The possibility of care engineering to enhance STEAM education in future care through the title analysis

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Abstract

Background

It is necessary to systematise care engineering to solve the social issues related to care in STEAM (Science, Technology, Engineering, Art and Mathematics) education. While the need for engineering and technology in care has increased, current trends are not well understood. This search was conducted using Web of Science, a literature database, with the study period spanning 1900 to 2019. The search term 'care' was used, as well as 'Science', 'Technology', 'Engineering', 'Art', or 'Mathematics'. Subsequently, the research field from the Web of Science was extracted every 10 years, from 1980 to 2019. The 'title' as selected by the Web of Science was analysed using KH Coder 3.Beta.01e analysis software, with frequent nouns, adjectives, verbs, and adverbs examined.

Results

The most frequently used words were extracted using KH Coder. Of the highest ranked words, 'children' was ranked high until 1969; 'health', 'medical', and 'cost' were ranked high in the 1970s; and 'system', 'information', 'assessment', and 'primary' were highest in the 1980s, 1990s, 2000s, and 2010s, respectively. Healthcare has always been the most qualified language, and especially in the 1990s, when it accounted for 59.1%. More frequently occurring in the 1980s, 1990s, 2000s, and 2010s were 'home care'; 'critical' or intensive; 'patients' or 'primary care'; and 'self', 'quality' or 'palliative care', respectively. The co-occurring network diagram most often categorised 'quality support', 'care engineering', 'primary' and 'intervention', 'medical care', 'human development', 'lifestyle', and 'social' issues.

Conclusion

The use of technology is expected to advance, and research on improving the quality of care is expected to increase. Systematising this as 'care engineering' creates a field to face the long-term problems in care. Literature on human development and the quality of care itself are expected to evolve, and new developments should occur from the care perspective.

Background

The financial and social service burdens of the increasing number of elderly will be easily addressed if changes are made now, rather than when this group actually needs long-term care. This '2030 problem' involves the challenge of assuring that sufficient resources and an effective service system exist [1], as the world's older population has dramatically increased. Further, the workforce must cultivate the skills to use available technologies and support patient care [2]. The existence, usage, and benefits of digital technologies in nursing care are relevant topics given the current discussion on technologies as possible solutions to such problems as a shortage of skilled workers and the increasing demand for long-term

care [3]. As the number of elderly increases and the disease structure changes, this has exacerbated the shortage of human resources in the caregiver industry. A range of assistive technology devices are expected to support people with dementia and their carers to manage their daily activities and enhance safety [4]. The number of older people with unmet care and support needs has also substantially increased due to the challenges facing both formal and informal care systems. However, limited works have identified emerging technological developments to potentially meet this ageing population's care and support needs [5].

Technology has emerged as a potential solution to alleviate some of the pressures on an already overburdened care system and meet the growing needs of an expanding population with serious cognitive impairments. However, issues arise as to the extent to which these technologies are already being used in residential care, and whether their use is both ethically and practically acceptable [6]. While devices and information technology (IT) are expected to compensate for the shortage of human resources, the realistic expectation of using such science and technology in the care industry has increased in the midst of the COVID-19 vortex. Care is a daily act that everyone is responsible for and can implement; care engineering in particular can contribute to this act by exploring its potential interventions. Although the need for engineering and technology in care has increased, these trends are not well-understood.

Until now, integrating science and engineering as two distinct and complementary paradigms could produce more effective outcomes in implementing evidence-based practices in healthcare settings [7]. Similarly, science and art were not always two separate entities.

A care-and-feeding educational system known as 'science, technology, engineering, art, and mathematics (STEAM)' offers a new way to utilise 'live' natural learning. This demonstrates that STEAM improved students' critical thinking, creativity, collaboration and communication skills, and care towards environmental problems (5C), in addition to their informational, media, and technology skills [8]. However, it has been observed that various cultural stereotypes—such as the idea that men are more suited for paid work and women are more suited for taking care of the home and family—may contribute to gender imbalances in STEM fields, among other undesirable gender disparities [9]. Similarly, education rooted in life care should become a more common interest among all people.

