance, a Covid-19 game for healthcare workers (Suppan et al., 2020) and perioperative game for children (Verschueren et al., 2019). Stages have specific aims. Broadly, stages 1-3 are concerned with game development. Whereas stage 4 and 5 are concerned with evaluation and implementation. The final game design was evaluated through a pilot study with n=3 nurses. In addition to producing the serious knowledge elicitation game, the lessons learned during the design stage were used to update the list of actors and set of use cases. During the design cycle, an additional actor was identified, the Seeker. This role is represented by the avatar in the game. The design process is discussed in detail in Appendix C, Section 1.1 (Design cycle 1: design framework and discussion). Following the design cycle, the game was implemented at the study site. This is discussed in the next stage (eADR Implementation - Cycle 1).

4.5 eADR Implementation Stage - Cycle 1

The purpose of this cycle was to evaluate the initial elicitation game design at the study site. The game was positively evaluated, changes proposed included developing prompts to initiate elicitation. Activities performed during this cycle are shown in Table 15 and a detailed account of the cycle is provided in Appendix D, Section 1.1.

Table 15 Implementation cycle 1

Problem Formulation/Action Planning (P)	The 1st iteration of the elicitation game was not evaluated at the study site.
Artefact Creation (A)	The artefact created during cycle 1 was: Artefact 2 (knowledge): Digital spreadsheet containing evaluated knowledge elicited during game (see Appendix D, Sub-section 1.1.4).
Evaluation (E)	Artefact 1 (game): Holder group discussions and post-game survey (see Appendix D, Sub-section 1.1.1). Artefact 2 (knowledge): by Holders, Reviewers and co-inquiry group (see Appendix D, Sub-section 1.1.2).
Reflection (R)	Reflection on the artefacts was consistent throughout cycle, via the group discussions (see Chapter 7).
Formalisation of Learning (L)	Updated use cases for knowledge elicitation and evaluation game (see Appendix D, Sub-section 1.1.4).

In this implementation cycle, knowledge was elicited from Holders (n=5) during the game. This knowledge was prepared and collated into a digital spreadsheet and an evaluation process was performed (see Appendix D, Sub-section 1.1.2). Evaluation of the elicited knowledge was performed by 3 Reviewers. Overall Reviewers commented that knowledge elicited was relevant to the clinical scenario. During the post-game discussion, feedback from Holders was captured by the author of the thesis, transferred to a digital document, and reviewed with the PI acting as Gatekeeper to ensure it represented what was discussed. Data collected during the group discussion was analyzed by the author of this thesis and the Gatekeeper using the process by Braun and Clarke (2006). Their 6-step process is shown in Appendix F. Overall, Holders noted enjoying engaging in the game and proposed changes were identified. A major finding from the feedback was that the evaluation process as challenging due to the number of entries and repetitive nature of the task. It was proposed to extend the game design into a single knowledge elicitation and evaluation game. As a result, the research incorporated a second design cycle to extend the game to include a knowledge evaluation part.

4.6 eADR Design Stage - Cycle 2

The cycle is the second design cycle performed in this research. The activities performed during the second design cycle are shown in Table 16 and a detailed account of the cycle is provided in Appendix C, Section 1.4 and 1.5.

Table 16 Design cycle 2

Problem Formulation/Action Planning (P)	Based on participant feedback it was noted that evaluation process was challenging. Proposed to extend the current elicitation game to include the evaluation part.
Artefact Creation (A)	1st iteration of the evaluation part of the serious knowledge elicitation and evaluation game based on the current evaluation process (see Appendix C, Section 1.4).
Evaluation (E)	Review by author, gatekeeper and 1 member of the co-inquiry group (see Appendix C, Section 1.5).
Reflection (R)	Ongoing reflection was constant throughout the stage and focused on the designing the artefact. Lessons learned were incorporated into the artefact. See Appendix E.
Formalisation of Learning (L)	Learning was formulised into the evaluation game board and community knowledge and challenge cards required to engage with the game (see Appendix C, Section 1.5)

This design cycle focuses on extending the initial elicitation game to an elicitation and evaluation game. The five-stage framework by Verschueren et al. (2019) was used. This framework was also used in the initial game design (see Design Cycle 1). It was applied in this cycle in the same way that is stages 1-3 were applied as described the authors, as stages 4 and 5 related to evaluation and implementation, these are captured in the eADR evaluation activity during the implementation stage. Sticking to the process used in the first design cycle, the knowledge elicitation method (WICKED method), developed prior to PhD research by the author of this thesis (Impey et al., 2023), was reviewed. According to this method, the review of the knowledge is by expert consensus. In the method, this group is referred to as Reviewers. This approach – consensus by expert reviewers – was already established as the evaluation process so no changes were made. It was proposed to adopt the format of the traditional board game 'Snakes and Ladders' as it would be familiar to participants. From this cycle, the first iteration of a serious knowledge elicitation and evaluation game was produced. Due to limited availability of participants, a pilot study was not performed. Instead, the final design was reviewed by the gatekeeper and another member of the co-inquiry group. In the next section, the extended elicitation and evaluation game was implemented and evaluated at the site.

4.7 eADR Implementation Stage – Cycle 2

The purpose of this cycle was to implement the extended knowledge elicitation and evaluation game at the study site. Activities performed during this cycle are shown in Table 17 and a detailed account of the cycle is provided in Appendix D, Section 1.2.

Table 17Implementation cycle 2

Problem Formulation/Action Planning (P)	Knowledge elicitation and evaluation game not evaluated at the study site (see Appendix 22).
Artefact Creation (A)	Two artefacts were created during the second implementation cycle: Artefact 1 (game): 2nd iteration of the serious knowledge elicitation and evaluation game design (see Appendix D, Sub-section 1.2.4 and 1.2.5). Artefact 2 (knowledge): Digital spreadsheet containing the evaluated knowledge elicited during game play from the first and second implementation cycles (see Appendix D, Sub-section 1.2.4 and 1.2.5).
Evaluation (E)	Artefact 1 (game): Holder group discussions and post-game survey (see Appendix D, Sub-section 1.2.1 and 1.2.2) Artefact 2 (knowledge): by Holders, Reviewers and co-inquiry group (see Appendix D, Sub-section 1.2.3).
Reflection (R)	Reflection was consistent throughout the cycle
Formalisation of Learning (L)	Updated set of use cases for a serious knowledge elicitation and evaluation game (see Appendix D, sub-section 1.2.5).

This initial elicitation game was implemented at the study site (Implementation cycle 1). Feedback from Reviewers noted that the evaluation process, which was not gamified, did not engage participants. In response the initial elicitation game was extended to include the evaluation process (see Design cycle 2). In this second implementation cycle, this extended serious knowledge elicitation and evaluation game was implemented and evaluated at the study site. Both parts of the game were played using different participants and at different times. The first part was focused on eliciting knowledge and participants were Holders (n=2). The second part was focused on evaluating the elicited knowledge and participants were Reviewers (n=2). The games were played two weeks apart. During this time, the knowledge elicited was prepared for evaluation by the author of the thesis and Gatekeeper. This prepared knowledge was developed into a set of Community Knowledge cards that could be evaluated. Attending both parts of the game was the author of the thesis and the gate keeper. Through implementing the game, knowledge was elicited and reviewed. Feedback from the participants identified potential changes to the game (see Appendix D, Sub-section 1.2.4 and 1.2.5).

4.8 eADR Implementation Stage – Cycle 3

The purpose of the third implementation stage was to evaluate the 2nd iteration of the extended game from cycle 2 at the study site. Activities performed during this cycle are shown in Table 18 and a detailed account of the cycle is provided in Appendix D, Section 1.3.

Table 18 Implementation cycle 3

Problem Formulation/Action Planning (P)	A final implementation cycle was conducted to review the 2nd iteration of the game to produce a final version of a low fidelity knowledge elicitation and evaluation game and the data reference set.
Artefact Creation (A)	Two artefacts were created during the third implementation cycle: Artefact 1 (game): Final Low fidelity prototype of a serious knowledge elicitation and evaluation game (see Appendix D, Sub-section 1.3.4 and 1.3.5). Artefact 2 (knowledge): A data reference set for an adult patient discharge from an oncology day care setting (see Appendix D, Sub-section 1.3.4 and 1.3.5).
Evaluation (E)	Artefact 1 (game): Holder group discussions and post-game survey (see Appendix D, Sub-section 1.3.1 and 1.3.2) Artefact 2 (knowledge): by Holders, Reviewers and co-inquiry group (see Appendix D, Sub-section 1.3.3).
Reflection (R)	Reflection was consistent throughout the cycle
Formalisation of Learning (L)	Design contributions (artefact 1 and 2), design knowledge contributions (see Chapter 5 (serious game) and Chapter 6 (data reference set).

This third cycle brought the total number of Holder participants in this research n=10 (n=5 in cycle 1, n=2 in cycle 2 and n=3 in cycle 3). While low numbers of participants in research could be a limitation, in this research it was seen as a challenge of the domain that any solution should address. For instance, the second challenge related to the busyness of the clinical environment and how patient care was a priority so any proposed solution should not add to this time burden. As such, the research progressed to monitor how suitable the solution was given low participant numbers. Similar to cycle1 and 2 both parts of the game were played using different participants. Elicitation of knowledge from Holders, and evaluation by Reviewers.

During this cycle the final artefacts emerged. These are the final serious knowledge elicitation and evaluation game and the data reference set extracted from the digital spreadsheet. These final

artefacts are presented individually in the following chapters. See Chapter 5 for the game artefact and Chapter 6 for the data reference set artefact. The reason for separate presentations is due to the word count, and that including a detailed description in this chapter could impact readability of this cycle. From the co-inquiry group meeting, the outputs from this chapter were a final set of use cases for a serious knowledge elicitation and evaluation game (see Appendix D, Sub-section 1.3.5).

The reflection activity was constant throughout the cycle and learning was incorporated into the artefacts. A final stage reflection was also undertaken that captured the author and their supervisors' discussions in relation to the application of eADR in this research. The stage reflection highlighted issues addressed in this research. These surround extending the scope of the game artefact based on participant feedback, stopping the research and moving towards a digital format. These are further discussed in Chapter 7 as a further contribution arising from this research.

4.9 Conclusion

In this research, a total three of the four eADR stages were performed – Diagnosis, Design and Implementation. Dictated by the needs of the research, in total 7 cycles were performed. This represents 2 cycles of the diagnosis stage, 2 cycles of the design stages and three cycles of the implementation stage. Within each cycle, the approach proposed five activities that should be performed. While this approach provides guidance on producing both an artefact and knowledge (related to the artefact), its iterative nature combined with multiple cycles and activities can make documenting and reporting the research challenging. The aim of this chapter, therefore, is to present an overview of the research process as a means of helping the reader understand the journey from problem statement to research contributions. Each section in this chapter includes signposts to relevant appendices, chapters or sections that provide a more detailed account of the discussion. In the next chapters (chapters 5-7) the contributions arising from this research are described in detail, beginning with the serious knowledge elicitation and evaluation game.

5 Contribution 1: Knowledge elicitation and evaluation game

This chapter presents the first design contribution (final game artefact) and design knowledge (10 problem statements used to guide the design of the game artefact) arising from this research. While the game produced evaluated knowledge, it was not without limitations. The chapter discusses the limitations of game in its low-fidelity format and proposes how a digital platform could potentially address these.

5.1 Introduction

The problem this research addresses is that not all nursing knowledge is captured in a way that is easy to access outside the border of a CoP, or beyond geography or time. To address this problem, the concept of serious games was proposed, designed, implemented, and evaluated in this research. This chapter discusses the final iteration of the game. The game is referred to as the Knowledge Bank and encompasses a knowledge elicitation and a knowledge evaluation part. During the implementation cycles, participant feedback was incorporated into iterations of the game. In addition to these proposed changes, participants were asked about their enjoyment of the game by completing a post-game questionnaire. The result from this questionnaire is presented in this chapter. The game designed and evaluated in this research produced evaluated knowledge. However, limitations were evident. These include how the game time was limited or that Reviewers would prefer to choose the knowledge they evaluated based on their experience. In total, 10 limitations of the game were identified from co-inquiry group discussions throughout the implementation cycles. These are presented in this chapter as a list and how a digital format could potentially address these limitations (see Section 5.6).

5.2 Artefact evolution

Each eADR stage encompassed five intervention activities. One of these activities was artefact creation. According to Mullarkey and Hevner (2019) artefacts are created to address the problem relevant to each stage or cycle. Baskerville et al. (2018) notes artefacts are 'novel and useful' are also design knowledge contributions. Throughout the process, the abstract nature of the artefact created will develop (Mullarkey & Hevner, 2019). This is described in Mullarkey and Hevner (2019) abstraction principle. This principle describes how artefacts created across the research is an abstraction at a suitable level to address the problem relevant to the specific stage (Mullarkey & Hevner, 2019).

In this research, the game artefact went through a number of iterations during the eADR stages moving from basic to more complex forms. Iterations of the game artefact were developed and evaluated at the study site across four eADR stages. The game was played by n=10 knowledge holders and n=8 knowledge reviewers from the study site. During each cycle, feedback from players was reviewed and where appropriate integrated into the subsequent artefact. The artefact evolved from a set of challenges to eliciting healthcare knowledge (see Chapter 5, Section 5.3) to the final game design. Each iteration of the artefact is appropriate for the eADR stage that it was created for. For instance, the diagnosis stage is concerned with understanding the problem and solution space. The artefact created to address these concerns was a table highlighting how the concept of serious games could be applied in the research to address the problem statements (see Appendix C, Section 1.2). The evolution of the game artefact is presented in this chapter. Following this the final game is presented. The chapter finishes with a comparison of the final game to the problem statements. The purpose of this comparison was to gauge to what extent a serious game addressed these statements. This comparison was conducted through discussions with the co-inquiry group and review of the game evaluations that occurred across the eADR stages. Artefact evolution across three eADR stages is shown in Figure 14.

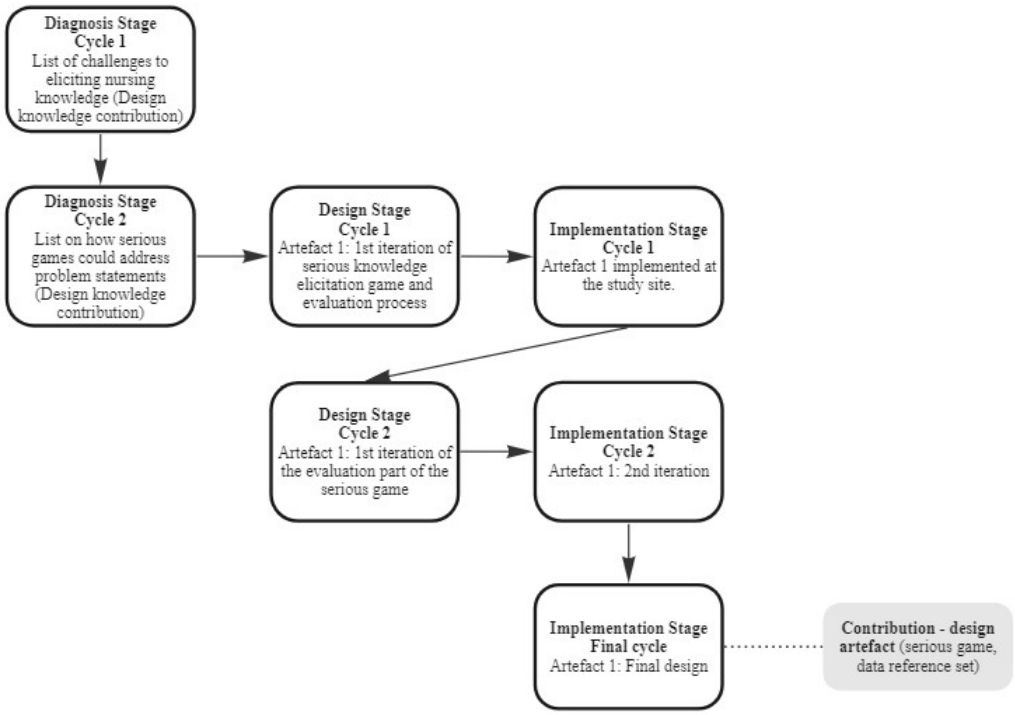


Figure 14 Evolution of the serious game design artefact

5.3 Final game overview

The game aimed to create a space where three types of interactions between nurses with different levels of experience can occur. Through these interactions knowledge can be elicited, evaluated, and shared. To elicit knowledge, participants referred to as Holders, act as preceptors or mentors to new nurses or knowledge seekers. The Seeker is represented as an avatar in the game. Through their interactions in the game, knowledge is elicited and captured on the evaluation game board. This was inspired by Nonaka and Takeuchi (1995). They discuss how, to understand the processes used by an expert bread maker and capture them in a way that can be replicated by technology, a team member took on the role of an apprentice. This mirrors how knowledge is shared in the clinical environment. Where experienced nurses, who receive training, act as preceptors to new nurses and students. The purpose of this mentorship is to share knowledge and skills with new staff members. This elicited knowledge is then evaluated before it can be shared. To evaluate knowledge, nurses based at the study site over 18 months act as Reviewers. The participant titles – Holder, Reviewer and Seeker – were taken from a knowledge elicitation method developed by the researcher prior to this PhD. This method is referred to as the WICKED method (Impey et al., 2023). Oher components from this method were also adapted in this research. For example, A knowledge topic (KT) is a relevant clinical topic that is explored (Impey et al., 2023). These components include a knowledge topic (KT). For this research, the topic proposed was a general adult discharge from an oncology setting. This was transformed into the following clinical scenario by the co-inquiry group:

> *"From your clinical experience, help prepare a newly employed nurse in this clinic to discharge a patient from the day care setting by writing any additional nursing advice you would like the nurse to ask but are not currently captured on the document. Please write any notes you think useful on the post-it and submit them to the researcher. Each post-it submitted will be awarded 1 point. Prompt: what should the nurse do, ask or observe during discharge."*

This final game was comprised of two parts. These are a knowledge elicitation part and a knowledge evaluation part. The purpose of the first part was to elicit knowledge in the first instance, that could then be evaluated in the second part so that it could be shared beyond the game. As there is no consensus as to what activities constitute 'Knowledge management' (Girard & Girard, 2015) the activities of eliciting, evaluating and sharing were identified as common among definitions. This is described in Chapter 2, Section 2.6. These were identified as key knowledge management activities in this research.

Each part of the game is played by a different player group, had a different purpose, was comprised of different activities, and was deployed at a different time. For example, during the knowledge elicitation part, the participant group were referred to as Holders. Holders were nurses based at the study site less than 18 months. Their function was to mentor a knowledge seeker in the game to conduct a patient discharge. The Seeker was represented by an avatar in the game. To mentor the avatar, holders document their knowledge on post-it notes and submit these to the game board. Each submissions earns the avatar a point. Knowledge could include what a nurse should do, ask, or observe during a patient discharge. This is the knowledge, that the avatar should have to discharge a hypothetical patient from the study site. The more points the avatar is awarded the better prepared they are to discharge their hypothetical patient. The submitted post-it notes are collected onto the evaluation game board. This collected knowledge was then considered community knowledge. That evaluation game board was an A0 poster that collects the community knowledge, with a section, referred to as the 'Winner's space' to highlight the avatar with most points received during the game.

The purpose of the second part - knowledge evaluation - was to review the elicited knowledge to ensure it was relevant and accurate so that it could be shared. To prepare for evaluation, the community knowledge underwent a number of steps. These steps were performed by the author of the research and the Gatekeeper. A full description of the preparation process is shown Appendix F. From this, the prepared knowledge was designed into a set of Community Knowledge cards. The evaluators group engaged in this stage. Members of this group were referred to as Reviewers. The game was played at different times. Firstly, the knowledge elicitation game was played. Then an amount of time passed to allow for the community cards to be designed and produced. This time was different for each cycle and took into account participant availability. Although presented as different parts, it should be seen as a single knowledge elicitation and evaluation game. Following this evaluation, knowledge evaluated positively or reviewed by gatekeeper was included in the digital spreadsheet by the author. This spreadsheet is described in detail in chapter 6. An overview of the two parts of the game and how they are connected is shown in Figure 15. The activities for both parts of the game in the game are shown in Tables 19 and 20. Table 19 describes the activities related to the elicitation part of the serious game. Table 20 describes the activities related to the evaluation part of the serious game.

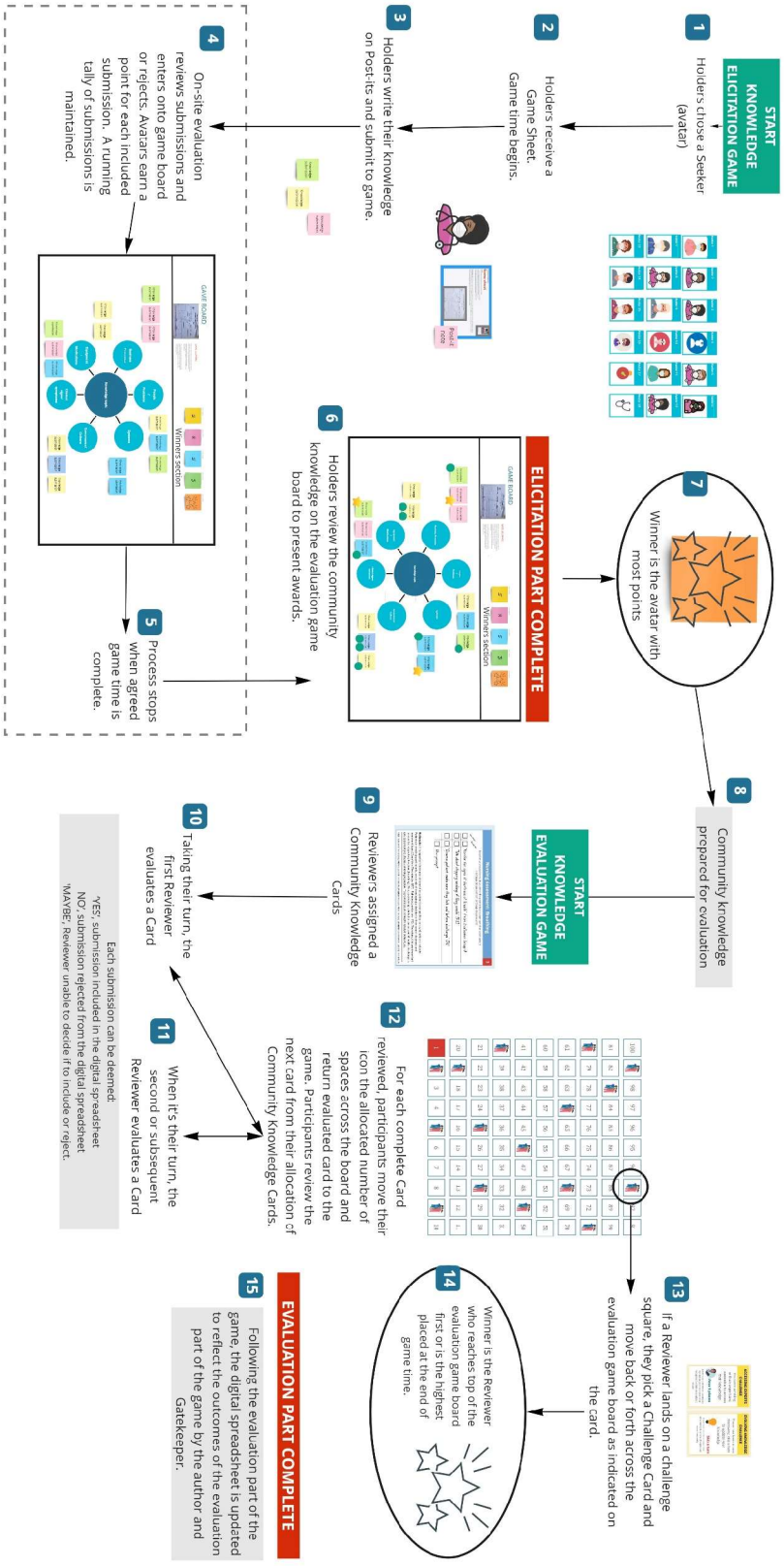


Figure 15 Final knowledge elicitation and evaluation game flow

Table 19 Activities related to the elicitation part of the serious game

Part	No.	Activity
Elicitation	1	Holders chose a Seeker from a prepared card deck. The Seeker is represented by an avatar in the game. Holders share their knowledge with the Seeker during the game.
	2	Holders receive a Game Sheet from the Gatekeeper. Game sheet contains the clinical scenario, control knowledge base. Participants also receive a pack of Post-it notes. Each Holder is assigned a specific colour post-it. This allows the knowledge submitted to be assigned to the specific avatar. The Gatekeeper describes how to play the game. Game time begins.
	3	During the game, Holders share their knowledge with their avatar by writing as much of their knowledge as they can on the Post-it notes and submitting these notes to the evaluation game board. The content of the submissions is limited to knowledge relevant to the clinical scenario.
	4	Knowledge is submitted to the game is via the Gatekeeper. The Gatekeeper reviews the submissions before including them on the elicitation game board or returning to them participants. Each Post-it submitted accepted by the Gatekeeper earns the avatar a point. A runny tally of the submissions for each avatar is maintained throughout the game and marked on the Winners section of the gameboard.
	5	Process stops when agreed game time is complete.
	6	After the game, Holders review the evaluation game board containing the community knowledge and can present awards to the submissions. Holders could award one gold star to knowledge deemed 'most important'. They could award unlimited number of green sticky dots to knowledge deemed 'relevant'.
	7	The winner is the avatar with most points at the end of the game time. The winning avatar is placed on the Winners section of the game board.
Post-elicitation game	8	Following the game, the Community knowledge contained on the evaluation game board is prepared into digital spreadsheet. From the digital spreadsheet, the knowledge is developed into a set of Community Knowledge cards by Author and Gatekeeper. Each card contains all submissions related to a specific topic.

Table 20 Activities related to the evaluation part of the serious game

Part	No.	Activity
Elicitation	9	The Community Knowledge Cards are divided equally and assigned at random between the Reviewers. Cards contain the prepared knowledge from the digital spreadsheet elicited in the first part of the game.
	10	The first Reviewer takes their turn and evaluates all submissions contained on their first card. Once reviewed, the evaluated card is returned to the game. From this review, potential outcomes for the knowledge contained in the card are: • 'YES', submission included in the digital spreadsheet • NO', submission rejected from the digital spreadsheet • 'MAYBE', Reviewer unable to decide if to include or reject.
	11	When it's their turn, the second or subsequent Reviewers review their allocation of cards. From the second or subsequent reviews the potential outcomes for the knowledge contained are the same for the first review: 'YES', 'NO' or 'MAYBE'.
	12	For each Community Knowledge Card reviewed, participants move their icon the allocated number of spaces across the board and return evaluated card to the game. This turn taking cycle (1st Reviewer then 2nd or subsequent Reviewer) continues until all cards have received at least two reviews. This process was managed by author of the game.
	13	Turn the cycle of turn taking between the Reviewers, a participant may land on a Community Knowledge square. When this occurred, a reviewer picks a Challenge Card and reviews the content. They move back or forth across the evaluation game board as indicated on the card.
	14	The winner of the evaluation part of the game is the Reviewer who reaches top of the evaluation game board first or is the highest placed participant at the end of game time.
Post-evaluation game	15	Individual submissions on the Cards that received all 'Yes' from Reviewers were included in digital spreadsheet. All 'No' evaluations were removed from the digital spreadsheet. Any evaluated submissions containing at least one 'No' or 'Maybe' was further evaluated by the Gatekeeper to decide if to include or reject from the digital spreadsheet. The digital spreadsheet was updated by the author and Gatekeeper to reflect the outcome of the evaluation.

5.4 Evaluation of game artefact

Following each game, participants were engaged in group discussions to review the game. These evaluation discussions are described in the three implementation cycles (See Appendix D). Serious games are both entertaining and fulfill a second function, traditionally this would be an educational purpose (Abt, 1970). This research is concerned with exploring the application of serious games as a knowledge management tool. The specific knowledge management activities identified for this research were elicitation, evaluation and sharing. It was proposed that the final game should be capable of managing knowledge, along with being entertaining for participants. To what extent a game could perform these knowledge management activities, it was proposed, could be gauged by the quality of the data set it produced. For a full account of the final data set see Chapter 6. To gauge the entertainment value of the game, access potential educational and knowledge sharing properties, participants were asked to complete a post-game questionnaire (See Appendices H-J. It was proposed that evaluating the enjoyment of participating in the games would allow the author to identify if participants enjoyed the game and, therefore, could be more likely to engage again at a future time. In total, 26 statements were contained in the questionnaire. Participants were asked to rate these statements using a 5 Point Likert Scale (strongly disagree, disagree, neutral, agree, strongly agree). Questionnaires were completed by n=10 Holders and n= 5 Reviewers. The model chosen for the evaluation is Gameflow (Sweetser & Wyeth, 2005). This is a widely used enjoyment evaluation tool used in a range of digital and non-digital games. In addition, questions related to the educational benefit of the game were included from the work of de Almeida and dos Santos Machado (2021). Questions were also included relating to knowledge sharing. The topics included in the post-game survey are shown in Table 21.

Table 21 Content of post-game survey

Gameflow elements (1-7, Sweetser and Wyeth, 2005)	**Purpose of question (from Sweetser and Wyeth, 2005)**
1. Concentration (CN)	"Games should require concentration, and the player should be able to concentrate on the game."
2. Challenge(CE)	"Games should be sufficiently challenging and match the player's skill level."
3. Control (CL)	"Players should feel a sense of control over their actions in the game."
4. Player skills	"Games must support player skill development and mastery."
5. Clear Goals (CS)	"Games should provide the player with clear goals at appropriate times."
6. Feedback (FK)	"Players must receive appropriate feedback at appropriate times."
7. Immersion (IN)	"Players should experience deep but effortless involvement in the game."

8. Social Interaction (SN)	"Games should support and create opportunities for social interaction."
9. Educational Content (ET) – (from de Almeida and Machado, 2021)	"The game must allow players to learn from interaction with other players" (from de Almeida and Machado, 2021)
10. Knowledge sharing (KS)	To access the utility and usefulness of the knowledge shared during the game.

The evaluation was largely positive. Findings noted that n=10 Holders strongly agreed or agreed that they enjoyed playing the game and would play the game again. The challenge of the game was deemed to be adequate (n=10, strongly agreed or agreed). The responses to if Holders would prefer to cooperate with others during the game was mixed from strongly agree to disagree. Holders did note that they enjoyed sharing their knowledge (n=10, strongly agreed or agreed) and that they gained knowledge from the game (n=10, strongly agreed or agreed). Findings from the Reviewers group were largely similar, with n=5 strongly agreed or agreed they enjoyed and would play the game again. There was a mixed response to an educational content question (I would prefer to capture my knowledge at my own pace and not in one sitting during game time) from both Holders and Reviewers group. However, as the participant numbers (n=10 Holders, n=5 Reviewers) was low the review the ability to generalize these findings is limited.

5.5 Knowledge contribution

eADR proposes to produce design in the form of an artefact, and design knowledge. This design knowledge is embedded in the artefact. This chapter presented the artefact, the serious game. This section focuses on the design knowledge that is embedded in the artefact. In the case of this research, this is a set of 10 problem statements used to guide the design of the game artefact constitute a contribution to design knowledge. Problems identified can be divided into three broad groups (1) related to knowledge, (2) related to the nursing domain and (3) related to the potential for any solution to create potential unintended consequences (PUC). These could arise as deploying any solutions to a context that could have an impact another element not initially considered. For instance, problem statement 3 describes "There is potential for unknown socio-technical challenges linked to the study site to present additional challenges for the solution, therefore, the researcher should hold a thorough understanding of the study site". The concept of unintended consequences draws from the work of Merton (1936). It is envisioned that this could be useful for designers designing serious knowledge elicitation and evaluation games for a nursing cohort.

The purpose of the game was to elicit knowledge that could be evaluated and mapped to a clinical terminology. As a data reference set was produced, see Chapter 6), the research was deemed to

have met its objectives. During the diagnosis and design stages a set of problem statements were constructed from the challenges to eliciting nursing knowledge identified in the literature and from the study site, see Appendix C, Sub-section 1.2. These were evaluated at the study site during the implementation stage. To understand to what extent the final game addressed these problem statements, during the final implementation cycle co-inquiry group meeting used the question 'did the game address the problem statement?' to conduct a final review of the challenges, problem statements and proposed. In this section, this table is updated to include a section on whether the proposed application was successful. This review uses the data collected from the participants post-game group discussion that occurred during each implementation cycle and feedback from the co-inquiry group meetings that occurred throughout the research. To answer the question the answer could be No, Unclear or Yes. To avoid researcher bias evidence is provided to support the answer. This updated table is presented here (see Table 22).

Table 22 Overview of challenges, problem statements and proposed application of a serious game and success of application.

Problems related to knowledge			
Challenge	**Problem statements**	**Proposed application**	**Was application successful**
1: Tacit	PS 1: The solution should be capable of eliciting tacit knowledge	Players: Proposed to utilise preceptor/preceptee relationship	Yes, knowledge holders in the elicitation game 'trained' an avatar to conduct a hypothetical patient discharge
4: Evolving knowledge	PS 4: The solution should be able to manage evolution of knowledge	Proposed to be played during scheduled education sessions.	Yes, the game is capable of being played without the researcher at a future time if the site wished.
5: Trust in knowledge	PS 5: The solution should be able to evaluate the knowledge elicited	Proposed building trust through multi-layer evaluation – player, evaluation, and co-inquiry group.	Yes, knowledge generated from Holders and evaluated by Reviewers. Knowledge was added and removed. For this research a final evaluation was performed by a senior specialist nurse. No knowledge was removed during this evaluation. Multi-layer evaluation helped build trust in the knowledge.

Table 22 is continued on the following page with the 'Problems related to the domain'.

Problems related to the domain			
Challenge	**Problem statements**	**Proposed application**	**Was application successful**
2: Time	PS 2: The solution should not add to any time burden for users	Proposed to incorporate game play into established education meeting times	Yes, both the elicitation and evaluation part of the game time were limited to the education meeting time.
6: Incomplete or inaccurate data sets	PS 6: The solution should not rely solely on established data sets due to the potential for them to be incomplete or inaccurate data sets	Proposed that game to generate knowledge, and not rely on data sets.	Yes, no data sets were used in this research.
7: Accessing experts	PS 7: The solution should be capable of accessing subject experts	Subject experts based at the site not directly involved in elicitation game. Proposed to limit player role to nurses at study site less than 18 months as this group access expert knowledge as part of their learning. Proposed that this could address time challenges as educational sessions are currently established at the site. This group acquires expert knowledge during their work.	Yes, knowledge holders accessed experts as part of their normal clinical work. In this scenario, the Holder is the learner. Holders were then able to bring this expert knowledge to the game.
8: Personal knowledge management systems	PS 8: The solution should provide outcomes (in terms of knowledge) for nurses to minimize use of personal management systems	Proposed to allow players access to 'community knowledge'. This can be facilitated by displaying the game board during game time and players can take a photograph to have as a reference while the data set is being developed.	No, Holders had option to photograph the community knowledge board following each game. However, Holders reported that the game board was difficult to navigate, therefore, was deemed that it could not act as a personal management system.

Table 22 is continued on the following page with the 'Potential unintended consequences (PUC)'.

Potential unintended consequences (PUC)			
Challenge	**Problem statements**	**Proposed application**	**Was application successful**
3. Socio-technical	PS 3: The solution should address the socio-technical challenges identified	Proposed that knowledge submitted anonymously in closed community and evaluated by subject experts from to the study site.	Yes, knowledge was submitted anonymously and evaluated by subject experts (Reviewers) from the study site. No additional subject experts were required.
9: Skills of researcher	PS 9: The solution should not rely on skills of an individual researcher	Proposed that the Gatekeeper role could include duties held by the researcher, such as setting up the game. An initial set of game rules and play instructions were developed so that the game could function independent of this research.	Yes, explicit game rules and play instructions along with the Gatekeeper role allow site to play the game as their knowledge needs dictate.
10: Unclear when to move to the next step	PS 10: The solution should provide guidance on when to move through the prescribed process	The game will be divided into two parts, a knowledge elicitation part and a knowledge evaluation part. These will be performed separately to allow time to collate the knowledge elicited into the digital spreadsheet for review. Time limits on game play will aid movement across both parts, data saturation will be used as an indicator that all available knowledge is elicited.	Unclear, time limits did allow game to move to next steps but unclear if this means that all knowledge was elicited. No baseline was possible as the point of the game was to elicit knowledge not currently captured. Data saturation did occur, and no new knowledge was added during the final evaluation.

5.6 Digitising the game

The game designed addressed 8 out of the 10 problem statements. It could not be used as a personal knowledge management system by Holders beyond the game due to the difficulty navigating the community knowledge. Furthermore, while participants could access the data reference set that emerged from this research, this took time to be mapped and subsequently published. The game did provide guidance on when to move to the next step, as the goal of the game was to elicit knowledge, it was unclear if all potential knowledge was captured. It was considered that these deficits could be addressed in a digital platform. Although digitisation was beyond the scope of this research, this section discusses how a digital format could address the limitations of the current game format identified throughout the research. These limitations were identified from the implementation co-inquiry group discussions (see Appendix D – co-inquiry group meetings sub-sections 1.1.3, 1.2.4 and 1.3.4). In total, 10 limitations were identified from both the elicitation and the evaluation parts. These limitations were reviewed during co-inquiry group discussions during the implementation cycles. 8 limitations were identified from the elicitation part and 2 from the evaluation part of the game. These 10 limitations are presented in a single (see Table 23), each linked to the theme it emerged from. This table also shows the cycle and the group who initially discussed them.

Table 23 Limitations of a low-fidelity serious knowledge elicitation and evaluation game

Limitation	Theme	Limitation identified	Cycle/group
1	1: Length of game	The length of the game was too short and due to the busyness of the clinical environment a longer game time could not be accommodated.	Cycles: 1, 2, 3 (Elicitation part and cycles 2,3: Evaluation part)
2	2: Prompts to aid recall	Not all participants required the same level of support. But all received the same information which took time away from game play.	Cycles: 1, 2 (Elicitation part)
3	3: Avatars	Participants who wished to personalize their avatars could not be accommodated due to time limitations and modality.	Cycles: 1, 2, 3 (Elicitation part)
4	4: Clinical scenario	Feedback from participants noted the clinical scenario was too broad (cycle 1,2) whereas participants in cycle 3 noted that if the scenario was too specific it could exclude	Cycles: 1, 2, 3 (Elicitation part)

		participants depending in their clinical experience.	
5	5: Community knowledge	The evaluation game board was described difficult to navigate. Although it was redesigned, the number of submissions made it difficult to navigate the community knowledge.	Cycles: 2, 3 (Elicitation part)
6	6: Competition (elicitation part)	Keeping a running tally of the knowledge submissions elicited during the game proposed in cycle 2 was difficult in the current low-fidelity format was difficult.	Cycles: 2, 3 (Elicitation part)
7	7: Building consensus	Awarding submissions was beneficial but the main limitation around this was the readability of the elicitation game board as it impacted the fairness of the award.	Cycles: 2, 3 (Elicitation part)
8	8: Onsite quality control	Feedback was beneficial for participants and provided a means of learning from experts. However, engaging with the Gatekeeper during the interrupted the flow of the game. Also, Reviewers would like to engage to engage Holders to clarify or query the knowledge they submit.	Cycles: 2, 3 (Elicitation part)
9	2: Game components	Reviewers would prefer to choose their own topics to evaluate.	Cycle: 3 (Evaluation part)
10	4: Providing rationale	Providing rationale was useful and should be given additional points as it took additional time for each participant to submit to the game due to increased word count.	Cycle: 2 (Evaluation part)

The 10 limitations were reviewed by the author and Gatekeeper and supported by literature and current game technology proposed ways a digital format could address them. These proposal changes are shown in Table 24.

Table 24 Proposed ways a digital format could address identified limitations

Limitation	Theme	Proposed change
1	1: Length of game	A digital game could potentially remove the game time and allow access based on participants schedule.
2	2: Prompts to aid recall	A digital game could potentially allow participants to access game instructions based on their needs.
3	3: Avatars	A digital game could potentially facilitate users to construct their own avatar if they wished.
4	4: Clinical scenario	A digital game could potentially allow participants to access a range of clinical scenarios that they might have more experience in.
5	5: Community knowledge	A digital game could allow participants to search submissions based on participant tags or by topic.
6	6: Competition	A digital game could potentially automate tasks such as maintaining a record of submissions and free up time for the Gatekeeper.
7	7: Building consensus	A digital game could allow participants to search all submissions before allocating awards.
8	8: Onsite quality control	A digital game could potentially maintain a feedback function in background without interrupting the game flow along with providing a means for Reviewers to engage Holders to clarify or query the knowledge they submit.
9	2: Game components	A digital game could allow Reviewers to select their preferred topics
10	4: Providing rationale	A digital game could allow for different points to be awarded for different types of submissions, for instance, based on word count. This could not be facilitated in the current format due to time constraints.

These themes were discussed with members of the co-inquiry group. The purpose of this discussion was to review limitations and to seek feedback on the proposed implications of adopting a digital format. The author of the thesis acted as the meeting moderator. The details of the co-inquiry group are shown in Table 25.

Table 25 Co-inquiry group meeting – game contribution

Group	Participants	Length	Moderator	Purpose of meeting
Co-inquiry group	N=3 including Gatekeeper	60 minutes.	Author of thesis	To review limitations and seek feedback on the proposed implications of adopting a digital format

From this discussion, the proposed changes were grouped into themes that describe how a digital game could address the identified limitations. This arose as some of the proposed changes arising from a digital game overlapped. These are shown in Table 26 and an overview of discussion is presented in the following text.

Table 26 Limitations grouped by proposed changes arising from a digital game

Theme proposed	**Addresses limitation**
Facilitate personalisation	1 (Length of game), 3 (Avatars), 4 (Clinical scenario)
Reduce cognitive load for participants	2 (Prompts to aid recall), 5 (Community knowledge), 7 (Building consensus)
Improve feedback processes	6 (Competition), 7 (Building consensus), 8 (Onsite quality control), 9 (Game components), 10 (Providing rationale)

5.6.1 Facilitate personalisation

The theme Personalisation surrounds how a digital format could facilitate participants to allow adapt the game to their own requirements. Personalisation can potentially improve engagement with serious games, by allowing individual users to customise their experience of the game (Daylamani-Zad et al., 2020) This encompasses ‘removing set game times’, ‘adapt the clinical scenario’ and ‘personalise the avatar’. In relation to the length of time allowed for game time, participants across all three cycles described how time went quick. Comments by participants surrounded how game time felt short and that it was difficult to recall everything under time pressure and without external stimulus i.e., patient in situ, the environment. To address this limitation, it is proposed that a digital game could be played over a longer period and allow participants to play at their own pace.

It was raised by participants in implementation cycles 2 and 3 (see Appendix D, section 1.2 and 1.3) that the clinical scenario was very broad. Participants in the third implementation cycle also noted that a scenario that was too specific could exclude participants based on individual experiences. It is proposed that a digital platform without set game times could provide more

flexibility and allow participants to personalize the scenario to fit their own experience. For instance, a patient discharge scenario could be distilled into types of patients or treatments. Based on numbers, participants can join established scenario game or set up their own. In this sense, a digital game format could be adopted as a competitive group exercise or an individual knowledge management platform. It is envisioned that knowledge generated from both the group and individual experience could be incorporated into a community knowledge bank. Thereby, remaining a knowledge elicitation game.

Another way to allow users to personalise their own game could be through the design of the avatar. Throughout all implementation cycles of the game, participants raised that they would prefer to construct their own avatar. This could not be facilitated in a low-fidelity platform due to time constraints. It is proposed that a digital system could provide the functionality to construct avatars. For participants who did not wish to construct their own, the game could provide a standard avatar for users. For example, in the social media site Reddit', (https://www.reddit.com/avatar) users can chose a standard avatar or are presented with the option to develop their own by choosing clothes, styles and colours that they wish. This is shown in Figure 16.

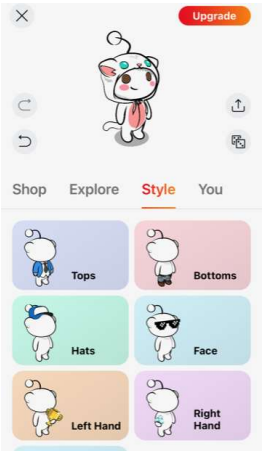


Figure 16 Personalizing the avatar in 'Reddit'

5.6.2 Reduce cognitive load for participants

The theme 'reduce cognitive load for participants' surrounds how a digital format could potentially automate routine tasks, produce an easier to navigate game board or provide other supports so that users can focus on other parts of the game. This encompasses 'starting phrases', 'easy to navigate the board community knowledge' adapt the clinical scenario and personalise the avatar

Following Cycle 2, (see Appendix D, Section 1.2) the starting phrases were developed to help participants initiate knowledge elicitation. Starter phrases proposed included "Tell patient to…." Or "Ensure patient is….". Starting phrases were described as useful by participants following Cycle 3 (see Appendix D, Section 1.3). These phrases, along with other game instructions were introduced during the Gatekeepers discussion at the start of the game. As participants become more familiar with the game, it is proposed that they could require less instructions. However, in its current format it is difficult to tailor instructions for each participant. A digital platform could address this by making information available when requested by participants. This is in line with Nielsen's 7th (Flexibility and efficiency of use) and 10th (Help and documentation) heuristic (Nielsen, 1992). These heuristics describe how a system should be capable of use by experienced as well as novice users with instructions easy to access if required. Heuristics are mental shortcuts or rules of thumb. In terms of design heuristics, the most well-known addresses digital systems, specifically user interface, and not game design. No usability heuristics, however, were found in the literature related to serious knowledge elicitation games. In addition, Nielsen's 6th heuristic surrounds 'Recognition rather than recall' notes how systems should not add to the cognitive load of users by providing information at the appropriate times (Nielsen, 1992).

