



Integrating informatics into undergraduate nursing education: A case study using a spiral learning approach

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ABSTRACT

A gap in informatics expertise amongst nursing students, practising staff and faculty has been noted globally, which reduces the potential for nurses to utilise technology to enhance patient care. National nursing education strategies and recommendations from professional associations have identified digital health as an area that needs investment. This case study describes how health informatics is being integrated into a Bachelor of Nursing programme in the United Kingdom. An international collaboration with a US-UK Fulbright Specialist Scholar enabled individual learning units corresponding to key health informatics competencies to be designed and incorporated into a pedagogic framework grounded in the spiral learning approach. This approach is proposed as one way to integrate informatics into nursing education, so students can become competent clinicians that are able to deliver technology enabled care in the health service.

1. Introduction

The use of computers and other technologies in healthcare can be traced back to the early 1950's, when health professionals in the United States (U.S.) began to introduce electronic systems into hospitals and other care facilities. From this grew the need for a new discipline in nursing – informatics – so nurses could understand how technology functions and by what means to apply it in practice to enhance patient care (Bakken, 2001). Nursing informatics has been defined by Saba and McCormick (2001, pg. 226) as, 'the use of technology and/or a computer system to process and communicate timely data and information in and across health care facilities that administer nursing services and resources, manage the delivery of patient and nursing care, link research resources and findings to nursing practice and apply educational resources to nursing education'. This area of nursing was pioneered in the U.S. and slowly spread worldwide. Unfortunately, nursing education has not kept up with the pace of technological change. The lack of informatics

expertise in nursing began to be highlighted by nurses in the 1980's (Grobe, 1989; Scholes et al., 1983) and is still an issue today (Peltonen et al., 2019). Some higher education institutions lack specific curricula and education programmes on this important area of nursing and healthcare practice (Mantas and Hasman, 2017). The reasons for this gap include a lack of capacity and interest amongst nursing faculty towards this field, a dearth of leadership to support the required changes, and the absence of specific informatics criteria in education standards set by professional regulatory bodies among others (De Gagne, Bisanar, Makowski and Neumann, 2012; Seo et al., 2019).

In the United Kingdom (U.K.), nursing education strategies and standards have identified health informatics as an area that needs investment. In Scotland, one of the four nations of the U.K., a national nursing and midwifery education strategy aimed to embed informatics in pre-registration curricula to prepare nurses to deliver technology enabled care. It also emphasised that post-registration education and continuing professional development should ensure nurses are able to

Abbreviations: ANA, American Nursing Association; ANMF, Australian Nursing and Midwifery Federation; CASN, Canadian Association of Schools of Nursing; EHR, Electronic Health Records; EMIS, Egton Medical Information Systems; HEE, Health Education England; HL7, Health Level-7; ICD, International Statistical Classification of Diseases and Related Health Problems; ICNP, International Classification for Nursing Practice; ICT, Information and Communication Technology; IMIA, International Medical Informatics Association; NHS, National Health Service; NMC, Nursing and Midwifery Council; RCN, Royal College of Nursing; SNOMED-CT, Systematized Nomenclature of Medicine–Clinical Terms; TIGER, Technology Informatics Guiding Education Reform; U.K., United Kingdom; U.S., United States.

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embrace technology and innovation (Scottish Government, 2014). In 2018, new standards for pre-registration nursing education were published by the Nursing and Midwifery Council (NMC), the professional regulatory body in the U.K. These also highlight the importance of digital and technological literacy explicitly in key areas such as admission requirements and technology enhanced learning (Nursing and Midwifery Council, 2018b, 2018c). There is no specific reference to informatics in other areas of the standards although the collection, sharing and use of information is noted multiple times, along with general knowledge, skills and competencies. Perhaps there is an assumption that this includes electronic forms of information and digital nursing practice.

However, the NMC have published new standards of proficiency for registered nurses which do include digital and technological skills and the effective and responsible use of digital technologies (Nursing and Midwifery Council, 2018a). In addition, other policies in healthcare, such as the Scottish Government's current eHealth strategy, highlight the need to educate and train the health workforce to ensure they can accurately record clinical data, utilise technology to deliver efficient and effective patient care, and empower citizens to self-care (Scottish Government, 2018). There has also been a large national programme called "Technology Enabled Care" in recent years to deliver telehealth, mobile health and other technologies in communities across Scotland (Scottish Government, 2016). This means both pre and post-registration nurses need to have adequate digital knowledge and skills to enable them to be competent practitioners not only in the National Health Service (NHS) in Scotland but also if they go to work abroad.