Health policies that primarily impact the elderly are being increasingly considered. While such engineering approaches as those involving science and technology can contribute to overall well-being, few approaches have focused on care engineering and technology. The implementation of welfare technology and the providing of care both require a knowledge of digitalisation, as well as an awareness of its meaning in terms of ethical principles and analyses [10]. Thus, care engineering should be systematised to enhance STEAM education in future care processes. This work aims to contribute to future well-being by analysing the possibility of an engineering approach to care by comparing related engineering and technology trends.

Methods

Data analysis

First, a search was conducted using Web of Science, a literature database. As the articles' reporting years are unclear and may fluctuate, this part of the study analysed the database at a particular extraction date (3 December 2020). The study period spanned 1900 to 2019; additionally, articles were selected with the extracted title and publication year as output. The search term 'care' was searched, as well as combinations with 'science', 'technology', 'engineering', 'art', or mathematics'.

Regarding the 'care technology' and 'care engineering' combinations, research data was extracted from the Web of Science for every 10-year period from 1980 to 2019. As the data included mixed-case titles, all were converted to lowercase letters using Microsoft Excel, and hyphens and parentheses were removed.

Text-mining analysis

The 'title' field as selected by the Web of Science was analysed using the KH Coder 3.Beta.01e analysis software [11]. This counted the most frequent nouns, adjectives, verbs, and adverbs used every decade.

A co-occurrence network analysis can illustrate the similarity of appearance patterns and the word connections among frequently used languages to create categories. This study included up to the top 60 extracted words from titles spanning 2010 to 2019, and selected the co-occurring relationships as the Jaccard coefficient which demonstrated that the higher this coefficient, the stronger the relationship.

Results

Number of articles with a title search word

The first article was in 1921. Among the article titles, the search results included 269,104 for 'care', 164,680 for 'engineering', and 109,505 for 'technology'. Of the studies that included STEAM, 2,918 articles (1.08%) included 'care' in their titles.

Of the articles, 1,707 (0.63%) included 'care' and 'technology' as search words, 616 (0.23%) included 'care' and 'science', 448 (0.17%) included 'art', 134 (0.05%) included 'engineering', and 13 (0.00%) included 'mathematics'. Research into care engineering and technology has increased annually, with 1,035 (0.62%) involving 'care' and 'technology' and 71 (0.05%) for 'engineering' in the 2010s.

Until 1969, 'engineering' was the most common keyword in titles. Since 1970, 'technology' surpassed 'engineering', with the most titles including 'care'. Of the 269,104 papers with 'care' in the title, 1,707 included 'technology' and 134 with 'technology' and 'engineering'. Further, 'care technology' or 'care technology research' accounted for 96.9% from 1980 to 2019 (Table 1).

Research fields and frequent words included in care technology or care engineering literature

Regarding the care technology or care technology as categorised every decade, and given the top five areas of Web of Science research, 1,818 articles were detected.

The research area was initially 'medicine—general internal'. The top fields include 'engineering biomedical' in the 1970s; 'health policy services' in the 1980s; 'health care science services', 'medical information', 'public electrical occupancy health', and 'computer science' in the 1990s, with 'information systems' as a top field. Further, nursing research increased in the 2010s.

The most frequently used words were extracted using KH Coder software. In subsequent decades, 'health', 'medical', and 'cost' were the most frequent in the 1970s, 'system' in the 1980s, 'information' in the 1990s, 'assessment' in the 2000s, and 'primary' in the 2010s. Overall, a focus on 'new', 'impacts', and 'improvements' in use was found.

Language pertaining to healthcare has always been the most qualified, and especially in the 1990s, when it accounted for 59.1%. More frequent keywords over the decades include 'home care' in the 1980s; 'critical' or 'intensive' care in the 1990s; 'patients' or 'primary care' in the 2000s; and 'self', 'quality', or 'palliative care' in the 2010s (Table 2).