Feedback from the second and third Holders group discussions noted that reviewing the community knowledge on the game board was challenging due to the difficult navigating the game board. This arose due to the number of submissions contained. While participants were instructed that they could take a 'photo' of the board to have a reference, this did not provide any utility due to the difficulty to navigate the content. See Figure 17 for a photograph of the board following game 3.

Figure 17 Photograph of game board following implementation cycle 3

A digital platform could potentially arrange the submissions in an easier to navigate format. Potential navigation methods could include review using participant tags or by the type of clinical scenario. For instance, a participant could review the submissions related to a specific clinical

scenario. Alternatively, participants could add tags to prompts as they are submitted from a pre-agreed list. These tags could identify the topic that the submission is related to, for instance, breathing or medication. Breathing and medication were among the topics used to catagorise the evaluated knowledge in the digital spreadsheet. The possibly of participants tagging their own submission was raised by the author and Gatekeeper during the first cycle to reduce the time spent preparing the submissions for evaluation. In a low-fidelity format, while it was discussed that allowing participants add tags to their own submission could potentially save submission preparation time. It could also add an additional task to the Holders which could further reduce time allotted to knowledge elicitation part of the game. It is proposed that knowledge that is easier to navigate could also have more relevance for the user and could potentially act as a personal knowledge system. A digital game format could potentially automate tasks involved in the game such as maintaining a tally of the submissions entered. This was a function of the Gatekeeper in the low-fidelity prototype.

5.6.3 Improve feedback processes

It proved difficult during game play to simultaneously collect and collate knowledge submissions and confirm their quality while providing feedback to users. This is even more difficult when feedback relates to not only the knowledge submitted but also game mechanics. For example, what is or is not allowed during the game or who is currently winning. It is proposed that a digital platform could provide a more effective means of providing feedback. This theme 'Improve feedback processes' surrounds describes how feedback could be improved and encompasses 'Competition', 'Visibility of winners in real-time', 'onsite quality control', and 'perceived fairness'.The competitive element of the elicitation and evaluation game was well received by participants. For example, based on feedback a 'winners' section was added to the evaluation game board, and the evaluation process was gamified. A digital format could potentially build on this by including previous winners or sections such as highest score, potentially showing visibility of the winner in real-time. For instance, while not a knowledge elicitation game, the mobile game 'Toon Blast' is a puzzle solving game developed by Peak (https://peak.com/products) for individual users who are also linked into groups. User win levels by matching destroying as many bubbles, cubes, or balloons (depending on the specific level) with a set number of moves. Although the game is played individually, each user belongs to a team. A scoreboard presets the user with their score in relation to their own team and their teams score in relation to other teams within their region or internationally. Figure 18 shows the scoreboard, highlighting a team's position in World ranking. The user view can be switched to show the team's position in relation to Irish rankings or to show an individual position within their team.

Figure 18 The leader board on the game 'Toon Blast'

Participants received feedback in a number of ways throughout the game from the Gatekeeper. For instance, onsite evaluation returned submissions that were deemed not relevant. Participants could discuss submissions with the Gatekeeper following the game. While participants were able to give awards to the community knowledge, they did not know if their submissions had received any as they were only involved in one game. Due to the anonymity of their submissions, there was no feedback processes to inform them their knowledge had received an award. Initially, these awards we introduced to as a means of evaluating knowledge by building consensus. However, a digital platform could allow awards to act as a form of feedback.

For another example of how a digital game could improve feedback for participants this research draws on the social media platform 'Reddit' (https://www.reddit.com/). In this platform, users post questions to the site (see Figure 19).

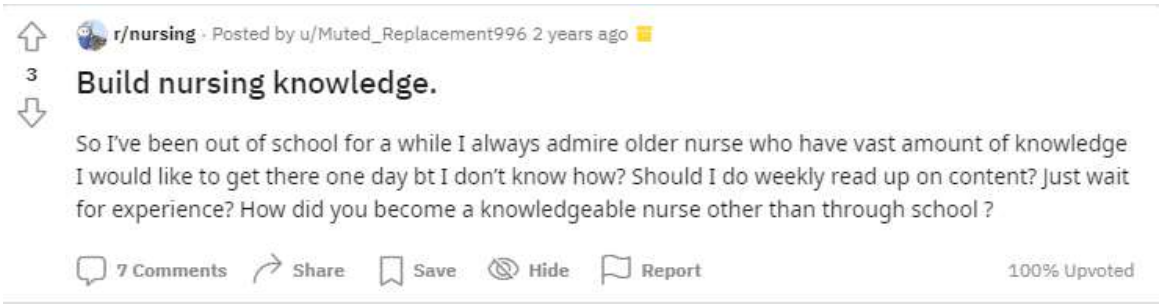


Figure 19 Example of feedback processes from a digital game.

These questions can be posted to specific groups within the wider community. For example, there is a nursing group. These groups are described as sub-reddits. Participants can engage with the post in a number of ways such as leaving a comment or adding an award. The original poster receives feedback of engagement in the form of comments, receiving badges or upvoting/down voting. While the feedback processes are highlighted as an example of digital feedback, users are anonymous which has implications for building trust in the knowledge elicited. This approach could also address comments raised by Reviewers in cycle 2 (see Appendix D, Sub-section 1.2.4). These comments raised that Reviewers would like to engage with Holders to discuss or clarify their posts.

Along with knowledge submitted, the game also elicited other information. For instance, participants from both the elicitation and evaluation game provided rational for some of their submissions. This was useful when transferring the evaluated knowledge in the digital spreadsheet into the data set and when mapping the evaluated knowledge to a clinical terminology. A discussion on the mapping process is presented in Appendix F. However, it was discussed that although these took longer to write they only received that same number of points for other submissions that could have contained less words. It is proposed that a digital game could potentially discriminate between the types of submissions based on word count. In addition, these types of submissions, if evaluated and deemed suitable, could receive feedback for the submitting participant.

As the changes are proposed based on literature and current digital game or social media formats, the use cases were not updated during this research.

5.7 Conclusion

The final game artefact is a low fidelity prototype of a scenario-based serious game. The game has two distinct parts – knowledge elicitation and knowledge evaluation. The first part, knowledge elicitation, uses a pre-agreed clinical scenario where players (nurses employed at the study site less than 18 months) mentor student nurses who are represented in the game by avatars. The goal is to mentor and share knowledge with the avatar so that they have the knowledge to perform a discharge from an oncology daycare setting. Knowledge used during the discharge is based on players experience and what they have learned at the study site. To mentor their avatar, players write discharge questions or topics on post-it notes and submit them to the game board. These submissions are referred to as knowledge prompts. Once these prompts are submitted to the game board, they are considered community knowledge. Each prompt submitted earns the player a point. The avatar at the end of the game with the highest number of points is deemed to be the most prepared and therefore the winner. For the second part, knowledge evaluation, the submitted

prompts collated onto the game board and are reviewed by three groups – game moderator, players and evaluation group. The first group is a subject expert acting as a game moderator during the game time. Their role is to act as a quality control during the game and award points or reject prompts. The second group is comprised of players who can review and give awards, in the form of gold stars or green dots, to the collated community knowledge. A third evaluation group was comprised of experienced nurses from the study site. This evaluation was conducted after the game has been played. Evaluators approved or rejected knowledge prompts (community knowledge) based on their experience. They could also add knowledge to the community knowledge. A final validation step was conducted by the most senior nurse at the study site. The purpose of this step was to act judge how successful the evaluation step had been. No knowledge was removed from the community knowledge at this point. Therefore, the game was deemed to be successful in eliciting knowledge from a specialist community of practice.

In the next chapter the second contribution is discussed – the data reference set. Through playing this game, specialist nursing knowledge was elicited, evaluated, and validated. This validated knowledge was mapped to a clinical terminology (SNOMED CT) so that it could be preserved beyond geography and time. A design knowledge contribution in the form of the mapping process is also presented.

6 Contribution 2: Data reference set

This chapter presents the second design contribution (an adult oncology day care discharge reference set) and design knowledge (mapping process) arising from this research. The reference set is comprised of elicited, evaluated, and coded knowledge. The mapping process describes how codes were added to the validated knowledge so that it could be represented in a clinical terminology.

6.1 Introduction

In the previous chapter, the final game artefact was discussed. This was a serious knowledge elicitation and evaluation game. Through playing this game, specialist nursing knowledge was elicited and evaluated. During the research process, this knowledge was maintained in a digital spreadsheet. The preparation process used to transform knowledge submissions from paper to the digital spreadsheet is described in this chapter (see Appendix F). While this provided a way to store the evaluated knowledge, a digital spreadsheet did not provide a way to share it across borders or time. A final evaluation of the knowledge by a subject expert, not previously connected to the research previously, reviewed the total knowledge collected and previously evaluated (see Section 6.3). The purpose of this was to ensure the evaluation part of the game was sound. To be able to share this evaluated knowledge beyond the border of the study site, it was mapped to a clinical terminology. In this research, two clinical terminologies were used – Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT) and International Classification for Nursing Practice (ICNP). This chapter describes the mapping process that was conducted (see Section 6.7). A description of the two terminologies and the outputs from the mapping process are also described.

6.2 Artefact evolution

Similar to the final game (see Chapter 5), the data reference set underwent a number of iterations before the final artefact emerged. For instance, following each of the three implementation cycles, the artefact produced was a digital spreadsheet. This spreadsheet contained evaluated knowledge that was deemed relevant by the Reviewers. To arrange the knowledge in the spreadsheet, the following headings were used: categories, topic, submission, similar and rationale. These related to each other in the following way. An initial review of the submissions was undertaken by the author and the Gatekeeper. In the event where a number of submissions were deemed to describe the same knowledge, one was identified as the 'submission' and the remaining were identified as 'similar'. The submissions were arranged under topics and topics were arranged under high level categories. These were used to manage the number of submissions and arrange them for review.

Each version of the spreadsheet included previously evaluated knowledge along with any new knowledge captured during the specific cycle. Reviewers were not informed what cycle knowledge was generated in. Although increasing the workload on the latter cycles, it was

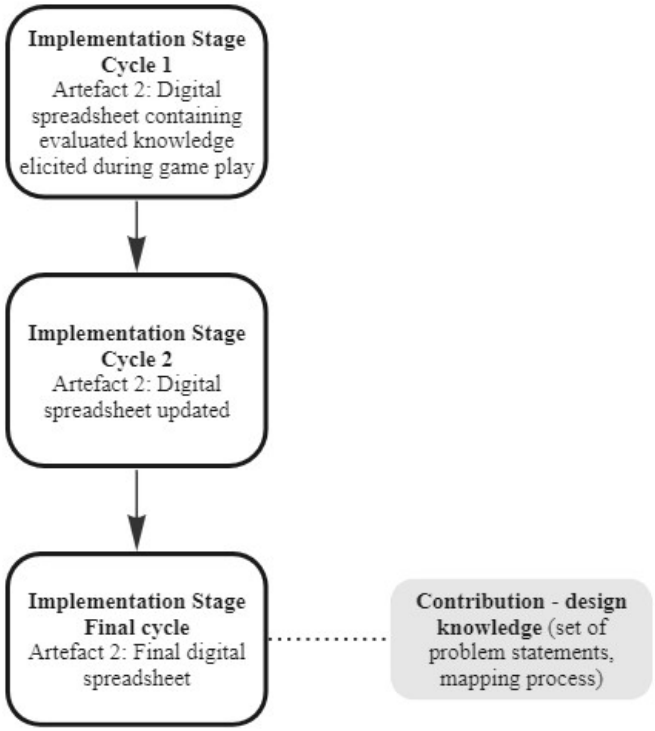


Figure 20 Evolution of data reference set artefact

envisioned that this would provide the most comprehensive evaluation given the number of participants (n=8) involved in the evaluation part of the game. The evolution of the second artefact, the data reference set, is shown in Figure 20.

To ensure the evaluated knowledge could be mapped to a clinical terminology and used in a reference data set for an oncology setting for an adult patient discharge, a further evaluation step was conducted. Again, this was prompted in part due to the number of Reviewer participants. This evaluation took the form of a review by subject expert. The expert was a senior nurse based at the site with over 25 years of specialist domain experience. This expert had not been involved reviewing the knowledge to date in the research. It was envisioned that this final evaluation step would answer whether that playing the game could be used to capture specialist nursing knowledge.

For this evaluation, the digital spreadsheet was printed and each submission including rationale was reviewed by the subject expert. The review was guided by the clinical scenario and presented as the question: “Is this [knowledge] relevant for a patient discharge from an oncology day care

setting?" Limiters were that the discharge was general and not specific to a patient or treatment type. These were identified from the participant feedback (see the evaluation sections in Appendix D) that noted a limitation of the clinical scenario was that it was too broad. To be considered valid each knowledge submission was reviewed and removed from the digital spreadsheet by the domain expert, if it was deemed incorrect, irrelevant or had patient safety implications. This review took was completed in one sitting and took 90 minutes. The author was present for the review but did not offer any opinions on the knowledge.

6.3 Output from final knowledge evaluation

In this research, the evaluated knowledge underwent a final evaluation by a subject expert not connected to the research up to this point. The evaluation used a printed version of the updated digital spreadsheet, and the expert reviewed each submission. The purpose of this was to ensure the evaluated knowledge was accurate and relevant. Following this subject expert review, no knowledge prompts were removed or deemed incorrect, irrelevant or had patient safety implications. Amendments were made to 8 submissions, these are:

1. Under the category 'People' the prompt 'Dietitian' was removed as this role was now referred to as 'clinical nutrition'. The role Clinical nutrition was previously captured in the submissions.
2. Based on this change, another mention of 'Dietitian' from: Process – Arrange any referrals: "They might need a dietitian" to Process – Arrange any referrals: "They might need a clinical nutrition"
3. Amend Nursing Assessment – AL Elimination: "Watch for episodes of diarrhoea" to Nursing Assessment – AL Elimination: "Watch for episodes of diarrhoea **and what to do if it happens**"
4. Amend Nursing Assessment – AL Elimination: "Watch for episodes of constipation" to Nursing Assessment – AL Elimination: "Watch for episodes of constipation **and what to do if it happens**"
5. Amend Nursing Assessment – AL Sleeping: "Patient should know about possible sleep disturbances" to Nursing Assessment – AL Sleeping: "Patient should know about possible sleep disturbances **and what to do if it happens**"
6. Amend Process – Discuss patient supports available: "Is the patient aware of the services available to them from ARC or Irish Cancer Society" to Process – Discuss patient supports available: "Is the patient aware of the services available to them from ARC or Irish Cancer Society **and other supports**"
7. Amend Processes: Nursing tasks: "Community Intervention Team (CIT): "Nurse is responsible for organising Neulasta injection and nurse to send referral to Community Intervention Team (CIT)" to Nursing tasks: "Community Intervention Team (CIT): "Nurse is responsible for organising Neulasta injection and nurse to send referral to **nurse connected to the** Community Intervention Team (CIT)"
8. Amend Artefacts – Patient information and supports: "Give patient wig prescription if required" to patient information and supports: "Give patient wig **and hair piece** prescription if required"

In addition, the domain expert suggested 6 knowledge submissions for inclusion. These were

1. **SIMILAR:** Nursing Assessment – AL Breathing: "Important to look at patient before you discharge" (A similar prompt was noted by Player 1 "Observe patient, make sure they look well before you discharge" [P1] SNOMED Code: 363791007 | General appearance of patient (observable entity).
2. **Not Included as TG:** Nursing Assessment – AL Breathing: "For some medications, watch for hypersensitivity to cold" *('Too general (TG)' describes prompts that are related to patient care in general but not the clinical scenario.)*
3. **Not Included as TG:** Nursing Assessment – AL Mobility: "Watch for issues around hands and feet (issues with skin or unusual feelings) that could impact mobility" *('Too general (TG)' describes prompts that are related to patient care in general but not the clinical scenario.)*
4. **Not included as N2N advice**: AL Skin: "Skin care management is very important and more so for certain medications"
5. **Included:** Nursing Assessment – AL Temperature: "Tell patient how to take a temperature"
6. **Included:** Equipment: Long-term venous access: "Teach the patient about the side effects of PICC insertion, if they have one"

From these proposed 6 submissions, 2 (number 5 and 6) were included in the final digital spreadsheet as they were deemed relevant and not already included. From this final evaluation step, the domain expert deemed the knowledge to be useful for nurses discharging an adult from the oncology setting. Following this, the next step in the research was to assign codes from a clinical terminology to the knowledge validated. The terminology chosen was SNOMED CT as it used by the health service executive (HSE). A second clinical terminology was also used, ICNP, as it was a nursing specific terminology. The purpose of assigning codes was to preserve this knowledge in a reusable form. The SNOMED CT data reference set was identified as the final artefact. This contained all evaluated knowledge that could be mapped to SNOMED CT and is referred to as its adult oncology daycare nursing discharge reference set Ireland (SNOMED CT refset ID 134791000220109).

6.4 Clinical terminologies

According to the World Health Organisation (WHO) a standardised clinical terminology is a "compilation of terms used in the clinical assessment, management and care of patients, which includes agreed definitions that adequately represent the knowledge behind these terms and link with a standardized coding and classification system" (WHO, 2006). Terminologies can enable nurses, indeed all healthcare professionals, to document and share knowledge across digital platforms.

The potential benefits of adopting a standardized language include improved communication and patient care along with interoperability and knowledge generation (Fennelly et al., 2021). Furthermore, nursing terminologies and classification systems provide a means of articulating nursing (Strudwick & Hardiker, 2016). There are many benefits to support a standardized

language for nursing, both for nursing and for the wider healthcare environment. Along with describing and representing nursing (ISO18104:2014), a standardised nursing language also allows nursing data to be collated from various sources and used for patient care, quality improvements, research and influencing policy. For example, a study by Sanson et al. (2019) found that nursing diagnosis can be used to predict hospital mortality. The authors highlight that it is important, therefore, to include standardized nursing data in electronic records (Sanson et al., 2019). Considering that approximately 59% of the world's healthcare professionals are nursing, this represents a substantial amount of healthcare data.

An ISO standard relative to a nursing standardized language is the ISO 18104:2014. This health informatics standard describes 'Categorial structures for representation of nursing practice in terminological systems'. At the time this thesis is being prepared, a replacement to this standard is in currently in the enquiry stage (stage 40.6). This replacement is the ISO/DIS 18104, as it is available publicly, the thesis will refer to the ISO 18104:2014 standard. The primary aim of the standard is to support interoperability between systems with respect to nursing diagnosis and actions.

Two terminologies were used in this research – SNOMED CT and ICNP. While one is a broad clinical reference terminology (SNOMED CT), the other provides more granularity needed to capture nursing work (ICNP). While there are several terminologies available, this thesis does not intend to identify one as superior. Rather they are used in this research as a means of demonstrating that for nursing knowledge to be capable of sharing beyond the community of practice (origin) and preserved beyond time and geography, knowledge used must be mapped into a standardized form. Standardised terminologies support this goal. To move from elicited, evaluated, and validated knowledge into a format capable of being shared, that is as a coded data reference set, knowledge needs to be mapped to a clinical terminology. It is important, therefore, that terminologies represent the full breath of nursing knowledge. However, not all knowledge elicited was capable of being represented in either standardized terminology used as suitable matches were not always found. Focusing on SNOMED CT the matches identified following the mapping process were developed into a refset for an 'Adult oncology daycare nursing discharge reference set Ireland' (SNOMED CT refset ID 134791000220109). This refset contains n=107 concepts. This demonstrates that knowledge elicited and evaluated during the game and validated by a subject expert can be capable of sharing to some degree. The degree to which this sharing is facilitated beyond time and geography is reliant on standardized terminologies representing nurses work. The following text is a description of the mapping process used in this research.

6.5 *Clinical terminologies*

There are a number of clinical terminologies available including ones that are nursing specific (Hardiker, 2011). For example, clinical terminologies such as SNOMED CT (HIQA, 2014). Or nursing specific terminologies such the North American Nursing Diagnosis Association (NANDA) International, Nursing Outcomes Classification (NOC) and the Nursing Interventions Classification (NIC) (Lunney, 2006) and ICNP (ICN, 2021a, 2021b). Although only one data reference set was published in this research, the evaluated knowledge was mapped to two clinical terminologies, SNOMED CT and ICNP. The following text is a summary of each terminology.

SNOMED CT is a multilingual health terminology, that is mapped to other international standards and is used in over eighty countries (https://www.snomed.org/snomed-ct/five-step-briefing). SNOMED CT contains concepts. These concepts have a unique clinical meaning and is identified by a numerical identifier. These identifiers act to identify concepts across systems.

The International Classification for Nursing Practice (ICNP) is a 'classification of nursing phenomena, nursing actions, and nursing outcomes that describes nursing practice' owned by International Council of Nurses (ICN) (Coenen, 2003). Founded in 1899, the ICN is a made up of over 130 national nursing associations and represent over 27 million nurses worldwide. Initially proposed in 1996, in 2000 the ICNP project was established (Coenen, 2003). Since its launch, the ICNP has been translated into 19 languages and has 14 research and development centers worldwide, (ICN, 2021a).

According to the ICNP Technical Report, a new release occurs every year in line with the SNOMED CT release cycle (ICN, 2021b). ICNP is represented within SNOMED CT and the nursing practice refset was released in 2021. ICNP was also accepted into World Health Organisation Family of International Classifications (WHO-FIC). Governance of ICNP is managed by a designated editorial board that was established in 2021 (ICN, 2021a).

While there are a number of terminologies available, these two were chosen as SNOMED CT was adopted by the national health services (HIQA, 2014). ICNP, which is incorporated into SNOMED CT, is a free to use nursing specific terminology (ICN, 2021a, 2021b). It is also part of the World Health Organisation Family of International Classifications. The reference set being developed related to an adult oncology day care discharge. No current reference sets were found in either terminology. Versions of terminologies used in this research were:

- SNOMED CT Irish edition 2022 access via https://browser.ihtsdotools.org/?perspective=full&conceptId1=404684003&edition=MAIN/SNOMEDCT-IE/2022-10-21&release=&languages=en

- ICNP 2019 release (English) access via https://www.icn.ch/what-we-do/projects/ehealth-icnptm/icnp-browser.

To prepare for the mapping process, the researcher engaged with experts from each terminology to ensure they were able to navigate the terminology interface and understood the terminology. This took the form of discussions with experts, joining SNOMED CT Working group and ICNP editorial board and reviewing relevant literature and presentations (by the terminologies). An overview of these meetings is shown in Table 27.

Table 27 Overview of SNOMED CT meetings and ICNP Meetings

Group	Participants	Length	Moderator	Purpose of meeting
SNOMED CT	N=2	10 meetings, 60 minutes each meeting	Author of thesis and SNOMED CT Expert	To describe terminology and map evaluated knowledge captured during the game into SNOMED CT.
ICNP	N=2	8 meetings, 60 minutes each meeting	Author of thesis and ICNP Expert	To describe terminology and map evaluated knowledge captured during the game into ICNP.

6.6 Mapping frameworks

During the implementation cycles, elicited knowledge was evaluated and constructed in a digital spreadsheet. In addition, a final evaluation of the content was performed by a senior subject expert. In total, the final digital document contained the 112 individual submissions of validated knowledge. While this provided a record of relevant and evaluated knowledge, the format of the document (digital spreadsheet) limited its shareability. As the aim of this research was not only to understand to what extent a serious game could elicit specialist nursing knowledge but also identify how this knowledge could be shared mindful of geography and time, mapping to a clinical terminology offered a potential sharing pathway.

Throughout the process, how the game and any associated process could be sustained beyond the research was considered. For the game artefact, sustainability was incorporated into the design. For example, the game uses current knowledge sharing processes, user instructions were developed, and all actors used in the game were roles in a clinical setting. The mapping process presented challenge as it was considered that not all clinical areas may have access to an

informatics nurse specialist. Thereby limiting the potential value of the game as a knowledge management tool to any study site where it is deployed. To address this, a process of mapping evaluated knowledge to a clinical terminology is described in this thesis.

In addition, while the author has a health informatics background, they had no previous experience mapping to a clinical terminology. As a result, the author was sought assistance from experts linked to both SNOMED CT and ICNP terminologies. To ensure the mapping was rigorous, a process was sought. Initially, Snap2SNOMED was considered. This is an online collaborative mapping tool that allows teams to author and review maps (SNOMED, 2022). It was ultimately discounted as it did not allow single users, only teams, to map to SNOMED. This could be difficult if the expert could not engage during the research. Furthermore, knowing what the right code is to attach to the right knowledge in the first instance is important. It was considered that while support is available around the actions used in mapping, for instance, how to find a specific code, identifying the most relevant code could be more challenging. A further search identified a study that described a concept mapping process (Block et al., 2021). Block et al. (2021) note that from their research, no single process was found that described clinical terminology mapping. Their research produced a nine-step procedural framework (see Table 28) that can be used to guide clinical terminology mapping. Their research incorporates existing ontology mapping activities to produce a single process. To enable nurses to manage their knowledge it was considered that all elements, such as developing a game, and associated processes, such as mapping validated knowledge to a clinical terminology, should be repeatable in a clinical environment.

Table 28 Nine-step procedural framework for clinical terminology mapping

Step	Description
1. Identification of source concepts	Concepts (linked to nursing topic) extracted from relevant documents, reviewed, and defined by two researchers.
2. Conceptual model	Concepts identified in step 1, presented in a Unified Modelling Language (UML) class diagram.
3. Scope of target terminology	The standardised terminology (target terminology) that will be used map the categorized concepts in the UML class diagram to is identified.
4. Mapping style	Concepts are manually mapped to the terminology. Block et al. (2021) used two researchers.
5. Mapping coordination	Only complete concepts were used (Pre-coordinated mapping) as opposed to multiple concepts in Block et al. (2021). They provide the following example to illustrate this step. Pre-coordinated mapping -

	Local wound infection (source) to Local wound infection (target). Post-coordinated mapping – 'wound' + 'local infection' as two concepts.
6. Hierarchical mapping awareness	Source concepts identified are mapped to target terminology by matching the position of the concept to where is appears in the terminology hierarchy.
7. Systematic search strategy	To identify the exact concept, additional online searches were conducted. The authors describe 5 possible steps. Users do not have to complete all the prescribed steps but stop when a match is found or if following the fifth step, there is no match is found. These steps are: 1. search using exact lexical arrangement, if no match 2. search using a clinical synonym, if no match 3. using the exact lexical arrangement but expanding to include broader or narrower matches, if none found 4. using a clinical synonym but expanding to include broader or narrower matches, if none found 5. conclude there is no match
8. Mapping cardinality	Matches were deemed • Exact match: Conceptual term and hierarchical representation are an exact match to source concept • Narrower match: Conceptual term and hierarchical representation are more granular than source concept. • Broader match: Conceptual term and hierarchical representation are less granular than source concept. • No match: no matches for the source concept in the target terminology.
9. Evaluation of mapping results	The process was followed by two researchers independently and findings compared at the end. Discrepancies were reviewed and discussed until consensus and then forwarded to the wider team for final review. This iterative review process was guided by the principle of 'reflexivity toward group dynamic'. That describes how individuals could forward decisions to the group on the understanding that 'others' have more experience than the individual.

While this framework proved useful, it incorporated computer science skills, such as UML, that may not be easily accessed in practice. The framework was used in this research, how it was applied is described in the text below.

6.7 Mapping process

The purpose of mapping the submissions for this research was to assess how much of nursing knowledge generated during a patient discharge could be represented in a clinical terminology. Thereby demonstrating a way that nursing knowledge elicited during a serious game could be preserved and shared. Or where no codes exist, demonstrating a weakness in managing nursing knowledge digitally.

As noted, no suitable framework was identified that described mapping elicited knowledge prompts (n=112) elicited during the serious game. And a process was established by the SNOMED CT expert. However, no method found described searching the terminology data base. Therefore, the process described by Block et al. (2021) was used as an initial framework. Not all steps proposed by the authors were suitable for this research. Where they diverge is highlighted in the following text.

6.7.1 Steps 1-3

For example, step's 1 and 2 of the framework by Block et al. (2021) is concerned with knowledge collection and model development. Block et al. (2021) prosed that capturing concepts from relevant documents occurs in Step 1. These concepts are developed into a conceptual model (step 2). These steps were not performed for this research as the initial data set was drawn from elicited knowledge captured during game play. Instead for this mapping process, the initial work was concerned with reviewing the digital spreadsheet that contained the validated knowledge prompts that was completed earlier in the research (see Section 12.2). This review was completed by two people, the author and an expert connected to each terminology. Across the two mapping processes this gave a total of three people in two groups. Group one comprised of the author and SNOMED CT expert. Group 2 comprised of the author and ICNP expert.

It was discussed during the digital spreadsheet review by both groups, that while the purpose of grouping knowledge submissions into topics and categories was to help manage the volume of prompts captured. These groupings provided a starting point for the mapping process where a relevant concept (for each topic or category) was identified in the chosen terminology. Essentially, providing a high-level view of the concepts from which a more specific code could be extracted.

Step 3 of the process described by Block et al. (2021) is concerned with identifying the target terminology. As noted for this research two terminologies were identified – SNOMED CT and ICNP. The combination (of SNOMED CT and ICNP) were also used by other researchers (Block et al., 2021). The reference set being developed related to an adult oncology day care discharge. No current reference sets were found in either terminology.

6.7.2 Step 4

In step 4 by Block et al. (2021), the concepts the researchers identified were mapped to the terminology manually. Manual mapping was performed in this research for each terminology by the author and associated the expert. The total list (of knowledge submissions and accompanying rationale) was broken down into smaller sections for example 1-20, 21-40 and so forth and discussed at scheduled regular meetings. This was deemed appropriate to ensure that if there were any questions there was opportunity to check in. Step 4, in this research was further distilled into 4 sub-steps. These can be described as understand, explore, label and consensus. These are discussed below.

6.7.2.1 Step 4a: Understand

The first part of step 4 as performed in this research was concerned with ensuring a common understanding of the knowledge submission between the researcher and the terminology expert. Each evaluated submission was discussed between Group 1 (author and SNOMED CT expert) and separately Group 2 (author and ICNP expert) members to ensure there was a common understanding of the meaning of the submission. For example, the researcher was able to discuss how the submission "Talk about stopping smoking, if they smoke" [P3] was understood to mean that during discharge the nurse had the opportunity to discuss smoking cessation with their patient. This discussion included the health and financial benefits of quitting. The nurse also had access to patient information leaflets and support services depending on the patient's preferences. Although the author is a nurse, oncology was not an area they were familiar with. This understanding of the submissions was established during discussions with participants, the co-inquiry group and from the rationale provided during the game. This submission was matched to following codes: 771155005 Brief intervention for smoking cessation (procedure) (SNOMED CT) and 10050954 Promoting Smoking Cessation (ICNP). If further clarity of explanation was required the author brought queries back to the co-inquiry group and/or looked up relevant literature, policies, and guidelines. During this process the rationale collected from participants during the game cycles was invaluable as it provided context for the submissions.

6.7.2.2 Step 4b: Explore

In the second sub-step, explore, both the author and expert explored the terminologies independently and captured their findings onto a shared digital spreadsheet. To do this each member of the group reviewed the knowledge submissions and extracted the key concept(s). For example, the submission "Check blood glucose levels, if needed" [P8] included the concept of 'blood glucose levels' or 'diabetes'. Some submission contained more than one concept, for example, "Advise patient to call local pharmacy to confirm availability of any high-tech medicines well in advance" [P6]. The concepts identified included 'advise patient', 'advice', 'medication', 'contact/arrange', 'pharmacy' and 'prepare'. Using these key concepts, an initial search of both the SNOMED CT and ICNP browsers occurred. The 'browser' describes the digital interface that was used to access each terminology. Where a concept was not found in the terminology, synonyms were sought and the process of exploring the terminology was repeated for example for 'contact' a synonym could be 'communicate'. These synonyms were identified through discussions with a second researcher and the co-inquiry group or a review of the relevant literature.

Another technique used was the reviewing the description, parents, and children (of identified codes). For example, in the ICNP browser this additional information appears when the user clicks into the proposed code. See example for SNOMED CT code '1217280008 Prescription ordered by telephone (situation)' in Figure 21 and for ICNP code '10022983 Complex Medication Regime' see Figure 22.

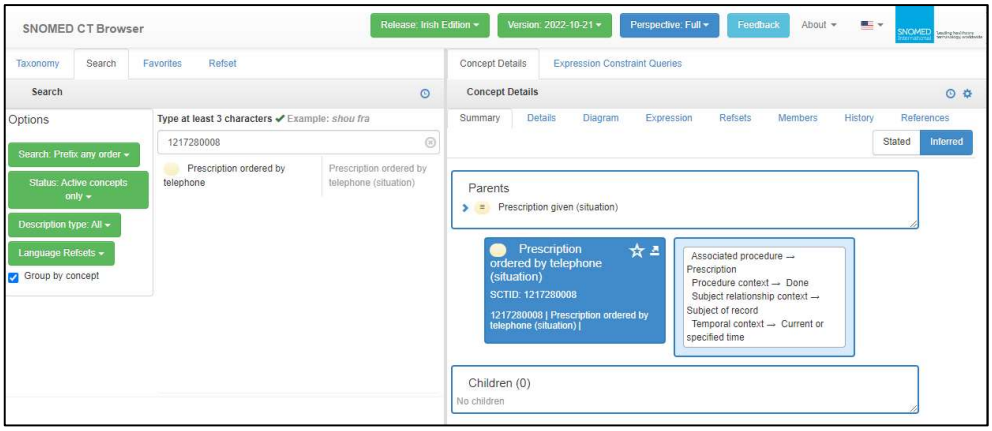


Figure 21 SNOMED CT browser

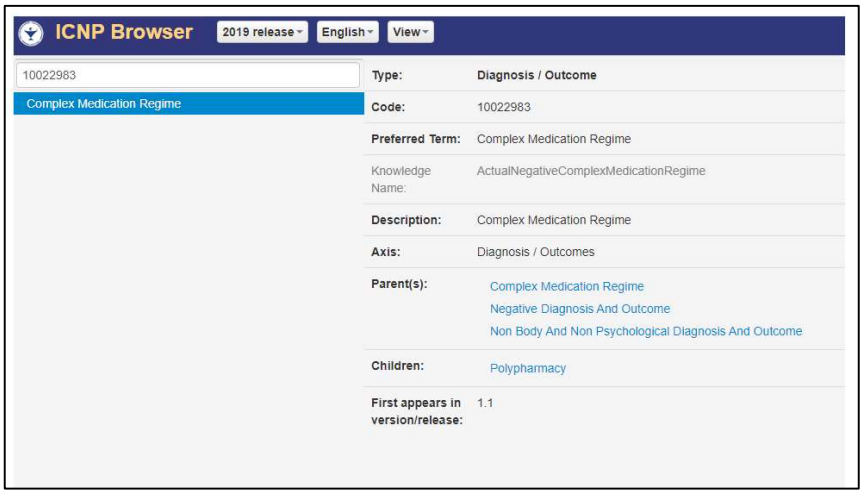


Figure 22 Code and additional information shown in the ICNP browser

6.7.2.3 Step 4c: Label

Following the explore process, two separate lists were constructed. One by the author and one by the expert. Each list contained the knowledge submissions, potential concepts and/or synonyms and the identified code (where one was found). Each list also identified if the code identified was deemed a 'match' or a 'near match' to the knowledge submission by the individual reviewer. In the case where a code was not identified, a 'no match' label was assigned. The terms 'match', 'near match', 'no match' were used by the SNOMED CT expert as part of their established mapping process. For continuity and to avoid terminology confusion they were used throughout the mapping process. They are described here in detail.

'Match' describes a scenario where a code assigned to the submission fully represents what the Holder had intended it to. In these cases, the knowledge prompt was deemed as represented in the clinical terminology. For example, the submission "Give patient the information leaflets such as 'Going home after chemotherapy leaflet'" [P2] was matched to the code 103313004 | Patient given information (contextual qualifier) (qualifier value) | (CHILD) Patient given written information (qualifier value)

'Near match' describes a scenario where some of the code assigned was relevant to the submission but ultimately did not represent exactly what the participant had intended it to. For example, the submission "Is there a Public Health Nurse (PHN) referral involved, should they be" [P2] was a near match to 306151002 |Referral to public health service (procedure)|373066001 |Yes (qualifier value), 373067005 | No (qualifier value)|. It was considered a near match as there was no reference to the role 'Public health nurse' in the clinical terminology.

'No match' describes a scenario where no appropriate code was found in the terminology for the submission. For example, no code for the prompt "Advise patient to call local pharmacy to confirm

availability of any high-tech medicines well in advance" [P6] was found. The nearest identified was 1217280008 |Prescription ordered by telephone (situation). This was deemed a 'no match' as the code, if included in a patient record would indicate that the event occurred (prescription ordered) rather than the patient was advised to do so. An example is provided in Table 29 of part of a knowledge submission list from an individual reviewer.

Table 29 Review knowledge submission list from individual reviewers

Knowledge submission	**Concepts and/or synonyms**	**Topic/Category**	**Proposed SNOMED CT Code**	**'match', 'near match', or 'no match'**	**Proposed ICNP Code**	**'match', 'near match', or 'no match'**
"Advise patient to call local pharmacy to confirm availability of any high-tech medicines well in advance" [P6].	'advise patient', 'advice', 'medication', 'contact/arrange', 'pharmacy' 'prepare' 'communicate'	Category: Medications Topic: Medication management	1217280008 |Prescription ordered by telephone (situation)|	Near match	10022983 Complex Medication Regime	No match
"Check blood glucose levels, if needed" [P8]	'blood glucose levels', 'diabetes'	Category: Nursing Assessment Topic: Activities of Living - Eating and Drinking	33747003 | Glucose measurement, blood (procedure) |	Match	10041212 Measuring Blood Glucose	Match

6.7.2.4 Step 4d: Consensus

This sub-step is concerned with building consensus among the two individual lists. This consensus building took the form of discussions during the regular meetings between the author and the

terminology expert. In the case of disagreements, the option to include or seek guidance from the Gatekeeper, as a subject expert was available but not required. The rational provided for some submissions elicited during the game was frequently accessed. Both to ensure the suitability of a code and to remind both the author and the expert of the initial context of the submission.

There was agreement on some findings, that is both reviewers mapped to the same code (or no code found) but not for all. This compare process was conducted over a number of sessions. The purpose of this was to reach a consensus. In the case of disputes, for instance, when the same prompt was not assigned the same code, group members returned to an earlier step of developing an understanding of the knowledge prompt. One example discussed was the prompt "Give education around sunbathing and wear a high factor every day when you are outside" [P4]. The word 'education' was highlighted by a group member for further discussion. Education was discussed as formal instruction by a group member. According to the players feedback that was presented by the other reviewer, 'education' in this instance did not refer to a formal process, rather it was more akin to giving the patient advice about sun care considering their treatment, health and disease status and any underlying co-morbidities, for example, if they had skin cancer. It was also discussed the assigning a task to nurse that they may not be what they were referring to could have legal implications at a future time. This was discussed with the subject expert linked to the study to ensure it was a true representation of what was discussed. It was noted that 'educate' did not always means the nurse has a formal education or training but could provide guidance based on their experience. In this instance, the appropriate code identified was 183079004 | Patient advised about exposure to the sun (situation). When agreement was reached and the knowledge prompt and assigned code were assigned a final 'Match', 'Near Match' and 'No Match' label.

6.7.3 Step 5

Following these sub-steps the process returned to the one described by Block et al. (2021). In their step 5, they describe the type of mapping used - pre-coordinated. A pre-coordinated mapping approach is where complex concepts are represented by a single code. Block et al. (2021) provide the example 'Local wound infection (source)' mapped to 'Local wound infection (target)'. In the work by Block et al. (2021) only complete concepts were used. In this research, not all nursing knowledge elicited (during the game) was capable of being represented by a single code. When this occurred, multiple concepts were grouped together to produce codes that represented the meaning of the knowledge prompt. This describes a post-coordinated mapping approach. Block et al. (2021) give the example 'wound' and 'local infection' as two concepts. Therefore, the outcomes of this research, resulted in both pre-coordinated and post-coordinated mappings (see Table 30).

Table 30 Examples of pre-coordinated and post-coordinated mapping

Mapping type	**Validated knowledge prompt**	**Terminology: SNOMED CT**	**Terminology: ICNP**
Pre-coordinated mapping	"Talk about stopping smoking, if they smoke" [P3]	(Match) 771155005 |Brief intervention for smoking cessation (procedure)|	(Match) 10050954 Promoting Smoking Cessation
Post-coordinated mapping	"Make sure to include any referrals sent or to be sent in the notes" [P5]	(Match) 385778002 | Nursing status report (procedure) | **AND** 721927009 | Referral note (record artifact) |	(Near Match) 10006173 Documenting AND 10016576 Referring

While only two approaches were discussed by Block et al. (2021), a third approach to grouping codes was also evident in this research that is not adequality described by either pre or post-coordinated mapping. This occurred when a submission could be coded using a single code but due to the meaning of the submission more than one code was suitable. For example, the knowledge prompt "Arrange interpreter before next appointment, if they need one" [P10] could be represented by the SNOMED CT codes 315594003 Interpreter needed (finding) or 736790000 Interpreter booked (finding) or 315593009 Need for interpreter (finding). Which code an end user would opt for is influenced by the specific patient needs. For this research, these were counted as a single code as only one would be used at a time.

There are benefits and limitations of both approaches. For example, post-coordinated mapping is more flexible and results in additional codes identified compared to a pre-coordinated approach. This has implications, however, for end users. In the case where a code is comprised of more than one part, the user has to capture both, and reporting of the data also has to include all the relevant codes. Focusing on the 'matched' group from both terminologies, Table 31 shows the breakdown between single codes and multiple codes.

Table 31 Breakdown between single codes and multiple codes

Terminology	Total 'Matches'	Single code	Two codes assigned	Three or more codes
SNOMED CT	67	50	13	4
ICNP	52	45	7	-

Using the examples discussed in the consensus sub-step, examples of outcomes are shown in Table 32.

Table 32 Examples of final agreement

Knowledge prompt	**Proposed SNOMED CT Code**	**'match', 'near match', or 'no match'**	**Proposed ICNP Code**	**'match', 'near match', or 'no match'**	**Final decision**
"Advise patient to call local pharmacy to confirm availability of any high-tech medicines well in advance" [P6].	1217280008 |Prescription ordered by telephone (situation)|	Near match	10022983 Complex Medication Regime	No match	**No match** as no code found explains that patient was to order their medication and the nurse was included in an advisory capacity.
"Check blood glucose levels, if needed" [P8]	33747003 | Glucose measurement, blood (procedure) |	Match	10041212 Measuring Blood Glucose	Match	**Match** as code deemed to represent the intention of the knowledge prompt.

6.7.4 Steps 6-9

Steps 6 and 7 of the process by Block et al. (2021) are concerned with mapping the previously identified concepts. For example, in Step 6, concepts identified by researchers in Block et al. (2021) were mapped to the target terminology. This was achieved by matching the position of the concept to where it appears in the terminology hierarchy. For step 7, Block et al. (2021) instigated a systematic search strategy. This is a five-step process used to identify exact concept. In this research, the evaluated submissions were used as the search terms. The rationale provided by Holders and Reviewers during gameplay, were used to give the submissions context. Additional

explanations if required were sought from the Gatekeeper, as a subject expert. In step 8, coders in the study by Block et al. (2021) were concerned with judging the appropriateness of each mapping (mapping cardinality). Block et al. (2021) provide four categories: 'Exact match', 'Narrower match', 'Broader match' and 'No match'. For this research the categories used were: 'Match', 'Near match' and 'No match'. These terms were initially assigned by the SNOMED CT expert involved in the mapping process. These terms were part of their established process that they used. As SNOMED CT was the first terminology mapped, it was deemed beneficial to maintain the same terms throughout. In the final step of the process by Block et al. 2021 (Step 9: Evaluation of mapping results) two researchers working independently up to this step, come together to compare their findings. This also occurred in this research when the two searchers conducted independently compared their outcomes.

Although sharing similarities, the steps 6-9 of the framework by Block et al. (2021) in this research were managed differently than the prescribed steps. In this research these steps were performed during the steps 4a-4d. Some of the differences include that unlike described in Block et al. (2021) step 6, the individual in this research did not map to the target terminology alone, rather it was a collaborative effort following individual review. This afforded the opportunity to discuss the identified codes before mapping began, to ensure the meaning of the submission was understood. Furthermore, Step 7 Block et al. (2021) identified codes by searching using the exact lexical arrangement. This was not always possible in this research as the submissions used in this research represented words and phrases used by the Holders and were not always presented in an easy to search format or could contain more than one possible code. For example, "Tell pt [patient] to monitor for any changes in appetite" [P6] could include refers to giving advice (Tell), or to observe (monitor), increase or decrease in normal appetite (changes in appetite) and also instructions on what to do if changes noted.

The final step described by Block et al. (2021) surround evaluation. In this research, the evaluation was consumed into the final sub-step (consensus). Evaluation was done through discussion with the co-inquiry group. Block et al. (2021) describe the principle of 'reflexivity toward group dynamic'. This is how individuals could forward decisions to the group on the understanding that 'others' have more experience than the individual. The researcher was aware of the halo effect. This describes how a single attribute of an individual can be used to form an overall impression of the person (Nisbett & Wilson, 1977). The term was coined 100 years ago by Thorndike (1920). As some members of the co-inquiry group were subject experts, there was potential for the halo effect. To try to minimise this, the co-inquiry group review (n=5) consisted of discussing the knowledge submissions with the rationale provided and along with the assigned codes to ensure suitability. No codes were changed following the co-inquiry review. Following the mapping process, the following codes emerged (see Table 33).

Table 33 Matches, near matches and no matches from SNOMED CT and ICNP

	SNOMED CT	ICNP
Match	67	52
Near Match	19	22
No Match	26	38
Total	112	112

An overview of how the framework described by Block et al. (2021) was applied in this research is shown in Table 34.

Table 34 How Block et al. 2021 was applied to this research

Proposed Step by Block et al. 2021	How step was performed in this research
1. Identification of source concepts	See preparing submissions for evaluation – Section 12.3
2. Conceptual model	
3. Scope of target terminology	Predetermined terminologies used based on national influence (SNOMED CT) and domain specific (ICNP). SNOMED CT had established processes for mapping to their terminology.
4. Mapping style	Sub-steps: Understand, Explore, Label and Consensus
5. Mapping coordination	Consumed into Step 4
6. Hierarchical mapping awareness	
7. Systematic search strategy	
8. Mapping cardinality	
9. Evaluation of mapping results	Outputs from step 4 discussed between author, terminology expert and co-inquiry group.