Despite these recommendations, there is no universally agreed or consistent approach to adapting nursing education to include informatics. A review of the literature identified nineteen published examples and numerous ways that informatics was integrated into bachelor of nursing programmes (De Gagne et al., 2012). The majority of studies, fourteen out of nineteen, were from the U.S. and none from the U.K., the most recent of which was published in 2010 and only some explained in detail how informatics was incorporated into nursing curricula or education programmes. Furthermore, new technologies and concepts in informatics such as Big Data (O'Connor, 2018), artificial intelligence (Robert, 2019), robotics (Frazier et al., 2019) and digital professionalism (O'Connor et al., 2020) are emerging and their application in healthcare is accelerating, requiring nursing education to keep up with these new developments which will influence professional practice and patient care. As there is a lack of published examples from the U.K., this case study describes how informatics is being integrated into a Bachelor of Nursing programme at a higher education institution in Scotland. It draws on a rapid review of the literature, faculty experiences of developing and integrating informatics into nursing curricula, and initial feedback obtained from students via a course evaluation survey. The focus was on a pre-registration adult nursing programme, with the aim of ensuring undergraduate students understood the core concepts that underpin informatics and how it is applied in nursing practice. This would enable them to enter the profession as graduate nurses with the necessary knowledge to adopt and leverage technology in their day-to-day clinical roles.

2. Review of informatics education frameworks

Competency-based education typically comprises identified knowledge and skillsets, organised within a framework that specifies key learning outcomes required for professional practice (Chapman, 1999). Hence, a review of published international nursing and biomedical informatics competencies was undertaken to identify key concepts that needed to be included in the curricula. Firstly, the American Nursing Association (ANA) Scope and Standards of Practice for Nursing Informatics was examined (American Nursing Association, 2015). These describe six distinct standards for nursing informatics which align to the phases of the nursing process. An additional ten standards that

encompass professional performance i.e. ethics, education, evidence based practice and research, quality of practice, communication, leadership, collaboration, professional practice evaluation, resource utilization and environmental health are also outlined. Next, the International Medical Informatics Association (IMIA) Recommendations on Education in Biomedical Health Informatics was explored (Mantas et al., 2010). This defines four domains of learning outcomes in terms of knowledge and skills for health professionals, which are (1) Biomedical and Health Informatics Core Knowledge and Skills, (2) Medicine, Health and Biosciences, Health Systems Organisation, (3) Informatics/Computer Science, Mathematics, Biometry, and (4) Optional Modules in BHMI and from Related Fields. The Technology Informatics Guiding Education Reform (TIGER) initiative was the third educational model reviewed as it recommends three main areas of competency in relation to nursing informatics; basic computer competencies, information literacy and information management (Technology Informatics Guiding Education Reform 2009).

The Canadian Association of Schools of Nursing (CASN) entry-to-practice informatics competencies for registered nurses was the next set of education standards to be examined. It specifies "information and knowledge management", "professional and regulatory accountability" and "information and communication technologies" as core principles and identifies performance indicators for each (Canadian Association of Schools of Nursing, 2012). National informatics standards for nurses and midwives from the Australian Nursing and Midwifery Federation (ANMF) was the fifth to be reviewed, which sets out ten standards under three core domains (Australian and Federation, 2015). Finally, the Code of Conduct produced by the U.K. Council for Health Informatics Professions was also assessed (UK Council for Health Informatics Professions, 2017). This outlines four standards of behaviour required of health professionals working in informatics. Although other informatics educational frameworks may exist, these six were selected for review due to their relevance to nursing and the strength of the expertise of the group of professionals who designed them. It was felt this was an adequate number from which to draw the core informatics concepts that would be needed to develop new curricula for a Bachelor of Nursing programme. Recently, Health Education England (HEE) and the Royal College of Nursing (RCN) in the U.K. released a joint capability framework to improve digital literacy across the health and social care workforce (Health Education England & Royal College of Nursing, 2018). This did not adopt a competency-based approach but instead outlines five key capabilities required by professionals such as nurses to be digitally literate. However, it lacks specific details describing exactly what these capabilities should be and how to develop and apply in practice, so this framework did not lend any additional core informatics concepts to this case study.