Co-occurring network diagram from 2010 to 2019

Of the care and technology or engineering articles, 1,106 were presented for the 10-year period beginning in 2010. In these articles, there were 19,378 words (tokens), with 11,612 including most frequently used words, 2,791 different words (types), and the use was 2,661 individual occurrences. There were 2,166 sentences and 1,083 paragraphs.

The Jaccard coefficients of 'care' and 'technology' in the search languages were both 0.43. Additionally, higher Jaccard coefficients were found for 'healthcare' (0.94), 'care technology' (0.77), 'intensive unit' (0.52), 'healthcare' (0.37), 'order' – 'adult' (0.30), 'health information' (0.29).

These were used to label the following groups: 1. Quality Support, or those articles involving 'patient', 'use', 'service', or mobile'; 2. Care Engineering, or those involving 'healthcare', 'information technology', 'information', or 'system'; 3. Primary and Intervention, or those involving 'study' or 'trial'; 4. Medical Care, or those involving 'intensive unit'; 5. Human Development, or those involving 'child care'; 6. Lifestyle, or those involving 'medical' or 'home'; and 7. Social Issues, or those involving 'older', 'adult', or 'dementia' (Figure 1).

Discussion

Care and STEAM education

While the number of studies on care itself has increased, research that uses 'care' in the title has also rapidly increased, or 2,918 STEAM studies (1.08%) as per our results.

Engineering principles and practices can be used to advance system reform and the implementation of science. While men are underrepresented in community roles as traditionally occupied by women—such

as careers in healthcare; early childhood education; and domestic roles, including child care—the promoting of equal opportunities for both women and men requires a better understanding of the psychological barriers to men’s involvement in these roles [12]. Conversely, a considerably higher proportion of women work in non-STEM jobs than men [13]. Women, minorities, and persons with disabilities are all vastly underrepresented in STEM fields [14].

The acknowledgment of nursing as a STEM profession could potentially provide more funding for nursing education within the United States and address nursing shortages, both clinically and academically. It has also been observed that technology involves scientific knowledge that requires the use of equipment and machinery [15]. Similarly, nursing is a rapidly increasing field within engineering and technology research, and should continue to increase in the future.

As care impacts everyone’s life, then applying the STEAM fields for care can potentially ensure that everyone develops equally. Thus, we focus on care engineering to possibly contribute to human development.

Characteristics of care technology and engineering by decade

This study focused on the ‘TE’ in STEAM, or specifically, technology and engineering. These fields are characterised by ‘new’, ‘improve’, and ‘use’ keywords, which were often used in the titles of articles on care and technology or engineering. ‘Medical’, ‘cost’ and ‘system’, ‘information’ and ‘assessment’, and ‘primary’ have been newly extracted terms in every decade. For example, ‘medical care’ and ‘healthcare’ were widely used until the 1970s, with ‘home care’ in the 1980s, ‘critical care’ and ‘intensive care’ in the 1990s, and ‘patient care’ and ‘primary care’ in the 2000s. In the 2010s, there were compound languages of care.

The text of the oldest paper was unavailable, as it was published in 1921, but the title involved official health care in epidemiology [16]. The next oldest were two articles. The development of biomedical engineering has indicated that care is important not only in hospitals, but also in homes and communities [17]. Further, one paper suggested that care in the operating room and hospital room with technology related to sterilisation [18].

Person-centred care has been emphasized since the 1980s. Wildevuur et al. [19] observed that person-centred information and communication technology (ITC) enables the patient to actively participate in health management and decision-making processes, and interact directly with the medical provider and their services. Specifically, words related to the point of care, home care, self-care, the quality of care, and palliative care increased in the 2010s. Given this background, miniaturisation and operability have improved due to advances in medical devices and information and communication technology, and it has become possible to use it for more familiar diagnoses and medical treatment.

In the future, this will more deeply relate to individual intentions and mental health, such as symptoms and electronic decision support [20]. Subsequently, the expectations for technology will continue to increase to improve the quality of care in various ways to meet target populations’ needs.