6.8 Data reference set artefact

This data reference set artefact is a contribution of this research and relates to objective number 4. The elicited knowledge submissions were also evaluated as part of the game before a final evaluation was performed by a subject expert. These validated knowledge submissions (n=112) were then coded using a clinical terminology. Two terminologies were used. The first, Systematized Nomenclature of Medicine--Clinical Terms (SNOMED CT), was chosen as it was a nationally recommended terminology (HIQA, 2013). The second, the International Classification for Nursing Practice (ICNP), was chosen as it was a nursing specific, is represented

in SNOMED CT but is also available to nursing groups free of charge. Following this coding the 'Matches' group from SNOMED CT (n=67) were submitted to SNOMED CT. This was published in October 2022 in the form of a refset for an 'Adult oncology daycare nursing discharge reference set Ireland' (SNOMED CT refset ID 134791000220109). This refset contains 107 concepts and is considered the data reference set artefact. The difference between the number of Matches (n=67) and SNOMED CT concepts (n=107) occurred as not all matches were represented by a single concept. For instance, the validated knowledge submission "Arrange interpreter before next appointment, if they need one" [P10] was assigned three concepts. These were: 315594003 Interpreter needed (finding), 736790000 Interpreter booked (finding) and 315593009 Need for interpreter (finding). As discussed not all validated knowledge was capable of being coded. Work is ongoing to review the near matches and no matches with both terminologies but is considered beyond the scope of this research. The purpose of the game was to demonstrate that knowledge could be elicited through play, the purpose of coding this knowledge was to demonstrate that it could be preserved beyond geography and time. Only submissions deemed 'Match' were included in the data reference set. Work in underway to continue to include 'Near matches' and 'No matches' in future work.

6.9 Discussion

To move from elicited and evaluated knowledge into a format capable of being shared, that is as a coded data reference set, knowledge needs to be mapped to a clinical terminology. However, not all knowledge elicited was capable of being represented in either standardized terminology used as suitable matches were not always found. Focusing on SNOMED CT the matches identified following the mapping process were developed into a refset for an 'Adult oncology daycare nursing discharge reference set Ireland' (SNOMED CT refset ID 134791000220109). This refset contains n=107 concepts. This demonstrates that nursing knowledge can be capable of being shared to some degree. The degree to which this sharing is facilitated beyond time and geography is reliant on standardized terminologies representing nurses work.

To ensure the mapping process was robust and submissions that could not be assigned a code were a true reflection of an absent code and not merely a code not found, a process to guide the mapping process was sought. Any process found, however, needed to be mindful that it needed to be capable of being used within any established processes that were currently in use by the terminology expert. While a framework was identified by Block et al. 2021). This describes the process from start (concept identified) to final review. The main limitation with this framework was that it included skills, such as the development of conceptual models, that may not be readily available in the clinical setting. While not a critique of their framework, this research wanted to

explore how a serious game and subsequent mapping process could be sustained using skills typically found in the clinical area.

It must be considered, however, that the inclusion of a terminology expert in this research could impact the any findings. As a result, the contribution, the mapping process comprising of four actions – understand, explore, label and consensus - should be further tested. Mapping processes are complex, and the addition of the terminology expert was valuable for many aspects including navigating the browser. However, to ensure best fit submissions needed to be interpreted. For example, some submissions included the word ‘advice’ or ‘education’. Therefore, while mapping is a technical act, there is also a creative process. As owners of the knowledge, nurses were best positioned to provide clarity and explanations for the prompts. This clarity was provided in the form of rationale collected during the game, but also submissions were discussed with the co-inquiry group all the way through the research. This extended the mapping time. The total time spent on mapping processes in this research including the initial learning that occurred to the final outcome was approximately 5 months. It also allowed the researcher to ensure the sentiment or meaning of the prompt.

From the research, an additional role of a Knowledge Mapper was identified that should be included in the game. It is proposed that this role is responsible for mapping evaluated knowledge into a clinical terminology so that it can be preserved and shared beyond the game. In the absence of an informatics skills in any game team, it was envisioned that providing a mapping process, could promote the sustainability of the game beyond research. To that end, the process used in this thesis is presented here as a design knowledge contribution. Additional studies should be performed to ensure its suitability. A full account of the roles and actors are provided in Appendix G.

The results from this mapping process demonstrate two main findings. Firstly, that knowledge can potentially be preserved beyond its use when incorporated into a standardized terminology. This can be shared beyond time and geography. This is particularly useful considering the study site is a specialist oncology site. It is envisioned that this refset could be useful to nurses who are charged with caring for oncology patients away from the specialist sites, for example, in the community setting. Such a refset may not provide the full knowledge required to perform a discharge (to the same level) but could help a novice nurse manage the care of the patient by providing a list of questions or considerations that arise during discharge. Secondly, not all nursing knowledge was present in the terminologies. This occurred for two reasons, either a suitable code was not identified in the current terminology, or the type of knowledge was not represented in a patient record. The latter describes nursing actions, for example, "Ring CIT to make sure they receive referral." [P5] or "Write up note and mention cycle and day [in nursing notes]" [P8]. These were

recorded as nurse-to-nurse advice. While this was important knowledge to share, they were difficult to code. Some nurse-to-nurse advice was given a code. For example, "Use the teach-back method to get an understanding of how much the patient took in" [P9] was given the SNOMED code 311401005 | Patient education (procedure). Missing codes have implications for nursing, as it could mean that all tasks completed by nurses may not be represented digitally. Overall, absent, or missing codes was evident in both the SNOMED CT terminology and the nursing specific ICNP. With matches noted in n=67 and n=52 respectively. However, ICNP had a higher number of 'no match' candidates (n=38) compared to (n=26) in SNOMED CT.

6.10 Conclusion

In this chapter how the reviewed knowledge submissions from the three previous implementation cycles were further evaluated and mapped to two terminologies – SNOMED CT and ICNP. While there are a number of terminologies available these were chosen as SNOMED CT is being adopted at a national level and ICNP provided a more granular account as it was a nursing specific terminology. The purpose of mapping the validated knowledge was not to identify a terminology that was superior. Rather the purpose was to demonstrate that elicited knowledge elicited via a serious game could be mapped to a terminology so that it could be preserved beyond its initial use. To that end, this was demonstrated in the development of a refset for an 'Adult oncology daycare nursing discharge reference set Ireland' (SNOMED CT refset ID 134791000220109). This refset contains n=107 concepts. These were drawn from the 67 'matched' SNOMED CT codes. The discrepancy between the numbers is accounted for as not all codes were represented by a single concept. For example, the validated knowledge submission "Arrange interpreter before next appointment, if they need one" [P10] was assigned three concepts. These were: 315594003 Interpreter needed (finding), 736790000 Interpreter booked (finding) and 315593009 Need for interpreter (finding). While this represents that nursing knowledge can be shared beyond its initial use, it also demonstrates not all nursing knowledge generated (but potentially used at the study site) was represented in either terminology used. While future work will include extending the refset (for SNOMED CT) by including codes deemed 'near match' and 'no match'. This is beyond the scope of the current study.

7 Contribution 3: How eADR was applied in this research

This chapter presents the final contribution arising from this thesis. This is a discussion on the learning that emerged using the eADR approach in this research. Learnings are described under each stage of the eADR performed and presented as a list at the end of the chapter. It is envisioned that these learnings, and subsequent list, could be useful for future researchers considering adopting an eADR approach.

7.1 Introduction

Reflection was a continuous process throughout the design stages undertaken. Learning that occurred was incorporated, where appropriate, into the design artefacts (updated problem statement and updated use case model). This section discussed the design stage reflection. The stage reflection is concerned with understanding the application of the eADR approach in this research for both design cycles conducted. The first design cycle is discussed in Chapter 4 and Appendix C. In total three events were reflected upon during the two design cycles. No limit on the number of reflections per stage or cycle was stated. Instead, the author and supervisor identified the lessons that they deemed could be useful to future research considering adopting an eADR approach.

Central to design science methodology is that research produces a relevant artefact (design) but also knowledge (Hevner et al., 2004). Design knowledge in the eADR approach is embedded in the designed artefact and is identified during design, implementation, and evaluation. However, capturing the lessons learned related to design theory are less visible in the process. This point has been raised by Mullarkey and Hevner (2019) who discussed that future development of action design research (ADR), including eADR should be toward including theory development explicitly in the approach. In addition, Mullarkey and Hevner (2019), noted that the utility of the eADR approach such be reviewed in domains such as healthcare. As this research was based in a healthcare, it offered the opportunity to consider the application of an eADR approach in this domain. This chapter discusses this application.

In this research, an additional reflection was conducted at the completion of each eADR stage. This stage reflection was an opportunity to consider the application of the approach throughout the research process. The stage reflections were conducted by discussions between the author and their supervisor, deliberately considering how the approach was applied during each stage. A framework was used to structure the discussion and guide the reflection (Rolfe, 1997).

Reflection was identified as one of the five prescribed eADR activities by Mullarkey and Hevner (2019). To distinguish between the two, the proposed reflection is referred to as a Stage Reflection. While the reflection activities are concerned with understanding the artefact. Stage reflection was performed as an additional 6th activity to understand the application of the eADR approach. While it is considered that both reflections could be represented by a single 'reflection' activity. Presenting as two distinct reflections supports that they have two different focuses.

Learnings from these stage reflections are presented as a discussion in this chapter using the stage headings performed – diagnosis, design and implementation – to structure the discussion (see Section 7.3, 7.4, 7.5 respectively). For balance, the limitations of reflection are discussed (see Section 7.6). The chapter concludes with a list of considerations for future researchers contemplating eADR as a research approach (see Section 7.7). These considerations are drawn from the stage reflections.

7.2 Reflection

Reflection as an activity was proposed by Mullarkey and Hevner (2019). While no guidance was given by Mullarkey and Hevner (2019) on how to perform the reflection activity, reflective practice is common in nursing (Patel & Metersky, 2022). In addition, as the participants in this study are from nursing domain including the author of this thesis, the discussion presented here will draw predominantly, but not exclusively, from the nursing literature on reflection.

Schön (1991) purports that through their academic and practical experiences professionals embody technical, scientific knowledge. Professionals can apply this 'technical rationality' to their decision making and problem solving. However, Schön (1991) notes that a focus on the technical or scientific does not present the whole picture as it does not account for the art or artistry displayed by professionals. Therefore, while some problems are capable of being managed by this technical or scientific knowledge, other problems professionals face, according to Schön (1991) live in a 'swampy lowland'. These problems are, according to Schön (1991), "confusing 'messes' incapable of technical solution' and require professionals to iteratively test solutions, reflect on their actions or outcomes and learning from each attempt.

There are many descriptions of what reflection is. For instance, in the context of nursing Pierson (1998) describes it as fostering 'critical and innovative thinking' (Pierson, 1998, p. 165) whereas Jarvis (1992) notes that reflection is the"… process of turning thoughtful practice into a potential learning situation" (Jarvis, 1992, p. 178). Whereas, not specific to nursing Boyd and Fales (1983) note that reflective learning is, "the process of internally examining and exploring an issue of concern" (Boyd and Fales, 1983, p. 100). Dewey (1933) presents a more straightforward account of reflection by linking it to thinking.

Schön (1991) describes two components to reflective practice. These are 'reflection in action' and 'reflection on action'. The main difference between the two concepts is the distance in time between an event occurring and the reflection and type of knowledge applied. For instance, 'reflection in action' occurs when an individual considers an event as it is happening and draws on the individuals 'feel' of the situation or their tacit knowledge. Schön (1991) presents the example of jazz musicians who improvise their play based on their own feedback during their performance. Greenwood (1993) describes reflection-in-action as 'reshaping what one is doing while one is doing it' (Greenwood, 1993, p. 2001). Whereas 'reflection on action' describes how an individual reviews a previous experience. This involves the individual re-evaluating their understanding of previous event to extract learning. Greenwood (1993) describes this re-evaluation as a 'cognitive post-mortem'. Both components of reflective practice aim to uncover insight from the event so that learning can emerge (Schön, 1991).

In addition to the reflection activity proposed by Mullarkey and Hevner (2019) performed during each eADR to extract learning that could be incorporated into the artefact. In this research, a second reflective activity was also performed. This second reflection was focused solely on the application of eADR in this research and was performed upon completion of each stage. To distinguish between the two reflections that were performed, the proposed second is referred to as 'Stage Reflection' in this research. This stage reflection took the form of discussions between the author of the thesis and their supervisor. During these discussions events that occurred during the eADR stage that were explored. There were no explicit criteria as to what could be considered an event. As a result, the research did not limit the number of events that could be included in the stage reflections. Instead, the author was free to discuss any event they felt was important during any specific stage. This could have resulted in a high number of reflections. While this was not the case in this research, as 9 events were reflected upon, future research should consider specific criteria.

To structure the reflection, the framework by Rolfe et al. (2001) was used. This framework was chosen as it was used by the author in their own nursing practice. The framework is concise and consists of three key questions – What?, So What? and Now What?. A benefit of this model is that each question is not presented once. Instead, following an initial question, for example 'What happened?' the individual follows up with additional questions starting with the same key question. In the case of 'What happened?' the next question would also start with 'What'. This could be 'What did you want to accomplish?' The purpose of these follow-up questions is to support the individual to consider the event or experience from multiple perspectives. The framework does not prescribe the follow-up questions. For this research, the author used to key question to start the discussion. No record was maintained of the follow-up question. The purpose of each key question and the initial question is shown in Table 35.

Table 35 Rolfe et al. (2001) Model of Reflection – three key questions

Question	Purpose	Question
What	This question prompts the individual to consider an event or experience in order to examine their understanding of it.	What happened during the stage that was not expected, slowed or expedited progress through the stage?
So What	The second question prompts the individual to consider the event or experience in order to generate additional information and insights. These could include how was impacted or the repercussions of an event or experience.	So what was the event/experience important to consider or what where the implications of what happened?
Now What	Using the insights and information generated in the previous questions, the final key question prompts the user to	Now what should happen in future to avoid/benefit from this experience or event?

The side-by-side reflection, that is the eADR reflection activity and stage reflection, proposed in this research is not unheard of. In the book 'Doing Action Research in your own Organisation', Coghlan (2019) describes projects conducted for an academic qualification, may have two concurrent action research cycles. One cycle is concerned with achieving the project aims. Zuber-Skerritt and Perry (2002) describe this cycle as Core Action Research and is focused on the thesis research. They describe how in academic projects a simultaneous cycle is concerned with thesis writing and includes reflecting on the whole research process (Zuber-Skerritt & Perry, 2002). This research adopted a similar perspective of dual processes. One set of actions focused on the performing the eADR stages and activities as described by Mullarkey and Hevner (2019). Using the term introduced by Zuber-Skerritt and Perry (2002) this research refers to these as 'Core actions'. In parallel, a set of actions focused on reflecting on the theory. In this research, collectively these are referred to as 'Reflective actions'. These actions encompass the stage reflections and subsequent additional stage (Reflection upon eADR). A benefit of presenting these as distinct sets of actions is that it allows researchers to focus on one or both, depending on the needs of their respective research projects. These processes are shown in Figure 23.

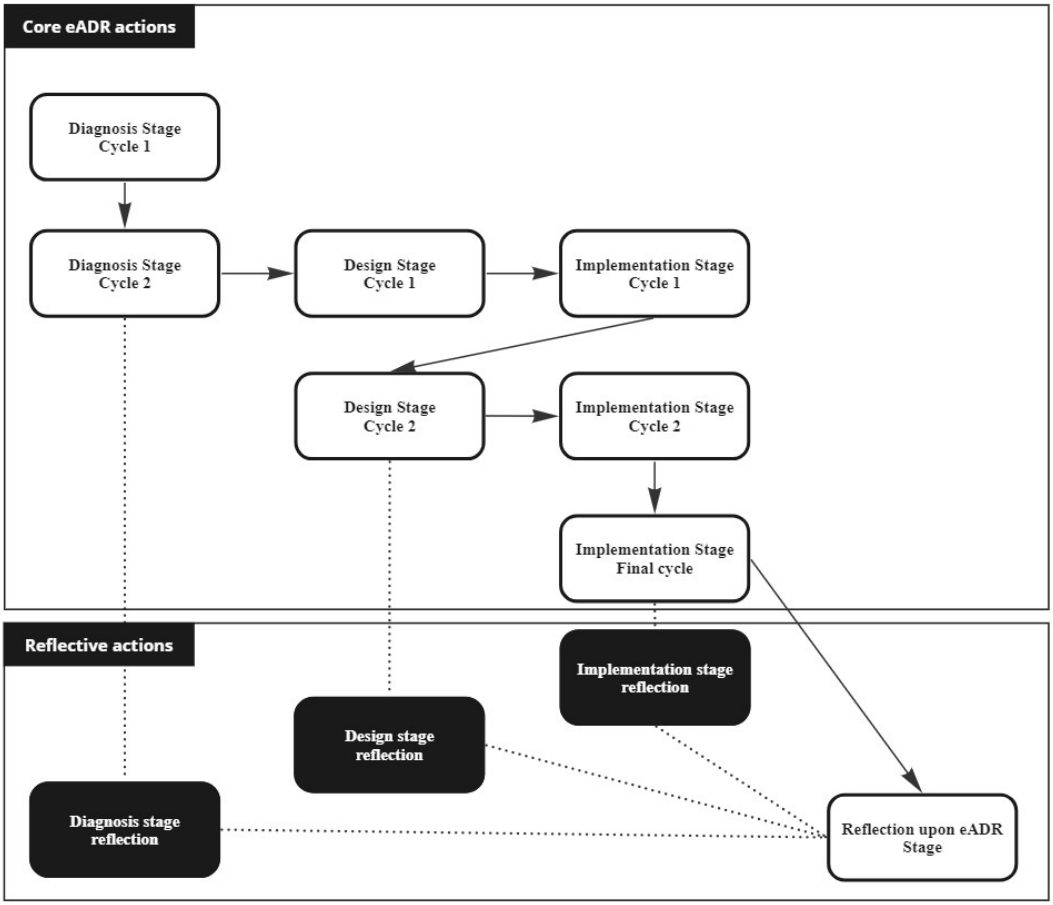


Figure 23 Core eADR actions and proposed reflective actions performed in this research

The following text explores the stage reflections using the eADR stages performed – diagnosis, design and implementation – to structure the discussion. Each reflection is discussed, and the lesson(s) learned in this research is formulised into a list of potential consideration for future researchers.

7.3 Stage reflection – Diagnosis

The purpose of the Diagnosis stage is to understand the problem with a view to identifying a potential solution (Mullarkey & Hevner, 2019). In this research, two diagnosis cycles were performed, and two events emerged that were reflected upon. These were:

- the importance of ensuring the problem addressed was relevant to the study site
- time challenges faced by potential participants in this research

The text in this section presents the reflection for the two cycles of the diagnosis stage. Reflections from each stage is presented in Appendix E. Each reflection ends with the lesson learned formulised into a consideration for future researchers.

7.3.1 Monitoring relevancy of problem

In relation to the first event, the learning that emerged surrounded the importance of ensuring challenges were relevant to the study site. While challenges to eliciting knowledge are evident in the wider literature, healthcare sites are unique. Therefore, evaluating challenges with the study site was important. This was evident by the addition of a further challenge, personal knowledge management systems, identified by the study site. The is addressed in the action design research (ADR) principle (practice-inspired) by Sein et al. (2011). This principle notes that research should be practice-inspired to ensure both the problem and solution are relevant to the study environment.

Consideration 1: Challenges could evolve over the course of the research and, therefore, review their understanding of the problem throughout the process.

7.3.2 Participant time commitment

Although prompted by different events, the second reflection in this stage has implications for the first consideration as it surrounds the challenges faced by potential participants in this research. The main challenge being the time commitment required by participants to take part in research. This is linked to the action research (AR) component of the eADR approach. AR employs participants from the study site as co-creators in the research. It was discussed during this diagnosis cycle, the number of meetings required to discuss aspects of the research and how this could be managed to accommodate participants working in a busy clinical environment. Capturing participants perspective is vital but can delay progress if participants are on different shifts or too busy to attend meetings. Rather than seek a different domain, where there may also be time pressures, this research took the opportunity to explore the challenges working in the healthcare domain in terms of participant requirements and impact on outcomes.

To addresses potential participation issues, where necessary meetings could be rescheduled. It was proposed that if no suitable date was found smaller groups could be accommodated and missing members updated in person or by email. Updating individual members could have implications if a member disagreed with an outcome so was only offered to update members on research progress or next steps. As the researcher was based close to the study site, meetings could also be arranged last minute to suit members. While this meant there was some down time where the author of the

thesis was waiting to see if a meeting could go ahead, this approach was deemed most suitable to the study site participants.

This time commitment was further exacerbated as each cycle included an evaluation activity. Continuous evaluation is a feature of an eADR approach (Mullarkey & Hevner, 2019). This continuous evaluation ensured the artefact created is relevant and helped identify problems at the earliest point. A difficulty encountered in this cycle, however, was the number of participants required for all the aspects of the study could be difficult to attain. For instance, participants were needed to be part of the co-inquiry group, engage in the game, evaluate the knowledge. While not occurring in this stage, but included here as it illustrates the problem, no participants were available to take part in a pilot study for the first iteration of the evaluation game (see Chapter 8). It was discussed that the research could stall if it was to wait for additional participants to engage in a pilot study. This had not only time implications, but as a specialist clinical area, there was a limit on the number of participants available. A decision was taken to move the design into implementation but use the problem formulation activity to highlight that this was an untested design. This limitation is linked to the second diagnosis reflection which surrounded the time required for participation. While the eADR approach does not dictate that different participants are required for all activities. It was deemed prudent to use different cohorts where possible to avoid a scenario where the same group that was engaged in the pilot could also be engaged in the implementation to get an unbiased response. It was discussed that due to the busyness of the clinical environment, low participant numbers could be a reoccurring issue. In fact, the busyness of the clinical environment was identified as a challenge to eliciting nursing knowledge during the domain analysis. For one of the games only two participants attended. A decision was made to proceed with the research as any solution identified would have to work even if nurses were too busy to engage with it in great numbers.

Consideration 2: High numbers of participants may not be able to engage in all parts of the process due to the busyness of the clinical environment.

7.4 Stage reflection - Design

The design stage is objective-centred and concerned with exploring solutions (Mullarkey & Hevner, 2019). In this research, non-sequential two design cycles were performed. Instead, between the first and second cycle, an implementation cycle was performed. From the two design cycles, three events emerged that were reflected upon. These were:

- Incorporating additional methods also introduced additional challenges
- The flexibility of the eADR has implications for structuring and readability of the final thesis

- Variety of expertise required

The text in this section presents the reflection for the two cycles of the design stage. Reflections from each stage is presented in Appendix E.

7.4.1 Introducing new challenges

Following the initial design cycle, the 'What' event that emerged for reflection surrounded how incorporating new methods could potentially introduce new challenges. This was evident in the adoption of the WICKED method (Impey et al., 2023) as a starting point for game design. While the method provided components and roles that could be adapted into a game, it was not without its limitations. These limitations are described in detail in Chapter 6, Section 6.3. It was important to update previously developed artefacts to include these limitations so that they fully represent the known challenges. Updating artefacts if additional methods incorporated introduce new limitations or challenges means that the research process is forward and backward moving. This forward and backward momentum in line with the eADR approach (Mullarkey & Hevner, 2019).

Consideration 3: If incorporating additional methods, researchers should consider that this could also introduce additional challenges that the solution needs to address.

7.4.2 Presenting the research findings

From the second design cycle surrounds two events were identified during reflection. These are presenting the research findings and variety of expertise required. Regarding the first reflection, this was introduced by the non-sequential movement throughout the eADR. While traditional information system development approaches, such as the Waterfall method, are top-town, sequential approaches (Bell & Thayer, 1976; Boehm, 1976; Royce, 1987). Traditional waterfall methods propose a forward motion where all user requirements are gathered at the beginning of the research. A difficulty is that not all requirements may be identified early in the research. This was the case with the evaluation part of the game. Moving back and forth through the eADR cycles as required by the research allowed the research to respond to feedback. While this was beneficial, it could also present difficulties for navigating the final thesis. A decision was made to present each stage or cycle in the order they were conducted. This would give the reader a true account of the trajectory of the research.

Consideration 4: The non-sequential movement through the eADR approach, benefits research but can be challenging to present findings.

7.4.3 Variety of skills required

The second reflection surrounds the variety of skills required by this research. It was identified early in the research that the following skills would be required: clinical subject experts, health informatics, and nursing educators. The clinical subject experts would bring domain knowledge and could be used in the elicitation and evaluation. Health informatics was required as the research aimed to manage nursing knowledge digitally. The nurse educators brought expertise on how nurses acquire their clinical skills and knowledge. The author also had a design background so could apply these skills in this thesis. However, other expertise was required during the research. These include clinical terminologies and serious games. This reflection is not limited to the eADR research, rather it is a general comment on research. However, as eADR aims to produce a design artefact and design knowledge, this could be more challenging.

Consideration 5: All research requires a variety of skills, as eADR aims to design, implement, and evaluate a design artefact along with design knowledge, identifying the required skills could be more challenging.

7.5 Stage reflection - Implementation

The purpose of this implementation cycle was to evaluate the game design at the study site to identify what worked and what changes may be required. In this research, three implementation cycles were performed. From these cycles four events emerged that were reflected upon. These were:

- Extending the scope of the initial game
- Stopping the research
- Moving towards a digital format of the low-fidelity serious knowledge elicitation and evaluation game

The text in this section presents the reflection for the three cycles of the implementation stage. For a full account of the implementation cycles, see Chapters 7, 9 and 10. Each reflection ends with the lesson learned formulised into a consideration for future researchers. Through engaging in the game, knowledge was elicited from Holders. This knowledge was prepared and collated into a digital spreadsheet by the author and Gatekeeper and an evaluation process was performed and reviewed. This preparation process is described in Appendix F. The main events that were reflected on during the implementation cycles surround extending the scope of the game artefact based on participant feedback, stopping the research, and moving towards a digital format.

7.5.1 Scope of artefact

The first reflection was initiated by feedback from the Reviewers group in the first implementation cycle. During the group discussion, participants described the evaluation process was challenging. This was due to the number of knowledge submissions and repetitious nature of the task. As the evaluation task was voluntary, enjoyment of the task was important to encourage engagement. A decision was taken to extend the scope of the initial elicitation game to include evaluation process as part of the game. This changed the initial knowledge elicitation game to a knowledge elicitation and evaluation game. The main learning that as feedback emerges the initial scope of the artefact could evolve. In the initial design cycle, only the group considered to be 'players', where considered in the design of the game. This occurred as this group were required to be involved for the game to produce knowledge during the diagnosis stage. However, implementation feedback extended game, and lead the evaluation process to be gamified. Feedback following the implementation of the evaluation part of the game was positive.

Consideration 6: As feedback emerges, the initial scope of the artefact could evolve over the course of the research

7.5.2 Stopping rule

The second reflection addresses a known characteristic of wicked problems (Churchman, 1967). That is wicked problems have no stopping rule. While three implementation cycles were performed, it was difficult to know when to stop engaging participants in the game to stop eliciting or evaluating knowledge. Data saturation was proposed as a heuristic to stop collecting knowledge. In practice, it is unclear if knowledge could ever be considered as fully captured due to the evolution of knowledge. Furthermore, due to the busyness of the healthcare environment, researchers need to balance the needs of the research with the availability of the site. Future researchers should consider that as knowledge is ever evolving, it should be considered that collection is never fully complete. Rather than data saturation, data collection could be more so impacted by the availability of the study site and participant interest.

Consideration 7: As there are no specific triggers to stop knowledge elicitation or to signal the research to stop, consider that measures could be incorporated into future research.

7.5.3 Towards a digital artefact

A third reflection surrounded moving from a low-fidelity prototype to a digital platform. A low-fidelity prototype (paper-based) for a scenario-based game was designed, implemented, and

evaluated in this research. However, initially digital platforms were considered as a potential solution. The main these were considered was that they could capture and store knowledge in a digital format. However, from the first exploratory study (see Chapter 3, Section 3.6) participants (n=15) described how they did not engage in online knowledge sharing for several personal reasons, including lack of knowledge of the technological platform or knowledge topic, fear of professional repercussions or preference for face-to-face knowledge sharing. Participants that did engage in online knowledge sharing (n=2) noted it was through a closed-community and that they had prior professional relationships with other members (of the community). Furthermore, no method of digitally eliciting knowledge identified in the literature was deemed to be superior and barriers were identified (Impey et al., 2023). As no digital knowledge elicitation approach was deemed superior and challenges emerged related to online knowledge sharing, a low-fidelity prototype of a serious knowledge elicitation and evaluation game was developed and evaluated in this research. Using a low-fidelity prototype allowed the research to test the extent to which a serious game could be used in managing nursing knowledge. It is envisioned that learning from the development and evaluation process could be useful in the design and development of a digital version of the game. While digital game is beyond the scope of this work, the research was conceived as a first step towards a digital game.

Consideration 8: The evolution of the artefact may not be limited to the current research project. This research did provide a way to test the solution in a low-fidelity prototype while identify learning that could be incorporated into a digital version.

7.5.4 Stage reflection - Evolution

While not originating in a specific stage, a fourth reflection presented in this chapter surrounds the Evolution stage of the eADR. The Evolution stage is observation-centered and surrounds monitoring any changes to the problem environment and considering how subsequent designs could evolve to meet these changes (Mullarkey & Hevner, 2019). This stage was not performed in this research due to time constraints. However, during the final implementation stage the problem statements were reviewed to ensure they were still relevant. No additional statements were identified, or none were removed. For future researchers, the Evolution stage would provide a space to explore the socio-technical challenges in the problem environment and over time.

7.5.5 Socio-technical challenges

Socio-technical challenges identified in the first exploratory study (see Chapter 3, Section 3.6) included lack of knowledge of the technological platform or knowledge topic, fear of professional

repercussions or preference for face-to-face knowledge sharing limited engaging in online knowledge sharing. These were represented in the third challenge (socio-technical challenges). This challenge was transferred into the problem statement (3) 'The solution should address the socio-technical challenges identified'. In Appendix C, Section 1.2, the final n=10 problem statements were further categorised as (1) related to domain (nursing in a specialist area), (2) related to specialist knowledge or (3) potential Unintended Consequences (PUC). Socio-technical issues were categorised as PUC. Unintended consequences describe outcomes of adoption that are neither predicted, nor anticipated but are a direct result of a change (Merton, 1936). In "The Unanticipated Consequences of Purposive Social Action" Merton (1936) referred to these as unanticipated consequences, however, they have come to be widely known as unintended consequences. Therefore, this research is unable to fully explore potential socio-technical impact of the game in context. Only address the socio-technical issues known previously from earlier research. Performing an evolution stage is highlighted as an area for future research.

Consideration 9: The extent of any potential socio-technical implications of adoption may only be fully realised over time the extent of the solution over time.

7.6 Limitations of reflection

While there are many purposed benefits of reflection, such as, it can help an individual make explicit the learning that occurred during an event (Greenwood, 1993; Schön, 1991). Or in this research, it provided a space where learning related to the application of eADR could be identified and discussed and be formulised into lessons learned. This was a different space from the intervention activities that included a reflection but were focused on artefact development and evaluation. There are also limitations. For instance, Greenwood (1993) discusses how reflection-on-action should be conducted immediately after the event. This should occur with practitioners understand the type of event and the domain so that they can reflect with the individual to help them make sense of the event. Reflections are also personal. In qualitative research, the inclusion of an experienced practioner can also help identify any unconscious bias the individual may hold about the event (Buetow, 2019). In this research, both the author and their supervisor have experience in health informatics. However, the inclusion of an additional practitioner could be problematic for some researchers. Firstly, not all researchers may have a second individual with whom they conduct their research. Secondly, if they do, this second person may not be familiar with both the domain and the research approach.

7.7 Considerations for future researchers

The main contribution described in this chapter is the proposal to include a second stage reflection and the fifth eADR stage. The lessons learned during these reflections are presented in Table 36. It is proposed that these could be useful to future researchers considering an eADR approach to review. No further conclusions can be reached as to their usefulness without further studies.

Table 36 Considerations identified from stage reflections

Stage	**Potential considerations for future researchers**
Diagnosis	Consideration 1: Challenges could evolve over the course of the research and, review their understanding of the problem throughout the process.
	Consideration 2: High numbers of participants may not be able to engage in all parts of the process due to the busyness of the clinical environment.
Design	Consideration 3: If incorporating additional methods, researchers should consider that this could also introduce additional challenges that the solution needs to address.
	Consideration 4: The non-sequential movement through the eADR approach, benefits research but can be challenging to present findings.
	Consideration 5: All research requires a variety of skills, as eADR aims to design, implement, and evaluate a design artefact along with design knowledge, identifying the required skills could be more challenging.
Implementation	Consideration 6: As feedback emerges, the initial scope of the artefact could evolve over the course of the research
	Consideration 7: As there are no specific triggers to stop knowledge elicitation or to signal the research to stop, consider that measures could be incorporated into future research.
	Consideration 8: The evolution of the artefact may not be limited to the current research project. This research did provide a way to test the solution in a low-fidelity prototype while identify learning that could be incorporated into a digital version.
Evolution	Consideration 9: The extent of any potential socio-technical implications of adoption may only be fully realised over time the extent of the solution over time.

7.8 Conclusion

In this chapter, the proposed reflection on eADR stage was described. It is proposed that in future research projects based in an academic setting, this additional stage is performed concurrently to the core eADR activities described by Mullarkey and Hevner (2019). This stage is allowed the author to present a discussion on the application of eADR. The content for this stage, emerged from an additional reflection activity performed at the end of each eADR stage. Hence, they were referred to as stage reflections. These reflections were performed through discussions between the author and their supervisor. It is proposed that this additional stage could be useful for academic researchers considering adopting an eADR approach. The purpose of the core eADR stages and activities surround the design, implement and evaluation of the artefact. The purpose of this proposed stage was to offer researchers interested in theory development an explicit route to identifying learning related to the application of the eADR approach and place in the thesis to formulise the lessons into a set of considerations for future serious knowledge game designers. This dual reflection activities has been discussed by other authors in relation to action research (Coghlan, 2019; Zuber-Skerritt & Perry, 2002). Using the four eADR stages as a structure, the chapter describes the associated stage reflections in detail. To present a complete discussion, the limitation of reflective practice is included in this chapter. The main limitations, as it applied to this research surrounded the addition of a second individual that could review the reflections. This individual would need to be familiar with both the research approach and the domain.

8 Conclusion

In this concluding chapter, an overview of the research is presented along with a discussion surrounding the extent to which the six research objectives were achieved. Suggested future work and final remarks conclude the chapter.

8.1 Introduction

The problem being addressed by this research is that not all nursing knowledge is captured in a way that is easy to access outside the border of a community of practice (CoP), or beyond geography or time. The first step in this research was to gain an understanding of the challenges surrounding eliciting knowledge. To do this, two exploratory studies were undertaken. This was discussed in Chapter 3, Section 3.6. While no approach to eliciting knowledge digitally was found that was suitable, the concept of serious games as knowledge management tool was discussed in some papers, see Chapter 4. Serious games have been used in nursing, but this was primarily around education and training. The aim of this research, therefore, was to understand to what extent a serious game designed for this research, could elicit specialist nursing knowledge so that it could be preserved and shared mindful of geography and time. This was developed into the research question: "To what extent can a serious game elicit and evaluate specialist nursing knowledge and preserve this knowledge so that it can be shared outside the community of practice (CoP), beyond time and geography, mindful of known challenges?". This question was distilled into six research objectives. These are discussed in Section 8.2 in this chapter.

To achieve these objectives, the research adopted an elaborated action design research (eADR) approach by Mullarkey and Hevner (2019) to design, implement and evaluate a serious game. Three types of contributions arise from this research. These are design contributions – a serious game and data reference set. Lessons learned that are embedded in the artefacts are presented are knowledge contributions. These are a list of problem statements to eliciting nursing knowledge and a process describing mapping evaluated knowledge to a clinical terminology. There is also a theory contribution which is presented as a discussion on the application of eADR in this research. These contributions are interlinked. For example, using an eADR approach, a serious game was designed to address the set of problem statements identified in this research. To explore to what extent the designed game could elicit and evaluating knowledge, the outputs (evaluated knowledge) from the game were tested in a real-world scenario. This scenario describes the mapping of the evaluated knowledge to a clinical terminology. This produced a mapping process and a data reference set for an adult oncology daycare nursing discharge reference set Ireland' (SNOMED CT refset ID 134791000220109). eADR is a relatively recent approach to arise from

design science methodology. The original authors, Mullarkey and Hevner (2019) noted that an important direction for the eADR approach is to include design theory development. This research presented an opportunity to understand the benefits and limitations of the approach as it applied to this research. This resulted in a contribution to theory. This final chapter will describe to what extent the research objectives were met (see Section 8.2) and discusses the expected impact the contributions are likely to have (see Section 8.3). The chapter also includes a section on suggested future work (see Section 8.4).

8.2 Extent to which ROs achieved.

To address the research question, 6 research objectives (RO) were identified. In this section, the rational for each objective and to what extent it was achieved is discussed. Where appropriate, how each objective is linked to a contribution is described. These 6 objectives are shown in the following text.

- RO1: Identify the challenges related to eliciting and sharing nursing knowledge.
- RO2: Describe current approaches to knowledge elicitation in healthcare.
- RO3: Describe the state-of-the-art surrounding serious games and their use in nursing.
- RO4: Design, implement and evaluate a low-fidelity prototype for a serious game that supports the elicitation of domain-specific knowledge mindful of the outcomes of RO1.
- RO5: Map elicited and evaluated knowledge arising from gameplay and test it in a real-world scenario, for example, a clinical terminology.
- RO6: Identify the benefits and limitations of an eADR approach as it applies to this research.

The following text presents these research objectives individually, however, in practice objectives 1-3 and 4-6 were investigated simultaneously.

8.2.1 RO1: Identify the challenges related to eliciting and sharing nursing knowledge.

To identify challenges to eliciting knowledge and to gain an understanding of the domain, two exploratory studies were undertaken (see Appendix B, Section 1.1 and 1.2). From these studies,

n=5 challenges to eliciting knowledge digitally were identified. Two additional challenges were identified from a review of the literature surrounding approaches to eliciting healthcare knowledge digitally (see Appendix B, Section 1.3 and 1.4). To ensure these challenges were relevant to the study site, they were reviewed and updated by the co-inquiry group during the first eADR stage - diagnosis. eADR diagnosis, as described by Mullarkey and Hevner (2019), surrounds understanding the challenges in the domain that relate to the research artefact. An additional challenge related to the use of personal knowledge management systems was identified by the study site (personal knowledge management systems). During the diagnosis stage, this updated list of challenges transformed into a set of problem statements by the co-inquiry group (see Appendix B). These were evaluated by nurse participants from the study site to ensure they were relevant. This is in line with the ADR principle of practice-inspired research. This principle notes that research should be driven by real-world problems (Sein et al., 2011). As these problem statements were evaluated as relevant, the objective was deemed to be achieved.

During the first design cycle, these problem statements were rearranged into three categories. These categories were (1) Problems related to knowledge, (2) Problems related to the domain, and (3) Potential unintended consequences (PUC). See Appendix C, Section 1.2 for the final list of challenges and problem statements. It was envisioned that by presenting the problem statements in distinct categories, they could be tested in future work in a non-nursing domain. However, two additional challenges were identified in the first design cycle. These surrounded skills of researcher and that it was unclear when to move to the next step. These challenges were introduced through the adoption of a knowledge elicitation method (The WICKED method, Impey et al. 2023).

The identification of additional challenges during the design stage highlighted how problems are not static but can evolve during the research. It is proposed that this is particularly relevant to research that attempts to address wicked problems. Wicked problems are complex, challenging and have no stopping rule (Churchman, 1967). Therefore, while the objective was deemed to be met in this work, in a scenario where the research was performed longitudinally, challenges would need to be reviewed to ensure continued relevancy. The eADR acknowledges this and provides an Evolution stage that is included to understand the problem space over the longer term of the project or research (Mullarkey & Hevner, 2019).

8.2.2 RO2: Describe current approaches to knowledge elicitation in healthcare.

To identify current approaches to eliciting knowledge, literature related to knowledge elicitation was reviewed. This review drew on earlier work by the author and is described in Chapter 4, Section 4.2. From this work, two broad approaches to eliciting knowledge were described – direct

and indirect and three barriers to eliciting knowledge were identified. However, no approach to eliciting knowledge was deemed superior. While the primary goal of this objective was to develop an understanding around how knowledge was elicited digitally, the barriers identified were also used to validate the current set of challenges. For example, the first barrier was 'Capturing an expert's knowledge'. This described the difficulty capturing expert knowledge due to the tacit aspects of knowledge, identifying the expert, and gaining access to the expert. These were represented in the current set of challenges in (1) Tacit challenges and (7) Challenges accessing experts. The second barrier was 'Confirming quality of knowledge'. This barrier described the trustworthiness of knowledge elicited and how this could be confirmed. This was represented in the current set of challenges in (4) Challenges around trusting knowledge. The final barrier identified related to 'Continual knowledge capture'. This related to how knowledge captured and validated, will need to be reviewed and updated at a future time, even in a digital platform. These were represented in (5) Challenges around evolving knowledge and (6) Challenges around incomplete or inaccurate data sets. While no approach identified was found that could address the challenges, the concept of serious games was identified in a small number of papers not including in the review. This prompted a review of the state of the art surrounding serious games and their use in the nursing domain. This is represented in the third research objective, which is discussed in the following text.

8.2.3 RO3: Describe state of the art surrounding serious games and their use in the nursing domain.

Following the discussion of eliciting knowledge digitally, the concept of serious games was identified as a potential solution that could be explored in this research, see Chapter 4. Based on this, a state of the art surrounding how serious games were used in nursing was performed. The review yielded a small number of papers (n=9). One reason for this relatively low number it is proposed relates to the inclusion criteria, specifically that it was limited to studies that included pre/post measures and a control group. It was proposed that the pre/post-testing would demonstrate whether knowledge was acquired by the study sample. Coupling this with a comparison group was to ensure that the knowledge acquired related to the incorporation of the serious game rather than a result of any intervention, for instance, traditional lectures. From this review, it was found that while serious games were used in nursing, this was primarily around education and training. A range of game modalities were identified, for instance, immersive virtual reality (Adhikari et al., 2021) or videogames (Del Blanco et al., 2017). No game was found that was used to elicit and evaluate nursing knowledge. This objective was deemed to have been met as a description of how serious games were used in nursing was identified.

8.2.4 RO4: Design, implement and evaluate a low-fidelity prototype for a serious game that supports the elicitation of domain-specific knowledge mindful outcomes of RO1.

As no suitable serious game was identified, the primary goal of this objective was to produce a prototype of a game that could be used to elicit and evaluate nursing knowledge. To do this an eADR approach by Mullarkey and Hevner (2019) was chosen. The methodology is discussed in detail in Chapter 3. The game design had to address the problem statements that describe the challenges to eliciting nursing knowledge. These challenges were the focus of research objective 1. A full description of the final set of 10 problem statements and challenges is provided in Appendix C. A review of the final game compared to the problem statements found that 8 out of the 10 statements were addressed (see Chapter 5). Of the two that were not, one related to how the game could not be used as a personal knowledge management system as the community game board was too difficult to navigate for it to be of use to the participants. In addition, while the game did provide guidance on when to move to the next part, it was unclear if all potential knowledge had been captured. Regardless of these deficits, this objective was deemed to be achieved. The research not only designed, implemented, and evaluated an elicitation game but the final design encompassed an evaluation part. The final game, referred to as the 'nurses knowledge bank', is a serious knowledge elicitation and evaluation game.

The game was designed to mirror a process of knowledge sharing used in practice. That is new nurses learn from their experienced peers. The final game design contained two parts - elicitation and evaluation. The premise of the elicitation part was that nurse participants act as preceptors or mentors and share their knowledge with a 'new nurse'. The 'new nurse' was represented by an avatar in the game. To share knowledge with their avatar, participants write down what they knowledge in relation to discharging a patient from the study site. Each piece of knowledge submitted earns the avatar a point. The winner is the avatar at the end of the game time with the most points. The elicited knowledge was collated into a set of knowledge cards, and these were used in the evaluation part of the game. The premise of the evaluation part is that nurse participants take turn to review the elicited knowledge. Each review moved the participant a set number of spaces across the game board. The winner is the first participant to reach the top square on the game board or the highest place participant at the end of game time.

The elicitation part surrounds a clinical scenario – the discharge of a hypothetical patient from an oncology daycare setting. Participants, referred to as Holders, share their knowledge related to the clinical scenario with an avatar in the game. To do this the Holders annotate post-it notes with relevant knowledge and submit these to the game. These knowledge submissions are assigned to

the Holders avatar, with each submission earning a point. At the end of the game, the winner is the avatar with the most points. This elicited knowledge was then evaluated in the second part of the game. Nurse participants in the evaluation part are referred to as Reviewers. The Holder and Reviewer roles are held by different nurses in this research. For evaluation, the elicited knowledge is constructed into a set of cards. The content of each card is evaluated, and Reviewers move an allocated number of points across a gameboard. The winner is the Reviewer who reaches the top of the board first. Or is the highest place participant at the end of the game time. In total three game cycles were conducted with n=10 Holders and n=8 Reviewers.

The game designed addressed 8 out of the 10 problem statements. The two outstanding problem statements related to personal knowledge management system and stopping rule. It could not be used as a personal knowledge management system by Holders beyond the game due to the difficulty navigating the community knowledge. Furthermore, while participants could access the data reference set that emerged from this research, this took time to be mapped and subsequently published. The game did provide guidance on when to move to the next step, as the goal of the game was to elicit knowledge, it was unclear if all potential knowledge was captured. It was considered that these deficits could be addressed in a digital platform. A full discussion on digitising the game is provided in Chapter 5, Section 5.6.