3. Pedagogic framework and curriculum development

In collaboration with a number of academic and nurse practitioners, a new pedagogic framework for nursing informatics was designed. Its foundations lie in the spiral learning approach (Harden, 1999; Stockhausen, 1994) which include the following features;

- Students revisiting key principles and transferrable skills throughout a programme.
- Each iteration builds new knowledge and skills about the key principles and more advanced applications of these are introduced to increase learning and understanding.
- This new material is linked back to learning in previous stages of the spiral to reinforce understanding and prevent students from being overwhelmed by the complexity of the subject area.
- The students' level of comprehension and competence in the subject area grows over time until the final learning objective is achieved.

It is not simply a matter of repetition but a process of introducing

students to the basic concepts and components of a topic and building on their knowledge, understanding and application of these over time. As learning progresses, more and more details are introduced in an intuitive way, while at the same time being related to previous educational content, to enable students construct a broader understanding of a subject and allow transferrable knowledge and skills to develop. Spiral curricula have been used to develop and deliver nursing and medical education (Brandon and All, 2010; Gibbs and Masters, 2007).

Specialist academic expertise in informatics was attained through the US-UK Fulbright Specialist programme. A Fulbright Scholar from the University of Pittsburgh undertook a four week visit to Scotland to assist a nursing faculty member who had a background in informatics, to map the international informatics education frameworks and develop a spiral learning model to support the integration of informatics into a Bachelor of Nursing programme. The Fulbright Scholar also spent time creating new learning, teaching and assessment resources to appropriately fit within existing course topics. Table 1 outlines the six competency domains that were developed from the mapping exercise and individual descriptors of the learning that students should achieve in each of the key areas. This includes (1) health service literacy, (2) information and communication technology literacy, (3) information management, (4) information systems literacy, (5) information systems management, and (6) patient/citizen digital health literacy. From this, a spiral learning framework was produced and aligned to a four-year degree programme (see Fig. 1). This outlines the core informatics competencies students will gain each year as they spiral upwards towards achieving the overall

learning objective of becoming a nursing practitioner competent in the knowledge and practice of digital health.

4. Evaluation

Individual learning units corresponding to the six competency domains and learning descriptors are being designed by faculty and integrated into a Bachelor of Nursing programme. An evaluation of one of these learning units, relating to the information management competency domain, was undertaken in 2018. The learning, teaching and assessment material created focused on digital professionalism to complement current nursing curricula and included how to communicate online and use a range of technologies appropriately. These were developed using a number of resources including literature on the subject (Guerra, 2019; Westrick, 2016), contemporary case studies of inappropriate use of social media by nurses (Ford, 2013; Grant, 2013), NMC guidelines on how to use social media responsibly (Nursing and Midwifery Council, 2019) and videos on this topic. This was incorporated into a 2nd year undergraduate adult nursing course on professionalism.

Ethical approval was obtained from a university research ethics committee to distribute an online questionnaire to a 2nd year adult nursing group, on completion of the professionalism course. An online tool called SurveyMonkey® (<https://www.surveymonkey.com/>) was used to generate a questionnaire to evaluate this new curriculum which had a mixture of Likert scale questions and open-ended text boxes to

Table 1
Core informatics competencies and learning descriptors.