Care engineering and technology

The co-occurring network diagram in Figure 1 illustrates the quality support, care engineering, primary and intervention, medical care, human development, lifestyle, and social issues categories. Figure 2 provides a simplified conceptual diagram of these categories, or specifically: care-related health, technology, and information. An overview of the term 'care' in this context would imply that engineering relates to the human development. The problem of aging and dementia has recently grown, the acceptance of such technology is paramount [21].

A combination of care, advanced medicine, and machine learning can help reduce mortality [22], additionally, home care has progressed, and requires such high-quality support as primary care intervention. Although it has developed in various ways, this study provides a simple network diagram to indicate that these types of care can also relate to each other as Figure 2. As we enter an information age in healthcare, digital health technologies offer significant opportunities to optimise both clinical care delivery and clinical research [23].

The use of technology in care includes such benefits as an improved quality of care. Health promotion by self-managing information and equipment are both expected, objective indicators, with such subjective effects as encouragement. Addressing the subject of care technology and engineering will contribute to patient-centred and palliative care while promoting people's health.

The possibilities for care engineering

Historically, care has been relegated to women—for example, mothers caring for children, nurses for the sick, or wives for the house. In other words, care is both a valuable and necessary part of living with and alongside others [24]. Human dignity is a dominant value that is respected and implemented everywhere in caring science and practical care; therefore, every human being has a right to be treated as a unique individual in care, and the care should aim to promote health, alleviate suffering, and tend to the living or dying. This fundamental essence of caring science aligns with that of technology given the perspective of this ethical dimension [25]. The field of care or engineering has previously been skewed towards interest. This relates to social issues, and especially health. While it may be difficult to safely implement the science and technology of care in this biased field of interest, STEAM education—as a well-known field—could contribute to the development of both equipment and humanity.

Gelting et al. [26] indicated that the branch of engineering that has been known at various times as sanitary engineering, public health engineering, or environmental engineering has been integral to the emergence of public health as a distinct discipline. Care engineering would also be needed given its focus on human development and quality care, and everyone involved in these processes. This study illustrates the process by which care in advanced medical and healthcare systems have collectively developed. Additionally, and based on societal changes, the focus of care has progressed to become patient-centred. Currently, Care engineering and STEAM education are not sufficiently linked. By systematising it as care engineering, this field can face the modern issues with care. For instance, human development and the

quality of care itself are expected to increase, while new developments should consider the care perspective.

The 2020s will signal an increase in papers on care, artificial intelligence (AI), and robots in countries worldwide. However, this study did not choose, as future research based on new keywords will also be required; this study's search for 'technology' includes various meanings of the word. Further, it will be necessary to analyse the knowledge developed in peripheral fields, such as welfare engineering.

Conscious of the future of care, the STEAM field will ultimately create new artefacts based on conventional research and development. However, the care or STEAM sectors retain some gender bias, and thus, will also need to raise awareness about STEAM and ethics. This study proposes a new field in which care engineering will be realised through manufacturing or tangible or intangible objects through mutual growth from developers, supporters, and patients. Based on changes in society, the focus of care has also progressed. As the use of technology and research on improving the quality of care are expected to advance, systematising it as care engineering will evolve the field to face the problems in care.

Declarations

Ethics approval and consent to participate

-This study is not applicable because it mainly searches for literature.

Consent for publication

-We agree.

Consent for publication from participants

- Not applicable

Availability of data and materials

- The datasets generated and/or analysed during the current study are not publicly available due the data changes depending on the search date but are available from the corresponding author on reasonable request.

Competing interests

- Not applicable

Funding

- Not applicable

Authors' contributions

- CF conceived the study, collected, analyzed, and interpreted the data, and authored the manuscript for publication. KO assisted in study design, data interpretation. IK, KH and MY conceived the study, assisted in data interpretation, and manuscript editing. All authors read and approved the final manuscript.

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- Not applicable

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Tables

Due to technical limitations, the tables are only available as a download in the supplemental files section.

Figures

Figure 1

Co-occurring network diagram of care engineering or care technology (2010–2019)

Figure 2

Conceptual diagram of care engineering

Supplementary Files

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