8.2.5 RO5: Map elicited and evaluated knowledge arising from game play and test it in a real-world scenario, for example, a clinical terminology.

The game was used to elicit and evaluate nursing knowledge surrounding the topic of discharging a patient from an oncology setting. Following each of the three implementation cycles, the artefact produced was a digital spreadsheet. This spreadsheet contained evaluated knowledge that was deemed relevant by the Reviewers following each implementation cycle. Knowledge in the spreadsheet was reviewed by the author and a clinical terminology expert. One expert was from the SNOMED CT and one from ICNP These reviews were conducted separately. From these reviews each evaluated knowledge submission was deemed: ‘match’, ‘no match’, or ‘near match’. This is fully discussed in Chapter 6. As a reminder these terms describe:

- ‘Match’ describes a scenario where a code assigned to the knowledge prompt fully represents what the player had intended it to.
- ‘No match’ describes a scenario where no appropriate code was found in the terminology for the knowledge prompt.
- ‘Near match’ describes a scenario where some of the code assigned was relevant (to the knowledge prompt) but ultimately did not represent exactly what the player had intended it to.

For this research, the submissions deemed a 'match' and 'near match' were represented in the SNOMED CT for an 'Adult oncology daycare nursing discharge reference set Ireland' (SNOMED CT refset ID 134791000220109). This final refset contained n=107 concepts. Work in ongoing to expand this reference set to include new concepts for the 'no match' submissions. This mapping process was also conducted for the ICNP nursing. While not all terms could be mapped, a large portion could. The output from these reviews is shown in Table 37.

Table 37 Overview of outcomes from mapping process

	SNOMED CT	**ICNP**
Match	67	52
Near Match	19	22
No Match	26	38
Total	112	112

Two terminologies were used in this research. While one is a broad clinical reference terminology (SNOMED CT), the other provides more granularity needed to capture nursing work (ICNP).

8.2.6 RO6: Identify the benefits and limitations of an eADR approach as it applies in this research.

The specific eADR approach is relatively new (published in 2019). Mullarkey and Hevner (2019) noted that an important direction for the eADR approach is to include design theory development. Therefore, a further contribution is a discussion based on the learning accumulated through the application of the eADR in this research. To identify the benefits and limitations of an eADR approach, an additional reflection activity was performed at the end of each eADR stage. This presented an opportunity to reflect and extract learnings, however, there was no place in the approach to capture these learnings. Therefore, a new stage was proposed, 'Reflections upon eADR'. This stage and associated reflective activities are proposed as a concurrent set of activities that are performed alongside the prescribed eADR activities described by Mullarkey and Hevner (2019), specifically for academic research.

8.3 Discussion on expected impact contributions likely to have,

This research was conducted during an international pandemic and in a domain that impacted by the pandemic. I would like to acknowledge the participants for giving for giving time and knowledge to this research. This is even more precision considering it was a very busy in a specialist healthcare unit. As can be seen in Chapter 1, through the papers published already, the contributions arising from the research is already having an impact upon the research community. More generally it is expected that the main impacts of the contributions relate to providing an additional way to manage nursing knowledge, the data reference set and the evolution of the eADR approach. These are described here.

8.3.1 Managing nursing knowledge:

The problem this research addresses is that not all nursing knowledge is captured in a way that is easy to access outside the border of a community of practice (CoP) or beyond geography or time. Through this research, 10 problem statements that impacted managing nursing knowledge were identified. These are discussed in the diagnosis stage (see Appendix B). While the research addressed 8 out of 10 of the statements, as knowledge was mapped to a clinical terminology, it was deemed that a serious game could have a potential role in managing nursing knowledge. The statements that were not addressed where that the game could not act as a personal knowledge management system or that there was no guidance on when to stop collecting knowledge. It is discussed in Chapter 5, Section 5.6, how that these limitations could be potentially addressed in a digital version of the game.

8.3.2 Data set

The data reference set produced from this research represents evaluated knowledge used in an oncology setting by specialist nurses. It is proposed that this contribution could be useful as part of an orientation document to the study site for new nurses. It also has potential impact beyond the study site for nurses working with oncology patients, but whom may not have the specialist experience. For instance, this data set could help non-specialist nurses identify areas of assessment, such as temperature, or be used to guide patient discharge conversations. While it is not proposed that all topics could be relevant to all patients, the data set could act as a cognitive tool or a reminder to help assist nurses.

8.3.3 Contribution to eADR

As noted in Chapter 3, eADR approach is relatively new (published in 2019). Mullarkey and Hevener (2019) who developed the approach, noted that an important direction for the eADR approach is to include design theory development. It is proposed that this theory contribution adds to the discourse around the approach. This discourse could potentially be useful for future researchers considering this approach.

8.4 Suggested Future Work

While the previous text discusses publications arising from this work to date, this section describes the proposed future direction of this work. It is hoped that future work can continue to address the wicked aspects of knowledge problems linked to a range of domains. A characteristic of a wicked problems is that there are not necessarily solutions, instead the aim is to identify improvements to the problem and monitor the impact of changes to avoid any unintended consequences (Churchman, 1967). To do this, it is proposed to continue to use the eADR approach for future work and to focus on the Evolution stage as proposed by Mullarkey and Hevner (2019). Another proposed area of future research is to continue to evaluate the game design in healthcare and non-healthcare domains. It is hoped that future iterations of the game could build on the learning that occurred in this work to produce a digital version of a serious knowledge elicitation and evaluation game. A digital version of the game also offers the opportunity to explore the role of nurses in organizational knowledge management. This echoes work by Hardiker et al. (2019), albeit in relation to electronic records and not serious games, who called for a nurses to be reinterpreted as 'knowledge workers' rather than as 'data collectors'.

8.5 Final Remarks

The problem addressed in this thesis was that not all nursing knowledge is captured in a way that is easy to access outside the border of a community of practice (CoP), or beyond geography or time. Serious games were identified as a potential solution. The aim of the research, therefore, was to understand to what extent a specially designed serious game could elicit specialist nursing knowledge so that it could be preserved and shared mindful of geography and time. A nursing cohort was identified as not only do they make up over half of the world's healthcare workforce (WHO, 2020), but their role is varied and knowledge base vast (NMBI, 2020, 2021, 2022). However, even though nurses spend a significant amount of their day completing documentation (Fore et al., 2019), there is evidence that not all tasks completed, or care given, is documented or documented fully (De Marinis et al., 2010; Fore et al., 2019; Gunningberg et al., 2008; Paans et

al., 2010; Thoroddsen et al., 2013). Furthermore, there are worldwide shortages of nurses (5.9 million in 2018). Deficits in numbers are not spread evenly across the world, with low to middle-income countries experiencing the shortage more acutely (WHO, 2020).

From this research it was demonstrated that a serious game could elicit knowledge and that it could preserved and shared using a data reference set. However, limitations remain. Firstly, the game could not be used as a personal knowledge management system. Nor did the process, provide a way to know when to stop collecting knowledge. It is proposed that these could potentially be addressed in a digital format. This is an area highlighted for future work. Secondly, not all knowledge submissions were represented in a clinical terminology. This occurred for two main reasons, either a suitable code was not identified, or the type of knowledge was not represented. Extending nursing clinical terminologies is also highlighted as an area for future work.

So, while serious knowledge elicitation and evaluation games for nurses, whether digital or paper-based, are not proposed as a panacea for all the challenges around managing nursing knowledge. Given the scope of the nurses' role and their clinical presence, they could potentially be part of the solution.

Appendices

Appendix A presents an illustration overview of how the eADR approach was applied to this research, including the proposed additional reflection activity and the Reflection upon eADR stage.

Appendix B details the research undertaken during the two diagnosis cycles. The first cycle is concerned with understanding the problem. The second cycle is concerned with identifying a potential solution.

Appendix C details the research undertaken during the two design cycles. From the first cycle, an elicitation game and evaluation process were produced. These were combined in the second cycle and a knowledge elicitation and evaluation game was the output.

Appendix D details the research undertaken during the three implementation cycles. The focus of these cycles was to evaluation the knowledge elicitation and evaluation game. In addition to knowledge elicited and evaluation, each cycle produced feedback that could be incorporated into the next cycle.

Appendix E presents the stage reflections from all eADR stages performed.

Appendix F describes the process around how elicited knowledge was prepared for evaluation.

Appendix G presents the actors, participant qualifications and functions used in the final serious knowledge elicitation and evaluation game.

Appendix H presents the post-game participant evaluation survey

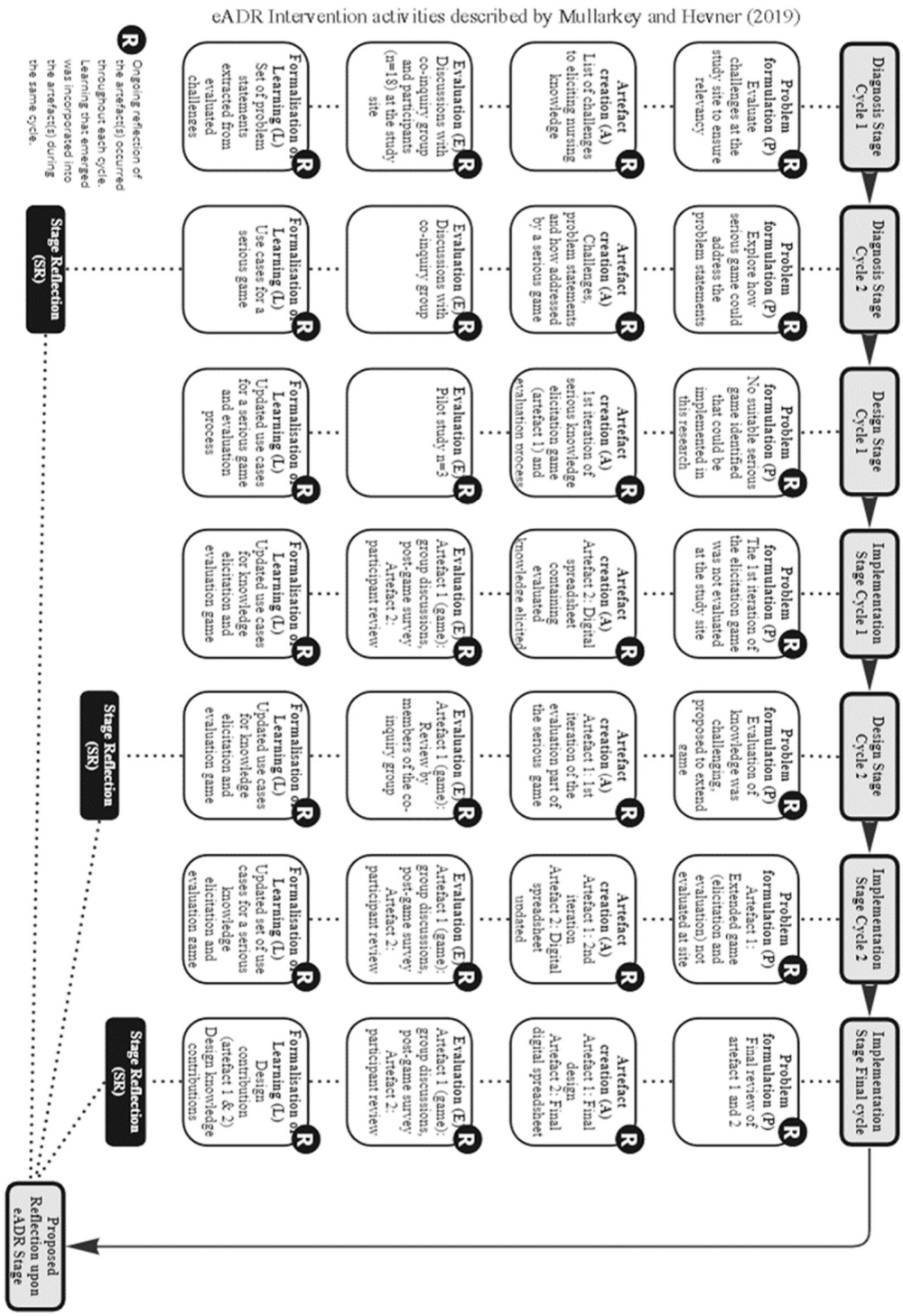
Appendix I presents an overview of findings from post-game evaluation survey – Holders group

Appendix J presents an overview of findings from post-game evaluation survey –Reviewers group

Appendix K presents the categories, topics and relevant examples of SNOMED concepts

Appendix L presents the 'Matched' submissions with the SNOMED and ICNP codes identified (by author and terminology expert).

Appendix A – eADR stages & activities applied to this research



Appendix B – eADR Diagnosis Stage (2 Cycles)

This appendix presents all the studies undertaken during the two diagnosis cycles. In the first cycle, these surround two exploratory studies. Study 1 related to how do nurses currently share their knowledge. Study 2 related to the motivations and barriers to online knowledge sharing. The purpose of these studies was to understand the problem domain and identify challenges to eliciting nursing knowledge. In the second cycle, the focus was on identifying a solution. The studies undertaken in this cycle were a review of how knowledge was elicited digitally in healthcare. No approach was deemed superior but serious games were identified as a potential solution. As a result, a review of the state-of-the-art was conducted during this cycle. Details of these studies are shown in this appendix.

1.1 Cycle 1 – Study 1: How do nurses currently share their knowledge?

This section presents the research approach and findings in relation to the first exploratory study conducted in cycle 1 (Study 1: How do nurses currently share their knowledge?). See Table 38 for an overview of the research approach.

Table 38 Study 1: overview of research approach

Aim of study	Ethical approval was granted from two healthcare institutions in the Republic of Ireland to conduct an in-depth study of nurses' knowledge sharing behaviours using an ethnographic approach.
Population	The total participant pool was n=17, and participants had an average of 17.8 years of nursing experience. Semi-structured interviews with participants about their knowledge sharing behaviours (n=15) were conducted. Two participants from the 17 declined interviews due to time constraints. Participants described their roles as staff nurses (n=5), senior staff nurse (n=3), clinical nurse specialist, CNS (n= 6), clinical nurse manager, CNM (n=2) and advanced nurse practitioners (n=1).
Study sites	Five specialist outpatient units – dermatology, radiology, neurology, multiple sclerosis, and cardiac lab - in two healthcare institutions.
Methodology	An ethnographic approach was chosen as the research methodology. Although it is difficult to define what is ethnography, Hammersley (2006) describes it as "a form of social and educational research that

	emphasises the importance of studying at first-hand what people do and say in particular contexts." Ethnography, as a research method, has been used in previous healthcare studies (Goodson & Vassar, 2011). Applying a qualitative, rather than quantitative approach, allowed the researcher to observe knowledge sharing in action (Gerrish & Lacey, 2010).
Data collection methods	Participant-observation, field notes and semi-structured interviews were chosen as research methods. Field notes were taken throughout the observation period, and a record of the whole research process was maintained and referred to frequently. Findings were discussed with participants during the study and coding process to ensure they were a true reflection of the phenomena. Over 8 hours of interviews were recorded and transcribed. Data collection took 6 months.
Analysis	The transcribed (verbatim) data was read and reread. The data analysis process used the framework described by Braun and Clarke (2006). As no hypothesis was being confirmed by the research, inductive thematic analysis was adopted. A second researcher was involved in the data analysis process.

Ethics approved by School of Computer Science and Statistics, Trinity College Dublin (Application Number: 20190802) and two healthcare institutions in the Republic of Ireland to conduct an in-depth study of nurses' knowledge sharing behaviours using an ethnographic approach. Five outpatient settings from two healthcare institutions were included in the study (n=17). An ethnographic approach was chosen as the research methodology. The purpose of the research was to understand how nursing knowledge is shared in an outpatient setting (a community of practice, CoP)?

Two main themes were identified from the study: ways knowledge is shared, motivations and barriers. Each theme comprised of sub-themes. Figure 24 provides an overview of themes and sub-themes that were identified. Knowledge sharing was ubiquitous in practice, knowledge generated within the CoPs (outpatient clinics) was captured in formal clinical and academic documents, and also embedded in the environment and embodied in people working within the environment.

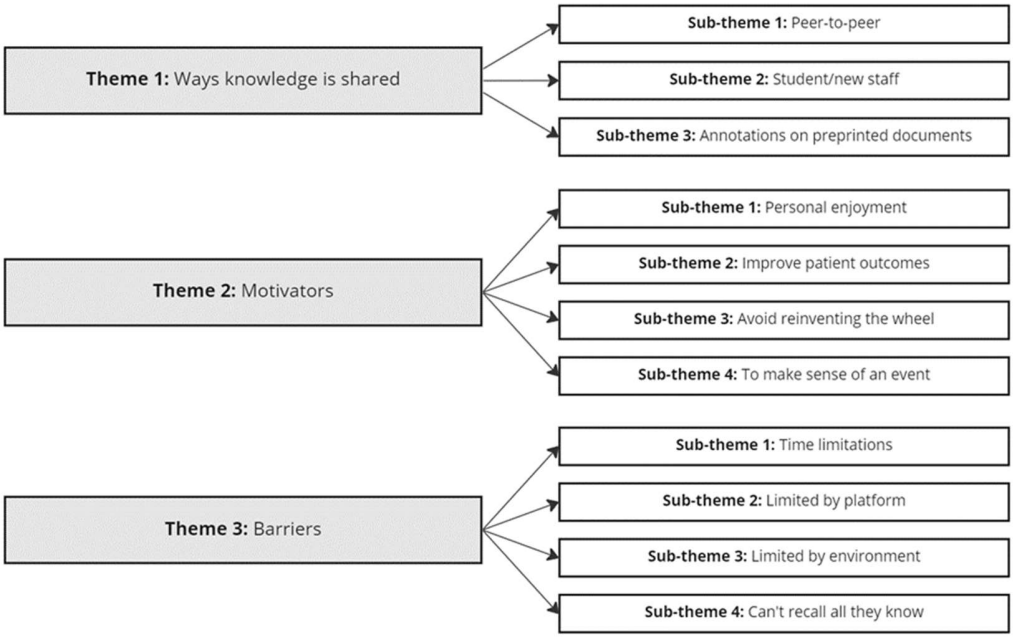


Figure 24 Overview of themes and sub-themes extracted from transcribed data

The study identified that nurses share knowledge in a predominately oral world, both within and with those outside the unit. Complicating knowledge capture was that knowledge was also found to be embedded in the clinical environment, such as posters, signs, placement of equipment and embodied in staff, such as knowledge passed from other staff members. Another way to share, and subsequently capture, knowledge discussed by participants was through annotations in patient documentation. Annotations (see Chapter 2) were used by participants to highlight anomalies in care, act as a reminder, document important information related to the patient or because new knowledge was available that did not have a 'space' to document in the structured nursing notes. Annotations allowed nurses to update documents, including patient care plans or patient information leaflets, as new evidence became available and in between the formal document being reviewed and reprinted.

One answer to increasing nursing knowledge captured could be through participation in online knowledge sharing platforms. However, participants described barriers to online knowledge sharing, such as lack of credibility, trust and time limitations. Only 2 participants engaged in online knowledge sharing. They explained that the online platform that they used was a closed group with strict entry requirements, and they knew the other participants personally off-line. They noted that they would feel different about a public on-line system.

1.2 Cycle 1 – Study 2: Motivations & barriers to online sharing

Table 39 Study 2: Overview of research approach

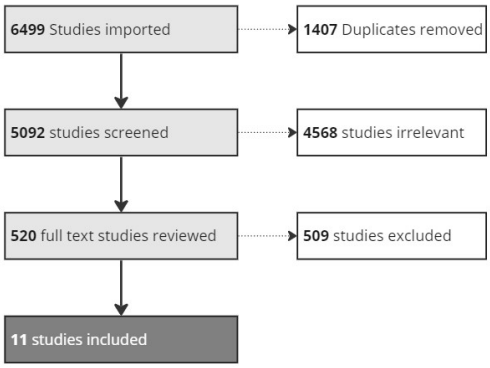
Databases	Include CINAHL, Cochrane Database, Medline, PsycInfo, Embass, IEEE, Scopus Peer reviewed, English language, years 2005-2020	
Search terms	Online:	Online Systems and/or Online Social Networking and/or Social Networks and/or Social Media and/or Social Networking and/or informatics+ and/or Communications Media+ and/or Information Science+ and/or User Generated Content and/or blogs and/or content communities and/or social networking sites and/or virtual game worlds and/or virtual social worlds and/or Web 2.0 **AND/OR**
	vCoP:	Virtual communities of practice and/or community of practice and/or communities of practice **AND**
	Nurse/Midwife:	nurs* and/or healthcare prof* and/or midwi* **AND**
	Knowledge:	Knowledge and/or Nursing Knowledge and/or Professional Knowledge+ and/or Knowledge Management and/or Knowledge Sharing and/or Knowledge Transfer and/or Knowledge Worker
Criteria	• Literature discussing motivations and/or barriers to participation. • Studies to include nurse or midwife participants, including students • Include virtual communities of practice or social media platforms, if meets the definition of CoP by Wegner et al. (2002). • Public or private, open or closed communities, limited to electronic platforms • Exclude platforms where participation in the group is mandatory. • Excluded: non-nursing healthcare professionals or patients only.	
PRISMA flow diagram		

Table 40 Study 2: motivations and barriers to online knowledge sharing – Literature table (articles 1-11)

Reference	Aims/objectives	Sample	Country	Platform	Motivations	Barriers
Babajani-Vafsi et al. .2019 Title: Factors Influencing the Participation Of Nurses In Knowledge-Sharing Within Mobile Instant Messaging Based Virtual Communities Of Practice: A Qualitative Content Analysis	Exploring the factors influencing nurses' participation in knowledge-sharing within mobile instant messaging (MIM) based vCoPs.	18 nurses	Iran	Mobile instant messaging (MIM) (Closed forum)	1. Individual drives: personal and material) 2. Attractive, interactive environment 3. User-friendly media: acceptability and popularity of media.	1. Individual hindrances include time pressure, fear of being judged. 2. Social harm: including disruptions to personal life, impact on personal life. 3. Unprofessional interactive environment refers mainly to non-professional vCoPs. 4. Undesirable media includes outdated or difficult to use technologies.
Francis-Coad et al. 2017 Title: Can a web-based community of practice be established and operated to lead falls prevention activity in residential care?	This study aimed to evaluate establishing and operating a web-based community of practice (CoP) to lead falls prevention in a residential aged care (RAC) setting.	20 Nurses and allied health staff, representing 13 sites of an RAC organization.	Australia	Web-based CoP (Closed forum)	1. Improve patient care: anticipated benefit of improving falls prevention management at their workplace."	1. Competing demands from other tasks 2. Technological know-how
Frisch et al. 2014 Title: Growing a Professional Network to Over 3000 Members in Less Than 4 Years: Evaluation of InspireNet, British Columbia's Virtual Nursing Health Services Research Network	Evaluation of InspireNet from data gathered over a three-year period on network growth, the parts of the network that support frequent use of the network platform, the establishment of password-protected electronic communities of practice (eCoPs).	23 interviews with Action Team leaders and members, surveys, tracking website use and focus groups.	Canada	InspireNet: a virtual professional network (Closed forum)	Not discussed Difficult to identify barriers as low response rate in survey by non-participants.	1. Usability: difficult to navigate. 2. Access: firewalls 3. Time constraints 4. Topic of discussion

Reference	Aims/objectives	Sample	Country	Platform	Motivations	Barriers
Hew & Hara 2006 Title: Identifying factors that encourage and hinder knowledge sharing in a longstanding online community of practice	This study examines knowledge sharing among critical-care and advanced-practice nurses, who are engaged in a longstanding online community of practice.	27 interviews with members (nurses) and content analysis of approximately 400 messages were conducted.	USA	The Nurse Practitioners (a pseudonym) is an e-mail-based listserv. (Closed forum)	1. Self-selection type of Membership 2. Desire to improve the nursing profession 3. Reciprocity 4. A non-competitive environment 5. The role of the listserv moderator.	1. No new additional knowledge to add. 2. Unfamiliarity with subject 3. Lack of time 4. Technology
Hara and Hew 2008 Title: An online listserv for nurse practitioners: A viable venue for continuous nursing professional development?	This study reports the results of a qualitative study involving a large and longstanding online nurse listserv in the United States.	10 participants (from 27 critical care and advanced-practice nurse practitioners)	USA	The Nurse Practitioners (a pseudonym) is an e-mail-based listserv. (Closed forum)	1. Reciprocity 2. Collectivism 3. Personal gain 4. Respectful environment 5. Altruism 6. Technology The two most common motivators for sharing knowledge were reciprocity and collectivism.”	Not discussed
Rolls et al. 2008 Title: Building a statewide knowledge network for clinicians in intensive care units: Knowledge brokering and the NSW Intensive Care Coordination and Monitoring Unit (ICCMU)	Describes the initial establishment and implementation of the Intensive Care Coordination and Monitoring Unit (ICCMU), and Listserv, ICUConnect.	113 survey respondents (106 nurses)	Australia	ICUConnect (Closed forum)	No explicit motivations to participate described.	Barriers to posting a query: 1. Lack of confidence 2. Lack of time 3. Existence of internal unit constraints 4. Nothing to say 5. Tone of discussion
Rolls et al. 2019 Title: Intensive care nurses on social media: An exploration of knowledge exchange on an intensive care virtual community of practice	Explore nature of knowledge exchange on a multi-disciplinary intensive care virtual community of practice (ICUConnect)	HCPs – 68% nurses	Australasian	ICUConnect-(Closed forum)	1. Discussion thread 2. Sharing of artefacts 3. Community 4. Cordiality 5. Promotion of the platform.	Majority of submissions from a minority of users but specific barriers not identified.

Reference	Aims/objectives	Sample	Country	Platform	Motivations	Barriers
Shehab et al. 2019 Title: Knowledge Sharing Behavior of Nursing Supervisors in Online Healthcare Communities	This study examines the effects of individual factors on knowledge-sharing behavior in online healthcare communities (OHC) in Amman, Jordan.	Usable questionnaires were 283 with a response rate of 84%. (Nursing supervisors)	Joran	Online health communities	Individual factors: 1. Trust 2. Reciprocity 3. Reputation 4. Knowledge to share	None discussed
Valaitis et al. 2011 Title: Online communities of practice as a communication resource for community health nurses working with homeless persons	This study aimed to explore major viewpoints of CHNs who work with homeless or marginally housed populations about their use of an online CoP as a tool to support their practice.	16 community health nurses	Canada	v CoP designed by and for CHNs working with homeless/marginally housed, Closed forum	Some respondents would have used the community of practice more with 1. Increased discussion 2. Facilitation 3. Prompt responses. Some respondents did not feel that a hectic workday was a barrier, although reported being more likely to devote personal time to participation.	1. Lack of knowledge about a topic 2. Technological issues
Brookes & Scott 2006 Title: Knowledge work in nursing and midwifery: An evaluation through computer-mediated communication	To explore the forms of communication that occurred on the forums against the transformation criteria for knowledge work in nursing identified previously.	42 nurse/midwife users and non-user interviews. Range from newly qualified to Matron	UK	Online discussion forum, part of Assisted Electronic Communication (AEC) project. (Closed forum)	1. Immediate patient care. 2. Design of the system seen as positive. 3. Allowed for communication with peers they may not be in regular contact with. 4. Seek and/or share knowledge	1. Participants reported topics discussed were not perceived as an integral or essential component of their work. 2. ‘‘Busyness’’ was frequently presented by nurses as blocking engagement. 3. ‘Time-pressured’ environment – going online not seen as important work.
Brooks and Scott 2006 Title: Exploring knowledge work and leadership in online midwifery communication	Study to answer the question: if given a user-friendly online system, that enabled communication across the practice community, would midwives function as knowledge workers?	15 midwives	UK	Online discussion forum, part of Assisted Electronic Communication (AEC) project. (Closed forum)	1. Give encouragement to peers 2. Seek and/or share knowledge	A potential disadvantage of public discussion in the workplace is that the increased visibility that comes from active participation could result in individuals being Fearful that they might be negatively sanctioned by management,

As only two participants from the Study 1 engaged in online knowledge sharing, a review of the literature was conducted to identify the motivations and barriers to online knowledge sharing. See Table 39 and 40 for the search strategy, PRISMA flow diagram and a table outlining the papers included. From the review three motivating themes and four barriers to engagement were identified. These are shown in Figure 25.

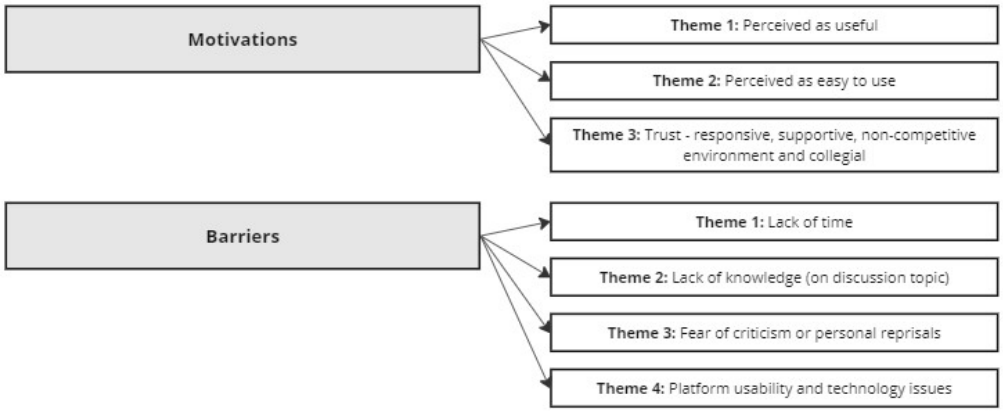


Figure 25 Themes identified from the review of the literature

Motivation: Motivation to participate was in line with the technology acceptance model (TAM3) by Venkatesh and Bala (2008). That is, findings indicated that participants were motivated to participate in platforms they perceived as 'useful'(Babajani-Vafsi et al., 2019; Fiona Brooks & Peter Scott, 2006; F. Brooks & P. Scott, 2006; Francis-Coad et al., 2017; Hew & Hara, 2008; Shehab et al., 2019); or were 'easy to use'(Babajani-Vafsi et al., 2019). The review also highlighted participation was driven by 'trust' in the platform. Although noting that there are many interpretations of 'trust'. Das and Bing-Sheng (1998) present a description of trust as the degree to which an individual is confident in the goodwill and reliability of another. Ford (2004) describes a range of levels of trust – from interpersonal to institutional. From the review, trust arose from platforms that were responsive (Babajani-Vafsi et al., 2019; Hew & Hara, 2006; Hew & Hara, 2008; Shehab et al., 2019; Valaitis et al., 2011); supportive (Babajani-Vafsi et al., 2019; Hew & Hara, 2008; Rolls et al., 2020); non-competitive (Hew & Hara, 2006) and collegial (Fiona Brooks & Peter Scott, 2006; F. Brooks & P. Scott, 2006).

Barriers: Whereas, barriers to participation were noted as 'lack of time'(Babajani-Vafsi et al., 2019; Francis-Coad et al., 2017; Frisch et al., 2014; Hew & Hara, 2006; Rolls et al., 2008); 'lack of knowledge' (on the discussion topic) (Fiona Brooks & Peter Scott, 2006; Frisch et al., 2014; Hew & Hara, 2006; Rolls et al., 2008; Valaitis et al., 2011); 'fear of criticism or reprisal' (Babajani-Vafsi et al., 2019; Fiona Brooks & Peter Scott, 2006; F. Brooks & P. Scott, 2006; Rolls et al., 2008) and 'usability and technological issues' (Babajani-Vafsi et al., 2019; Frisch et al., 2014; Hew & Hara, 2006; Rolls et al., 2008; Rolls et al., 2020; Valaitis et al., 2011).

Discussion: Several limitations are evident with Study 2's review. Firstly, a relatively small number of articles were included (11 from 6,499 articles screened). This could be due to the focus of the study on motivations and barriers, and on nurse-to-nurse interactions. However, developing insight into barriers to knowledge sharing was identified as an area for future studies by Charband and Navimipour (2016). The applicability of these findings to a broader nursing audience can be examined without additional studies. Secondly, no papers were identified that focused on student nurses. It is thought that this could have arisen due to exclusion criteria. Specifically, platforms that did not function as a CoP or platforms there were related to education/training. Therefore, it is not known whether the same motivations or barriers would apply to a student cohort. This is important as literature describes how nursing students use online platforms including social networks in many ways including as a learning tool (Daly et al., 2019; Tower et al., 2014; Walsh & Crumbie, 2011; Wang et al., 2019); to provide support (Ryan & Davies, 2016; Tower et al., 2014) or to connect disparate groups of students (Daly et al., 2019). While students in a study by Ryan and Davies (2016) valued the speed and accessibility of information online (a Facebook group), they had concerns about the accuracy of the information. Despite the limitations, outcomes of this study support findings from Study 1 on how nurses currently share their knowledge. That is lack of time, trust and technological know-how, along with professional repercussions fear of criticism or making a mistake and the effect it would have on their nursing registration.

1.3 Cycle 2 - Digital knowledge elicitation

Cycle 1 of the eADR Diagnosis stage was focused on understanding the problem. In the second diagnosis cycle, the focus is on identifying a potential solution. The first step in identifying a potential solution was to understand how healthcare knowledge is currently elicited digitally.

From a previous study, conducted at the same time as this thesis research, a review of how healthcare knowledge was elicited digitally (Impey et al., 2021). Findings from this review noted two broad approaches to eliciting knowledge – direct and indirect. In addition, three barriers to eliciting knowledge digitally were identified from this work. These are shown in Figure 26.

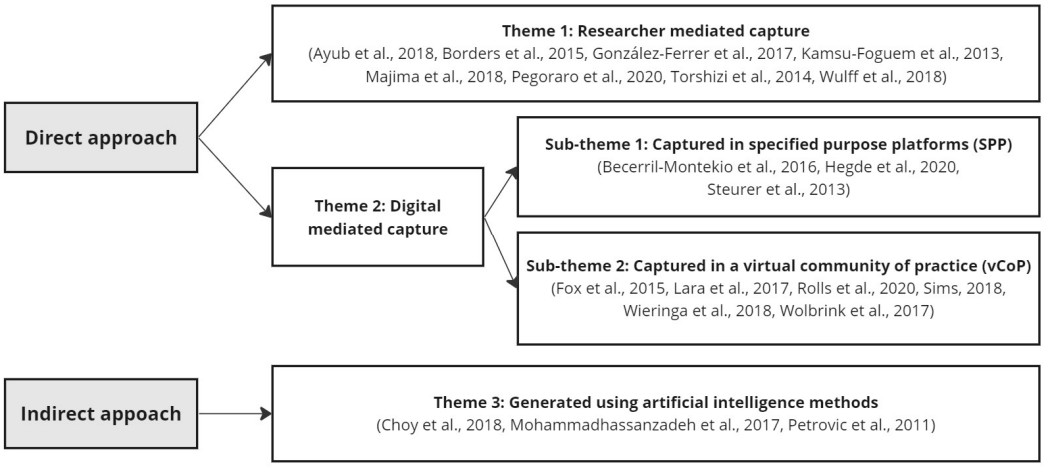


Figure 26 Overview of approaches, themes and sub-themes identified

Direct: Direct describes a process whereby knowledge is elicited from subject experts (Torshizi et al., 2014). Two themes were identified relating to a direct approach: 'Researcher mediated capture' and 'Digital mediated capture'. 'Researcher mediated capture' describes a process whereby an investigator elicits knowledge directly from the subject experts using approaches, such as, interviews, observation, guideline review or developing videos (Ayub et al., 2018; Borders et al., 2015; González-Ferrer et al., 2017; Kamsu-Foguem et al., 2013; Majima et al., 2018; Pegoraro et al., 2020; Torshizi et al., 2014; Wulff et al., 2018). 'Digital mediated capture' describes how expert knowledge can be elicited from experts via digital interactions.

Indriect: Indirect approaches rely on eliciting new knowledge from previously captured data from various digital sources, including medical records, using artificial intelligence techniques An indirect approach identified was 'Generated using artificial intelligence methods (Choy et al., 2018; Mohammadhassanzadeh et al., 2017; Petrovic et al., 2011). Knowledge is generated using artificial intelligence techniques, such as plausible reasoning or fuzzy logic (Choy et al., 2018; Mohammadhassanzadeh et al., 2017; Petrovic et al., 2011). Although presented as distinct themes,

some articles retrieved discuss combining more than one approach when eliciting expert knowledge (Choy et al., 2018; Hegde et al., 2020; Steurer et al., 2013; Torshizi et al., 2014).

Another finding from this review was that no approach emerged as superior and common barriers across the approaches were identified. These barriers are: Capturing an expert's knowledge, confirming quality of knowledge and continual knowledge capture. These are shown in Figure 27.

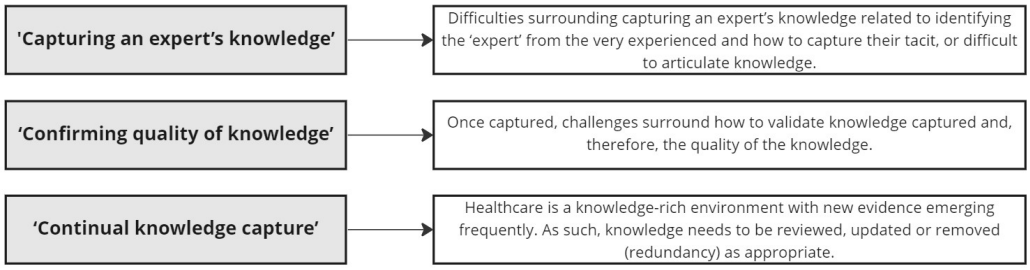


Figure 27 Barriers to knowledge elicitation identified in the literature review

Capturing an expert's knowledge: Expertise can describe skills, knowledge or abilities across a broad range of activities (Farrington-Darby & Wilson, 2006) and are often distinguished by their performance which Ericsson and Smith (2011), described as "consistently superior". Identifying the expert and subsequently, their expert knowledge presents challenges, particularly for non-experts or those unfamiliar with the domain (Ericsson et al., 2018).

Confirming quality of knowledge: Once the expert is identified, and their knowledge captured, the next step is validation. In the papers related to 'Researcher mediated capture' and 'Captured in specified purpose platforms (SPP)' validation of knowledge could be grouped into two approaches – consensus (Becerril-Montekio et al., 2016; Kamsu-Foguem et al., 2013; Majima et al., 2018; Torshizi et al., 2014; Wulff et al., 2018) or comparison. The later including comparisons between pre and post system deployment (Pegoraro et al., 2020), novice and expert results (Borders et al., 2015) or diagnostic comparisons between expert and system results (González-Ferrer et al., 2017).

Continual knowledge capture: System developers should also consider how to maintain its knowledge base in the future. Intuitively indirect approaches might provide a solution as they utilise existing data sets to extract new knowledge using techniques such as plausible reasoning (Mohammadhassanzadeh et al., 2017) or case-based reasoning (Petrovic et al., 2011). Challenges, however, exist and include the absence of standardised terminologies (Thoroddsen et al., 2014), availability of records (Ati, 2014) and reliability of initial data captured (Ati, 2014; González-Ferrer et al., 2017; Mohammadhassanzadeh et al., 2017; Thoroddsen et al., 2014; Wulff et al., 2018). There was no consensus in the papers reviewed on how expert knowledge could be continually captured (or removed if redundant).

1.4 Cycle 2 – State-of-the-art (SOTA): serious games

No method was found to be superior from the previous review (eliciting healthcare knowledge digitally), however, serious games were identified as a potential solution. To explore this a state-of-the-art (SOTA) review was conducted. This SOTA review addresses the question 'Can serious games be used by nurses to elicit, evaluate and share nursing knowledge?'. From this work, it was noted that the role that serious games could have in managing nursing knowledge is under explored, and no existing serious game was identified that could be implemented and evaluated at the study site. The search strategy, literature table and review are presented in Table 41. The final papers retrieved are shown in Table 42.

Table 41 SOTA: Search Strategy

Databases	Include IEEE, CIHNAL, Science Direct, Web of Science, and Scopus. Peer reviewed, English language, years 2012-2022	
Search terms	Type:	'serious Game' and/or 'game-based learning' and/or 'gamification' and/or 'game' **AND**
	Knowledge:	'knowledge elicitation' and/or 'knowledge acquisition' and/or 'knowledge sharing' and/or 'knowledge retention' and/or 'knowledge management' and/or 'knowledge evaluation' **AND/OR**
	Nurse:	'healthcare' and/or 'nurse', and/or 'midwife' and/or 'nursing student(s)' and/or 'midwifery student(s)' **AND**
	Domain:	'healthcare' and/or 'health'
Criteria	• Serious game as defined by Abt (1970). That is, games that are primarily educational but also entertaining. • Games come in a variety of modalities, for instance, immersive virtual reality (Adhikari et al., 2021) or Jeopardy-style game format (Boctor, 2013). This review did not limit inclusion to any specific modalities. • Many studies described users' perceptions of games in nursing education favourably (Boctor, 2013; Stanley & Latimer, 2011). Although important, inclusion was limited to studies that could demonstrate an impact on nursing knowledge using pre and post testing or used comparison group.	

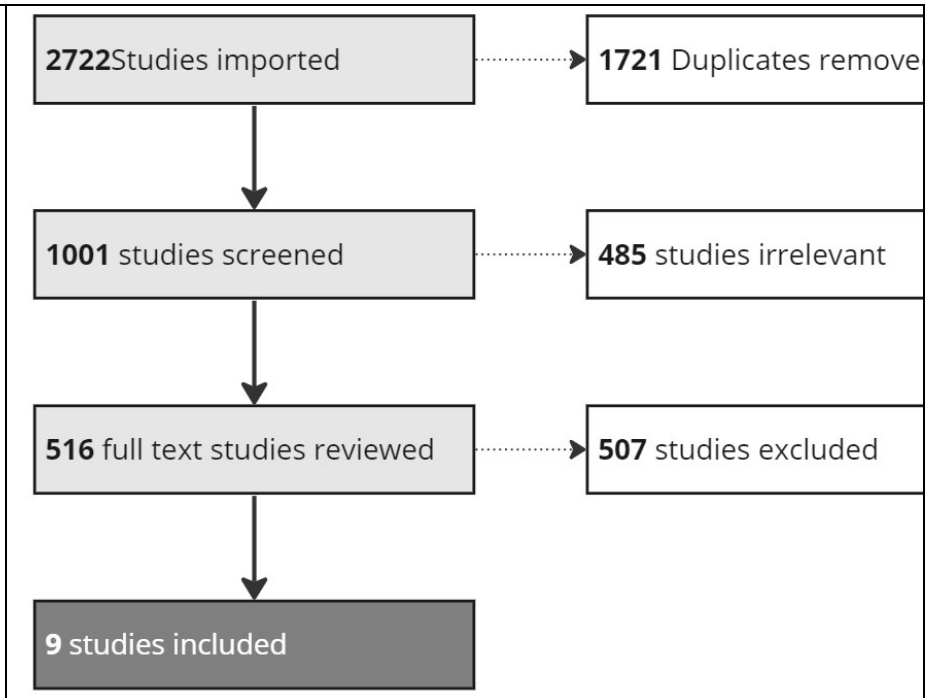
PRISMA flow diagram	

Table 42 SOTA: Literature Table (articles 1-9)

No.	Author	Population	Groups	User perceptions	Study type	Intervention	Methodology	Post-intervention	Comparator
1	Aljezawi and Albashtawy 2015	N=66 students (nurse)	Control (n=34) Experimental: (n=32)	Self-assessment satisfaction survey: 10 statement Likert scale Game more satisfying than traditional lecture	Parallel group randomised controlled trial	Jeopardy!-style game format	Pre and Post-test, 10-week post-intervention test	15 topic-specific multiple-choice questions (post and 10-week post)	Alternative: Traditional teaching
2	Bayram and Caliskan 2019	N=86 students (nurse)	Control (n=43) Experimental (n=43)	-	Single-blind randomized controlled trial	Game-based virtual reality phone application	Pre and Post-test	23 multiple-choice questions	Supplement
3	Brull et al. (2017)	N=115 qualified nurses	Group 1: didactic (n=31) Group 2: online modules (n=32) Group 3: gamification (n=52)	Postintervention questionnaire (free response section): 'Engaging', 'informative' and 'entertaining'	Quasi-experimental study	Digital game	Pre-test and Post-test	Post intervention questionnaires with free text	Alternative: Traditional teaching and online
4	Chang et al. 2020	N=72 students (nurse)	Control (n=36) Experimental (n=36)	Post interview (with 12 students): Experimental group found game "interesting," "authentic" and "promoting deep thinking."	Quasi-experimental design	Digital role-playing game	Pre and Post-test	25 multiple choice questions	Alternative: Traditional teaching

5	Chee et al. 2019	N=46 qualified nurses	Control (n=23) Experimental (n=23)	Perception scale (Huang et al., 2010): Participants evaluated the game positively	Randomized controlled trial	Digital role-playing game	Pre and Post-test	Performance evaluation checklist	Alternative: Traditional teaching
6	Hwang and Chang 2020	N=56 students (nurse)	Control (n=28) Experimental (n=28)	Learning motivation scale (Wang & Chen, 2010). Learning attitude scale (Hwang et al., 2013) Flow experience scale (Pearce et al., 2005) Critical thinking tendency scale (Chai et al., 2015) Interview framework (adapted Hwang et al. (2009) Post-questionnaire	Quasi-experimental study	Game-based flipped learning approach (GBFL)	Pre and Post-test	20 multiple-choice questions	Alternative: Conventional flipped learning
7	Soyoof et al. 2022	N=160 students (nurses)	Control (n=80) Experimental (n=80)	Perception survey (based on Chen and Hsu (2020): 17-item (13 five-level Likert scale items and 4 open-ended questions)	Mixed-methods (pre- and post-tests, an open- and closed-ended questionnaire)	Digital game – '*Saving Lives'*	Pre and Post test	10-item multiple-choice questionnaire	Alternative: Traditional methods
8	Tan et al. 2017	N=103 students (nurse)	Control (n=46) Experimental (n=57)	Perception scale (Huang et al., 2010): 16-item scale Evaluated positively by participants.	Randomized controlled trial	Digital role-playing game	Pre and Post-test	20-item multiple-choice questionnaire	Supplement
9	Tsai et al. 2015	N=68 students (nurse)	Control (n=35) Experimental (n=33)	Satisfaction questionnaire (Tsai et al. (2008) - 5 Closed, 3 open questions): 26 out of 33 were satisfied or very satisfied	Randomized pre-/post-control design	Digital role-playing game	Pre and Post test	5 items of the COPD care knowledge test	Supplement

According to McGonigal (2011) games share four defining traits – a goal players are trying to achieve, rules that limit how players can achieve the goal, a feedback system telling players how they can achieve the goal and voluntary participation of players (McGonigal, 2011). Whereas Juul (2011) highlight six common elements across games, noting they are 'rule-based, formal systems' that have 'variable and quantifiable outcomes'. Players 'exert effort to influence outcomes' and 'feel emotionally attached to these outcomes' (Juul, 2011). Finally, they note that "consequences are optional and negotiable". While games possess these characteristics, to qualify as 'serious' they must also include another purpose. This additional purpose surrounds a games ability to educate, train and inform (Michael & Chen, 2005).