| Competency Domain | Learning Descriptors |
|--|--|
| Health Service Literacy | <ul style="list-style-type: none"> Understand the basic structure and function of the National Health Service (NHS) in Scotland and how it is organised, funded and delivered. Comprehend the basic demographics and determinants of health of the people in Scotland. Distinguish the role of nursing professionals in the NHS and how they care for and support the health of people in Scotland. |
| Information and Communication Technology (ICT) Literacy | <ul style="list-style-type: none"> Understand basic concepts and components of Information and Communication Technology (ICT) and their development over time e.g. hardware, software, computer systems (including mobile platforms) and electronic networks. Recognise how ICTs can contribute to health e.g. collecting, storing, processing, managing and sharing information to support decision-making and the delivery of different models of care across a range of settings. |
| Information Management | <ul style="list-style-type: none"> Understand the concepts and components of data quality and the differences between data, information and knowledge in healthcare. Realise how ICTs are used for documenting, managing and communicating clinical and organisational information to support decision-making and care delivery. Demonstrate an ability to access and manage electronic health information and communicate this via a range of technologies. Identify the legal and ethical issues with collecting, accessing, using, sharing and destroying health information and the role of information governance in healthcare. Comprehend how ICTs are utilised for evidence-based healthcare to influence education, practice and policy. |
| Information Systems Literacy | <ul style="list-style-type: none"> Appreciate the basic types of health information systems e.g. administrative, clinical and public health and their contribution to health services over time. Recognise the benefits, risks and limitations of health information systems such as electronic health records, clinical decision support systems, electronic prescribing, and telehealth/telecare systems. Understand how the context e.g. physical, social, cultural, economic, or political can affect how information is recorded, accessed, interpreted, used and communicated by both health professionals and patients/citizens. Recognise how the context e.g. physical, social, cultural, economic, or political can affect how ICTs are applied in practice by both health professionals and patients/citizens. Identify emerging trends in ICT such as Big Data, artificial intelligence and robotics, and the implications these have for nurses and patients/citizens. |
| Information Systems Management | <ul style="list-style-type: none"> Understand the concepts and components of interoperability of ICTs and the importance of data standards and clinical coding e.g. SNOMED-CT, ICD-10, HL7, ICNP. Realise the principles and components of ICT security and how they help to protect data and ensure confidentiality of information including legislative frameworks and the role of regulatory authorities. Appreciate how ICTs help to organise, deliver and evaluate health services including managing risk and measuring quality and outcomes. Comprehend the need for organisational policies and procedures to support ICTs and their safe and effective use in healthcare. Differentiate the role of nursing professionals in information management and the design, development, implementation and evaluation of ICTs in healthcare in collaboration with computing, engineering and other professional groups. |
| Patient/Citizen Digital Health Literacy | <ul style="list-style-type: none"> Understand why patients/citizens need access to electronic health information and digital health services and what ICTs are available for these purposes including their benefits, risks and limitations. Realise the importance of patients/citizens accessing health information and social support via online applications such as social media, virtual communities, avatars, chatbots etc. Ascertain how other types of ICTs e.g. wearable and assisted living devices, gaming technology, and virtual and augmented reality can support patients/citizens health and recognise their benefits, risks and limitations. |

capture nursing students' perspectives on the value of being taught about digital professionalism. Descriptive statistics were employed to analyse the quantitative data and thematic analysis used to code and categorise the qualitative data and identify key themes (Fereday and Muir-Cochrane, 2006). As the response rate to the online questionnaire was low, at 5.5% (n = 18/325), only the results from the qualitative analysis are summarised here.

All respondents were female and were between 18 and 25 year of age. One theme that emerged focused on boundaries that students were more aware of after receiving education on digital professionalism, "it is useful to know digital boundaries" and "Not likely to post inappropriate information but good to know the legal boundaries". Another theme centred on the benefits of this type of training for their future nursing careers, "I think that the material covered on Digital Professionalism will be useful in the future, as the use of social media is increasing, and it is being used in a variety of different ways" and "Yes, as it makes sure that future nurses do not make mistakes in posting anything online about patients or their job". A third theme on how to use technology to communicate appropriately also emerged, "The section regarding the use of social media was most useful for me, as I use a number of sites. Following the digital professionalism content of his module, I can now use my social media platforms more responsibly" and "yes I think it is helpful, a lot of the students are quite young and don't seem to realise how far social media travels". Overall, nursing students seemed to value learning about this topic in informatics and gained foundational knowledge that could enhance their professional practice.

A wider evaluation of the new nursing informatics curricula and pedagogic framework is currently underway to determine its usefulness in giving nursing students the competencies they need to become skilled in digital health. The approaches put forward by McDowell and Ma (2007) and McNeil et al. (2003) for evaluating informatics competencies in nursing students on admission and graduation and assessing faculty preparedness to teach this subject are being explored, which means this longitudinal evaluation will encompass a mix of methodologies and theories. The Gassert/McDowell Computer Literacy Survey will be used to examine the digital skills of nursing students over time (Gassert and

McDowell, 1995), with pre and post evaluations being used before and after nursing informatics curricula are delivered. Faculty wide surveys, such as the Information Technology Education in Nursing Curricula Survey (McNeil et al., 2005), will also be distributed to teaching staff to understand their ability to explain informatics to nursing students. Furthermore, qualitative inquiry will be employed at key points to explore the individual experiences of both educators and students with the nursing informatics curricula and pedagogic framework as recommended by (Fetter, 2008, 2009). Theories such as Rogers Diffusion of Innovations (Rogers, 2003; Sahin, 2006) and General Systems Theory (Nelson and Staggers, 2016; Von Bertalanffy, 1969) may be used to underpin its evaluation.