The term, **serious games**, is attributed to Clark C. Abt 1970. Serious games "have an explicit and carefully thought-out education purpose and are not intended to be played primarily for amusement" (Abt, 1970, p.9). A later description by Michael and Chen (2005) notes a serious game is a "game in which education (in its various forms) is the primary goal, rather than entertainment". Although this does not mean that serious games are not fun or played for amusement (Abt, 1970). While all games could be capable of being both educational and entertainment. The distinction between games and serious games appears to lie in what is the primary purpose of the game i.e., entertainment then education or vice versa.

While Abt (1970) did not categorise serious games as digital, more recent authors have. For instance, Stokes (2005) notes that serious games increasingly denote digital games where the 'primary goal goes beyond entertainment to education, outreach or training'. More recent definitions, such as Dörner et al. (2016) highlight how current technological advances and new mediums are often explored as a potential learning platform, using the introduction of television and education shows as an example. They propose the following definition: a serious game is a "digital game created with the intention to entertain and to achieve at least on additional goal (e.g. learning or health) (Dorner et al. 2016, p. 3). Dorner et al. (2016, p. 3) describes these additional goals as 'characterising goals'. Examples of these goals include 'exergames' where the goal is to increase users' activity. These labels are useful way to categorise the myriad of games within the serious game field.

From reviewing the definitions and traits of serious games, a common theme among them draws from the original definition by Abt (1970). That is a serious game is educational and entertaining and in that order. Therefore, for this review Abt (1970) definition is used. Based on the work of Abt (1970), McGonigal (2011), Juul (2011) and Dörner et al. (2016) the list in Table 43 was derived using the common traits across the descriptions provided by the authors.

Table 43 7 Traits of a serious game

System:	A game is a formal system, that is closed, and can be understood via explicit rules.
Goals:	A game has a goal and a means (in the form of explicit rules) of achieving this goal.
Feedback:	A game has a feedback system to alert players to whether they are achieving this goal or not.
Competition:	A game has a competitive element with winners and losers.
Entertaining:	A game should be engaging with a social element for players.
Voluntary:	Participation in a game should be voluntary.
Platform:	A game may take a variety of forms that include digital, paper or a combination of both.

Additional terms linked to serious games were identified. Terms, such as serious game, gamification and simulation, while often used interchangeably, represent different concepts. For instance, gamification is the "use of game elements in non-game contexts", Deterding et al. (2011)(p.9). Deterding et al. (2011) discussing the difference between the concepts notes that serious games are standalone games used for non-entertainment. In relation to 'simulation', Abt (1970)(p. 9) provides the following advice that while "all games simulate something from the real world, not all simulations are games". Ricciardi and De Paolis (2014) propose 4 factors in which simulation and serious games differ from simulation games. These relate to entertainment factors, development costs, development time and deployment costs (Ricciardi & De Paolis, 2014). Providing a more fluid perspective, Qin et al. (2009) note that serious games and simulation games lie central on a spectrum between simulation (skills training) and games (imaginative and played for fun) (see Figure 28).

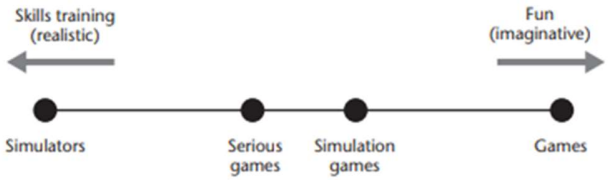


Figure 28 Illustration from Qin et al. (2012)

SOTA: Managing nursing knowledge using serious games

Games have been widely used for reasons other than entertainment. For instance, Snakes and Ladders is a well-known board game, that can trace its origin to 18th century India (Topsfield, 1985, 2006). The game was originally envisioned as a 'pilgrim's journey'. Where different colour snakes (red or black) move players up or down the board, based on the laws of karma (Topsfield, 1985, 2006). More recent versions replaced one of the colour snakes with ladders. Whereas the board game 'Monopoly' was developed in 1904 by Lizzie Magie to demonstrate the implications of individuals buying up vast lots of land. Called 'The Landlords Game'. Initially played with two sets of rules. One set focused on winning by applying anti-monopolist approach. Whereas the second, used a monopolist approach (Pilon, 2015).

Serious games have been used for many reasons in healthcare. For instance, clinical education (Adhikari et al., 2021; Foss et al., 2014), skill development (Bayram & Caliskan, 2019) or teaching soft skills (Calik & Kapucu, 2022). The aim of this review was to explore if serious games could be used by nurses as a knowledge management tool. The term, 'knowledge management' is broad with many interpretations Girard and Girard (2015). The question guiding this review was: Can serious games be used by nurses to acquire, elicit, evaluate and share nursing knowledge? The terms elicit, evaluate and share were identified as relevant knowledge management activities in Chapter 2, Section 2.6. Knowledge acquisition was identified as a primary purpose of serious games (Abt, 1970), therefore, was included in this review.

Findings: From an initial 2,722 papers retrieved, 9 were deemed to have met the inclusion criteria. The majority of papers retrieved discuss the potential of serious games in knowledge acquisition, but less was discussed in relation to creation or sharing knowledge. Seven of the 9 studies included a sample population of student nurses. Participant numbers for this cohort ranged from n=56 to n=160. Two of the 9 studies included a sample population of qualified nurses. Participant numbers for this cohort ranged from n=46 to n=115. The large proportion of student participants was by default and not by design. Additional studies with qualified nurses were found but did not meet the inclusion criteria. It is unclear why students are featured prominently; this was not fully explored in any of the studies.

From the studies retrieved, two main approaches to comparing the utility of a serious game were found. These were as an alternative to traditional teaching methods (Aljezawi & Albashtawy, 2015; Brull et al., 2017; Chang et al., 2020; Chee et al., 2019; Hwang & Chang, 2020). Or as a supplement to traditional teaching (Bayram & Caliskan, 2019; Tan et al., 2017; Tsai et al., 2015). Traditional teaching describes methods such as didactic lectures (Aljezawi & Albashtawy, 2015), classroom-based lectures and practice (Chang et al., 2020) or conventional flipped learning

(Hwang & Chang, 2020). The experimental groups in these studies received lessons using a serious game. In the supplemental approach, both groups received lectures with the serious game incorporated as an additional element for the experimental group. The studies included focused on a range of clinical knowledge and skills topics (Aljezawi & Albashtawy, 2015; Bayram & Caliskan, 2019; Chang et al., 2020; Chee et al., 2019; Hwang & Chang, 2020; Tan et al., 2017; Tsai et al., 2015) and clinical knowledge (Brull et al., 2017). A range of game types were utilized. such as a 'Jeopardy!' style game format (Aljezawi & Albashtawy, 2015), or a digital scenario game (Tan et al., 2017).

There is a wealth of studies describing how learners positively rate incorporating serious games into nursing education (Aljezawi & Albashtawy, 2015; Bayram & Caliskan, 2019; Brull et al., 2017; Chang et al., 2020; Chee et al., 2019; Cook et al., 2012; Del Blanco et al., 2017; Hwang & Chang, 2020; Soyoof et al., 2021). For instance, participants (nursing students) in a study by Aljezawi and Albashtawy (2015) preferred the game format for learning compared to traditional lectures. Participants also perceived the training session as more engaging, as reflected by their significantly increased motivation, according to findings by Bayram and Caliskan (2019). Other benefits of serious games discussed in the literature included how students could work at their own pace (Cook et al., 2012; Hwang & Chang, 2020) or that serious games were a useful addition to the traditional lectures (Cook et al., 2012).

In a study by Chang et al. (2020) who used pre and post intervention testing between two groups (control, n=36 and experimental, n=36) to compare a serious game to traditional teaching of electrocardiogram (ECG) training, found that the game was rated more positively. Participants (student nurses) described it as 'interesting', and that it promoted 'deep thinking'. But the authors note that 'novelty factor' (of incorporating a game instead of traditional lectures) could influence this result (Chang et al., 2020).

While challenges to incorporating serious games were not well described in the studies examined, some comments were noted in the wider literature. For example, in an earlier study, technical issues were raised by participants as challenges of serious games (Cook et al., 2012) Participants in Brull et al. (2017) described the game as 'engaging', while weaknesses discussed were computer glitches and user error. The types of user errors were not described. From an organisational perspective, barriers to implementing serious games include financial (Brull et al., 2017) and time investments (Brull et al., 2017; Hwang & Chang, 2020). On a positive, from an organizational perspective, Brull et al. (2017) found adopting a game (into nursing orientation) removed the requirement for food and beverages, space, materials to be provided (during the orientation). The following text is a discussion to answer the question: Can serious games be used by nurses to acquire, elicit, evaluate and share nursing knowledge?

Knowledge Acquisition: Overall studies found that serious games were a means of acquiring knowledge. In the traditional teaching comparator group, participants engaged in only one type of learning (traditional learning or serious game), authors report that the experimental group had better outcomes in terms of post-test scores. For instance, the authors in one study used an adaptation of the game show Jeopardy! tailored to a nursing cohort (n=66) (Aljezawi & Albashtawy, 2015). Pre-tests showed no educational differences between groups, and post-intervention test scores (of the experimental group) were significantly higher. Similarly, Chang et al. (2020) found students learning with the contextual game showed better learning performance compared to the control group. Their study focused on Electrocardiogram (ECG) training with a sample of 46 student nurses. A quasi-experimental study by Hwang and Chang (2020) separated participants into two groups: control (n=28) and experimental (n=28). They found the experimental group had higher post-test scores than the control group. Pre-test scores showed no significant difference between groups.

Whereas in Chee et al. (2019) a significantly higher number of participants from the experimental group, compared with the control group, obtained perfect performance scores. The experimental group was made up of nurses (n=23) who used the game to teach inhaler techniques to a standardised patient. In this study, a standardised patient describes a person who is trained to give specific 'ques' to a participant to test their clinical skills or knowledge. The 'standardised' denotes that all participants receive the same ques. While the experimental group used the game, the control group applied their own teaching methods. Feedback from participants described that they felt very positive toward the game. The authors note, however, that even though they adopted a randomised control trial more participants in the experimental group were working in respiratory wards (where inhaler technique would be a clinical standard). In the three studies where the serious game was employed as a supplement to traditional teaching (Bayram & Caliskan, 2019; Tan et al., 2017; Tsai et al., 2015) post-test results were mixed (when compared to the traditional lecture group). For example, one study reviewed knowledge and skill acquisition relating to tracheostomy care in n=86 first-year nursing students (Bayram & Caliskan, 2019). They found that knowledge acquisition was the same among the control and experimental group. But found a difference in the acquisition across two of the three tracheostomy skills (that were included in the study) when pre and post-test scores were considered. In this study, the serious game was incorporated as an addition to traditional teaching.

Whereas Tan et al. (2017) in their randomized controlled trial, found post-test knowledge and confidence mean scores of the experimental group improved significantly ($p < 0.001$) after the serious game intervention compared to pre-test mean scores and to post-test mean scores. In a study of N=68 student nurses, Tsai et al. (2015) found that knowledge scores were significantly improved after playing the game in the experimental group. Tsai et al. (2015) employed a

randomized pre-/post-control experimental methodology. Although including a control can give a level of robustness to a study, it is difficult to account for all variables, outside of a lab setting, with absolute certainty. For instance, participants will all have individual characteristics, learning ability or previous experience. It is also difficult to accurately measure what additional learning (if any) occurred following the intervention and before the post-test assessment. Furthermore, in the studies where games were used as a supplement to teach, it is unclear what impact this additional teaching had on outcomes.

Knowledge sharing: The ability of serious games to share new knowledge was more difficult to ascertain as no refence was made explicit in any studies retrieved. Learning outcomes (of the games) and learning content, when mentioned, was driven by domain experts. For instance, in Chang et al. (2020) the ECG tests were designed by two experienced nursing instructors. Tuma (2021) discusses how educational technology can facilitate knowledge sharing. Knowledge sharing (KS) is the "behaviour of disseminating one's acquired knowledge with other members within one's organisation". KS has been highlighted as critical to knowledge management (Nonaka & Takeuchi, 1995). However, no studies examined discussed knowledge sharing in serious games. One potential reason for this could be that all games were played by individual players. It is conceivable that group-facilitated games could yield evidence to support serious games as a means of creating and sharing nursing knowledge. Indirectly, as serious games incorporate domain specialist knowledge or national guidelines, this could be viewed as a means of storing and sharing nursing knowledge. Similarly, there was no evidence found in the examined literature that discussed retention or storage of nursing knowledge within the game (from a knowledge management perspective). However, some games were based on national guidelines (Chang et al., 2020) or developed by domain experts (Chee et al., 2019) in this sense, it could be argued, that the game potentially acted as a store or means of retaining this knowledge.

Knowledge management: Activities around eliciting and evaluating knowledge were not discussed in the papers retrieved, therefore no conclusion could be reached. This could be a result of the number of papers included in the final review or that the terms were consumed under the broader term of knowledge management. No papers examined discussed serious games as a means of knowledge management for nursing. However, papers found (n=3) in the initial search did discuss serious games for knowledge management in relation to other domains. These are: higher education (Bayart et al., 2014), business (Friedrich et al., 2020) and banking sector (Allal-Cherif et al., 2016; Allal-Chérif & Makhlouf, 2016). Although some papers used the SECI model in their research (Allal-Cherif et al., 2016; Allal-Chérif & Makhlouf, 2016; Bayart et al., 2014), no paper described all elements of knowledge management (acquire, creation, retention and sharing). For example, a paper by Bayart et al. (2014) discussed the use of SG as a leverage for knowledge management in the higher education domain. Student participants (n=196) had attended a project

management course. The purpose of the game was for students to apply what they have learned about project management. While a pre and post evaluation did demonstrate that participants did acquire knowledge, no other knowledge management concepts were discussed. Friedrich et al. (2020) focused on the potential of gamification of knowledge management systems to increase employee motivation to share their knowledge. From a review of the literature, their findings indicate that the use of game elements, such as awarding high scoring players 'badges', can positively impact knowledge sharing. However, Friedrich et al. (2020) notes that benefits from gamification could be short term and so organisations should also consider the impact their corporate culture has on knowledge sharing.

Two papers found discussed research related to the same serious games (and study sites) (Allal-Cherif et al., 2016; Allal-Chérif & Makhlouf, 2016). Their work surrounds the application of serious games in knowledge management in banking sector in France, USA and India. An exploratory research approach was used that included website review (for each site) and relevant literature (on the topic of serious games). The authors acknowledge the limitations of this approach such as its reliance on a single perspective. Despite limitations, the authors assert that serious games can make contributions to organisational knowledge across all four models of knowledge conversion model (SECI) proposed by Nonaka and Takeuchi (1995) but they do not provide much detail or adequately explore to how this occurs at the three sites. The papers reviewed in this chapter showed that while there may be a potential role for serious games in knowledge management, currently the research concentrates on the knowledge acquisition component. Additional studies are required to assess whether serious games are useful as a knowledge management tool. Exploring serious games as a knowledge management tool for a nursing cohort is the subject of this PhD research.

Limitation of literature review: The review had a low small of papers which, that did not allow for any definitive conclusions to be reached. While expanding the scope beyond Abt's (1970) definition of SG could generate further papers, it could also open the possibility of included data from studies that are not serious games, but rather simulation or gamification. While these both could act as serious games if we consider Qin et al. (2009) contribution, it is noted that serious games and simulation games lie central on a spectrum between simulation (skills training) and games (imaginative and played for fun). Another limitation is the difficulty gauging entertainment of players. Seven of the papers retrieved used a student nurse sample and the game was deployed as part of their curriculum, rather than entered voluntarily.

Conclusion: The review found that while serious games are used in nursing, this is predominantly around education and training. In addition, no game was identified that could be implemented and evaluated at the study site.

Appendix C - eADR Design Stage (2 Cycles)

An output from the previous eADR diagnosis stage was the set of evaluated problem statements and indications as to how a serious game could be applied to address them. No existing game was found that could be implemented to support the aims of this research. Therefore, the purpose of this stage was to design and evaluate a serious game that could be implemented and evaluated at the study site. To guide game design, a five-stage framework by Verschueren et al. (2019) was adopted. A knowledge elicitation method called the WICKED method, developed prior to PhD research by the author of this thesis (Impey et al., 2023) was used as a starting point for the design. In addition to the game design, in this cycle how elicited knowledge could be evaluated was also considered. Two methods were considered. These were evaluation by consensus and by comparison.

The initial game design was evaluated during a pilot study with n=3 nurse participants. Learning from this cycle determined that including components of the WICKED method (Impey et al., 2023) while beneficial, also introduced two new challenges. These challenges were (1) skills of researcher and (2) unclear when to move to the next step. As a result, the problem statements identified in the diagnosis stage were updated. Throughout the research, meetings were conducted with members of the co-inquiry group and with participants from the study site. Meetings occurred in person at the study site, or at the university where the author of the thesis is based. All meetings were attended by the author of the thesis. Details of these meetings, such as number of participants and reason for the meeting are referred to throughout the chapter as relevant.

The work described in the design stage chapter relates to research objective 3. Objective 3 is concerned with designing and evaluating a low-fidelity prototype of a serious game. No suitable game was identified in the literature; therefore, the design stage produced the 1st iteration of the serious game in this research. The artefact was created using components from a knowledge elicitation method developed previously by the researcher (Impey et al., 2023). The game was evaluated by participants from the study site in a pilot study. A lesson that emerged during this stage, was that methods adopted could also introduce additional challenges. This was the case with the inclusion of elements of the WICKED method into the game design. While the method provided a systematic approach to knowledge elicitation, it also had limitations. These limitations were formalised into an updated set of problem statements.

1.1 Cycle 1: Design framework and discussion

To design the game, the framework developed by Verschueren et al. (2019) was used. This 5-stage framework had been used previously for designing serious games for the healthcare domain. The framework was previously used to develop a Covid-19 game for healthcare workers (Suppan et al., 2020) and perioperative game for children (Verschueren et al., 2019). Stages have specific aims. Broadly, stages 1-3 are concerned with game development. Whereas stage 4 and 5 are concerned with evaluation and implementation. Stages 1-3 were performed as described by Verschueren et al. (2019). The stages 4 and 5 described by Verschueren et al. (2019) were subsumed into the eADR implementation stage and the evaluation activity in the eADR design and implementation stages.

Table 44 Framework for designing serious games for healthcare (Verschueren et al. 2019)

Stage	**Aim of stage**
Stage 1: Scientific foundations	To ensure that the final game design is suitable for end users
Stage 2: Design foundations	To identify the game mechanics, design and technological features that support the outcomes of stage 1
Stage 3: Game development	The practical development of outcomes from stage 2 into the initial game design
Stage 4: Game evaluation	To evaluate the initial game design with end users
Stage 5: Implementation	Depending on outcomes stage 4 initial game design is deployed, reviewed, or withdrawn.

The initial game design also incorporated components from the WICKED method (Impey et al., 2023). This is a four-step researcher-mediated knowledge acquisition method developed for the healthcare domain. To elicit knowledge, researchers role-play as a new staff member and ask domain experts questions on an agreed topic. The method proposes a range of requirements, such as a knowledge topic, which is a relevant clinical topic that is explored during the research. In addition, key knowledge roles are described in the method. These roles are the actors and their function required to elicit and evaluate knowledge. They include Reviewers, Holders and Seekers. Reviewers are actors with domain expertise, that can evaluate knowledge. Holders are nurses with domain knowledge that they can share. Seekers is the role that acquires knowledge from Holders. In the original research Holders were clinical experts that shared their knowledge, Reviewers were subject experts that evaluated knowledge and the Seeker was the researcher whose role was to elicit knowledge from holders (Impey et al., 2023). This work was presented at International Conference on Health Informatics and Health Information Management and a full paper is currently in press.

The title, WICKED, is both an anagram of the words eliciting and confirming data, information, knowledge, wisdom. It is also a reference to the concept of wicked problems. Wicked problems are complex, challenging and have no stopping rule (Churchman, 1967; Rittel & Webber, 1973). The method proposes that researchers adopt a 'new staff member' persona to elicit knowledge. The method was positively reviewed at a second healthcare site by an independent researcher. It was found that role-playing as a new staff member allowed tacit aspects of knowledge to be converted to explicit (and codified) knowledge (Impey et al., 2023). This approach was deemed complementary to the proposed premise of the game i.e. a player acts as a preceptor to new nurses and shares knowledge with them. As this interaction occurs during play, the knowledge is captured in the game. As the WICKED method was evaluated positively in two healthcare settings (Impey et al., 2023) it was considered a suitable starting point. How components from the method are incorporated into the game design are highlighted throughout this chapter. The initial game was designed by the author of the thesis and discussed with members of the co-inquiry group throughout the development process. These discussions were conducted as parts of the game were designed with a final meeting held to review the game produced. Details of this co-inquiry group meeting are shown in Table 45. As multiple meetings took place, the author was unable to include an exact time.

Table 45 Co-inquiry group meeting (Design cycle 1)

Group	Participants	Length	Moderator	Purpose of meeting
Co-inquiry	N=6	Multiple in person meetings across the design stage.	Author of thesis and PI	To review initial game design produced by author of the thesis.

1.1.1 Design Stage 1: Scientific foundations

The aim of Design Stage 1 (Scientific foundations) is to ensure that the final game is relevant for end users (Verschueren et al., 2019). Questions to be asked in this stage include who the target audience are, what are expected outcomes, and how will these be evaluated. In relation to the target audience, actors and initial set of use cases had been identified during the diagnosis stage (Chapter 5). These are shown in Table 46.

Table 46 Actors and qualifiers identified in diagnosis stage

Actor	Name
New Nurses	Nurses based at the study site less than 18 months
Experienced Nurses	Nurses based at the study site more than 18 months
Co-inquiry group	Subject experts based at the study site and a member of the co-inquiry group

These actors were compared to key knowledge roles proposed by the WICKED method (Impey et al. 2022) (Impey et al., 2023) to ensure none were overlooked. Key roles identified in the method were Knowledge holder (KH), Knowledge seeker (KS), Knowledge reviewer (KR) and Knowledge gatekeeper (KG) (Impey et al., 2023). This research will use these role titles as they represent the function of each actor to the game. From this review, it was identified that the knowledge seeker's role was not explicitly identified. The purpose of the Seeker's role is to access knowledge from Holders and was held by the researcher in the WICKED method (Impey et al., 2023). Instead of a researcher's role, the game itself represents the Seekers role via a specially designed avatar. Descriptions of the actors, participant qualifications and functions of the role for both the elicitation game and evaluation process are shown in the Table 47.

Table 47 Actors, participant qualifications and function

Actor ID/Actor	Participant qualification	Function
AID01 – Experts based at the study site	No direct involvement in game	Shares their knowledge with Holders as part of their normal work.
AID02 - Knowledge Holder (KH) Previously referred to as 'New Nurses'	Proposed role is held by nurses based at the study site less than 18 months	The role that shares knowledge they have accumulated in practice with an avatar during the knowledge elicitation game.
AID05 - Knowledge Seeker (KS)	Proposed role is represented by the avatar in the game	The role that elicits knowledge from the Holder during the game.

AID03 - Knowledge reviewer (KR) Previously referred to as 'Experienced nurses'	Proposed role is held by nurses based at the site more than 18 months	The role that evaluates knowledge elicited during game.
AID04 - Knowledge gatekeeper (KG) Previously referred to as the co-inquiry group	Proposed role to be held by the PI	The role that arbitrates in case of disputes relating to knowledge.

The roles will be referred to as: Holders, Seekers, Reviewers, and Gatekeeper going forward. As the word 'knowledge' is frequently used in this thesis, it was considered that introducing additional opportunities to include the word could impact readability.

1.1.2 Design Stage 2: Design foundations

The purpose of the game is to elicit specialist nursing knowledge so that it can be shared. Design Stage 2 (Design foundations) of the framework by Verschueren et al. (2019) is concerned with identifying appropriate game mechanics to achieve this purpose. Game mechanics refer to how players interact within the game (Sweetser & Wyeth, 2005). They are described in the rules or methods that direct player interactions with the game and include turn-taking or penalties (Verschueren et al., 2019). In this section, the mechanics proposed to achieve the purpose of the game are described. These are a set of avatar cards, Knowledge topic (KT), Control knowledge base (CKB), and Knowledge bank (KB). With the exception of the avatar cards, these were identified from the WICKED method (Impey et al., 2023). These are described in the following text. The Seeker is represented by pre-designed paper avatar in the game. The purpose of the knowledge sharing is to prepare the Seeker to discharge a patient from the study site. The initial set of avatars developed for this research are shown in Figure 29.

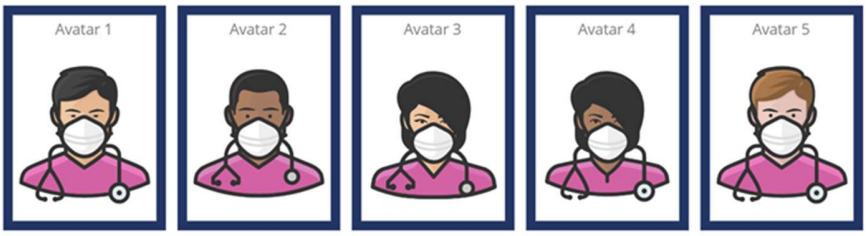


Figure 29 Initial set of avatar cards

A knowledge topic (KT) is a relevant clinical topic that is explored (Impey et al., 2023). For this research, it was a general adult discharge from an oncology setting. This topic was identified by

the co-inquiry group as important as it is an opportunity for nurses to prepare patients for going home and discussions concern the problems to monitor for and what to do in case of an emergency. This topic was developed into a clinical scenario for the game by the co-inquiry group. This scenario describes a hypothetical patient discharge process from the study site. The scenario proposed was:

> *"From your clinical experience, help prepare a newly employed nurse in this clinic to discharge a patient from the day care setting by writing any additional nursing advice you would like the nurse to ask but are not currently captured on the document. Please write any notes you think useful on the post-it and submit them to the researcher. Each post-it submitted will be awarded 1 point. Prompt: what should the nurse do, ask or observe during discharge."*

Patient discharge was identified as it was envisioned that it could be knowledge-rich and had a high probability that Holders had experience of. The clinical scenario is used to focus knowledge collection and stop it from becoming too unwieldy.

A control knowledge base (CKB) is a pre-existing object that can be used to initiate knowledge collection (Impey et al., 2023). For this research, a 'Haematology/Oncology Day care Patient Medication record' was identified by the co-inquiry group. This document is also used at the study site by pharmacy to capture patient discharge advice on medication management. For this study, only nursing advice was captured. Patient information leaflets were also considered as CKB. The patient medication record was chosen as it is used in most discharges, whereas patient information leaflets could be condition specific. To minimize the number of pages a Holder would require, a photo of the CKB and the KT were incorporated into a single document. The document also had post-it notes where they could document their knowledge and then submit each post-it to the game. Each Seeker was randomly assigned a different colour pack of post-it notes. As knowledge is submitted anonymously, different coloured post-it notes provided a way to track points awarded to each Seeker. This document was referred to as the game sheet. The game sheet also contained the rules of the game. The initial game sheet is shown in Figure 30.

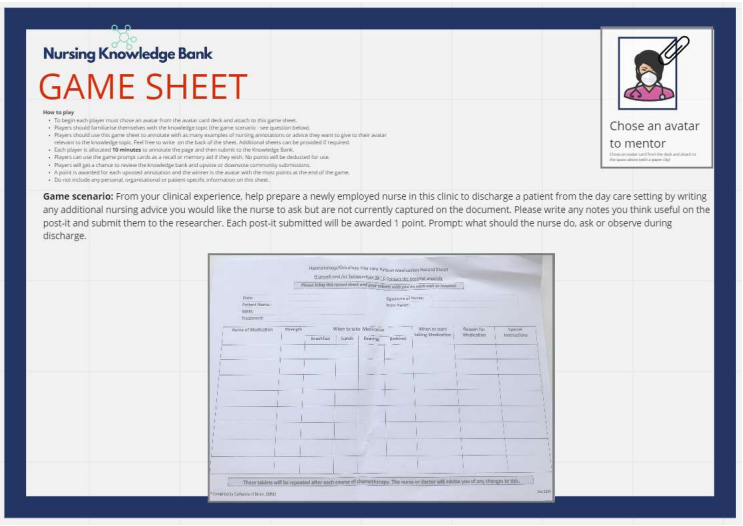


Figure 30 Proposed game sheet

A knowledge bank (KB) as described by Impey et al. (2023) is a paper or electronic repository containing knowledge relevant to the knowledge topic. It is proposed that knowledge submitted is presented on the elicitation game board. This game board is a printed poster with space to put the submitted post-its (see Figure 31). Submissions collected are referred to as 'community knowledge' as no record of the holder who submitted it is kept.

Following the game, this community knowledge will be constructed into a digital spreadsheet by author of the thesis and reviewed by the Gatekeeper. This digital spreadsheet is an initial iteration of the knowledge artefact, the data reference set for an adult discharge from an oncology setting. It is proposed that knowledge contained will be evaluated by Reviewers and following a final validation step by a subject expert, will be developed into a data reference set for an adult discharge from an oncology setting.

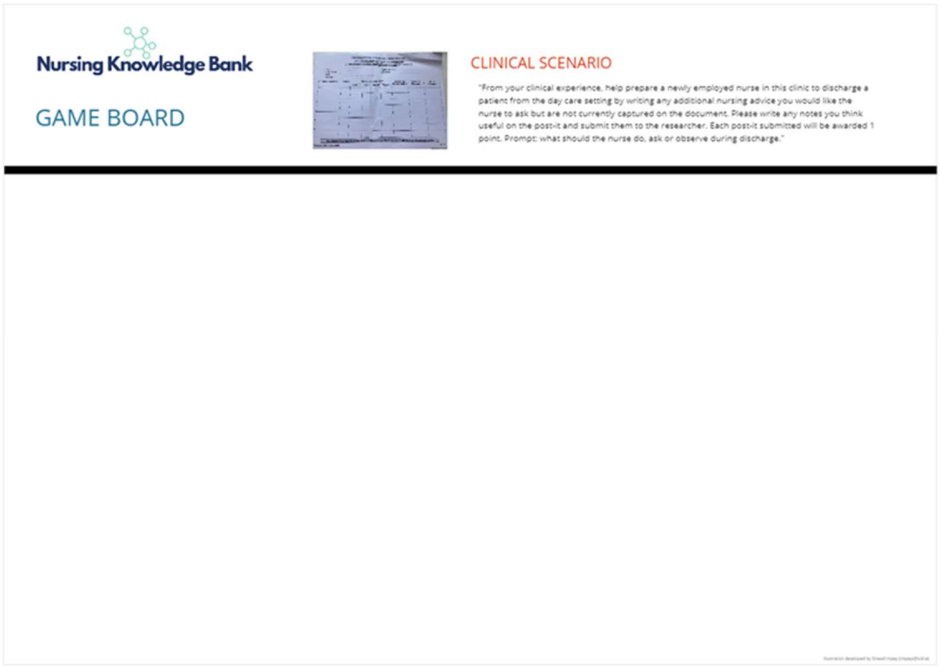


Figure 31 Proposed evaluation game board

This section introduced several key terms that will be referred to throughout this research. In the case of the KT and CKB they were combined and presented as the game sheet. Whereas the knowledge bank was represented by the elicitation game board. For clarity, an overview presented in the Table 48.

Table 48 Overview of how components are applied in this research

WICKED method	**Purpose in this research**	**Referred to in elicitation game as:**
KT	Represented as a clinical scenario. The scenario was 'Nursing advice for patients being discharged from the Adult Oncology Day Care setting'.	Game Sheet
CKB	Haematology/Oncology Day care Patient Medication record document	
KB	The knowledge bank is represented by the elicitation game board. This is an A0 paper poster. Post-its generated during the game are collected onto the game board.	Elicitation game board

In addition to key roles and game components, the co-inquiry group reviewed the problem statements, paying specific attention to what mechanics could be incorporated into the game to address them. As noted, the initial game design took inspiration from the WICKED method (Impey et al., 2023). While the WICKED method provided a systematic approach to knowledge elicitation, it is not without limitations. These limitations surround the skills of the researcher and lack of guidance on ceasing knowledge collection. Four limitations were identified from the WICKED method (Impey et al., 2023). However, not all limitations required specific problem statements. Two of the four limitations identified were subsumed into current set of challenges. These are:

- Limitation: 'must be repeated at a future time as knowledge evolves' was consumed into challenge 4: Challenges around evolving knowledge.
- Limitation: 'laborious process' was consumed into challenge 2: Time challenges.

The remaining two limitations identified were added as new challenges. These new challenges are shown in Table 49.

Table 49 Two additional challenges arising from the WICKED method (Impey et al. 2023)

Challenge	**Description**
9. Challenges around skills of researcher	The WICKED method relies on the skills/availability of the researcher to identify what is important and how to translate what is observed into explicit knowledge (Impey et al., 2023).
10. Challenges around ceasing knowledge collection	The WICKED method provides no guidance given to users on when to move through the prescribed steps or when to cease knowledge elicitation. Saturation was used as a heuristic in the original study (Impey et al., 2023).

Following discussions between the author and the PI, challenges were transformed into problem statements. These new problem statements are shown in Table 50. A discussion on these is presented in the following text.

Table 50Additional problem statements arising from the WICKED method (Impey et al. 2023)

9. Challenges around skills of researcher	PS 9: The solution should not rely on skills of an individual researcher and should provide explicit instructions.
10: Challenges around ceasing knowledge collection	PS 10: The solution should provide guidance on when to move through the prescribed process and when to cease knowledge collection.

The WICKED method relies on the skills/availability of the researcher to identify what is important and how to translate what is observed into explicit knowledge (Impey et al., 2023). It was proposed that a serious game could remove the need for a researcher by expanding the role of the Gatekeeper to include a moderator role, in addition to being the arbiter. Proposed functions of the moderator role include setting up the game, circulating the game sheet, collecting the knowledge submissions and collating onto the game board and monitoring game time.

In addition, the method provides no guidance given to users on how to know when all knowledge available in a particular environment has been elicited and collection can cease (Impey et al., 2023). It was proposed that a serious game could provide guidance on when to move through any prescribed steps and when to cease knowledge collection. This could take the form of a set time

for playing the game to facilitate movement across the game and knowledge saturation to identify when to cease knowledge elicitation. It is proposed that game time is influenced by available time, for example, the current education sessions (see 'PS 2: The solution should not add to any time burden or be laborious for users' for further explanation). While no ideal time was identified in the current or previous exploratory studies that could be used as a measure when all knowledge was captured. It was discussed by the co-inquiry group that not all knowledge might be elicited in a single game session, it is proposed that knowledge saturation be adopted as a proxy measure in lieu of a formal time scale. For clarity, the new challenges identified related problem statements and how a serious game could potentially address them is presented in Table 51.

Table 51 Overview of challenges, problem group, problem statements and application of solution

Challenge	**Problem statements**	**How SG could potentially address this problem statement**
9: Skills of researcher	PS 9: The solution should not rely on skills of an individual researcher	Proposed that the Gatekeeper role could include duties held by the researcher, such as setting up the game. An initial set of game rules and play instructions were developed so that the game could function independent of this research.
10: Unclear when to move to the next step	PS 10: The solution should provide guidance on when to move through the prescribed process	The game will be divided into two parts, a knowledge elicitation part and a knowledge evaluation part. These will be performed separately to allow time to collate the knowledge elicited into the digital spreadsheet for review. Time limits on game play will aid movement across both parts, data saturation will be used as an indicator that all available knowledge is elicited.

1.1.3 Design Stage 3: Game development

During the game development stage, the components, actors and potential remedies to address the problem statements identified were reviewed by the co-inquiry group using the traits of a game identified in Chapter 4, Section 4.3. The number of available co-inquiry group members available to discuss this was low. No reason was identified for this. To ensure all members were fully informed the author spoke to absent members to ensure they were satisfied with what was discussed. Details of this co-inquiry group meeting are shown in Table 52.

Table 52 Co-inquiry group meeting of challenges (Design cycle 1)

Group	Participants	Length	Moderator	Purpose of meeting
Co-inquiry	N=3	60 minutes	Author of thesis and PI	To discuss how proposed approach demonstrates identified game traits.

The traits addressed in the 1st iteration of the game are shown in Table 53.

Table 53 Traits addressed in 1st iteration of the game

Trait	**Proposed design requirement**
System:	The game will be a closed system, engagement with the game for all roles will be limited to the study site and subject experts.
Goals:	The goal of the game is to submit knowledge to the game and earn points. The Seeker with the most points at the end of the game time will be deemed to be the winner.
Feedback:	Knowledge submitted during the game will be visible to all Holders and they will have an opportunity to review and provide feedback on this group knowledge.
Competition:	The Seeker, and by default the Holder, with the most points earned, and therefore most points awarded, will be deemed the winner.
Entertaining:	To evaluate whether the game is entertaining and enjoyable for participants, a post-gave evaluation will be circulated to knowledge holders.
Voluntary:	Participation in the game is voluntary.
Platform:	The game will be a low-fidelity prototype to evaluate the utility of the game.

Following this discussion, the first iteration of the knowledge elicitation game was produced. To play the knowledge elicitation part of the game, Holders are given an avatar and a game sheet. This sheet includes the clinical scenario or knowledge topic, the CKB and a set of post-it notes. The clinical scenario is described by the Gatekeeper. The game has an agreed time limit which was dictated by the study site to coincide with the length of the education session. During the game time, Holders document as much of their knowledge relating to the clinical scenario on the post-it notes. These are entered onto the game board. Following the game, Holders are encouraged to review the game board and give knowledge they consider relevant a green sticky dot 'award' or in the case that it is not relevant, give a red sticky dot award. For each post-it note submitted,

Seekers receive a point. The Seeker at the end of the game time with the most points is deemed to be most prepared. This process is shown in Figure 32.

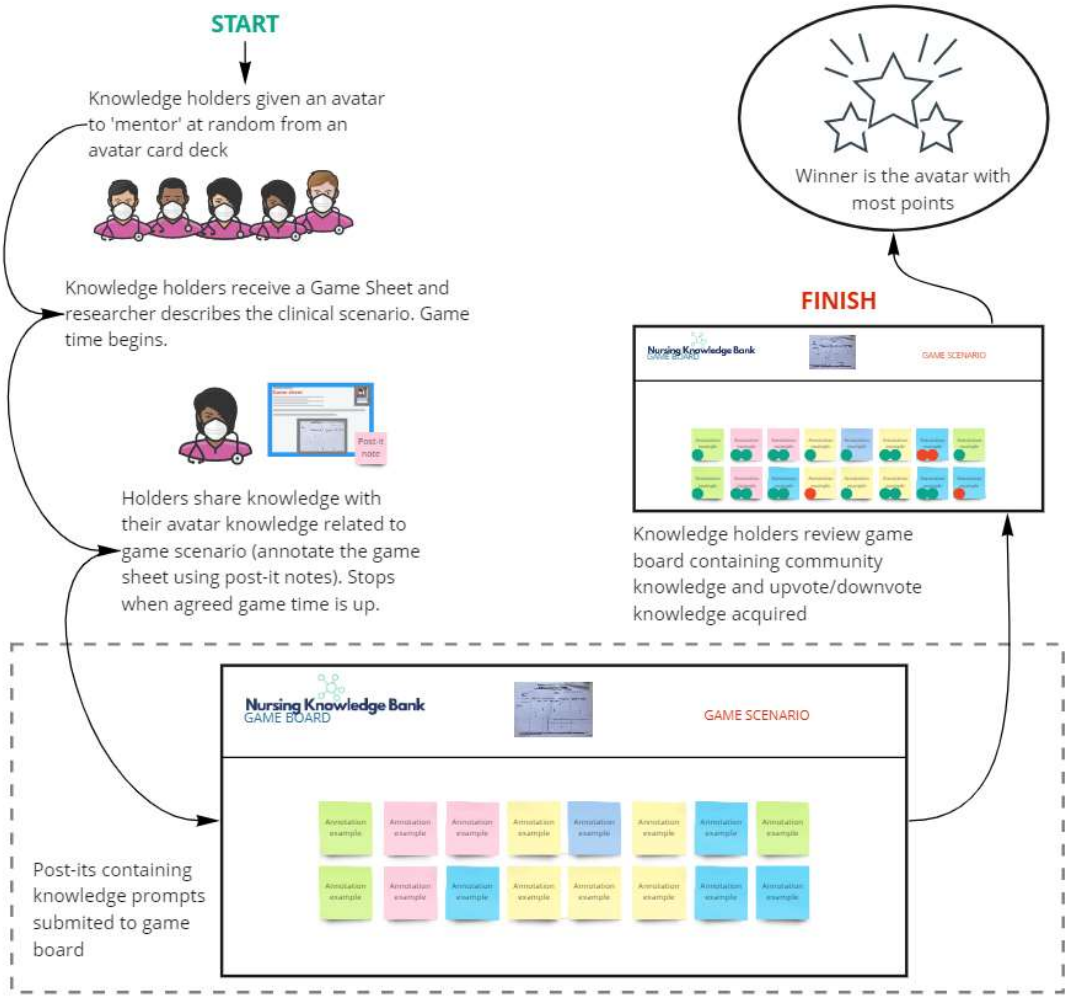


Figure 32 Proposed knowledge elicitation game flow (1st iteration)

1.1.4 Design Stage 4: Game evaluation

Design Stage 4 of the framework developed by Verschueren et al. (2019) surrounds game evaluation. This stage overlapped with eADR activities and so were therefore subsumed under the relevant headings. However, a pilot study was conducted to ensure the game was suitable to implement at the study site. No data from the pilot study was included in the research findings. The game was played during the site's regular education sessions. Details of the pilot test is shown in Table 54.

Table 54 Pilot test 1st iteration of the knowledge elicitation game (Design cycle 1)

Group	Participants	Length	Moderator	Purpose of meeting
Nurses from study site	N=3	45 minutes	Author of thesis and PI	Evaluate 1st iteration of the initial game design.

No amendments were made to the game rules or play instructions or the flow of the game following the pilot study. However, during the pilot test, participants required clarity on the wording of the clinical scenario. Also, included was a prompt to players as to what knowledge was required, 'Prompt: what should the nurse do, ask or observe during discharge'.During the cycle, the knowledge evaluation process was developed. To evaluate the knowledge, two approaches were identified (see Chapter 4, Section 4.2). These approaches were evaluation by consensus (Becerril-Montekio et al., 2016; Kamsu-Foguem et al., 2013; Majima et al., 2018; Torshizi et al., 2014; Wulff et al., 2018) and evaluation by comparison. Evaluation by expert consensus describes achieving group agreement, where majority rules and the Gatekeeper had the final say in case of disputes. Evaluation by comparison, include between pre and post system deployment (Pegoraro et al., 2020), novice and expert results (Borders et al., 2015) or diagnostic comparisons between expert and system results (Ati, 2014, González-Ferrer et al., 2017). In this research evaluation by expert consensus was chosen as it could be performed following each game rather than wait for all knowledge to be collected before a fair comparison could be conducted.

To begin the review process, it was proposed that the community knowledge would be transcribed, reviewed, and constructed into a digital spreadsheet by the author and the PI. A full account of how the community knowledge was prepared is described in Appendix F. A paper copy of the spreadsheet would be printed and given to the Reviewers during the evaluation meeting. In a group, it was proposed that the Reviewers could discuss each piece of knowledge submitted and as a group included or rejected it from the spreadsheet. This spreadsheet was updated following the Reviewers meeting by the author and reviewed by principal investigator to ensure accuracy. A group discussion was also held with the Reviewers to following the evaluation to capture their thoughts on the process and feedback on the knowledge they had reviewed. It was also proposed that other participants could also play a role in evaluation. For instance, Holders were also given an opportunity to give awards to the community knowledge as a means of evaluation. The co-inquiry group reviewed any new knowledge following the evaluation group. Following each game knowledge was added to the digital spreadsheet so that each Review group had the opportunity to review it in its entirety. In this research, a final evaluation step was conducted with a subject expert not previously connected to the site. This was conducted as a final safety measure to decide to what extent a serious game could elicit nursing knowledge.

1.1.5 Design Stage 5: Implementation

Stage 5 is concerned with implementing the game. Similar to Stage 4 of the framework developed by Verschueren et al. (2019) there is an overlap with the eADR activities. Implementation of the game is described in Chapters 7, 9 and 10.

1.2 Cycle 1: Outputs

Except for the wording to the clinical scenario, no further changes to the game were made following evaluation. Therefore, this 1st iteration of the knowledge elicitation game is an output from this stage. Other learning that occurred during this stage was formalised into two outputs. These are

- Updated and categorised set of problem statements
- Updated set of use cases to capture learning that occurred during the design stage

1.2.1 Updated and categorised problem statements

Updates to the problem statements arose from the inclusion of the WICKED method (Impey et al., 2023) as a starting point for game design. These changes were discussed in Chapter 6, Section 6.3. This discussion concerned how incorporating additional methods can introduce additional challenges that the researcher needs to address. As the list of problem statements evolved, they were reviewed by the co-inquiry group. From this review, it was discussed that the statements could be further catagorised as (1) related to domain (nursing in a specialist area), (2) related to specialist knowledge or (3) potential Unintended Consequences (PUC). It was envisioned that by presenting the problem statements in distinct categories, they could be tested in future work in a non-nursing domain. The first category describes challenges that arise from the domain, such as the busyness of a healthcare setting. The second describes problems that arise due to the complexity of knowledge, such as its tacit aspects. The third category, Potential Unintended Consequences (PUC), statements that were more akin to warnings for things to monitor for. For instance, the possible range of socio-technical challenges could be too unwieldy and site specific to list. However, without an awareness that these could impact the proposed solution, this could present difficulty later. These were considered potential unintended consequences. Unintended consequences are outcomes of adoption (not necessarily a technology adoption) that are neither predicted, nor anticipated but are a direct result of a change (Merton, 1936). In “The Unanticipated Consequences of Purposive Social Action” Merton (1936) referred to these as unanticipated consequences, however, they have come to be widely known as unintended consequences. The final list of categorised problem statements with the addition of the two challenges related to the WICKED method is shown in Table 55. This table adopts the format used to present challenges, problem statements and proposed application from Chapter 5, Section 5.3 for consistency.

Table 55 Updated challenges, problem statements, proposed application of a serious game

Problems related to knowledge		
Challenge	**Problem statements**	**Proposed application**
1: Tacit	PS 1: The solution should be capable of eliciting tacit knowledge	Players: Proposed to utilise preceptor/preceptee relationship
4: Evolving knowledge	PS 4: The solution should be able to manage evolution of knowledge	Proposed to be played during scheduled education sessions.
5: Trust in knowledge	PS 5: The solution should be able to evaluate the knowledge elicited	Proposed building trust through multi-layer evaluation – player, evaluation, and co-inquiry group.
Problems related to the domain		
2: Time	PS 2: The solution should not add to any time burden for users	Proposed to incorporate game play into established education meeting times
6: Incomplete or inaccurate data sets	PS 6: The solution should not rely solely on established data sets due to the potential for them to be incomplete or inaccurate data sets	Proposed that game to generate knowledge, and not rely on data sets.
7: Accessing experts	PS 7: The solution should be capable of accessing subject experts	Proposed to limit player role to nurses at the study site less than 18 months as this group access expert knowledge as part of their learning.
8: Personal knowledge management systems	PS 8: The solution should provide outcomes (in terms of knowledge) for nurses to minimize use of personal knowledge management systems	Proposed to allow players access to 'community knowledge'. This can be facilitated by displaying the game board in the room during the game time and players can take a photograph to have as a reference while the data set is being developed.
Potential unintended consequences (PUC)		
3. Socio-technical	PS 3: The solution should address the socio-technical challenges identified	Proposed that knowledge submitted anonymously in closed community and evaluated by subject experts from to the study site.
9: Skills of researcher	PS 9: The solution should not rely on skills of an individual researcher	Proposed that Gatekeeper role could include duties traditionally held by a researcher, such as setting up the game. An initial set of game rules and play instructions were developed so that the game could function independent of this research.
10: Unclear when to move to the next step	PS 10: The solution should provide guidance on when to move through the prescribed process	The game will be divided into two parts, a knowledge elicitation part and an evaluation process. Performed separately to allow time to collate the knowledge elicited into the digital spreadsheet for review. Time limits on game play will aid movement across both parts.

1.2.2 Updated set of use cases

The lessons learned during the design stage were used to update the list of actors and set of use cases. During the design cycle, an additional actor was identified, the Seeker. This role is represented by the avatar in the game. In addition, actors were identified in the diagnosis stage, were renamed to reflect the roles identified in the WICKED method (Impey et al. 2022). These are shown in Table 56.

Table 56 Actors identified (Design Cycle 1)

Actor	**Name**
AID01	Experts based at the study site - No direct involvement in the game
AID02	Holder was 'New nurses'
AID03	Reviewer was 'Experienced nurses'
AID04	Gatekeeper was 'Co-inquiry group'
AID05	Seeker's role represented by an avatar in the game

To formulise the learning, discussions between the author and their supervisor were conducted. From this additional use cases were identified for the elicitation game. These are show in Table 57.

Table 57 Use cases elicitation game (Design Cycle 1)

Use Case ID	**Description**	**Actor**
UC07	Circulate game sheet	AID04
UC08	Accept game sheet	AID02
UC09	Arbitrator in case of disputes	AID04
UC10	Prepare elicited knowledge for evaluation	AID04
UC11	Award points to knowledge submitted	AID04
UC12	Collate submissions onto the game board	AID04
UC13	Count knowledge submissions	AID04
UC14	Identify winner	AID04
UC15	Upvote or downvote knowledge submitted	AID02
UC16	Monitor game time	AID04
UC17	Accept points for knowledge submitted	AID02, AID05

To formulise the learning discussions between the author and supervisor were conducted relating to the evaluation process. Identified actors and related uses cases are illustrated in Table 58.

Table 58 Use cases evaluation process (Design Cycle 1)

Use Case ID	Description	Actor
UC01	Prepare knowledge for evaluation	AID04
UC02	Circulate prepared knowledge	AID04
UC03	Monitor process time	AID04
UC04	Receive evaluated knowledge	AID04
UC05	Arbitrator in case of disputes	AID04
UC06	Review prepared knowledge	AID03
UC07	Approve prepared knowledge	AID03
UC08	Reject prepared knowledge	AID03
UC09	Submit knowledge	AID03

1.3 Cycle 2: Overview

There are many definitions and activities related to managing knowledge (Girard & Girard, 2015). For this research, the activities identified were eliciting, evaluating and sharing knowledge. These are discussed in Chapter 1, Section 1.2. The initial design presented in Appendix C produced a knowledge elicition game and a knowledge evaluation process. From feedback captured during the first implementation cycle (see Appendix D) participant engagement with the initial elicitation game design was positive. However, the evaluation process was described as challenging by participants. This was due to the number of entries and the repetitive nature of the task. As the list was expected to grow as more knowledge was elicited, it was proposed by the author to gamify the evaluation process. This could be implemented and evaluated at the study site to explore if this could make the evaluation process less challenging for reviewers. Evaluating the elicited knowledge is important if it is to be shared beyond the study site. According to Blanié et al. (2020) satisfaction and motivation to engage in serious games are linked, so it was deemed important to address potential barriers to engagment in the evaluation process. The design of the evaluation part of the game is described in this chapter. This represents the second design cycle performed in this research; however, these cycles are not consecutive.

To design the evaluation part of the game the 5 stage framework by Verschueren et al. (2019) was used. This was initially used to design the elicitation game. The design also included components from the WICKED method (Impey et al., 2023). This is a knowledge elicitation method that was used as a starting point for the initial elicitation game design. The use cases identified in the previous chapter guided the design. This design process is described in this chapter 4 and Appendix C. The full game, that is the elicitation and evaluation, was implemented and evaluated at the study site in the next chapter (See Chapter 4 and 5).

The design incorporates the use cases and evaluation process identified in the first implementation cycle (see Appendix D). The game was designed by the author and was based on the traditional format of 'Snakes and Ladders' game. The first iteration was reviewed by the Gatekeeper and a second member of the co-inquiry group. While it would have been favourable to review with the larger group, due to time commitments this was not feasible. A further limitation noted was that a pilot study was not conducted. Again, this was influenced by timing and availability of participants.

The work described in the second design cycle relates to research objective 3 and is concerned with designing and evaluating a low-fidelity prototype of a serious game. In this chapter, the initial game was extended to include the evaluation process. This produced the first iteration of a serious knowledge elicitation and evaluation game. The design of the evaluation part of the game followed the current evaluation process used in the design of the elicitation part of the serious game. The design of the game drew from the traditional 'snakes and ladders' game. Incorporating challenge cards that could move participants forward or backward, while at the same time teaching about the challenges to eliciting knowledge. Due to limited availability of participants, a pilot study was not performed. Instead, the final design was reviewed by the gatekeeper and another member of the co-inquiry group. In the next chapter, the extended elicitation and evaluation game was implemented and evaluated at the study site

1.4 Cycle 2: Design framework and discussion

To guide game design, the five-stage framework by Verschueren et al. (2019) was adopted. This framework was also used in the first eADR design cycle. It was applied in this cycle in the same way that is stages 1-3 were applied as described the authors, as stages 4 and 5 related to evaluation and implementation, these are captured in the eADR evaluation activity during the implementation stage. Sticking to the process used in the first design cycle, the knowledge elicitation method (WICKED method), developed prior to PhD research by the author of this thesis (Impey et al., 2023), was reviewed. According to this method, the review of the knowledge is by expert consensus. In the method, this group is referred to as Reviewers. This approach – consensus by expert reviewers – was already established as the evaluation process so no changes were made. Potential game designs were discussed between the author and Gatekeeper. It was proposed to adopt the format of the traditional board game 'Snakes and Ladders' as it would be familiar to participants. How the stages proposed by Verschueren et al. (2019) are applied in this research as shown in Table 59 and described in the following text.

Table 59 Design of knowledge evaluation game, framework by Verschueren et al. (2019)

Stage 1: Scientific foundations	
• What are the outcomes to be achieved?	Elicited knowledge captured in the first part of the game needs to be evaluated. The proposed evaluation process was not part of the game and Reviewers described it as challenging due to the repetitive nature of the task and number of knowledge submissions. To make evaluation process more enjoyable for Reviewers it was proposed to gamify it. Therefore, the outcome to be achieved is to extend the knowledge elicitation game into a knowledge elicitation and evaluation game.
• How will outcomes be achieved?	Proposed to adopt the game of 'Snakes and Ladders' and include relevant components from the knowledge elicitation method (Impey et al., 2023) used in the first design cycle.
• How will achievements be evaluated?	For elicited knowledge to be considered evaluated, it must have two positive reviews. In the case where a knowledge prompt does not receive two positive reviews, the prompt is forwarded to the gatekeeper for review.
Stage 2: Design foundations	
• Which game mechanics are best suited to achieve the intended outcome objectives?	The design of the proposed turn-taking game was based on the traditional 'snakes and ladders' game. It is proposed that elicited knowledge will be constructed into a set of cards by the author. To play the game, it is proposed that the Reviewer and evaluates content of the card and decides, based on their experience, to include or reject it from the game. To be considered evaluated, each knowledge submission must have two positive reviews. In the case where a knowledge prompt does not receive two positive reviews, it is forwarded to the gatekeeper for review. For each review a participant completes, they move along the game board and the winner is the one who reaches the top of the game board first.

Stage 2: Design foundations – continued from previous page	
• What are the design requirements?	Game components include: • Evaluation game board, containing 100 sequentially numbered squares. 16 squares contain challenge icons. When a patient lands on these they chose a challenge card. The purpose of the game board is to capture play and show player progress. • Community knowledge cards containing the prepared knowledge and the number of moves a player can take once that evaluate the card content. • Challenge cards that can move players forward and back additional spaces. It is proposed that these cards are activated when a player lands on a particular square of the game board.
• How can the game design best accommodate the evaluative trial?	The extended knowledge elicitation and evaluation game will be implemented at the study site and evaluated through group discussions and a post-game questionnaire. These evaluation processes are the same for the knowledge elicitation part of the game – group discussions and post-game survey.
Stage 4: Game evaluation and Stage 5: Implementation	
• How will the game be evaluated and implemented?	Similar to the first design cycle, the Stages 4 and 5 described by Verschueren et al. (2019) were subsumed into the eADR implementation stage and the evaluation activity in the eADR design and implementation stages. Therefore, the initial evaluation game design will be reviewed during the eADR implementation stage of the eADR approach. This review will consist of a group discussion and participant survey.

The initial game design also incorporated the WICKED method (Impey et al., 2023). This is a four-step researcher-mediated knowledge acquisition method developed for the healthcare domain. In this method, knowledge elicited by the researcher was reviewed and validated by subject experts by consensus. This role was referred to as a knowledge reviewer. In the case of any disputes, a gatekeeper role was enacted. This role was held by a subject expert who was not

part of the knowledge review group. This approach was also adopted as the evaluation process for this research. Similar to the initial design, the evaluation part of the game was developed by the author of the thesis. Due to time constraints a full co-inquiry group was unable to be convened for this cycle. Instead, the group consisted of the Gatekeeper and one member from the co-inquiry group. Discussions were ongoing throughout the design process between the three members with a final meeting held to review the final game design. Details of this co-inquiry group meeting are shown in Table 60. As multiple meetings took place, the author was unable to include an exact time.

Table 60 Co-inquiry group meeting 1 (Design Cycle 2)

Group	Participants	Length	Moderator	Purpose of meeting
Co-inquiry	N=2	Multiple in person meetings across the design cycle.	Author of thesis	To review initial evaluation game design produced by author of the thesis.

1.4.1 Design Stage 1: Scientific foundations

The aim of Design Stage 1, Scientific foundations is to ensure that the final game is relevant for end users (Verschueren et al., 2019). Questions to be asked in this stage include who the target audience are, what are expected outcomes, and how will these be evaluated. No changes or additional roles were identified from the initial evaluation process. Descriptions of the proposed actors and functions of the role are shown in the Table 61.

Table 61 Actors, participant qualifications and function

Actor ID/Actor	**Participant qualification**	**Function**
AID03 - Knowledge Reviewer (KR)	• Proposed that nurses from Haematology/Oncology Day ward (more than 18 months)	Held by experienced nurses. The primary function of the evaluation group is to evaluate knowledge generated during game play.
AID04 - Knowledge gatekeeper (KG)	• Proposed to be held by the PI	Held by a PI who is also a clinical member of the co-inquiry group. Their primary role is to arbitrate in case of disputes relating to knowledge

1.4.2 Design Stage 2: Design foundations

The purpose of this part game is to evaluate the knowledge elicited so that it can be shared beyond the community where it is generated. Stage 2 is concerned with identifying appropriate game mechanics to achieve this purpose Verschueren et al. (2019). Game mechanics are how players interact within the game (Sweetser & Wyeth, 2005). The proposed premise of part 1, elicitation, was that knowledge Holders act as a preceptor to a 'new nurse' in the form of an avatar within the game. The premise of the second part, evaluation, builds on this and tasks Reviewers with ensuring knowledge elicited is relevant and high quality so that it can be shared beyond the game. The game was designed by the author as a turn taking game based on the traditional format of 'Snakes and Ladders' game. To play the game, three components were developed. These are a game board (evaluation), community knowledge cards and challenge cards. These are described in the text below. An evaluation game board was designed that contained 100 sequentially numbered squares (see Figure 33). The design of the game board mirrored the traditional snakes and ladders game. The purpose of the evaluation game board is to capture play and show player progress. It was proposed that participants could take turns to move a marker, a small plastic disk, around the board. These disks described as 'icons' in the use case are coloured to represent different players. The number of spaces a participant can move is based on points they earn by reviewing the elicited knowledge. This knowledge would be constructed into a card deck rather than a spreadsheet. These cards described in the next part of this section. Participants were free to discuss the knowledge they were reviewing with the group if they wished. It was proposed that the winner was the participant who reached the 100th square first. Should the game time end before any participants had reached the 100th square, the highest placed individual was considered the winner.

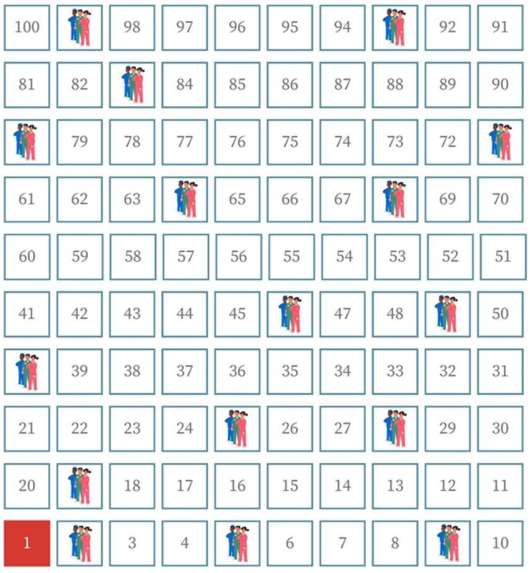


Figure 33 Proposed evaluation game board

In the original evaluation process, the submitted community knowledge was prepared and constructed into a digital spreadsheet. How knowledge was prepared is discussed in Appendix F. Reviewing this list was deemed challenging due to the number of entries and the repetitive nature of the take. It was discussed between the author of the thesis and the Gatekeeper to represent the prepared knowledge in a set of community knowledge cards, see Figure 34.

Figure 34 Example of proposed community knowledge card

Each card, designed by the author, would describe a single knowledge submission that was elicited during the first part of the game. At the top of each card was a topic, in the example shown in Figure 34, this is 'Nursing Assessment: Breathing'. At the bottom, marked in a red square, was a number that informed Reviewers how many places they could move through the game board when the knowledge contained was evaluated. These numbers were assigned randomly, no formal weighting method was used.

Blank cards were also developed to accommodate any new knowledge that emerged during the evaluation game. Reviewers would be asked if the knowledge captured in the card was relevant or not relevant based on their experience. For each knowledge prompt (on the card) evaluators can assign: YES, NO or Maybe. It was proposed that the number of cards would be duplicated, and each participant would receive a full deck to review. A minimum of two participants were required so that each knowledge submission received at least two reviews.

It was proposed that when all participants have reviewed their card deck. These cards would be collected into the game and reviewed by the Gatekeeper. The Gatekeeper review is not focused on the knowledge but on the reviewers' decisions. This review arranges the evaluations into three categories (Yes, No, Maybe):

- When all evaluators mark submission as ‘YES’, then knowledge is included in the digital spreadsheet.
- When all evaluators mark submission as ‘NO’, the knowledge is rejected from the digital spreadsheet.
- Any submissions that that include ‘YES’, ‘NO’ or ‘MAYBE’ will be reviewed by the Gatekeeper who has the final say as to whether the knowledge is included or rejected from the digital spreadsheet.

Following the Gatekeeper review, the digital spreadsheet was be updated to reflect the findings from the evaluation game.

A second type of card was designed for the evaluation game. Again using the ‘Snakes and Ladders’ game as a guide it was proposed, some of the squares on the evaluation game board were allocated ‘challenges’. It was proposed that these would be activated when a participant landed on them and would result in the participant receiving a ‘challenge card’ (see Figure 35). In total 16 squares on the game board (evaluation) contained a challenge. Each challenge related to a problem statement and could move the participant back or forward through the game board. For example, “You were working with an expert and were able to access their knowledge - Move 5 places” or “Personal notebook was lost that contains all the lessons learned during your time on the unit - Lose 5 places”. The purpose of the challenge cards was to add a sense of excitement to the game (entertainment) and also include an education component around the problems surrounding eliciting nursing knowledge. Incorporating education and entertainment elements is aligned with the concept of serious games as described by Abt (1970).

Figure 35 Examples of proposed challenge cards

1.4.3 Design Stage 3: Game development

During the game development stage, the components, actors and potential remedies to address the problem statements identified were reviewed by the author, Gatekeeper and the co-inquiry group member using the 7 traits of a game identified in Chapter 4, as a guide. The outcome of this discussion is shown in Table 62.

Table 62 Traits addressed in 1st iteration of the game

Trait	**Proposed design requirement**
System:	The game will be a closed system, engagement with the game will be limited nurses based at the study site more than 18 months. 18 months was identified as a benchmark for experienced nurses by co-inquiry group earlier in the research.
Goals:	The goal of the game is to evaluate knowledge elicited during the first part of the game moving toward the final square on the game board and be deemed the winner of the game.
Feedback:	Knowledge reviewers can view other participant's place on the game board.
Competition:	The winner will be the reviewer who reaches the top of the board first.
Entertaining:	To evaluate whether the game is entertaining and enjoyable for players, a post-gave evaluation will be circulated to knowledge reviewers.
Voluntary:	Participation in the game is voluntary.
Platform:	The game will be a low-fidelity prototype to evaluate the utility of the game.

To play the knowledge evaluation part of the game, each Reviewer receives a deck of community knowledge cards. Each deck has the same type and number of cards. When it is their turn, the Reviewer evaluates the knowledge contained on one of their cards. The reviewer marks each card with a 'YES', 'NO' OR 'MAYBE', returns the evaluated card to the game board and moves their icon the appropriate number of squares. If this move results in the Reviewer landing on a challenge square. The participant choses a challenge card, reads the content and moves backward or forward depending on the individual card instruction. The winner of the evaluation game is the first participant to reach the 100th square at the end of the game. If game time runs before all cards are reviewed, the winner is the participant on the highest number square. If this occurs the remaining cards will be reviewed by evaluators in the next game. During the game time, reviewers are free to discuss their cards and the gatekeeper is onsite to answer any questions they may have. The author was responsible for setting up the game.

1.4.4 Design Stage 4: Game evaluation

Design Stage 4 of the framework developed by Verschueren et al. (2019) surrounds game evaluation. This stage overlaps with eADR activities and so were therefore subsumed under the relevant headings. Due to a lack of available participants, a pilot study was not undertaken, instead a review was conducted with the author, gatekeeper and another member of the co-inquiry group. During this review a full run through of the game was performed. This took several times to ensure the game flowed and that all the components required were included. Further evaluation with participants from the study site is described in the implementation cycle (Appendix D). This evaluation included a group discussion post-game and a post-game survey. This is the same evaluation as conducted for the first part of the game, knowledge elicitation. The post-game survey is the same for both parts and is based on work by Sweetser and Wyeth (2005).

1.4.5 Design Stage 5: Implementation

Stage 5 is concerned with implementing the game. Similar to Stage 4 of the framework developed by Verschueren et al. (2019) there is an overlap with the eADR activities. This is described in Appendix D.

1.5 Cycle 2: Outputs

The output from the second design cycle was the evaluation game board and community knowledge and challenge cards required to engage with the game. The proposed flow of the knowledge evaluation game is shown in Figure 36.

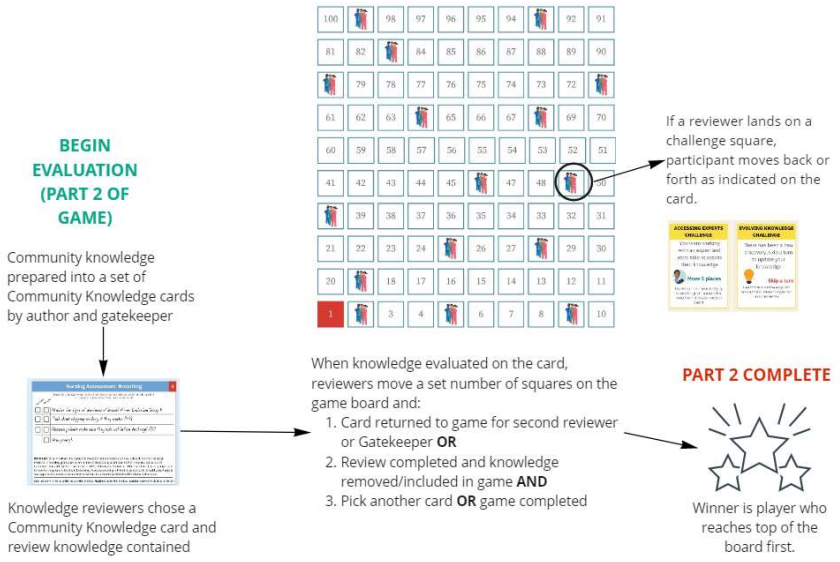


Figure 36 Proposed knowledge elicitation game flow (1st iteration)

Appendix D - eADR Implementation Stage (3 Cycles)

The purpose of this implementation cycle was to evaluate the serious game at the study site, to identify what worked and what changes may be required, and to elicit and evaluate specialist nursing knowledge. In total, three implementation cycles were performed. Details of these cycles are presented in Appendix D.

1.1 Implementation Cycle 1

The problem used as a starting point for the first implementation cycle was that, while the serious knowledge elicitation game and evaluation process was designed (see the first Design cycle in Appendix C), this were not tested at the study site. Evaluation feedback from this first implementation cycle highlighted how reviewing knowledge elicited was challenging for the knowledge holders. Following this cycle, the research returned to the design stage. This was required so that the evaluation process could be redesigned as a game. The proposed evaluation game was developed in the second design cycle.

1.1.1 Cycle 1: Evaluation of artefact 1 (Elicitation part of the game)

Before each game played in all cycles, signed consent forms were collected from Holders. As participation was anonymous, no record of the identity was maintained. Holders were nurses based at the site less than 18 months. Their role was to share their knowledge with a Seeker in the game. The Seeker was represented by an avatar. Attending each game was the author of the thesis and Gatekeeper. The Gatekeeper was the PI, who was a clinical expert and a member of the co-inquiry group. Before each game began the Gatekeeper gave details of the game to Holders. During this cycle, the game was played with 5 Holders. Details of the Holders group meeting for this cycle are shown in Table 63.

Table 63 Holders group (1st Implementation Cycle)

Group	Participants	Length	Moderator	Purpose of meeting
Holders Group 1: nurses based at the study site less than 18 months	N=5	Game time: 25 minutes Discussion time: 30 minutes.	Author of thesis and Gatekeeper	To evaluate initial game design and elicit knowledge through game play

During each game cycle, the discussion was captured by the author of the thesis, transferred to a digital document, and reviewed with the PI acting as Gatekeeper to ensure it represented what was

discussed. Their primary function of the Gatekeeper was to act as an arbiter should any knowledge disputes arise. However, they also helped organize and manage game play and were onsite during all game cycles. Data collected during the group discussion was analyzed by the author of this thesis and the Gatekeeper using the process by Braun and Clarke (2006). Their 6-step process is shown in Table 64 alongside how it was applied to this part of the PhD research.

Table 64 Application of Braun and Clarke (2006)

Familiarizing yourself with your data:	Data collected read and reread and reviewed by the author of thesis and Gatekeeper.
Generating initial codes	An initial set of codes were identified – enjoyment, community knowledge, building consensus, avatar, clinical scenario, player interactions from initial review.
Searching for themes:	Codes generated from the data were used to review the data collected to identify supportive evidence and to build up into themes.
Reviewing themes:	Themes identified were reviewed to ensure they were suitable by comparing each to the total feedback captured.
Defining and naming themes:	The wording of some themes and definitions were refined for example, 'Overall enjoyment' became 'Enjoyment'. This produced a definitive set of themes and meanings for each theme.
Producing the report:	Themes identified were reviewed to extract lessons and potential game design improvements.

From this process, 7 themes were identified. These are shown in Table 65 along with the main points described by participants in this cycle for each theme.

Table 65 Themes identified from Holders group post-game discussion

Themes	**Feedback from participants**
Theme 1: Length of game time	Overall game deemed enjoyable, but too quick
Theme 2: Prompts to aid recall	Felt examples of knowledge would be beneficial
Theme 3: Avatar	Did not feel 'engaged' with the avatar
Theme 4: Clinical scenario	Clinical scenario was perceived to be too broad

Theme 5: Community knowledge	'Useful', and 'interesting' to review community knowledge. Community knowledge is all the knowledge captured on the game board at the end of game time.
Theme 6: Competition	Liked the competitive nature of a game
Theme 7: Building consensus	By 'upvoting' or 'downvoting' knowledge submitted to the game

These findings were discussed with the co-inquiry group. This took two meetings due to member time commitments. The primary purpose of these meetings was to review the feedback and to identify what worked with the game and what did not and what if any changes would be required for the next game cycle. This is discussed in the following text. Details of these co-inquiry group meetings are shown in Table 66.

Table 66 Co-inquiry group meetings 1 and 2 (Implementation Cycle 1)

Group	Participants	Length	Moderator	Purpose of meeting
Meeting 1: Co-Inquiry group	N=3	60 minutes	Author of thesis and PI acting as Gatekeeper	To evaluate participant feedback from 1st game deployment at study site.
Meeting 2: Co-Inquiry group	N=2	40 minutes	Author of thesis and PI acting as Gatekeeper	To evaluate participant feedback from 1st game deployment at study site.

Feedback noted that overall, Holders, found the game enjoyable but that there was a rush to get all their knowledge documented and submitted to the game. Participants felt they would benefit from seeing examples to get started. Based on this, the co-inquiry group discussed that while they could be beneficial, prompts could also influence the knowledge submitted. There was agreement to develop examples of prompts and to monitor feedback in the next game cycle. Holders noted they did not feel 'engaged' with the avatar. As it was not possible for participants to design their own avatars, to promote engagement a decision was made to extend the prepared library of avatars and allow players to choose their own. The clinical scenario was perceived to be too broad by some participants. The co-inquiry group noted that a scenario that is too specific may not be relevant to all players. It was decided that there would be no changes to the scenario as the research was in progress – but the group would continue to monitor feedback.

The elicitation game board was displayed in the room where the game was played. Holders discussed that it was 'useful', and 'interesting' to review this community knowledge. While the group aspect of the game allowed knowledge to be discussed during the game if they wished, participants also liked the competitive nature of a game. It was raised by a participant that if they played as a group "how would we know who won… it would all be group knowledge". However, it was raised by the author of this thesis who was based onsite during the game that it was difficult to discuss the concept of 'winners' in such a small group (n=5). Nevertheless, it was noted from the feedback, that players were interested in knowing who won and liked the competitive aspect of the game. The co-inquiry group proposed increasing the visibility of winner on the game board.

Following the game, participants could build consensus in the community knowledge by 'upvoting' or 'downvoting' submissions. No downvotes were awarded during this cycle and this was discussed with the Holders. It emerged that this could have two motivations. Firstly, all knowledge could be useful for something. Secondly, they did not want to be seen 'downvoting' a colleague's knowledge. As the 'downvote' function was not used, the co-inquiry group considered it beneficial to remove this function in the next iteration of the game but maintain the 'upvote' function. It was discussed that this might not be the case in anonymous platforms, but this was beyond the scope of the current research. This concludes the evaluation of the game artefact in cycle 1. In the next sub-section, evaluation of the knowledge elicited during the game is presented. To evaluate the knowledge two groups were employed. Firstly, Reviewers who were nurses who were based at the study site over 18 months evaluated the knowledge elicited. Following this review, the co-inquiry group reviewed any submissions made by the Reviewers group.

1.1.2 Cycle 1: Evaluation of artefact 2 (Knowledge elicited)

Before the evaluation process, signed consent forms were collected from Reviewers. This group comprised of nurses based at the site more than 18 months. Their role was to evaluate the knowledge elicited during the game so that it was relevant to the knowledge topic and of a quality that could be shared beyond the study site. The evaluation meeting took place in person at the study site. Attending the game was the author of the thesis and Gatekeeper. During this cycle, the knowledge was evaluated by 3 Reviewers. As participation was anonymous no record of the identity of the reviewers was maintained. Details the Reviewers group meeting for this cycle are shown in Table 67.

Table 67 Reviewers Group meeting 1 (Implementation Cycle 1)

Group	Participants	Length	Moderator	Purpose of meeting
Reviewers Group 1: Reviewers who were nurses based at the study site more than 18 months	N=3	60 minutes	Author of thesis and Gatekeeper	To evaluate knowledge elicited during the cycle 1 game contained in the digital spreadsheet

To prepare for evaluation, the community knowledge underwent a number of steps. These were performed by the author of the research and the Gatekeeper. A full description of the preparation process is shown in Appendix F. An overview of the steps undertaken are shown in Table 68.

Table 68 Steps undertaken to prepare community knowledge for evaluation

1.	Individual knowledge submissions transcribed verbatim into a digital spreadsheet.
2.	Full words included for any abbreviations
3.	Complex submissions were Split
4.	Similar submissions were removed
5.	Submissions grouped by topic
6.	Topics were arranged into high level categories
7.	A record of rationale for the submitted knowledge included if supplied

To review the digital spreadsheet a paper copy was printed and given to each reviewer. Reviewers discussed each piece of knowledge and reached a consensus to either include or reject. The author of the thesis kept a record of what was discussed during these meetings. The Gatekeeper acted as an arbiter in case of any disputes over knowledge or if a consensus could not be reached. Overall, Reviewers deemed knowledge captured to be relevant. From an initial total of n=68 submissions reviewed, n=28 were removed post review. Reasons for removal were:

- N=1: IS (‘Submission was deemed incorrect or not suitable for inclusion)’. The prompt submitted was "Remove port before going home, flush first" [P5] removed as port itself is not remove, but the hubber needle that is attached to the port.
- N=15 SW (‘Single words or isolated phrases, SW)’ describes submissions containing individual words who’s meaning to the scenario could not be inferred. For example, "Antiemetics" [P2])
- N=6 TG (‘Too general, TG)’ describes submissions that are related to patient care in general but not the clinical scenario. For example, "Be particular about signs of cough/cold" [P2])
- N=6 SU (Removed ‘Submission unclear)' describes a situation where the submission contained writing that was illegible, unable to decipher content or relevance to clinical scenario was unclear. For example, "Avoid touching cold objects" [P2])

Although engaging with Holders was not possible due to the anonymity of participants. The review group did express that had this been feasible they would have like to discuss why submissions were rejected. With regard to the knowledge elicited, one omission noted by the reviewers was any references to monitor patients for signs of shortness of breath on discharge. Reviewers described this as important as impaired respiratory function could indicate an underlying issue, such as Pulmonary Embolism (PE). In total the reviewers suggested n=6 submissions. These were not included in the digital spreadsheet at this time. As the game was ongoing, it was considered that some or all of these submissions could be elicited during subsequent games. A decision was made to record all suggested submissions and add at the end of the study. During the reviewer group meeting, participants described rationale for exclusion/including prompts. While not a knowledge submission per se, this was valuable learning, and a decision was made by the author and gatekeeper to include these in the digital spreadsheet. Examples of rational for knowledge submissions was also provided by the Holders group. Examples of rationale submitted are provided below:

"… not all appointments can be made on the day. Therefore, the patient should know what to do if they don't receive an appointment." [Reviewers group 1]

"Before they leave the unit, discharged patients should ideally know when their next appointment is (to avoid any confusion, missed appointments or delays)" [Holders group 1]

Following the meeting, the digital spreadsheet was updated by the author and the gatekeeper. The proposed submissions (n=6) were evaluated by the co-inquiry group. See details of this co-inquiry group meeting in Table 69.

Table 69 Co-inquiry group meeting 3 (Implementation Cycle 1)

Group	Participants	Length	Moderator	Purpose of meeting
Co-inquiry	N=2	30 minutes.	Author of thesis and Gatekeeper	To evaluate additional submissions from reviewer group and identify lessons learned from first cycle

From these 6 proposed submissions, three were rejected. The reasons for removal are:

- N=1: N2N (Nurse to Nurse, N2N)'. The knowledge submitted was "If you have any worries about a temp [temperature], report, seek help, don't just let the patient go". Nurse to Nurse describes knowledge prompts captured that were knowledge shared among nurses that related to carrying out a nursing task or observation.
- N=2 AI (Already included, AI)' describes submissions that have been approved and previously included in the knowledge artefact. For example, "Make sure to send a PHN [Public Health Nurse] ref [referral], if its needed". An included submission ("Is there a public health nurse involved, should they be?" [P2]) was deemed to be similar.

Following the Reviewer and co-inquiry group evaluation a total of n=40 unique knowledge submissions were generated from Cycle 1. The digital spreadsheet was updated by the author of the thesis to reflect the outcome from the review. For an overview of the knowledge contained in the digital spreadsheet created in Cycle 1 see Table 70.

Table 70 Overview of digital spreadsheet created (Implementation Cycle 1)

Description	**Number**
All community knowledge submitted (including Splits)	124
Similar examples of knowledge (removed)	56
Prepared knowledge for evaluation by Reviewer group	68
Removed by Reviewer group	28
Reason for removal	IS=1, SW=15, TG=6, SU=6
Knowledge submission proposed by knowledge reviewers' group	6 (not included in count at this point)
Proposed submissions rejected by Co-inquiry Group	3 N2N=1, AI=2 (not included in count at this point)
Total prompts remaining from cycle 1	40 (and 3 proposed submissions)

While not an issue with the elicited knowledge, it was raised by Reviewers during the process that evaluating knowledge as a list was challenging due to the number of entries and repetitive nature of the task. It was raised by participants that this could be a disincentive to engage in the process. This is further discussed in Section 7.4.

1.1.3 Cycle 1: Co-inquiry group meeting

Feedback from cycle 1 was reviewed by the author of the thesis and the gatekeeper to ensure all learning that had occurred was captured. To manage the lessons so that none were overlooked they were developed into a list. This list is presented in Table 71.

Table 71 Learning identified from Implementation Cycle 1

Lesson	Related to theme	Participant group
1. Length of game time	1	Holders
2. Prompts to aid recall	2	Holders
3. Avatar	3	Holders
4. Clinical scenario	4	Holders
5. Community knowledge	5	Holders
6. Competition	6	Holders
7. Building consensus	7	Holders
8. Challenging evaluation process	Not related to a theme	Reviewers
9. Quality control	Not related to a theme	Author of thesis and Gatekeeper
10. Tagging prompts	Not related to a theme	Author of thesis and Gatekeeper

Where relevant, lessons are linked to a theme from knowledge holders discussion. Lessons are also linked to the group that initially discussed it. Two further issues were introduced during this discussion and added to the list. These relate to the length of time preparing submissions for evaluation and how not all knowledge submitted was of the same quality but generated the same number of points for the participants avatar. These were highlighted by the author and Gatekeeper and were based on their experience of reviewing and preparing the knowledge submitted for evaluation. The content of the list was discussed with the co-inquiry group. Due to schedule conflicts this required two meetings. Each member only attended one meeting. Details of these meetings are shown in Table 72.

Table 72 Co-inquiry group meeting 4 and 5 (Implementation Cycle 1)

Group	Participants	Length	Moderator	Purpose of meeting
Co-inquiry group meeting 1	N=2	40 minutes.	Author of thesis and Gatekeeper	To review lessons learned during cycle 1
Co-inquiry group meeting 2	N=2	60 minutes	Author of thesis and Gatekeeper	To review lessons learned during cycle 1

Lessons learned included the development of additional components, such as examples of knowledge prompts. These prompts were based on examples from the first game. The purpose of these prompts was to show players the format rather than provide content for submissions. The Gatekeeper role was extended to include review of knowledge submissions before they are entered onto the elicitation game board and to return submissions to players if deemed unclear or irrelevant to the knowledge topic. There were no proposed changes to the scoring system at this time with all submissions being awarded 1 point. However, Holders would be allowed to review and resubmit if they wished. Although feedback had noted it was too broad, no changes were proposed to the clinical scenario following this cycle. The reason for this was that changes to the scenario could have implications for the total knowledge collected during the research as it could relate to at least two clinical scenarios. Another change was to increase the visibility of winner on the game board by including a dedicated 'winners' section on the game board. It was proposed that following the game, the avatar with the greatest number of points would be displayed in this 'winners' section along with their score. There was agreement that players assigning tags their knowledge submission could be useful and potentially save time during the preparation of the knowledge prompts. This could take time away from game play.

It was raised by the author and the gatekeeper that preparing knowledge for evaluation could be laborious. The co-inquiry group raised the possibility that tags could be added to submissions by participants to speed up the preparation process. It was discussed that allowing players to 'tag' their own prompts could potentially save time. However, adding an additional task to the players group could further reduce time allotted to knowledge elicitation part of the game. Another issue raised by the author and the Gatekeeper, was that not all knowledge prompts submitted were the same in terms of quality. For example, some contained only one word whereas others were some full sentences. Regardless of complexity both awarded same score for example "Nail care" [P2] versus "Make sure patients knows how to manage an emergency at home" [P4]. Also, some entries were difficult to decipher (handwriting, abbreviations, or context unclear). To address this, it was proposed that the Gatekeepers role could include an onsite evaluation during the game.

It was discussed by the Reviewers' group that interrogating a spreadsheet to identify the relevant knowledge presented challenges. These challenges arose from the entries and the task of reviewing each one. The process was described as 'boring' by one Reviewer. As the number of entries was likely to increase as the research progressed it was discussed by the co-inquiry group to develop this into a game also. The proposed change was to move from a one-part knowledge elicitation game to a two-part knowledge elicitation and evaluation game. Both parts would have a different focus and a different participant group. The first part, knowledge elicitation would continue as proposed using Holders. The target audience for the evaluation part of the game would be the Reviewers. This is the same as the evaluation process. The review of the digital spreadsheet was to be gamified. However, the spreadsheet would not be removed from the

research entirely. Instead, it would be maintained by the author to capture evaluated knowledge and act as repository. This repository would house evaluated knowledge and represents an early iteration of the data reference set, which is the second contribution arising from this research. Outcomes from the co-inquiry group discussion along with the proposed actions are presented in Table 73.

Table 73 Proposed actions arising from cycle 1 related to the serious game artefact

Lesson learned	**Action**
Although knowledge holders had commented that the game was unable to extend as time dictated by availability at the study site. Related to theme 1 from knowledge holders discussion.	No change proposed
Prompts to aid recall: Proposed gatekeeper could develop examples of knowledge prompts to aid player recall. Related to theme 2 from knowledge holders discussion.	• Add [UC18] 'Review examples of prompts' • Add [UC19] 'Develop examples of prompts'
Personalising the avatar: Proposed that researcher extends the prepared library of avatars and allow players to choose their own. Related to theme 3 from knowledge holders discussion.	• Add [UC21] 'Choose an avatar'
Broadness of the clinical scenario: No changes proposed to the clinical scenario from this cycle. Related to theme 4 from knowledge holders discussion.	No change proposed
Community knowledge: Proposed submitted prompts to remain on the game board so that accumulated community knowledge can be viewed. Related to theme 5 from knowledge holders discussion.	• Add [UC20] 'View accumulated community knowledge'
Competition: Proposed to increase visibility of winner on the game board. Related to theme 6 from knowledge holders discussion.	• Add [UC22] 'View winner'
Building consensus: Proposed to remove 'downvote' function as not used but maintain the 'upvote' function. Related to theme 7 from knowledge holders discussion.	• Changes to [UC15] 'Upvote knowledge submitted'
Challenging evaluation process: Based on participant feedback, it was discussed by the co-inquiry group that the evaluation section of the process should be transferred to a serious game. The target	Current game design to be extended to include a knowledge evaluation part.

audience for this part of the game were the knowledge reviewers. Identified from knowledge reviewers' discussion.	
Quality control: Proposed gatekeeper role extended to review submissions and return knowledge submissions if deemed unclear or irrelevant to the knowledge topic. Identified by author and gatekeeper.	• Add [UC23] evaluate knowledge submitted
Tagging prompts: While it would be useful for participants to tag their own prompts as it would reduce time required to prepare the submissions for evaluation. This will reduce the time available for game play. Therefore, there is no change proposed at this time.	No change proposed

1.1.4 Cycle 1: Outputs

This learning was formulised into a set of updated use cases for a serious knowledge elicitation and evaluation game. These are presented in two parts. The first part surrounds knowledge elicitation and is an update to the first iteration of the game design. The second part surrounds the proposed knowledge evaluation part of the game. Table 74 shows the additional proposed use cases identified in this cycle related to the elicitation part of the game.

Table 74 Use cases elicitation game (Implementation Cycle 1)

Use Case ID	**Description**	**Actor**
UC15	Upvote knowledge submitted	AID02
UC18	Review examples of prompts	AID02
UC19	Develop examples of prompts	AID04
UC20	View accumulated community knowledge	AID02
UC21	Choose an avatar	AID02
UC22	View winner	AID02
UC23	Evaluate knowledge submitted	AID04

In relation to the second part, knowledge evaluation, specific use cases were identified from the evaluation process and discussions between the author and the gatekeeper and the author and their supervisor. The knowledge evaluation use cases are shown in Table 75.

Table 75 Use case evaluation game (Implementation Cycle 1)

Use Case ID	Description	Actor
UC01	Prepare knowledge for evaluation	AID04
UC02	Set up game	Gatekeeper
UC03	Access game components	AID04
UC04	Evaluate prepared knowledge	AID03
UC05	Monitor game time	AID04
UC06	Receive evaluated knowledge	AID04
UC07	Arbitrator in case of disputes	AID04
UC08	Update digital spreadsheet with evaluated submissions	AID04

1.2Implementation Cycle 2

The purpose the second cycle was to implement and evaluate the 1st iteration of serious knowledge elicitation and evaluation game at the study site that arose from the second design cycle. In this implementation cycle, this extended serious knowledge elicitation and evaluation game was implemented and evaluated at the study site. Both parts of the game were played using different participants and at different times. The first part was focused on eliciting knowledge and participants were Holders. The second part was focused on evaluating the elicited knowledge and participants were Reviewers. The games were played two weeks apart. During this time, the knowledge elicited was prepared for evaluation by the author of the thesis and Gatekeeper. This prepared knowledge was developed into a set of Community Knowledge cards that could be evaluated. Attending both parts of the game was the author of the thesis and the gate keeper.

1.2.1 Cycle 2: Evaluation of artefact 1 (Elicitation part of the game)

Before each game, signed consent forms were collected from Holders. To evaluate the elicitation part n=2 Holders engaged in the game and then took part in a group discussion. As participation was anonymous, no record of identity was maintained. During the game, knowledge submissions were made via coloured post-its. Each colour is linked to a different Seeker and given a code [P6] and [P7]. No record of what participant was linked to what Seeker was maintained. Seekers were represented by an avatar in the game. Details of the Holders group meeting in cycle 2 are shown in Table 76.

Table 76 Holders group meeting (Implementation Cycle 2)

Group	Participants	Length	Moderator	Purpose of meeting
Holders group: nurses based at the study site less than 18 months	N=2	Game time: 25 minutes Discussion time: 30 minutes.	Author of thesis and Gatekeeper	To evaluate the elicitation part of the serious game through game play. To elicit knowledge through game play that could then be evaluated during part 2 of the game.