Digital skills such as how to navigate online environments and use Electronic Health Records (EHR) and other technologies appropriately in a range of clinical settings with patients and other professionals will also be taught and assessed. Lucas (2010) provides a useful case study of how training students to use an EHR was achieved in partnership with a local acute care facility, which is one approach that could be taken. Liaising with a national EHR provider in Scotland such as TrakCare Patient Management System or Egton Medical Information Systems (EMIS) to provide a free training platform for nursing students could be another. A number of strategies to improve the technical skills of undergraduate nursing students are reported in the literature and may be used. These include collaborations with librarians to enhance students digital skills (Barnard, Nash and O'Brien, 2005), using mobile devices to improve communication skills in online environments such as social media (O'Connor and Andrews, 2018; O'Connor et al., 2018) and running Wikipedia workshops to improve students' information literacy skills (Walker and Li, 2016).

5. Discussion

A wealth of literature exists calling for the inclusion of informatics education in nursing (Honey and Procter, 2017; Skiba, 2017). This case study represents a snapshot of contemporary pedagogical practice

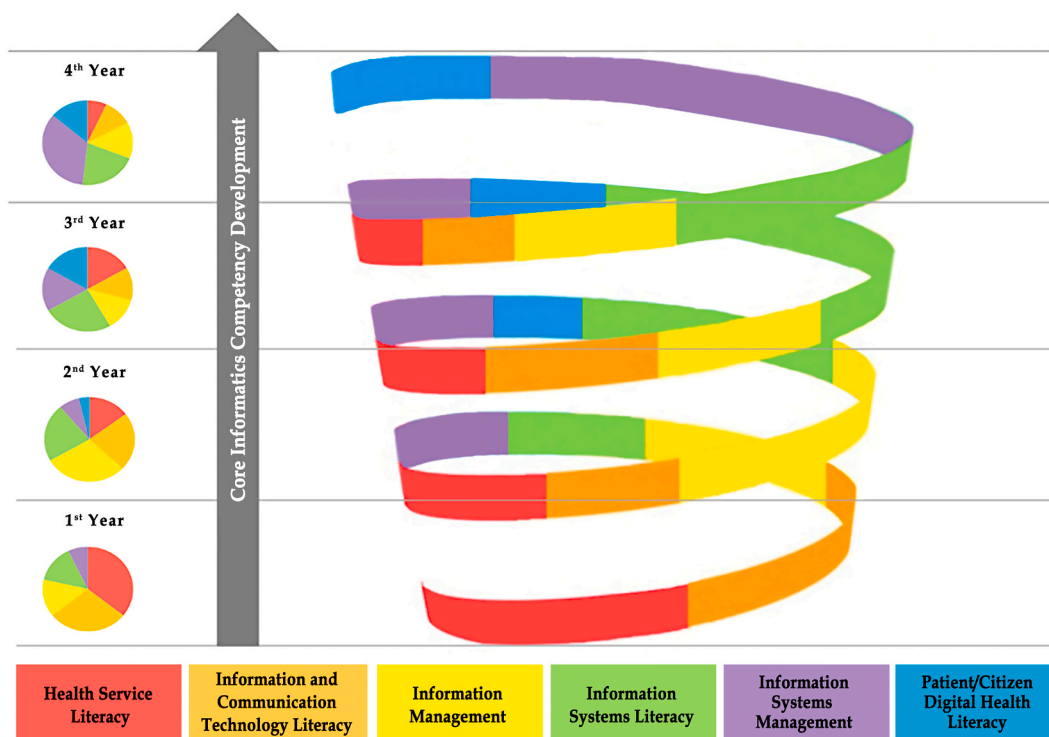


Fig. 1. Spiral learning framework of core informatics competencies (adapted and reproduced with kind permission from Charanga Ltd (2017)) - For print in colour (online only).

around developing, implementing and evaluating informatics competencies and curricula in undergraduate nursing education. There may be benefit in fully integrating informatics in this way so that the topic is seen by educators and students as an essential building block to professional nursing practice and one that complements and enhances many of the other clinical subjects taught. The holistic approach outlined may be useful to others, particularly in the United Kingdom, as a way to permanently embed knowledge and skills in informatics into the foundations of nursing education. Cummings, Shin, Mather and Hovenga (2016) adopted a similar tactic to embed informatics education in an undergraduate nursing degree in Australia. They scaffolded learning across the three years of the programme and utilised nursing informatics specialists within the faculty to review all courses and work with staff to develop content where relevant. However, they did not present any specific competencies or pedagogic framework, but referred to using the CASN and TIGER competencies, and no student or staff evaluation of this educational initiative was reported limiting its usefulness.