As in the first cycle (see Chapter 7), data was captured during the discussion by the author of the thesis. Themes identified in the first cycle (see Chapter 7, Section 7.3) were used as a prompt in this cycle by the author to explore users' perspective on the changes from the previous cycle. For instance, the prompt 'did you feel there was enough game time' arose from theme 1: Length of game. The purpose of this was to gather the participants perspectives on the changes made since cycle 1. In addition to these prompts the participants were asked a more general question. This was the same question used in the first cycle: Can you talk about what you liked or did not like about the game? The purpose of this question was to give participants an opportunity to express any views not captured in the prompt questions. No data collected during the discussion was linked to a specific participant, any quotes or data collected is assigned to Holders group Cycle 2. At the end of the group discussion, a recap of the main points was given verbally to participants. After the meeting, notes captured were transcribed onto a digital document by the author. This document was reviewed with the Gatekeeper to ensure it accurately represented what was discussed. The data captured was then analysed using the process described by Braun and Clarke (2006), see Section 1.1 of this Appendix. The review conducted in this cycle uses the previously identified themes as the initial set of codes (see Section 1.1). From this review an additional theme – quality control – was identified. The prompts and related themes are shown in Table 77 along with the main points raised by participants in this cycle. These are discussed in the following text.

Table 77 Themes identified from Holders group post game discussion

Theme	Prompt used	Participant feedback
1: Length of game	Did you feel there was enough game time?	Noted that the game time went quickly
2. Prompts to aid recall	Did you feel the prompts used were helpful?	Prompts were deemed to be somewhat useful
3. Avatars	Did you think the avatars were relevant to you?	Participants would prefer to construct their own
4. Clinical scenario	Did you think the clinical scenario was relevant to you?	Would prefer a more specific scenario i.e. age, gender, treatment.
5. Community knowledge	Did you find viewing the elicitation game board and the knowledge on it useful?	Found to be beneficial to view the community knowledge on the game board as it raised some prompts that individuals did not recall but board was a 'little messy'.
6. Competition	Did you find it useful that the 'winner' was identified?	Yes, but also noted it would be useful to include a tally of the scores in 'real time' during the game.
7. Building consensus	What did you think about giving other participants knowledge awards?	Upvoting using green sticky dots positively reviewed and participants would like to present additional awards.
New theme: Quality control	N/A as new theme identified.	Participants noted it as a positive, however, the Gatekeeper felt under pressure to review and give explanations for all rejected prompts and also felt that they engaged with players too much and ended up discussing prompts in detail.

These findings were discussed with the co-inquiry group. Outcomes from this discussion is shown in sub-section 1.2.4 of this chapter.

1.2.2 Cycle 2: Evaluation of artefact 1 (Evaluation part of the game)

The purpose of the evaluation part of the game was to review the knowledge elicited from the first part of the game. From the previous implementation cycle it emerged that evaluating knowledge was challenging when presented in a digital spreadsheet. As a response, the evaluation process was designed into a turn-taking game. In this Appendix, the evaluation game was reviewed by nurses who were based at the study site more than 18 months. Their function was twofold. Firstly, to evaluate the game and this is discussed in this section. Secondly, to review the knowledge elicited to assess what should be included or rejected from the digital spreadsheet. The same Reviewers were used for both functions. Details of the Reviewers group meeting for this cycle are shown in Table 78.

Table 78 Reviewer group meeting 1 - evaluation game (Implementation Cycle 2)

Group	Participants	Length	Moderator	Purpose of meeting
Reviewers Group: nurses based at the study site less than 18 months	N=2	Discussion time: 30 minutes.	Author of thesis and Gatekeeper	To review the evaluation part of the serious game through game play.

Before each evaluation game, signed consent forms were collected from participants. The Reviewers group were asked to discuss their experience of engaging in the knowledge evaluation game, focusing on what they liked and what they would like to change. Participation was anonymous and data collected is assigned to Reviewers group cycle 2. From the feedback, the game was deemed enjoyable to engage with and participants noted they liked the competitive nature of the game. A comparison between the digital spreadsheet and game was not captured as the group only engaged with the game. From this review 4 themes were identified. These are shown in Table 79 along with the main points described by participants in this cycle for each theme.

Table 79 Themes identified from Reviewers group post game discussion

Themes	**Feedback from participants**
Theme 1: Length of game time	Game time seem limited, and participants felt rushed to review the card deck.
Theme 2: Community knowledge cards	The high number of individual cards in the deck was viewed as numerous and participants were initially unclear if they could review the amount in a single setting.

Theme 3: Awards	Participants described it as interesting to see what knowledge was given an award and would like to explore the concept of downvoting.
Theme 4: Providing rationale	Described as very useful for people not familiar with the domain and helped build trust in the knowledge submitted.

These findings were discussed with the co-inquiry group. The co-inquiry group also discussed feedback from the Holders group meeting.

1.2.3 Cycle 2: Evaluation of artefact 2 (Knowledge elicited)

This section discusses the outcome from the review of the knowledge elicited during the Holders group in this cycle. Prepared knowledge was constructed into the community knowledge cards by the author and reviewed by the Gatekeeper. The evaluation part of the game was played by n=2 knowledge reviewers. The researcher and the Gatekeeper were in attendance. The same Reviewers took part in both the game review and knowledge review. This occurred as engaging in the game is the process of evaluating the elicited knowledge. Details of the Reviewers group meeting for this cycle are shown in Table 80. The following text describes findings from the game in relation to the knowledge.

Table 80 2nd cycle implementation stage Reviewers group – Knowledge evaluation

Group	Participants	Length	Moderator	Purpose of meeting
Reviewers Group 1: nurses based at the study site less than 18 months	N=2	Game time: 45 minutes	Author of thesis and Gatekeeper	To evaluate the elicited knowledge from cycle 2 elicitation game.

During the elicitation stage of the game, n=7 submissions were returned to players during the game on site. The reasons for removal were:

- N=2: ‘Too general (TG)’ describes submissions that are related to oncology but not the clinical scenario i.e., not relevant to discharge. Instead describes nursing care at different stages of patient journey or to the oncology domain in general.
- N=3: Submission unclear (SU)' describes a situation where the submission contained writing that was illegible, unable to decipher content or relevance to clinical scenario was unclear.
- N=2: ‘Single words or isolated phrases (SW)’ describes submissions containing individual words who’s meaning to the scenario could not be inferred.

It was up to each player to review rejected submissions and resubmit if they wished. A count of resubmissions was not kept. Following the game, a total n=34 knowledge submissions were entered as community knowledge. The n=34 submitted prompts were then reviewed by the Reviewer group with a further n=8 was removed. Reason for removal was:

- N=3: ‘Too general (TG)’ describes submissions that are related to oncology but not the clinical scenario i.e., not relevant to discharge. Instead describes nursing care at different stages of patient journey or to the oncology domain in general.
- N=2: ‘Submission unclear (SU)' describes a situation where the submission contained writing that was illegible, unable to decipher content or relevance to clinical scenario was unclear.
- N=3: ‘Single words or isolated phrases (SW)’ describes submissions containing individual words who’s meaning to the scenario could not be inferred.

This left a total of n=26 prompts generated from Game 2. Overall, the evaluation group deemed the knowledge in the submissions to be relevant to a general adult discharge from the oncology day care. Similar to the first group, this evaluation group suggested that it would be useful to engage with players and that this could be another form of clinical education. The group identified the submission "Avoid using air conditioner" [P7] as something that they would like to explore further with the player to access their rationale for this entry. Although one Reviewer did note that this would be time consuming, but offered that if they were mentoring a student, it would be interesting if the prompts could form part of their clinical documentation. Another point raised by the group was the use of the word ‘regular’. Noting this word means different things to different patients. Examples include *"Monitor temperature regularly" [P3] and "Tell patient to observe weight regularly" [P1]*. Reviewers removed word ‘regularly’ but deemed the submission suitable, so it was included in the spreadsheet.

Similar to first cycle 1, the Reviewer group suggested new prompts (n=3). Same as in the first game, these were not included at this time as game was ongoing. In relation to the content of the knowledge captured, a second omission was noted by Reviewers. This related to following up on appointment made. This was added to the list of knowledge submitted by the Reviewers. The group discussed that they were happy to see ‘Temperature’ featuring frequently in the prompts submitted as it was important for their care. Submissions around temperature were varied and included not only to "Monitor temperature regularly" [P3]. But also, what is out of normal range and what to do if this occurs: "Inform patient to take temperature if feeling unwell - if above 37.5 go straight to closest accident and emergency and contact us, do not wait for us to ring you back before you go to accident and emergency" [P7]. Following the game, the evaluated knowledge was included in the digital spreadsheet. An overview of the knowledge submissions managed in cycle 2 are shown in Table 81.

Table 81 Overview of knowledge submissions (Implementation Cycle 2)

Cycle 2 – Overview	
Prompts removed during the game	7
Reason for removal	TG=2, PU=3, SW=2
Prompts submitted (including prompts split)	34
Similar prompts (removed)	17
Removed by Evaluation Group	8
Reason for removal	SW=3, PU=2, TG=3
Submitted by Evaluation Group	15 (not included in prompts submitted)
Removed by Co-inquiry Group	11 (not included in prompts submitted)
Total prompts remaining from cycle 2	9
Total prompts from cycle 1 and cycle 2	49

1.2.4 Cycle 2: Co-inquiry group meeting

Following each game, elicitation and evaluation participants discussed what worked with the current iteration of the elicitation or evaluation game and identified potential changes for future iterations. These discussions were conducted separately, and the author of the thesis and Gatekeeper attended each meeting. Participant evaluations are discussed in the previous text. Following these meetings, the data collected was reviewed by the co-inquiry group. The purpose of this meeting was to agree changes for the next iteration of the game. The outcome from this meeting was an updated set of use cases for an elicitation and evaluation serious game is presented this section. Details of the co-inquiry group meeting are shown in Table 82.

Table 82 Co-inquiry group meeting 1 (Implementation Cycle 2)

Group	Participants	Length	Moderator	Purpose of meeting
Co-inquiry group	N=5	60 minutes.	Author of thesis and Gatekeeper	To evaluate participant feedback from cycle 2, elicitation and evaluation games.

According to the feedback, overall participants in the Holders group found engaging in the game enjoyable. A full discussion on participant enjoyment is presented in this chapter in Section 9.3. Similar to participants in the first cycle, it was noted the time went quickly. Participants reported that there was a fear they would not be writing as much as other participants and might be seen as not as good as their peers. Participants noted they would have like more time to keep writing – "I was actually impressed by how much I was getting down on the post-it, the more I wrote the more

I remembered" [Holders group cycle 2]. Comments by participants included how it was difficult to recall everything they knew. This was made more difficult because there was a time limit and no external stimulus, for instance, a patient in situ. It was discussed that participants tried to think of the most important discharge knowledge first or tried to imagine themselves in a discharge situation.

A participant noted that (?) how the first piece of knowledge they recalled influenced subsequent submissions. raised that "*well… I suppose… the first thing you write down, kinda starts you off and you go from there*". It was discussed that the first prompt could impact the content of the next. Thereby acting as prompts for the player. As an example, the following submissions were received from an individual Holder in sequence.

"*Patient may need transport to hospital to be arranged*" [P6]

"*Find out how are they getting home and call contact*" [P6]

"*Give car parking letter*" [P6]

Based on previous feedback, examples of prompts from cycle 1 were developed and shown to players prior to the game. There was a consensus that the examples were somewhat useful. It was noted from the submissions collected that the examples supplied were closely replicated in the knowledge elicited in cycle 2 (see Table 83).

Table 83 Prompts supplied (before game) and submissions elicited (during the game)

Example supplied pre-game	**Knowledge elicited during game – cycle 1**
"Tell the patient about potential changes to appetite"	"Tell patient to monitor for any changes in appetite" [P6] "Talk about appetite" [P7]
"Check that the patient has a lift home"	"Find out how are they getting home and call the contact" [P6] "Make sure they are safe going home - that includes a lift, that they are feeling okay, happy to be discharged" [P7]
"Give the patient the contact number for the specialist nurse attached to the team"	"Give Clinical Nurse Specialist (CNS) contact details to patient" [P7] "Tell patient to contact Clinical Nurse Specialist (CNS) if has questions" [P7]
"Send referral for social worker"	"Social worker number on sheet - highlight to patient as they have to follow up if required." [P6]
"Discuss how to take antiemetics"	"Take antiemetics at least for 2 days in a row if you feel nausea" [P6]

The examples of the prompts were not used to generate new knowledge as much as their content was replicated. Therefore, the co-inquiry group discussed that an improvement could be to use 'starting phrases'. These starting phrases could be based on prompts collected, such as, "Tell the patient about..." Or "Check that the patient…" Rather than full prompts. Another addition to the elicitation game in this cycle was the extended library of avatars. Although Holders could choose their own avatar, the ideal, according to the participants, would be to construct their own. As it was a paper-based game and given time limitations this was not possible during this research. Echoing findings from cycle 1, Holders noted they would prefer a more specific scenario i.e., age, gender, treatment. However, as the research was in progress, the co-inquiry decided to continue with the current scenario as changes could impact the ability of the total knowledge elicited to be developed into a data reference set.

Holders discussed that it was beneficial to view the community knowledge on the game board as it raised some prompts that individuals did not recall. Also, if they did see similar prompts in the community knowledge that they submitted, this gave them confidence in their own knowledge. The participants commented that it would have been useful to see the community knowledge board beforehand – it was not hidden from participants, but no time allocated to review beforehand. Similar to the Holders group in the first cycle, the second were interested in getting a copy of the community knowledge. Participants were instructed that they could take a photograph of the board if they wished. One participant did note however, that while a photo is good the board was a 'little messy' and enquired if it could be 'put in an order… or some arrangement so that we can see the writing or … well make sense of it…". The co-inquiry group agreed to explore how to rearrange the game board for the next game. Following the first cycle, the visibility of the winner was increased by allocating a 'winners' space' on the game board. This space on the board comprised of five coloured boxes, each represented the post-it note used to submit knowledge. The 'winners' space' appeared to be well received by participants. However, as the number of participants in the Holders group was low (n=2) a conclusion is unable to be reached at this time. In addition to a final score, participants also noted that it would be useful to include a tally of the points allocated in 'real time'. Without these 'real-time' tally's participants did not know how many submissions they had made in relation to other players. The co-inquiry group agreed that this could be implemented in next cycle. Although, the co-inquiry group advised caution as this adds to the role of the moderator (and researcher) in the room.

Participants discussed liking being able to award green sticky dots to knowledge they deemed relevant via the upvote function but that they would also like to give additional awards. The co-inquiry group discussed that an additional award in the form of a gold star sticker could be incorporated into the next cycle and awarded to knowledge participants considered 'most

important'. The interpretation of 'most important' would be left to individual participants. Only one gold star could be awarded per participant. The number of green sticky dots a player could award for 'relevant' knowledge was unlimited.

Onsite knowledge evaluation function by the Gatekeeper was proposed following cycle 1 as a means of quality control. From this function 7 knowledge submissions were returned to players during this game cycle. The reason for return were 2 were deemed too general, 3 were deemed unclear and 2 were single words that did not have much meaning for the game. Onsite evaluation was beneficial as it added another layer of knowledge evaluation to the game. Participants discussed that it was great to get feedback during the game and this allowed them to make any changes or clarify their submissions and then resubmit to get points. It also offered an opportunity to learn from their submissions and understand what was wrong with them from a subject expert. However, it was also discussed that at times it was 'distracting' as the game was played in a small room. The Gatekeeper described they felt under pressure to address all participant queries and as the game time was limited it also meant that at times, the game stopped, and 'teaching' began. The co-inquiry group proposed and agreed to limit the moderator function during the game to role to removing prompts and provide reasons to participants after the game if they were interested.

In relation to the evaluation game, feedback noted that overall participants from the Reviewers group were positive about a knowledge evaluation game. In this game cycle, n=34 submissions were developed into the Community Knowledge card deck. Participants noted that they felt time was limited and at times they felt rushed to review all the cards. Reviewers described that when they saw the card deck, they felt it was a lot to get through in the allocated time. It was also voiced that it was difficult to identify any omitted knowledge as topics were not together. The author described the spreadsheet, showed an example to the group and enquired if this would be a better way to review knowledge. A comment raised was that a benefit of the spread sheet is that submissions were categorized by topic. However, the game distracted from the task of reviewing a spreadsheet and made it enjoyable.

Although participants in the Reviewers group did not make any awards to elicited knowledge, the concept was discussed as it related to the submissions in the community cards. They did consider the awards useful to the role as evaluators. They thought that this was valuable but would have liked to have discussed with Holders why they thought it was a 'relevant' submission. It was also discussed that a one-size-fits-all award could be overused. For instance, a less experienced nurse might find a basic nursing task relevant, but this might not be the same for a more experienced nurse. It was suggested that awards should highlight who the knowledge is relevant for. The idea of extending the possible awards was addressed with the Holders group previously in the cycle (see Section 9.3). From this, it was agreed previously to include an additional gold star award. A range of awards could be considered in future games. As part of this discussion, the author raised

how Holders could ‘downvote’ knowledge they felt was not relevant, but this function was removed from the game as participants felt that all knowledge was relevant in some ways, and they did not want to ‘downvote’ a colleague’s knowledge. The Reviewer group presented a different perspective on ‘downvoting’. They discussed how it was a missed opportunity as it provided a way to further categorize the knowledge. For instance, a red sticky dot could mean it was not relevant to a type of patient or treatment.

The co-inquiry discussed that the reviewed expert prompts included what the group are describing as ‘rationale’ that means these are not prompts by themselves but rather they provide an explanation of why prompts were important or useful or other considerations that nurses should be mindful of in relation to a specific prompt. An example is seen when one evaluator noted that with regards to weight, while patients should monitor their weight but that they should not become obsessive about it. A prompt submitted linked to weight from [P3] was “But don't be obsessive about it (measuring weight). It was discussed by the group that these were very useful for people not familiar with the domain to build trust in the knowledge captured as it provided an understanding and supported the inclusion of topics, as well as specific prompts, in the knowledge artefact.

Based on the discussion from this meeting, the learning that occurred was reviewed by the author and the Gatekeeper. These lessons were formulised into a set of proposed changes to the game. These changes were reviewed by the co-inquiry group before implementation. This is described in the next section.

1.2.5 Cycle 2: Outputs

In this section, the learning was reviewed by the author and the Gatekeeper and proposed changes were identified. Changes proposed for the knowledge elicitation part included that instead of providing examples of previously submitted knowledge as a prompt to aid recall, starting phrases would be included instead. This arose as the examples of the prompts tended to be replicated rather than used to generate new knowledge. Starter phrases proposed included “Tell patient to….” Or “Ensure patient is….”. These examples were based on previously submitted knowledge in both implementation cycles. The researcher undertook to redesign the game board to include categories to organise the knowledge submitted. Proposed catagories were People/Problems, Systems, Governance/Culture, Clinical Signs and Symptoms, Equipment/Medications and Business Processes. These categories were identified from the knowledge elicitation method, the WICKED method (Impey et al., 2023), that was used in the design of the initial game. This change was proposed in response to participants description of the game board as a ‘little messy’. Noting it would easier to navigate the content if was ‘put in an order’. The updated game board is shown in Figure 37.

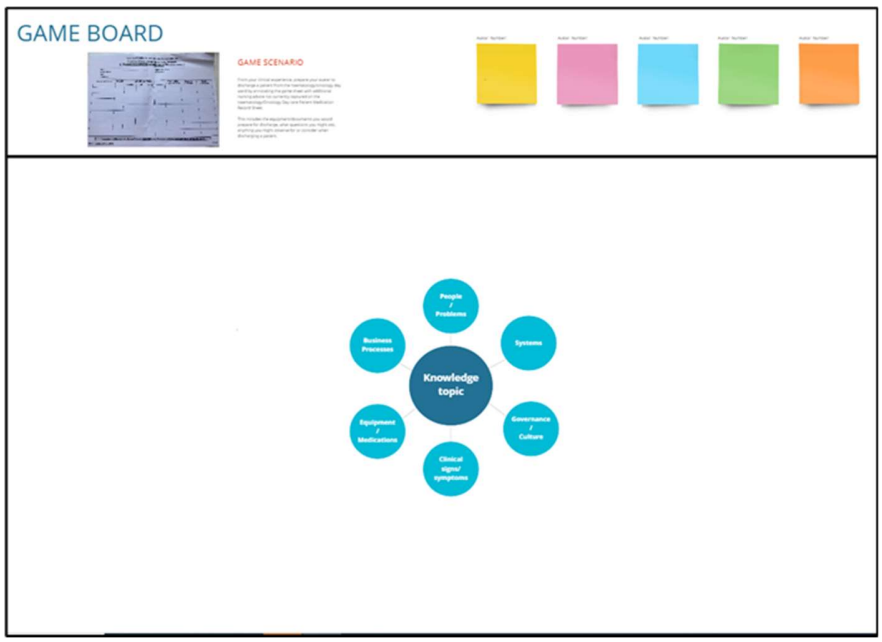


Figure 37 Updated game board to include Everything categories from WICKED method (Impey et al. 2023) and the 'Winners' space

While the participants discussed liking the upvote function, the ability to present additional awards was discussed. In response the co-inquiry group proposed a 'gold star award' to any knowledge participants considered 'most important'. The interpretation of most important would be left to individual participants. While the gatekeeper as a quality control was beneficial, it was raised that engagement with players interrupted the flow of the game. It was proposed to limit the Gatekeeper function to removing prompts during the game and provide reasons to players after the game. Rationale for knowledge submitted, although not solicited, was collected from evaluation group and players. This was useful for non-subject experts when reviewing the knowledge collected. It was proposed to include this a starting prompt, "The reason for this is…" and to discuss it with participants at the start of the game. The same points would be awarded for rational as for knowledge submitted.

In relation to the knowledge evaluation game, the main change was the proposed redesign of the community cards. The evaluator group discussed that they would prefer to review knowledge by grouped by topic rather than one knowledge submission at a time. Reflecting how knowledge was presented in the digital spreadsheet. According to feedback, reviewing single knowledge submissions was challenging as the relationships between the individual submissions was difficult to ascertain. It was also more difficult to identify if any relevant pieces of knowledge were missed from the topic when reviewing them one at a time. A decision was made to redesign the community knowledge so that each card contained all submissions relevant to a specific topic. Where available, the rationale relating to the topics was also included. Each card had space for any new prompts that the evaluator might want to include in the community knowledge. Each card was awarded a number, for example 3 was awarded to the card related to nursing assessment. This number indicates the number of moves a knowledge reviewer can make on the evaluation game board. For each knowledge prompt on the card reviewers can assign: YES; NO; Maybe; Unable. The proposed redesigned community knowledge card is shown in Figure 38.

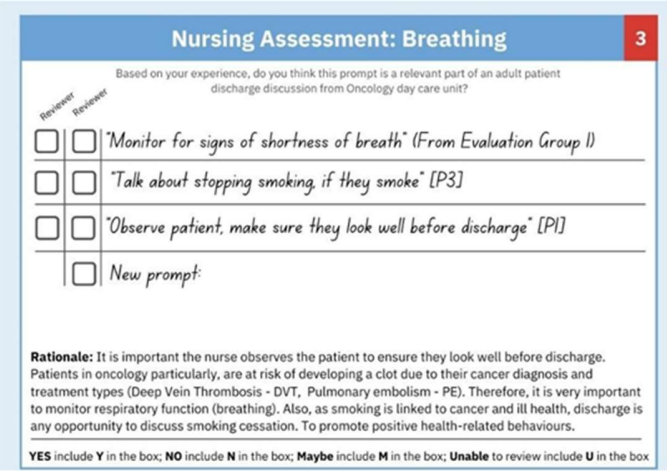


Figure 38 Redesigned community knowledge card (implementation cycle 2)

In the proposed redesigned card, in the top right-hand corner was a number that informed reviewers how many places participants can move through the game board when the evaluation is completed. These numbers were assigned randomly, no formal weighting method was used. Each card had space allocated for any new knowledge that the reviewer might want to include in the community knowledge. Also included on the card was rationale for the topic and prompts. Evaluators were also able to review the rationale to ensure it was correct. Reviewers would be asked if the knowledge captured in the card was relevant or not relevant based on their experience. For each knowledge prompt (on the card) evaluators can assign: YES; NO; Maybe; Unable. Following the second, review the cards were further reviewed by the Gatekeeper. This review was

not focused on the knowledge but on the reviewers' decisions. Each combination of the YES, NO, MAYBE had a different outcome, for example:

- Yes + Yes = knowledge is deemed relevant and included in the digital spreadsheet
- Yes + No = as no consensus, knowledge is reviewed by gatekeeper who includes or rejects
- No + No = prompt is rejected from the digital spreadsheet
- Any combination that includes 'Maybe' (unsure about decision but has experience to reach a decision) or 'Unable' (unable to review, does not have the experience to reach a decision) is deemed for review for gate keeper (before final validation).

To play, it was proposed that the total number of cards was divided between the number of participants present. Each reviewer evaluated a card, moved the spaces allocated, and returned to card to the game. Returned cards were circulated to other participants so that every card had two reviews. Following the gatekeeper review the digital spreadsheet was updated to reflect the findings from the game. It was proposed that reviewers were free to evaluate all or as many as prompts as they wished and gaining the allocated points for each submission reviewed. Each submission required a minimum of two evaluations. Once a prompt was evaluated by a single reviewer, the card was be returned to the game. Once all prompts received two reviews, the knowledge was deemed evaluated and forwarded for final validation by a subject expert. This final evaluation is discussed in Appendix F. If an evaluator reached the top of the board the game was deemed complete, even if knowledge prompts were outstanding. In this case a second game would commence. The group were free to discuss the knowledge submitted or not if they prefer. A full list of the lessons learned, and proposed changes are shown in Table 84 and 85.

Table 84 Lessons learned related to knowledge elicitation part (Implementation Cycle 2)

Description	**Action**
Theme 1: Length of game - no changes proposed to game time (elicitation game) as limited to scheduled education session time.	No change proposed
Theme 2 - Prompts to aid recall: Proposed to use starting phrases instead of examples of knowledge submitted.	• Changes to wording of: • [UC18] 'Review examples of starter phrases' • [UC19] 'Develop examples of starter phrases'

Theme 3: Avatars – no changes proposed for a low-fidelity prototype due to limitations of platform	No changes proposed for next cycle
Theme 4: Clinical scenario – no changes proposed as changes could have impact for data reference set.	No change proposed for next cycle
Theme 5: Community knowledge - Proposed to rearrange game board using categories – Artefacts, Equipment, Medications, Nursing Assessment, People and Processes – from the digital spreadsheet.	Redesigned evaluation game board
Theme 6: Competition - Proposed Gatekeeper to maintain a running tally of the score as knowledge is submitted while game is in progress. This score will be documented on the game board and visible to players in the game room.	• Add [UC24] 'Maintain tally of knowledge submitted to game board' • Add [UC25] 'View tally of knowledge submitted to game board
Theme 7: Building consensus: Proposed to include an additional award (gold start) to any knowledge considered 'most important' by participants.	• Changes to wording of: [UC15] 'Present awards to knowledge submitted'
Theme 8: Quality control - Proposed to limit the moderator function, held by the Gatekeeper, during the game to participant engagement post-game.	Gatekeeper role amended but no change to use case

Table 85 Lessons learning during cycle 2 related to knowledge elicitation stage

Description	**Action**
Theme 1: Length of game time - no changes proposed to game time (evaluation game) as limited to scheduled education session time.	No change proposed
Theme 2: Community knowledge cards	Redesign community knowledge cards
Theme 3: Awards	Change identified in elicitation game – no further changes for this cycle
Theme 4: Providing rationale – as rationale was useful for, game will continue to collect	No impact on use case

Based on the proposed actions, the use cases identified in Cycle 1 were amended by the author and the Gatekeeper. These proposed changes were reviewed by the co-inquiry group and following this were incorporated into the game and evaluated in the next implementation cycle. No changes proposed for evaluation game at this time. This is discussed in the next chapter. The details of the co-inquiry group review are shown in Table 86.

Table 86 Co-inquiry group meeting 2 (Implementation Cycle 2)

Group	Participants	Length	Moderator	Purpose of meeting
Co-inquiry group	N=4	50 minutes.	Author of thesis and Gatekeeper	To review and agree changes proposed.

The set of amended use cases are shown in Table 87 for the elicitation part of the game, no use case changes proposed for the evaluation game.

Table 87 Use cases elicitation game (Implementation Cycle 2)

Use Case ID	**Description**	**Actor**
UC15	Present awards to knowledge submitted	AID02
UC18	Review examples of starter phrases	AID02
UC19	Develop examples of starter phrases	AID04
UC24	Maintain tally of knowledge submitted to game board	AID04
UC25	View tally of knowledge submitted to game board	AID02

1.3 Implementation Cycle 3

The purpose of the third implementation stage was to evaluate the 2nd iteration of the extended game from cycle 2 at the study site. During this cycle the final artefacts emerged. These are the final serious knowledge elicitation and evaluation game and the data reference set extracted from the digital spreadsheet.

1.3.1 Cycle 3: Evaluation of artifact 1 (Elicitation part of the game)

In this game cycle, n=3 Holders engaged in the game. Attending the game was the author of the thesis and the Gatekeeper. No personal information was required for this study, so no record was maintained. For each game played during this research, a different group of Holders were engaged. Each participant chose an avatar to represent a Seeker. That is the role that is seeking knowledge. Each Seeker was assigned a specific colour post-it notes to monitor the number of points assigned. Seekers were also assigned a code based on the colour of the post-it. These were [P. 8], [P.9], [P. 10] and were used to manage the knowledge in the digital spreadsheet. Details of the Holders group meeting in cycle 3 are shown in Table 88.

Table 88 Holders group (Implementation Cycle 3)

Group	Participants	Length	Moderator	Purpose of meeting
Holders group: nurses based at the study site less than 18 months	N=3	Game time: 25 minutes Discussion time: 35 minutes.	Author of thesis and Gatekeeper	To evaluate the elicitation part of the serious game through game play. To elicit knowledge through game play that could then be evaluated during part 2 of the game.

When the knowledge elicitation part of the game was completed a group discussion with Holders was conducted. The author and Gatekeeper attended, and the discussion focused on what participants liked or did not like about the game. Themes identified during the second cycle were used as prompt questions. In addition, the Holders were asked to talk about what they liked or did not like about the game. Notes were taken by the author during the discussion. Following the group discussion, the author read aloud points raised a means of validating data captured from participants during the meeting. Data collected relating to the game artefact was analysed using

the process by Braun and Clarke (2006). This was the same process was used in the first two implementation cycles (see Chapter 4). No additional themes emerged during this discussion. The total set of themes following this evaluation, the prompts questions from them and an example of participant feedback is noted in Table 89. No new themes emerged during this discussion.

Table 89 Themes identified from Holders group cycle 3 post game discussion

Theme	Prompt used	Participant feedback
1: Length of game	Did you feel there was enough game time?	Same as previous cycle, participants noted that the game time went quickly
2. Prompts to aid recall	Did you feel the starter phrases used were helpful?	Starting phrases were described as useful by participants
3. Avatars	Did you think the avatars were relevant to you?	Same as previous cycle, participants would prefer to construct their own
4. Clinical scenario	Did you think the clinical scenario was relevant to you?	Unable to state group considered scenario too broad, but did note scenarios that were too specific could exclude participants based on individual experiences
5. Community knowledge	Did the categories help you navigate the community knowledge on the game board?	No, as the number of submissions covered the categories
6. Competition	Was the 'running tally' of knowledge submitted during the game useful? Did you find it motivating that the 'winner' was identified and was giving different awards was useful?	The focus of the game was on elicitation, so the tallies were not considered useful during the game. No feedback was captured in relation to identifying the winner.
7. Building consensus	What did you think about giving other participants knowledge awards?	Participants did enjoy giving awards to submissions.
8. Onsite evaluation	Did you find it useful to know why knowledge you submitted was rejected?	Described as potentially useful for participant learning but this benefit was not realized due to time constraints.

1.3.2 Cycle 3: Evaluation of artifact 1 (Evaluation part of the game)

To provide feedback in relation to engaging in the game, a Reviewers group discussion took place after the evaluation part of the game. The group also completed a post-game survey. The post-game questionnaire was used to specifically elicit feedback in relation to enjoyment of the game. Questionnaire responses were collected from all Holders and Reviewers group and collated into a discussion on enjoyment in Appendix H-J. As the game was used to evaluate the knowledge, the same Reviewers were used in both groups. Details of the Reviewers group discussion for this cycle are shown in Table 90.

Table 90 Reviewers group –evaluation game (Implementation Cycle 3)

Group	Participants	Length	Moderator	Purpose of meeting
Reviewers Group: nurses based at the study site less than 18 months	N=2	Discussion time: 40 minutes.	Author of thesis and Gatekeeper	To review the evaluation part of the serious game through game play.

Before each evaluation game, signed consent forms were collected from participants. The data collection and analysis process used for the elicitation game were also used for the evaluation review. This is described in Chapter 7, see Section 7.3. The Reviewers group were asked to discuss their experience of engaging in the knowledge evaluation game, focusing on what they liked and what they would like to change. Participation was anonymous and data collected is assigned to Reviewers group cycle 3. Overall, the game was well received by participants. The main challenges noted were linked to time and participants described a preference for choosing the topics they could review. A comparison between the digital spreadsheet and game was not captured as the group only engaged with the game. From this review 4 themes were identified. A change from cycle 2 to cycle 3 was that the second theme was extended from Community knowledge cards to include challenge cards. This theme was renamed to ‘Game components’. These are shown in Table 91 with the main points described by participants in this cycle for each theme.

Table 91 Themes identified from Reviewers group cycle 2 post game discussion

Themes	**Feedback from participants**
Theme 1: Length of game time	Participants would have like additional time to consider the entries due to the importance of the task.

Theme 2: Game components (Community knowledge cards and Challenge cards)	Participants discussed that they would like to choose the topics they reviewed instead of them being assigned at random. It was discussed that participants had a preference or more experience in specific topics so would like to choose these ones. Participants discussed that they enjoyed the uncertainty introduced by the challenge cards.
Theme 3: Awards	Proposed that the number of categories that could receive an award should be broadened, for instance, for first time patient.
Theme 4: Providing rationale	Noted that it helped Reviewers identify the level of understanding Holders had in relation to knowledge they were submitting.

1.3.3 Cycle 3: Evaluation of artifact 1 (Knowledge elicited)

The evaluation of the elicited knowledge is discussed in this sub-section. The prepared knowledge was captured in the digital spreadsheet and designed into a set of Community Knowledge Cards. In this cycle, n=2 Reviewers took part. Details of the Reviewers group are shown in Table 92. The text that follows is a description of the knowledge evaluation process.

Table 92 Reviewers group – Knowledge evaluation (Implementation Cycle 3)

Group	Participants	Length	Moderator	Purpose of meeting
Reviewers Group 1: nurses based at the study site less than 18 months	N=2	Game time: 60 minutes	Author of thesis and Gatekeeper	To evaluate the elicited knowledge from cycle 3 elicitation game.

In cycle 3, a total n=71 prompts submitted during the game - n=9 removed during game by evaluation on site and not resubmitted. These 9 prompts are not included in the n=71 prompts submitted. Reasons for removal were:

- N=5: ‘Too general (TG)’ describes prompts that are related to oncology but not the clinical scenario i.e., not relevant to discharge. Instead describes nursing care at different stages of patient journey or to the oncology domain in general.
- N=2: ‘Submission unclear (SU)' describes a situation where the prompt contained writing that was illegible, unable to decipher content or relevance to clinical scenario was unclear.
- N=2: ‘Single words or isolated phrases (SW)’ describes submissions containing individual words who’s meaning to the scenario could not be inferred.

The n=71 submitted prompts were reviewed by Reviewers and a further n=5 was removed. Reason for removal was:

- N=1: ‘Too general (TG)’ describes submissions that are related to oncology but not the clinical scenario i.e., not relevant to discharge. Instead describes nursing care at different stages of patient journey or to the oncology domain in general. For example, "Reinforce teaching on not taking paracetamol/(based medications) when on chemotherapy" [P8]
- N=3: ‘Single words or isolated phrases (SW)’ describes submissions containing individual words who’s meaning to the scenario could not be inferred. For instance, in cycle 3 the word ‘temperature’ was submitted by all three Holders. As it was a single word it was removed, however, the concept of temperature was noted previously in the knowledge submitted. For example “Patient to contact ward (or out of hours services) if temperature increases" [P9].One submission [P10] contained it three times in the same submission “temperature, temperature, temperature!”. Although removed from the game as it was similar to previously submitted knowledge, it was considered that the frequency of the appearance of the word could be an indication of its importance to the study site.
- N=1: ‘Submission unclear (PU)' describes a situation where the submission contained writing that was illegible, unable to decipher content or relevance to clinical scenario was unclear. For example, "Prior to discharge, after having tea for BMT" [P8]

This left a total of n=66 prompts generated from cycle 3. As it was raised in the previous games, the author was monitoring for any reference to monitoring for shortness of breath or DVT/PE. No reference to monitoring for any shortness of breath or DVT/PE was found in the prompts submitted in a previous cycle and so this was discussed with the players. They noted they just did not have time to write everything they knew down, in fact one participant raised that they were sure that there was a lot of relevant knowledge missing but “it’s impossible to get everything down in the time… a whole career of experience…”. Overall, the Reviewers group deemed the elicited and prepared knowledge to be relevant to a general adult discharge from the day unit. Similar to the first two cycles, the Reviewers in cycle 3 noted that it could be beneficial to engage with Holders to discuss knowledge submitted for clarification or to offer the chance for player to provide further rationale.

With regard to the game, evaluation group described that it was an interesting way to review the prompts and one that was not too burdensome. They discussed how it was good to engage with other evaluators to discuss the prompts but did like that it was also a game and enjoyed the competitive aspect of it. One challenge raised was that it took time to play, while this time was set aside (for the study), this time might not always be available in the clinical setting. One potential solution discussed was that the game could be played over time rather than in a single setting.

During the game, Reviewers proposed n=14 additional knowledge submissions. These were reviewed separately by the co-inquiry group. From this 14, eight prompts were removed. The reasons given for removal was:

- N=4: N2N (Nurse to Nurse describes knowledge submissions captured that were knowledge shared among nurses that related to carrying out a nursing task or observation). For example, “It is important to discuss what to expect post-visit as the patient will need to be aware so that they can monitor for any side effects and report as appropriate”.
- N=3: AI (Already included - AI)’ describes submissions that have been approved and previously included in the knowledge artefact. For example, "Tell patient to monitor for episodes of diarrhoea/constipation" (from Evaluation Group 3). The prompt "Watch for episodes of diarrhoea/constipation and what to do it if happens" [P5] was already included.
- N=1 NR (Not relevant to nursing care describes knowledge prompts captured that were not a direct responsibility of the nurse, for example, "Check has pharmacist rang local pharmacy to arrange prescription?" (From Review Group 3). There was only one example of NR in the total data collected.

Unlike the first two cycles, the 6 remaining submissions were included in the digital spreadsheet. Of the n=6 that were included these represented two topics missed by Holders – (1) breathing and (2) follow up appointment. It is unclear why these were omitted and no agreed explanation for this were found. Three potential explanations were discussed by the co-inquiry group were offered. Firstly, time limitations. Secondly, raised by Player 6 who noted that “well… I suppose… the first thing you write down, kinda starts you off and you go from there”. Topics like temperature and medications are common and important topics for this group. In addition, it was raised that players could have been influenced by their surroundings, for example, submissions on the game board or group discussions, and this impacted prompts or at least how they were thinking and therefore what they submitted. It was also discussed that the general versus specific game scenario might be able to focus on different topics. For instance, the group expected that a scenario relating to a patient with diagnosis of lung cancer might raise issues surrounding breathing. Changing the clinical scenario mid study was not deemed viable due to time constraints. In addition, it was raised that not all players might have had the same experiences so a scenario that was too specific might limit participation given the sample pool was relatively small to begin with. In total 10 players took part in the three game cycles. In addition to more specific scenarios, future work could consider letting players develop their own scenario based on their clinical experiences. Over the three cycles, the total number of submissions made by the evaluation group was n=35. These were reviewed by the co-inquiry group and only n=6 included as prompts (n=22 rejected). An overview of the knowledge submissions managed in cycle 3 are shown in Table 93.

Table 93 Overview of knowledge submissions from (Implementation Cycle 3)

Cycle 3 – Overview	
Prompts removed during the game	9
Reason for removal	N=5 (TG), N2 (SU), N=2 (SW)
Prompts submitted (including prompts split)	71
Similar prompts (removed)	35
Removed by Evaluation Group	5
Reason for removal	TG=1, SW=3, SU=1
Submitted by Evaluation Group	14
Removed by Co-inquiry Group	8
Total prompts remaining from cycle 3	31
Total prompts from cycle 1,2,3	80

1.3.4 Cycle 3: Co-inquiry group meeting

Following each game, elicitation and evaluation participants discussed what worked with the current iteration of the elicitation or evaluation game and identified potential changes for future iterations. These discussions were conducted separately, and the author of the thesis and Gatekeeper attended each meeting. Following these meetings, the data collected was reviewed by the co-inquiry group. The purpose of this meeting was to evaluate participant feedback from Cycle 3. The outcome from this meeting was an updated set of use cases for an elicitation and evaluation serious game is presented this section. This is the same process used in previous implementation cycles. Details of the co-inquiry group meeting are shown in Table 94.

Table 94 Co-inquiry group meeting 1 - implementation cycle 3

Group	Participants	Length	Moderator	Purpose of meeting
Co-inquiry group	N=4	60 minutes.	Author of thesis and Gatekeeper	To evaluate participant feedback from cycle 3, elicitation and evaluation games.

The feedback from Cycle 3, was largely positive in relation to engaging in the elicitation game. Holders described enjoying the experience during the game and they also completed a post-game survey on the topic of enjoyment. This survey was collated with the feedback from cycle 1 and 2 and is presented in Appendix H-J. A common comment to emerge from the data was that Holders

described that the game time went very fast. This was a common theme across the three implementation cycles.

Based on previous feedback relating to the theme 'Prompts to aid recall', a set of starter phrases were developed. Feedback from the Holders group noted that these phrases were useful as it gave participants a way to start but also made it very clear what the game was looking for. The starter phrases were discussed with the group before the game and were displayed in the game room. The starter phrases were:

1. "Talk to patient about…"
2. "Observe patient for …"
3. "Check patient has…"
4. "Make sure …"
5. "Send referral for …"
6. "Document …"
7. "Give patient …"
8. "Discuss how to…"
9. "Patient should know about…"

Of the nine phrases developed, two were not used. These were "Observe patient for …" and "Send referral for …". No reason for this was noted during the discussion.

While the prototype could not facilitate Holders to personalize their own avatar, a range of objects, such as a stethoscope or fob watch, were included in the selection for this cycle. The purpose of this was to give the participants more options to choose from. It was noted that all participants opted for avatars that resembled people. Participants did not identify why they did not choose the icons. Unlike previous game groups, participants did not consider the scenario to be too broad. Two potential reasons were proposed by the co-inquiry group for this. Firstly, additional details of the scenario and starter phrases were offered which could have meant participants were more likely to understand the game. Secondly, the game board was available to review with all previously collected submissions visible. It was proposed by the co-inquiry group that even though the board was difficult to navigate it could have given the players an idea of what to collect. In relation to the clinical scenario, participants did not offer feedback as to whether it was too broad. However, a participant noted that "If it [clinical scenario] was more specific, I might not know anything or have anything to add". As the number of participants was n=3 a more definitive answer relating to specific or broad clinical scenario is difficult to ascertain. In addition, it was raised by a member of the co-inquiry group that it is difficult to control for previous experiences. It is unclear if this Holders group had more experience in discharging a patient when compared to the other groups.

Reviewing the community knowledge, a participant noted that if they see knowledge on the board that they also submitted, it was a source of pride for them. The co-inquiry group agreed that participants should be allocated more time to review the community knowledge in future iterations of the game. To help users navigate the game board Feedback from the previous cycle noted the game board was hard to read as it was a 'little messy'. Based on this feedback the elicitation game board was redesigned to include the categories that could be used to arrange the submitted knowledge. Submissions from cycle 1 and 2 were arranged onto the board for this cycle. Feedback from the author and the gatekeeper noted that using these categories to arrange knowledge captured during the game did not make the game board any less difficult to navigate due to the number of submissions on the board. The co-inquiry group offered no solution was identified to help navigating the game board easier due to the number of submissions on the board. A point raised by the co-inquiry group was that this was the whole point of the game to review the community knowledge so this could be problematic going forward. A photograph of the game is shown in Figure 39.

Figure 39 Photograph of elicitation game board following cycle 3

While not a feature of this cycle, the option of adding topic tags to their own submissions was raised with Holders. This was initially introduced by the author and Gatekeeper in cycle 1 as a way to help prepare the elicited knowledge for evaluation. This option was put to the participants and there was general agreement that this could be a useful exercise and could also help to structure the game board. There was no agreement on how this could be managed in a paper-based game given the potential volume of prompts and tag/categories and limited game time. One suggestion was to include additional gatekeepers but given that clinical areas are busy finding another clinical expert who can take time away from the unit may not be realistic.

During the elicitation part of the game, submissions were collected by the author who counted them and kept a 'running tally' of scores during the game. These figures were written on post-it notes and included in the Winners Space (top right-hand corner) on the game board. As more submissions were made, the post-it's were updated to reflect the new number. The knowledge submissions, once counted, were given to the Gatekeeper to review before including on the game board. Maintaining a runny tally of submissions throughout the game was a change prompted by participants in Cycle 2. Participants in this cycle reported liking the running tallies but noted that it was not very useful as they did not have time to really look at them or take them in. They described that even without the actual numbers (on the tally) they had an idea of how other players were doing as they could see other players submitting prompts or writing. The author described how managing the process of collecting, counting, and giving to the Gatekeeper was difficult at times when the number of submissions increased. Participants also noted that seeing the winner at the end was good and made it feel like a 'game' but agreed that it would be nice to see 2nd and 3rd place. Similarly, to other cycles there was a fear expressed that they may not be seen as producing as many submissions as other members of the group. One participant discussed their surprise that they really got "stuck in and forgot it was just a game… it was like I was with a patient and going through all the questions I would ask or the stuff that I would look out for".

Holder participants in cycle 2 discussed liking the upvote function but would also like to give additional awards to build consensus in the knowledge submitted. For this cycle, a gold star award was added for any knowledge considered by Holders to be deemed 'most important'. What players considered 'most important' could be interpreted by the individual. The green sticky dot remained and could be awarded to any knowledge submitted that a player through 'relevant' to the clinical scenario. Only one gold star could be awarded per participant, but the number of green sticky dots a participant could award for 'relevant' knowledge was unlimited. All three participants awarded gold stars. This was discussed following the game. The following feedback was captured.

- "Give patient the information leaflets such as 'Going home after chemotherapy leaflet'" [P2] was awarded a gold star. The awarding participant noted this is something they often overlooked in favour of more clinical nursing tasks such as observing a patient when they are leaving the unit or monitoring temperature. The described it as a very important part of the care nurses give, as 'you don't just give them the leaflet you talk them through it'.
- Another participant awarded a star to "Discuss how to manage if temperature is out of range" [P5]. They discussed that temperature is very important and they felt this was a good prompt as it highlights not just that temperature is important but also telling patients how to manage if or when it occurs.

- This submission was also awarded a second gold star entry a gold star, citing the importance of patients managing temperature and how the nurse's role in education around temperature including what is normal and what is not normal.

It was noted by Holders that the game board was not easy to navigate, so they did not get time to review the entirety of the entries. However, participants noted they did enjoy that they could 'award' community knowledge and that their submissions could receive awards. Receiving an award would infer to the participant that the knowledge they submitted had value, was correct and relevant. Participants noted they would have liked to have received feedback if their submission was given an award. Holders were asked their opinion on whether they would like to downvote and all agreed they would not be comfortable downvoting their peer's knowledge (unclear if because they were in the same room) and that all knowledge could be relevant at some time but also because it was noted they may not have enough knowledge to properly judge if the knowledge was incorrect. [P.10] "I don't really… know… well feel comfortable saying this is bad or this is not relevant. I am only learning here too so I could be wrong about it". The co-inquiry group discussed that extending the range of awards should be something considered in future games.

During the game, the author collected the submissions from the participants and gave them to the Gatekeeper who was acting as onsite evaluation. These were reviewed and added to the game board. In the previous cycle, the evaluation on site was deemed invasive and interrupted the game flow, so the Gatekeeper was mindful of this and did not engage with a participant. To minimize any interruptions, participants could discuss submissions with the Gatekeeper following the game. In this cycle, 9 submissions were returned to participants – 5 were deemed too general, 2 were unclear and 2 were just single words that did not have much meaning for the game. This onsite evaluation was performed as a quality control measure. Participants feedback described how it was very beneficial for their learning that they could engage with a subject expert to discuss submissions. However, there was very little time to explore rejected submissions after the game due time constraints.

In relation to the evaluation part of the game, feedback from Reviewers indicated that they enjoyed engaging in the game. The competitive aspect of the game was well received as was the uncertainty introduced by the challenges cards. For instance, evaluators were unsure if they would move forward or backward until the card was read. The group noted that time passed quickly. The group raised that while they enjoyed that game, the purpose (to review elicited knowledge) was a very important topic, and they would have like additional time to consider the entries. It was put to the Reviewers to consider if they would prefer to play at their own pace. It was discussed that this could take the form of a game played over a week and then submit entries during game time. Two issues were raised in relation to this approach. Firstly, if it was not a priority or part of their role, evaluating knowledge could be overlooked in favour of more pressing tasks. Secondly,

seeing the movement up the game board provided an entertainment component and helped keep focus on the task. This cohort did not review the digital spreadsheet, so a comparison is not available.

Grouping the topics together in a Community Knowledge card was described as more beneficial (than as a single knowledge submission) as Reviewers were able to identify any missing knowledge more easily. Reviewers noted that they would have preferred to choose the cards themselves, rather than have them assigned the Gatekeeper. This was based on the Reviewers preference or experience relating to some topics over others. One participant noted that the topic 'expressing sexuality' was something that they always discuss with patients so would have liked to review that topic. The relevant Community Knowledge card was not given to the Reviewer, and they added the prompt "Give information on how treatment may affect you sexually". Under this topic was references to "Patient could potentially have hair loss" [P2] and "Give information for wig to patient" [P1]. The more direct prompt ("Give information on how treatment may affect you sexually") from the evaluator was considered a new knowledge.

While participants did not give any knowledge an award, the Reviewers did highlight that they were interested in seeing what type of knowledge was giving the gold star. There was agreement that knowledge relating to 'Temperature' was a very important topic at the study site and agreed that it should have received an award. However, they also noted that other types of awards would also be useful as all knowledge was important. It was proposed that topics like how to manage emergencies would also be an important to topic to discuss during a patient discharge. The co-inquiry group agreed that a range of awards could be beneficial as it would allow the Holders to consider the importance of knowledge many aspects of the patient journey. For instance, for knowledge relevant to a patients first appointment or their final appointment. It was proposed that will this could result in all knowledge receiving an award of some kind, this could act as a way to categorize the knowledge In relation to reviewing rational the Reviewers found it useful and described that it allowed them to discern if the knowledge was understood by the Holder or if they were just submitting a concept to the game that they had learned in practice The co-inquiry group discussed that providing rational in future games was important and consider awarding extra points to encourage Holders to take the additional time required to submit it.

Following the format of the previous implementation cycles, the lessons learned from the co-inquiry group meeting was reviewed and reflected upon by the author and the Gatekeeper and formulised into a set of proposed changes to the game. These changes were reviewed by the co-inquiry group. This is described in the next section.

1.3.5 Cycle 3: Outputs

As no major changes to the game were identified that could be implemented in its current low-fidelity format, this was deemed to be the final implementation cycle for this research. To consolidate the learning that occurred during this stage and to complete the research process, the output from cycle 3 was a final set of requirements for a serious knowledge elicitation and evaluation game for a nursing cohort. These requirements are based on the learning that occurred throughout the three implementation cycles. The final game is presented in the next chapter and is accompanied by a discussion on how the game could evolve in a digital format. The lessons learned in relation to the elicitation part of the game is shown in Table 95 and evaluation part of the game in Table 96.

Table 95 Lessons learned related to knowledge elicitation game (Implementation Cycle 3)

Description	**Action**
Theme 1: Length of game – no changes proposed as game time limited by availability of participants and scheduled education time at study site.	No further changes proposed
Theme 2: Prompts to aid recall - starting phrases proposed in cycle 2 proved useful to initiate knowledge elicitation	No further changes proposed
Theme 3: Avatars - unable to facilitate participants to personalize their avatars due to time limitations and modality.	No further changes proposed
Theme 4: Clinical scenario - no changes proposed as changes could have impact for data reference set.	No further changes proposed
Theme 5: Community knowledge - Evaluation game board redesigned and evaluated as proposed in cycle 2. As the redesign did not make navigating the board easier, no. further changes are proposed as the number of submissions is difficult to catagorise in a low-fidelity prototype	No further changes proposed
Theme 6: Competition - Keeping a running tally of the knowledge submissions elicited during the game proposed in cycle 2 was difficult in the current low-fidelity format was difficult, proposed to remove the relevant use cases (UC20 and UC21).	Remove UC20 and UC21 for a low fidelity prototype.
Theme 7: Building consensus - The additional award (gold star) proposed in cycle 2 was well received, but readability of the elicitation game board	Remove UC13 for a low-fidelity prototype

impacted fairness of the award as not all submissions could be considered in the current low-fidelity format.	
Theme 8: Onsite quality control - Limiting engagement of the onsite evaluation function of the Gatekeeper minimized interruptions to game flow.	No further changes proposed

Table 96 Lessons learned related to knowledge evaluation game (Implementation Cycle 3)

Description	**Action**
Theme 1: Length of game time - no changes proposed to time (evaluation game) as limited to scheduled education session.	No change proposed
Theme 2: Game components (Community knowledge cards and Challenge cards)– The redesign of community knowledge cards was well received but participants would like to choose the topics they review based on their experience. Participants described enjoying the uncertainty introduced by the challenge cards.	Allow participants to choose the community knowledge cards they reviewed Use Case added: [UC09] Reviewers choose community knowledge cards
Theme 3: Awards – in the elicitation game, awards were well received in theory but the difficulty navigating the elicitation game board reduced the impact of the award. This had a knock effect in the evaluation game as the awards could not be considered as impactful.	No further changes proposed in a low-fidelity prototype
Theme 4: Providing rationale – as the rationale was useful for, game will continue to collect	No impact on use case

Based on the proposed actions, the use cases identified in the design and implementation stages were amended by the author and the Gatekeeper to capture the learning that occurred in cycle 3. These proposed changes were reviewed by the co-inquiry group. The details of the co-inquiry group review are shown in Table 97.

Table 97 Co-inquiry group meeting 2 (Implementation Cycle 3)

Group	Participants	Length	Moderator	Purpose of meeting
Co-inquiry group	N=5	90 minutes.	Author of thesis and Gatekeeper	To review and agree changes proposed to the use cases for a low-fidelity serious knowledge elicitation and evaluation game

The final set of use cases for a low-fidelity serious knowledge elicitation and evaluation game are presented in Table 98 and 99.

Table 98 Final USE CASES for low-fidelity elicitation game

Use Case ID	**Description**	**Actor**
UC01	Submit knowledge to game	AID02
UC02	Evaluate knowledge submitted to game	AID02, AID03, AID04
UC03	Remove knowledge submitted to game	AID02, AID03, AID04
UC04	Provide clinical expertise to the game	AID03, AID04
UC05	Review community knowledge	AID02, AID03, AID04
UC06	Take photograph of community knowledge	AID02
UC07	Circulate game sheet	AID04
UC08	Accept game sheet	AID02
UC09	Arbitrator in case of disputes	AID04
UC10	Prepare elicited knowledge for evaluation	AID04
UC11	Award points to knowledge submitted	AID04
UC12	Collate submissions onto the game board	AID04
UC14	Identify winner	AID04
UC15	Present awards to knowledge submitted	AID02
UC16	Monitor game time	AID04
UC17	Accept points for knowledge submitted	AID02, AID05
UC18	Review examples of starter phrases	AID02
UC19	Develop examples of starter phrases	AID04
UC22	View winner	AID02
UC23	Evaluate knowledge submitted	AID04
UC24	Maintain tally of knowledge submitted to game board	AID04
UC25	View tally of knowledge submitted to game board	AID02

Table 99 Final use cases for evaluation game

Use Case ID	Description	Actor
UC01	Prepare knowledge for evaluation	AID04
UC02	Set up game	AID04
UC03	Access game components	AID04
UC04	Evaluate prepared knowledge	AID03
UC05	Monitor game time	AID04
UC06	Receive evaluated knowledge	AID04
UC07	Arbitrator in case of disputes	AID04
UC08	Update digital spreadsheet with evaluated submissions	AID04
UC09	Reviewers choose community knowledge cards	AID03

Following the completion of the third implementation cycle, both the game and the digital spreadsheet were deemed to have been designed, implemented, and evaluated.

Appendix E - eADR Stage Reflections

Reflection is an activity conducted during each eADR cycle (Mullarkey & Hevner, 2019). These reflections identified potential changes that could be incorporated into the artefact if relevant. The reflection activity involved discussions between the author and the Gatekeeper. A further reflection was undertaken when each stage was completed. These were referred to as Stage Reflections in this research. The purpose of these reflections was to explore the application of the eADR in this research. Reflection used the model described by Rolfe (1997). This model presents three questions: What, So What and Now What. Each reflective event goes through each of the three questions to make sense of the event and identify the learning. In this Appendix, reflections from each cycle are presented in table form (see Table 100, 101 and 102 Each table represents a stage of the eADR. A full discussion on the stage reflection is provided in Chapter 7 as a contribution of the application of eADR in this research.

Table 100 Diagnosis stage reflections

Diagnosis stage reflection cycle 1	
What	The initial set of challenges was identified from the literature. A further challenge (personal knowledge management systems) was not discussed in the literature but was identified by the study site.
So What	Challenges to eliciting knowledge are evident in the wider literature, healthcare sites are unique. Therefore, evaluating challenges with the study site was important.
Now	This reflection highlighted the importance of ensuring challenges were relevant to the study site. This is identified by the ADR principle
Diagnosis stage reflection cycle 2	
What	Capturing participants perspective is vital but can delay progress if participants are on different shifts or work sites and unable to engage in the research. Indeed, action research which centers on participants from the study environment, is represented by the Action in Action Design Research.
So What	This could happen in if the serious game was deployed in 'real life'. Therefore, it was important to understand how this could impact the research outcomes. Rather than switch domains to find a less challenging environment.
Now	While high participant numbers can help support the generalisability of findings, this reflection highlighted how challenges such as the busyness of the clinical environment could impact the availability of participants. This was exacerbated by the ongoing evaluations required by the eADR approach (Mullarkey and Hevners 2019).

Table 101 Design stage reflections

Design stage reflection Cycle 1	
What	Elements from a knowledge elicitation method The WICKED method by Impey et al. (2023) were used in the design of the serious game. This provided a starting point, incorporating additional methods also introduced additional challenges.
So What	While eADR provide an overarching framework to design, implement, and evaluate artefacts, additional methods are incorporated throughout the process. It was discussed that incorporating these additional methods, could have an impact on the initial set of challenges.
Now	When new methods are incorporated, the impact on other parts of the research should be considered.
Design stage reflection 1 Cycle 2	
What	Traditional approaches, such as the Waterfall method, are top-town, sequential approaches. This can be problematic as learning that occurs during the process may have implications for earlier stages in the research.
So What	It emerged when the thesis was being written that the sequential nature was easier to present to readers. The back-and-forth movement through the research prompted by the needs of the research and the flexibility of the eADR meant that navigating the final thesis risked being difficult to follow for the reader.
Now	To give the reader a true account of the trajectory of the research, a decision was made to present each stage or cycle in the order they were conducted.
Design stage reflection 2 Cycle 2	
What	There were several parts to this research. Each part required a different set of participants – Holders, Reviewer, and co-inquiry group members. A difficulty encountered in the second design cycle, was the number of participants required was not available to engage in a pilot study.
So What	The study site was a busy specialist clinical area, so finding time for all the required activities was challenging for participants. This meant that a pilot study was not performed for the evaluation part of the game in the second cycle.
Now	It was discussed that the research could stall if it was to wait for additional participants to engage in a pilot study. This had not only time implications, but as a specialist clinical area, there was a limit on the number of participants available. A decision was taken to move the design into implementation but use the problem formulation activity to highlight that this was an untested design.

Table 102 Implementation stage reflections

Implementation stage reflection Cycle 1	
What	Extending the scope of the initial game: the Reviewers group described the evaluation process as challenging due to the number of knowledge submissions and repetitious nature of the task.
So What	The scope of the game needed to be extended to gamify the evaluation process.
Now	An elicitation game design should consider impact on all stakeholders required to be involved for the game to produce knowledge during the diagnosis stage, but be mindful that as the artefact evolves so could the stakeholders.
Implementation stage reflection 1 Cycle 2	
What	Stopping the research: it was difficult to know when to stop engaging participants in the game to stop eliciting or evaluating knowledge.
So What	Data saturation was proposed as a heuristic to stop collecting knowledge. In practice, it is unclear if knowledge could ever be considered as fully captured due to the evolution of knowledge. Furthermore, due to the busyness of the healthcare environment, researchers need to balance the needs of the research with the availability of the site.
Now	As knowledge is ever evolving, it should be considered that collection is never fully complete. Rather than data saturation, data collection was impacted by the availability of the study site and participant interest. No guidelines were prescribed by the eADR approach as to stopping the implementation cycles.
Implementation stage reflection 2 Cycle 3	
What	Moving towards a digital format: this research: the research was conceived as a first step towards a digital game.
So What	While the eADR notes artefact develop over the course of the research, there was no guidance on evolving formats, that is moving from a low-fidelity prototype to a digital platform.
Now	The eADR approach includes a stage (Evolution) that is available to review the problem environment. This could provide an opportunity to gauge if the artefact and the environment was prepared to evolve.

Appendix F - Preparing elicited knowledge for evaluation

The community knowledge was constructed into a digital spreadsheet for evaluation. To ensure all knowledge elicited from the game was prepared in a systematic, repeatable, and transparent way so that any comparisons between the all knowledge captured would be fair and accurate. Therefore, the preparation process was performed by the author and Gatekeeper with all the community knowledge undergoing the same steps. These steps were identified in the following the first preparation process. These steps are:

- Individual knowledge submissions transcribed verbatim into a digital spreadsheet.
- Submissions grouped by topic
- Topics were arranged into high level categories
- Full words included for any abbreviations
- Complex submissions were Split
- Similar submissions were removed
- A record of rationale for the submitted knowledge included if supplied

The first step to prepare the knowledge was to transcribe each post-it notes verbatim onto a digital spreadsheet document. To do this each submission written on a post-it note was transcribed verbatim into a digital spreadsheet. In the case where a submission could not be deciphered, for instance, illegible handwriting. The content of the digital spreadsheet was reviewed and submissions grouped together by topic using the Activities of Living (ALs) framework (Roper et al., 1998). Examples of ALs include breathing and elimination. This framework was chosen due to its use in nursing domain. Submissions that did not fit into the AL framework were reviewed and additional themes extracted. The total set of topics, including ALs and additional themes, were then reviewed iteratively, and 6 high level categories emerged – Nursing assessment, Processes, Equipment, Artefacts, Medications and People. The purpose of using topics and categories was to help manage the volume of submissions captured, to identify knowledge themes that emerged and to remove any duplicate entries. Following this and to prepare the data for evaluation three tasks were undertaken – remove abbreviations, submissions were split and prompts that were similar were removed.

Some submissions captured included abbreviations such as ‘PHN’ for Public Health Nurse or ‘Temp’ for temperature. When this occurred the full word, along with the abbreviation, was included. The purpose of this was to minimize the chance of any misinterpretation in the evaluation process. To convert abbreviations to full text the research referred to the Health Service Executive Code of Practice for Healthcare Records Management – Abbreviations (HSE, 2010).

From this review, it was noted that not all abbreviations used were easily converted to their proper meaning. For example, ‘Pt’ was used as an abbreviation for ‘patient’. This was based on the context of the prompt submitted. However, ‘Pt’ was not in the guide, however, ‘PT’ was but that represented ‘Prothrombin time’ which is a test to evaluate blood clotting (HSE, 2010).

Some prompts submitted contained more than one concept. A decision was made by the author and Gatekeeper to ‘split’ these entries. These ‘split’ submissions were counted as individual entries in the data collected, however, during the game they received 1 point (as they were submitted as a single entry). N=12 submissions were ‘split’ from the first game cycle. Splits were counted as individual entries in the N=128. Examples include:

> Original: "They might experience nausea/vomiting and what to do if it happens" (SPLIT) [P4]
> Split 1 "They might experience nausea and what to do if it happens" (SPLIT) [P4]
> Split 2 "They might experience vomiting and what to do if it happens" (SPLIT) [P4]
>
> Original: "Watch for episodes of diarrhoea/constipation" (SPLIT) [P5]
> Split "Watch for episodes of diarrhoea" (SPLIT) [P5]
> Split "Watch for episodes of constipation" (SPLIT) [P5]

From the submissions collected it was noted that some were similar to others. This was more apparent when topics and categories were added. Submissions deemed similar were removed, leaving a single submission to represent the concept. Examples include:

> Include: "Observe patient, make sure they look well before discharge" [P1]
> Similar removed: "Make sure to look at them to see if they are okay" [P4]
>
> Include: "Discuss how to manage if temperature is out of range" [P5]
> Similar removed: "Observe temperature (temp) and if it goes above a certain number tell them what to do" [P1]

The decision to deem a submission ‘included’ or ‘similar’ arose from discussions between the author and Gatekeeper. It was could that the is if submissions could be assigned the same code, only one needed to be included as a representative submission. Some submissions included a rationale, for example, "Always get a lift home after their first chemotherapy because you don't know how well they (the patient) will tolerate the medication" [P5]. Or "Before they leave the unit, discharged patients should ideally know when their next appointment is (to avoid any confusion, missed appointments or delays)" [P2]. Including rationale was not a requirement of the game but proved very useful when reviewing the community knowledge as it enabled the author to develop an understanding of the context of the knowledge. When these occurred, a record of rational was maintained with the topic. The digital spreadsheet was updated reflect the outcome from the preparation process.

In the first game cycle (see Chapter 7), a paper copy of the spreadsheet was printed and given to the Reviewers during the evaluation meeting. In the second and third game cycle, the content of

the spreadsheet was constructed into a set of Community Knowledge Cards for evaluation. This change was required as the evaluation process was transformed into a game following the first implementation cycle. The spreadsheet was updated following each Reviewers meeting by the author and Gatekeeper.

Appendix G - Actors, participant qualifications and function

Actor ID/Actor	Participant qualification	Function
AID01 – Experts based at the study site	No direct involvement in game	The role that shares their knowledge with Holders outside of the game.
AID02 - Knowledge Holder (KH)	Proposed role new nurses to a clinical area where the game is being deployed (the environment)	The role that is responsible for sharing knowledge they have accumulated in practice with a Seeker during the knowledge elicitation game.
AID05 - Knowledge Seeker (KS)	Proposed role is represented by the avatar in the game	The role that elicits knowledge from the Holder during the game.
AID03 - Knowledge reviewer (KR)	Proposed role is held by experienced nurses in a clinical area where the game is being deployed (the environment)	The role that is responsible for evaluating knowledge elicited during game.
AID04 - Knowledge gatekeeper (KG)	Proposed role to be held by a subject expert familiar with the clinical area where the game is being deployed (the environment)	The role that is responsible for initiating the game. The role that arbitrates in case of disputes relating to knowledge.
AID05 Knowledge mapper	Proposed role to be held by a subject expert familiar with the clinical area where the game is being deployed (the environment)	The role that is responsible for mapping evaluated knowledge to a clinical terminology.

Appendix H - Post-game evaluation survey

To help us understand how you enjoyed playing this game, please complete this post-game questionnaire by rating these statements using a 5 Point Likert Scale (strongly disagree, disagree, neutral, agree, and strongly agree).

Code	Question	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
CN	I would play the game again					
CE	I enjoyed playing the game					
CN	The game maintained my focus for the length of play					
CE	The challenge is adequate, neither too difficult nor too easy					
CE	The prompt cards are a good feature of the game					
CE	The game sheet is a good feature of the game					
CE	The game scenario is a good feature of the game					
CE	The upvoting/downvoting is a good feature of the game					
CE	The avatars are a good feature of the game					
PS	I did not have to learn any new skills to play the game					
CL	I was able to play the game without spending too much time reading the instructions					
CS	Overall game goals were presented clearly					
CS	Using a clinical scenario was useful					
FK	I would like to receive feedback during the game					
FK	I enjoyed that I received a score					
FK	I enjoyed that there was a winner					
IN	I felt like looking to see what the other players in the group were doing					
IN	I forgot about time passing while playing the game					
IN	The design of the game documents helped me focus					
SN	I would prefer to cooperate with other players during the game					
ET	I learned more about (the knowledge topic) from taking part in the game (adapted from de Almeida and Machado, 2021)					
ET	The game motivated me to recall my knowledge (on the agreed topic)					
ET	I would have liked more time to recall all my knowledge (on the topic)					
ET	I would prefer to capture my knowledge at my own pace and not in one sitting (during game time)					
KG	I enjoyed sharing my knowledge with the group					
KG	I gained additional knowledge from playing the game					

(Adapted from Sweetser and Wyeth, 2005, F.-L. Fu et al. / Computers & Education 52 (2009) 101–11)

Code: Concentration (CN), Challenge (CE), Player Skills (PS), Control (CL), Clear Goals (CS), Feedback (FK), Immersion (IN), Social Interaction (SN), Educational Content (ET), Knowledge sharing (KG).

Appendix I - Holders (n=10) post-game evaluation survey

Code	Question	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Concentration (CN)	I would play the game again	7	3	-	-	-
Challenge (CE)	I enjoyed playing the game	7	3	-	-	-
Concentration (CN)	The game maintained my focus for the length of play	6	4	-	-	-
Challenge (CE)	The challenge is adequate, neither too difficult nor too easy	7	3	-	-	-
Challenge (CE)	The prompt cards are a good feature of the game	7	2	1	-	-
Challenge (CE)	The game sheet is a good feature of the game	6	4	-	-	-
Challenge (CE)	The game scenario is a good feature of the game	7	3	-	-	-
Challenge (CE)	The upvoting/downvoting is a good feature of the game	5	3	2	-	-
Challenge (CE)	The avatars are a good feature of the game	6	3	1	-	-
Player Skills (PS)	I did not have to learn any new skills to play the game	5	5	-	-	-
Control (CL)	I was able to play the game without spending too much time reading the instructions	7	3	-	-	-
Clear Goals (CS)	Overall, game goals were presented clearly	8	2	-	-	-
Clear Goals (CS)	Using a clinical scenario was useful	8	2	-	-	-
Feedback (FK)	I would like to receive feedback during the game	7	3	-	-	-
Feedback (FK)	I enjoyed that I received a score	7	3	-	-	-
Feedback (FK)	I enjoyed that there was a winner	6	2	1	-	-
Immersion (IN)	I felt like looking to see what the other players in the group were doing	3	6	2	-	-
Immersion (IN)	I forgot about time passing while playing the game	7	3	-	-	-
Immersion (IN)	The design of the game documents helped me focus (aesthetics)	7	3	-	-	-
Social Interaction (SN)	I would prefer to cooperate with other players during the game	5	2	2	1	-
Educational Content (ET)	I learned more about (the knowledge topic) from taking part in the game	7	3	-	-	-
Educational Content (ET)	The game motivated me to recall my knowledge (on the agreed topic)	8	2	-	-	-
Educational Content (ET)	I would have liked more time to recall all my knowledge (on the topic)	6	3	-	1	-
Educational Content (ET)	I would prefer to capture my knowledge at my own pace and not in one sitting (during game time)	4	4	1	1	-
Knowledge sharing (KG)	I enjoyed sharing my knowledge with the group	5	5	-	-	-
Knowledge sharing (KG)	I gained additional knowledge from playing the game	7	3	-	-	-

Appendix J - Reviewers (n=5) post-game evaluation survey

Code	Question	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Concentration (CN)	I would play the game again	4	1	-	-	-
Challenge (CE)	I enjoyed playing the game	4	1	-	-	-
Concentration (CN)	The game maintained focus for the length of play	4	1	-	-	-
Challenge (CE)	The challenge is adequate, neither too difficult nor too easy	4	1	-	-	-
Challenge (CE)	The prompt cards are a good feature of the game	n/a	n/a	n/a	n/a	n/a
Challenge (CE)	The game sheet is a good feature of the game	n/a	n/a	n/a	n/a	n/a
Challenge (CE)	The game scenario is a good feature of the game	4	1	-	-	-
Challenge (CE)	The upvoting/downvoting is a good feature of the game	4	1	-	-	-
Challenge (CE)	The avatars are a good feature of the game	n/a	n/a	n/a	n/a	n/a
Player Skills (PS)	I did not have to learn any new skills to play the game	3	-	2	-	-
Control (CL)	I was able to play the game without spending too much time reading the instructions	2	2	-	1	-
Clear Goals (CS)	Overall, game goals were presented clearly	3	1	1	-	-
Clear Goals (CS)	Using a clinical scenario was useful	3	2	-	-	-
Feedback (FK)	I would like to receive feedback during the game	2	3	-	-	-
Feedback (FK)	I enjoyed that I received a score	2	3	-	-	-
Feedback (FK)	I enjoyed that there was a winner	2	2	1	-	-
Immersion (IN)	I felt like looking to see what the other players in the group were doing	3	2	-	-	-
Immersion (IN)	I forgot about time passing while playing the game	3	1	1	-	-
Immersion (IN)	The design of the game documents helped me focus (aesthetics)	3	2	-	-	-
Social Interaction (SN)	I would prefer to cooperate with other players during the game	2	1	2	-	-
Educational Content (ET)	I learned more about (the knowledge topic) from taking part in the game (adapted from de Almeida and Machado, 2021)	2	2	1	-	-
Educational Content (ET)	The game motivated me to recall my knowledge (on the agreed topic)	3	2	-	-	-
Educational Content (ET)	I would have liked more time to recall all my knowledge (on the topic)	3	1	1	-	-
Educational Content (ET)	I would prefer to capture my knowledge at my own pace and not in one sitting (during game time)	2	1	1	1	-
Knowledge sharing (KG)	I enjoyed sharing my knowledge with the group	3	2	-	-	-
Knowledge sharing (KG)	I gained additional knowledge from playing the game	2	2	1	-	-

Appendix K - Categories, topics and relevant examples of SNOMED concepts

Categories (n=6)	**Topics (n=34)**	**SNOMED CT Concepts**
Artefacts	Patient information and support	413318004 | Patient given written information (qualifier value) |
Equipment	Intravenous cannulation (IVC)	392231009 | Intravenous cannulation (procedure) |
	Long-term venous access	398013009 | Implantable venous access port (physical object) |
	Pump	44668000 | Pump, device (physical object) |
	Sharps Box	402102001 | Sharps bin (physical object) |
	Spill Kit	468062004 | Cytotoxic waste receptacle (physical object)|
	Thermometer	27991004 | Thermometer, device (physical object) |
Medications	Anticoagulants	307571006 | Anticoagulant drug monitoring (regime/therapy) |
	Antiemetics	52017007 | Medicinal product acting as antiemetic agent (product) |
	Medication management	182832007 | Procedure related to management of drug administration (procedure) |
	Neulasta	386948008 | Filgrastim (substance) |
	Pain Management	278414003 | Pain management (procedure) |
	Steroids	116566001 | Steroid (substance) |
Nursing Assessment (Activities of Living, AL)	AL - Breathing	719983008 | Breathing process (qualifier value)
	AL - Communication including pain	263536004 | Communication (attribute) | **AND** 278414003 | Pain management (procedure) |
	AL - Eating and Drinking	384759009 | Nutrition, function (observable entity) |

	AL - Elimination	63911002 | Excretory function (observable entity) |
	AL - Mobility	363803005 | Mobility (observable entity) |
	AL - Personal cleansing and dressing	710150006 | Promotion of hygiene (procedure) |
	AL - Skin	225360001 | Skin care (regime/therapy) |
	AL - Sleeping	395069004 | Sleep management (procedure) |
	AL - Temperature	703421000 | Temperature (observable entity) |
	AL - Expressing sexuality	386468009 | Sexuality education (procedure) |
	AL - Maintaining a safe environment	1179122001 | Safe environment (finding) |
People	Family members	303071001 | Person in the family (person) |
	Heath and social care professionals and support staff	223366009 | Healthcare professional (occupation) |
Processes	Arrange any referrals	3457005 | Patient referral (procedure) |
	Discuss potential side effects of treatment	304531008 | Treatment side effects education (procedure) |
	Arrange next appointment	308817005 | Appointment status (finding) |
	Check patient's understanding of their care	66216009 | Understanding, function (observable entity) |
	Discuss how to manage an emergency at home	385868005 | Emergency treatment management (procedure) |
	Discuss patient supports available	226006008 | Support of chronically ill patient (regime/therapy) |
	Give important contact details	406548001 | Emergency contact details (observable entity) | AND 406534001 | Out of hours contact details (observable entity) |
	Nursing task	9632001 | Nursing procedure (procedure) |

Appendix L - 'Matched' submissions with SNOMED and ICNP codes

Evaluated submission	SNOMED Code
"What is their respiratory rate" (from Evaluation Group 3)	86290005 | Respiratory rate (observable entity) |
"Talk about stopping smoking, if they smoke" [P3]	771155005 | Brief intervention for smoking cessation (procedure)|
"Observe patient, make sure they look well before you discharge" [P1]	363791007 | General appearance of patient (observable entity)|
"Tell patient to observe weight ~~regularly~~" [P1]	698471002 | Patient advised about weight management (situation)|
"Check blood glucose levels, if needed" [P8]	33747003 | Glucose measurement, blood (procedure) |
"Give dietary education" [P8]	11816003 | Diet education (procedure)|
"Watch for episodes of diarrhoea~~/constipation~~ and what to do if it happens" (SPLIT) [P5]	408875008 | Diarrhea care education (procedure)|
"They might experience nausea~~/vomiting~~ and what to do if it happens" (SPLIT) [P4]	408881000 | Nausea care education (procedure)|
"Talk about infection prevention measures like washing hands etc" [P1]	385820004 | Infection control education (procedure)|
"Give information on how treatment may affect you sexually" (from Evaluation Group 3)	386468009 | Sexuality education (procedure)
"Give education around sunbathing and wear a high factor every day when you are outside" [P4]	183079004 |Patient advised about exposure to the sun (situation)|
"Give information about dressings, if needed" [P8]	15502008 | Wound treatment education (procedure) | *(CHILD) Dressing change/wound care education, guidance, and counseling (procedure)*
"Discuss with patient how to manage any fatigue" [P9]	1153557000 | Education about fatigue (procedure)|
"Patient should know about possible sleep disturbances and what to do if it happens" [P8]	410305008 | Rest/sleep education, guidance, and counseling (procedure) |
"Be particular about monitoring signs of high temperature" [P2]	310403001 | Temperature control education (procedure) |
"Discuss how to manage if temperature is out of range" [P5]	310403001 | Temperature control education (procedure) |
"Arrange interpreter before next appointment, if they need one" [P10]	315594003 | Interpreter needed (finding)| 736790000 |Interpreter booked (finding)| 315593009 | Need for interpreter (finding)|

Evaluated submission	SNOMED Code
"If patient has peripherally inserted central catheter (PICC) insitu - check on discharge" [P8]	445611009 | Assessment of peripheral intravenous catheter site (procedure)|
"Discuss how to care if patient has a peripherally inserted central catheter (PICC) ~~or port~~" [P8] (SPLIT)	698596001 | Peripheral venous catheter care education (procedure)|
"Discuss how to care if patient has a ~~peripherally inserted central catheter (PICC) or~~ port" [P8] (SPLIT)	735348004 | Education about central venous catheter care (procedure)|
"Remove intravenous cannula (IVC) before going home" [P8]	225066003 | Removal of intravenous cannula (procedure)|
"Check intravenous cannula (IVC) site" [P3]	444713005 | Assessment of catheter entry site (procedure)| CHILD Assessment of peripheral intravenous catheter site (procedure)
"Make sure they have a Sharps Box for home" [P1]	402102001 | Sharps bin (physical object) |
"Don't forget to give prescription" [P5]	1217105006 | Prescription given (situation)|
"Patient might need education around their prescription" [P5]	423076000 | Medication prescription education, guidance and counseling (procedure)|
"They may be on anticoagulants, make sure to discuss" (from Evaluation Group 3)	442284008 | Education about anticoagulant therapy (procedure) |
"Give patient the information leaflets such as 'Going home after chemotherapy leaflet'" [P2]	103313004 | Patient given information (contextual qualifier) (qualifier value) | (CHILD) Patient given written information (qualifier value)
"Organise the next appointment, if needed" [P10]	1156892006 | Scheduling of follow up appointment (procedure) | 308817005 |Appointment status (finding)| 185407009 |Person making appointment (finding)|
"What side effects of treatment to be aware of?" [P8]	304531008 |Treatment side effects education (procedure)|
"Write up note ~~and mention cycle and day~~ [in nursing notes]" [P8] (SPLIT)	385778002 | Nursing status report (procedure) |
Record appointment: "Put next appointment on planner." [P5]	1156892006 | Scheduling of follow up appointment (procedure) |
"Discuss if they want the nurse to educate a family member or carer regarding medication or treatment and side effects" [P9]	709269007 | Family education about treatment regime (situation)|
"Advise patient's family over the telephone when next appointment is, if patient requests nurse to do so." [P5]	709269007 | Family education about treatment regime (situation)|
Clinical nurse specialist (CNS)	224570006 | Clinical nurse specialist (occupation) | *(CHILD) Oncology nurse (occupation)*
Public health nurse (PHN)	26369006 | Public health nurse (occupation) | *(CHILD) Public health nurse practitioner (occupation)*

Evaluated submission	SNOMED Code
Social worker (SW)	106328005 | Social worker (occupation) | *(CHILD) Medical social worker (occupation)*
Support groups (such as the ARC Cancer Support Centres, Irish Cancer Society and the Daffodil Centre)	413331009 | Voluntary services (qualifier value) |
Occupational therapy	80546007 | Occupational therapist (occupation) | *(CHILD) Hospital-based occupational therapist (occupation)*
Physiotherapy	36682004 | Physiotherapist (occupation) |
Day unit secretary	394572006 | Medical secretary (occupation) |
Consultant secretary	394572006 | Medical secretary (occupation) |
Administration/reception staff	159483005 | Clerical occupation (occupation) | *(CHILD)* Health services receptionist (occupation)
Staff nurse	158994007 | Staff nurse (occupation) |
Voluntry helpers (based at unit)	276035002 | Voluntary helper (person) |
Family members	303071001 |Person in the family (person)| 394854006 |Immediate family member (person)|
Care givers	229774002 |Caregiver (occupation)|
"Mouth care - discuss" [P2]	243085009 | Oral health education (procedure) |
Tell patient how to take a temperature (Final Evaluation)	410192007 | Temperature taking education (procedure) |
"The need for a spill kit if patient is going home with any pump, for their first treatment" [P9]	468062004 |Cytotoxic waste receptacle (physical object)| 373066001 |Yes (qualifier value)|, 373067005 |No (qualifier value)|
"They might need a clinical nutrition" [P9]	428461000124101 | Referral to nutrition professional (procedure) | 373066001 | Yes (qualifier value)|, 373067005 |No (qualifier value)|
"Talk to patient - antiemetic use"[P1]	223421004 | Recommendation regarding when to take drug (procedure)| **AND** 394835006 | Patient medication education (procedure) |
"Organise Neulasta injection" [P5]	129438006 | Prescription - action (qualifier value) | **AND** 781885009 |Product containing precisely filgrastim (as pegfilgrastim) 10 milligram/1 milliliter conventional release solution for injection (clinical drug)|
"Explain the importance of taking steroids ~~and explain possible side effects~~" [P10] (SPLIT)	967006 | Medication education (procedure)| **AND** 116566001 Steroid (substance) |

Evaluated submission	SNOMED Code
"~~Explain the importance of taking steroids and~~ explain possible side effects" [P10] (SPLIT)	396080005 | Medication side effects education (procedure) | **AND** 297279009 |Steroid therapy (procedure)|
"Give information for ~~care to drive, social worker and~~ wig to patient" [P1] (SPLIT)	60110001 | Wig, device (physical object) | *(CHILD)* Artificial hair wig, device (physical object) **AND** 103313004 | Patient given information (contextual qualifier) (qualifier value) |
"Give clinical nurse specialist contact details to patient" [P7]	103313004 | Patient given information (contextual qualifier) (qualifier value) | **AND** 224570006 | Clinical nurse specialist (occupation) |
Teach patient about the side effects of peripherally inserted central catheter (PICC) insertion, if they have one (Final Evaluation)	392020005 | Peripherally inserted central catheter care (procedure) | **AND** 409073007 | Education (procedure) |
"Make sure they are clear about return appointment time and date" [P9]	1156892006 | Scheduling of follow up appointment (procedure) | **AND** 103313004 | Patient given information (contextual qualifier) (qualifier value)|
"Get a thermometer for home" [P4]	183084005 | Patient advised to buy medical kit (situation)| **AND** 27991004 | Thermometer, device (physical object) |
"~~Write up note and~~ mention cycle and day [in nursing notes]" [P8] (SPLIT)	385778002 | Nursing status report (procedure) | **AND** 399042005 | Chemotherapy cycle (procedure) |
"Make sure to include any referrals sent or to be sent in the notes" [P5]	385778002 | Nursing status report (procedure) | **AND** 721927009 | Referral note (record artifact) |
"Nurse is responsible for organising Neulasta injection and nurse to send referral to to nurses connected to the Community Intervention Team (CIT)" [P1]	306042008 | Referral by oncology nurse (procedure) | **AND** 385544005 | Pegfilgrastim (substance) |
Consultant (Oncologist)	768839008 | Consultant (occupation) | **AND** 310512001 | Medical oncologist (occupation)|
"Ensure patient is aware of next appointment - ask to repeat back to me." [P5]	390840006 | Next appointment (finding) |**AND** 419733004 | Patient notified (situation)|
"Any available resources - Irish Cancer Society - give to patient" [P8]	413331009 | Voluntary services (qualifier value) | **OR** 413125004 | Referral to voluntary service (procedure) | 373066001 | Yes (qualifier value)|, 373067005 |No (qualifier value)|
"Give contact details for voluntary support services" [P3]	413125004 | Referral to voluntary service (procedure)| **OR** 103313004 | Patient given information (contextual qualifier) (qualifier value)| **AND** 413331009 | Voluntary services (qualifier value) |
"Does patient need to see social work? Check?" [P4]	308440001 | Referral to social worker (procedure) | **AND** 373066001 | Yes (qualifier value)|, 373067005 |No (qualifier value)|

Evaluated submission	ICNP Code
"What is their respiratory rate" (from Evaluation Group 3)	10046338 Measuring Respirations
"Talk about stopping smoking, if they smoke" [P3]	10050954 Promoting Smoking Cessation
"Tell patient to observe weight ~~regularly~~" [P1]	10033001 Teaching About Effective Weight
"Check blood glucose levels, if needed" [P8]	10041212 Measuring Blood Glucose
"Give dietary education" [P8]	10046533 Teaching About Diet
"Watch for episodes of diarrhoea~~/constipation~~ and what to do if it happens" (SPLIT) [P5]	10043660 Teaching About Managing Diarrhoea
"They might experience nausea~~/vomiting~~ and what to do if it happens" (SPLIT) [P4]	10043687 Teaching About Managing Nausea
"Talk about infection prevention measures like washing hands etc" [P1]	10038112 Teaching About Preventing Cross Infection
"Give information about dressings, if needed" [P8]	10045149 Teaching About Wound Dressing Change
"Discuss with patient how to manage any fatigue" [P9]	10050996 Teaching About Fatigue
"Patient should know about possible sleep disturbances and what to do if it happens" [P8]	10037615 Risk For Impaired Sleep
"Be particular about monitoring signs of high temperature" [P2]	10044738 Teaching About Measuring Body Temperature
"Discuss how to manage if temperature is out of range" [P5]	10044738 Teaching About Measuring Body Temperature
"Arrange interpreter before next appointment, if they need one" [P10]	10004722 Communication Service **AND** 10002527 Arranging
"Patient might need education around their prescription" [P5]	10019470 Teaching About Medication
"They may be on anticoagulants, make sure to discuss" (from Evaluation Group 3)	10036531 Teaching About Anticoagulation Therapy
"Give patient the information leaflets such as 'Going home after chemotherapy leaflet'" [P2]	10024493 Providing Instructional Material **OR** 10011251 Learning Material
"Organise the next appointment, if needed" [P10]	10038741 Scheduling Follow Up Appointment

Evaluated submission	ICNP Code
"What side effects of treatment to be aware of?" [P8]	10024625 Teaching About Treatment Regime
Documenting nursing care: "Write up note ~~and mention cycle and day~~ [in nursing notes]" [P8] (SPLIT)	10006173 Documenting **AND** 10014178 Patient Record
Record appointment: "Put next appointment on planner." [P5]	10038741 Scheduling Follow Up Appointment
"Discuss if they want the nurse to educate a family member or carer regarding medication or treatment and side effects" [P9]	10024656 Teaching Family About Treatment Regime
"Advise patient's family over the telephone when next appointment is, if patient requests nurse to do so." [P5]	10024656 Teaching Family About Treatment Regime
Social worker (SW)	10024088 Social Worker
Occupational therapy	10051276 Occupational Therapy
Physiotherapy	10014551 Physiotherapist Role
Staff nurse	10013346 Nurse Role
Family members	10007605 Family Member Role
Care givers	10003958 Caregiver
"Mouth care - discuss" [P2]	10038108 Teaching About Oral Care
Tell patient how to take a temperature (Final Evaluation)	10044738 Teaching About Measuring Body Temperature
"They might need a clinical nutrition" [P9]	10046788 Referring To Nutritionist
"Talk to patient - antiemetic use"[P1]	10043673 Managing Nausea Intervention **AND** 10021918 Knowledge Of Medication Regime
"Organise Neulasta injection" [P5]	10043116 Collaborating With Health Care Provider On Medication Procurement
"Explain the importance of taking steroids ~~and explain possible side effects~~" [P10] (SPLIT)	10019470 Teaching About Medication
"~~Explain the importance of taking steroids and~~ explain possible side effects" [P10] (SPLIT)	10044614 Teaching About Medication Side Effects

Evaluated submission	ICNP Code
"Give information for ~~care to drive, social worker and~~ wig to patient" [P1] (SPLIT)	10019502 Teaching ICNP Primitive **AND** 10021081 WIG ICNP Primitive
"Make sure they are clear about return appointment time and date" [P9]	10038741 Scheduling Follow Up Appointment **AND** 10010162 Informing **AND** 10014132 Patient
"Ensure patient is aware of next appointment - ask to repeat back to me." [P5]	10038739 Follow Up Appointment **AND** 10010162 Informing **AND** 10014132 Patient
"Does patient need to see social work? Check?" [P4]	10043128 Referring To Social Worker
"Patient may need transport to hospital to be arranged" [P6]	10024171 Arranging Transportation Service
"Use the teach-back method to get an understanding of how much the patient took in" [P9]	10024279 Assessing Response To Teaching
Monitor for signs of DVT or PE (from Evaluation Group 1)	10051932 Risk For Embolism **AND** 10012154 Monitoring
"Monitor for signs of shortness of breath" (From Evaluation Group 1)	10012196 Monitoring Respiratory Status
"Tell patient to monitor for any changes in appetite" [P6]	10046994 Teaching Self Monitoring **AND** 10002455 Appetite
"Who is their support network?" [P8]	10024298 Assessing Social Support
"Tell patient to be active if well" [P6]	10040834 Promoting Exercise
"Tell patient what a normal temperature is" [P4]	10044738 Teaching About Measuring Body Temperature
"Write appointment on yellow card [patients record of next appointment] and give to patient." [P5]	10038741 Scheduling Follow Up Appointment **AND** 10010162 Informing
Clinical nutrition	10013426 Nutritionist Role
"Give information on how treatment may affect you sexually" (from Evaluation Group 3)	10001288 Impaired Sexual Functioning **AND** 10019502 teaching
"Remove intravenous cannula (IVC) before going home" [P8]	10020677 Venous Cannula **AND** 10016763 Removing

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