Procter (2012) described an alternative approach, a fully online course called "Systems of eCare", that was developed so undergraduate nursing and midwifery students could learn about information and communication technology. This self-directed course was offered to students in addition to their degree programme and allowed them to navigate through the educational content at their own pace. Nursing students were required to complete an online summative assessment and a multiple-choice questionnaire at the end of each of the six sections. A faculty member monitored student progress and was available for support and guidance when needed. While this seemed to work, the informatics competencies and curricula that were developed and assessed were not elaborated on, limiting the transferability and applicability of this approach to other higher education contexts. Furthermore, providing informatics education as a supplementary activity could be problematic given students' busy schedules and the demands of learning in academic and clinical settings. If left as an option, students may choose to ignore it, thereby missing out on critical knowledge and skills acquisition. Another way to deliver this type of training to nurses was put forward by Kleib et al. (2016), who ran a one-day bootcamp in Canada to provide informatics education to qualified nurses to improve the safety and quality of patient care. This method could be employed to imbue undergraduate students with an understanding of specific topics in informatics that may not be possible to introduce into a degree programme. This could add a level of flexibility and be particularly useful where innovative digital tools and applications that are emerging, such as the Internet of Things (Mieronkoski et al., 2017), are taught to ensure nursing students learn about new technological developments.

Others have used a variety of ways to introduce some informatics concepts and competencies into nursing education, particularly around using EHRs. Baillie, Chadwick, Mann and Brooke-Read (2012) explored the perspectives of nursing students who used EHRs in practice, as clinical placement offers students a real-world understanding of the application of information technology in healthcare. This type of hands-on experience enabled them to identify both the benefits and drawbacks of EHRs for both nursing practice and patient care. Kowitlawakul, Wang and Chan (2013) adopted a slightly different approach as they wanted to ensure students were ready for clinical placement. Hence, they tested an electronic health record with nursing students in a simulation laboratory to increase their competence with this type of technology to prepare them for professional practice. Similarly, Elliott et al. (2018) developed a simulated electronic patient record application for nursing students so they could interact with the system to learn how to record clinical information to facilitate decision making. Students reported this as a positive experience and valued the opportunity to develop these skills in a safe and supportive environment.

Despite some progress in this area of nursing education, there are still a myriad of barriers that affect the adoption of informatics such as the lack of faculty expertise on the topic and a lack of consensus locally, nationally and internationally on which informatics concepts should be

taught among others (De Gagne et al., 2012). Risling (2017) also notes that revisions to nursing curricula along with rapid changes in technology creates challenges to ensuring the principles of informatics and emerging trends are included in nursing education programmes. More research is needed on how to address these barriers and examine which models of informatics education work best in particular contexts as higher education systems vary across the globe. Kinnunen, Rajalahti, Cummings and Borycki (2017) discuss informatics competencies for nurse educators which could be expanded upon and specific training programmes developed and evaluated to support faculty to teach this subject. Another approach could be to embrace interprofessional education (O'Connor, 2018) and work with colleagues in medicine and allied health to pool resources and share health informatics expertise so students can learn about the importance of working across disciplines to leverage technology that enhances patient care.

6. Conclusion

Over thirty years have passed since nurse educators first identified informatics as a subject that should be taught to nurses. Its integration into undergraduate nursing curricula is still an issue today, although it is slowly being adopted worldwide. Given that we live in a digital age, one where the majority of nursing students have grown up with technology and use it every day in their personal lives, nurse educators need to invest in informatics education to ensure graduates have the knowledge and skills to be competent professionals when they enter the health workforce. The case study presented here could be used by nursing faculty to help students gain an understanding of information technology and how it can be applied with patients, carers and the public to improve health outcomes and the delivery of health services.

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Authors' contributions

SOC conceived the study and secured funding. SOC and EL designed the pedagogical framework and curricula. SOC wrote the first draft of the manuscript. All authors reviewed and edited the manuscript and approved the final version. The views expressed are those of the authors and not necessarily those of the US-UK Fulbright Commission.

Declaration of competing interest

The authors declare no conflict of interest.

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Appendix A. Supplementary data

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