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PERSPECTIVE **OPEN ACCESS**

Innovations and Technologies in Education for Sustainable Health and Development: Challenges, Opportunities, and Implications for Future Research

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Abstract:
Recent development and advancement of digital technologies and artificial intelligence have given rise to changing landscapes and modalities in health education and promotion, leading to significant impacts on sustainable health and development. For example, telecommunication and information technologies have been incorporated into health education associated with the prevention, diagnosis, and treatment of diseases. Digital technologies, such as virtual reality, metaverse, and digital storytelling, have been applied in the education of health professionals to improve knowledge, cognitive skills, attitude, and overall satisfaction with the learning experience. Furthermore, there are increasing applications of artificial intelligence in public health education and practice. This perspective article aims to provide a brief overview and further insights into professional education and training in health professions, health promotion, and education for sustainable development. Relevant suggestions are discussed under the specified themes. It is further recommended to have extensive studies to investigate the adoption of technologies and the development of innovative approaches in health education and promotion. More research is also needed to focus on the design for fully exploiting the potential of digital technologies and artificial intelligence while examining efficiency and assessing barriers to the technology-supported learning environment. Given the evolving societal landscapes and shifting public health priorities, periodic reviews of digital technologies and artificial intelligence in health profession training and health promotion are also encouraged.

Keywords: Education for sustainable development, Health promotion, Health education, Digital technologies, Artificial intelligence, Competence, Lifelong, Sustainable Health, Sustainability.

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1. INTRODUCTION

Schools play a role in the promotion of good health and sustainable development. Education contributes to sustainable healthcare in a variety of contexts, not only in the training of health professionals and managers but also in health promotion and nurturing of socially responsible students [1-3]. Entering the post-pandemic era with emerging new technologies in artificial intelligence and digitalization, the evolving landscapes have given rise to new opportunities in the modality of education for sustainable development. The use of new technologies is also recognized as a key factor for lifelong learning. This article aims to highlight key studies and offer insights into future directions for education in sustainable health and development.

2. PROFESSIONAL EDUCATION AND TRAINING

Innovations in pedagogical tools and the increasing use of emerging technologies have impacted every discipline in education [4-6]. Pedagogical digital technologies and the application of artificial intelligence have

been recognized for their added value in enhancing teaching and learning in health education [7]. Meum *et al.* conducted a qualitative study to explore the use of digital technologies in the facilitation of interactive learning in nursing education [8]. More recently, Beketov *et al.* reported the use of intelligent learning support systems to increase students' motivation in medical education while reducing their anxiety during academic practice [9]. Applications of artificial intelligence in metaverse and gamification could also boost motivation and promote active engagement, leading to enhanced outcomes of health literacy and learning experience [10, 11]. Artificial intelligence has also been applied to simulation-based training of healthcare professionals, incorporated with various modalities of the transformative approach, including high-fidelity mannequins, virtual-reality environments, standardised patients, and hybrid simulations [12].

In recent years, digital technologies such as virtual reality, the metaverse, and digital storytelling have been increasingly applied in the education and training of health professionals to enhance knowledge, cognitive skills, attitudes, and overall satisfaction with the learning experience. Recent reviews have provided evidence of digital technologies improving knowledge and skills [13-15]. However, further research is needed to evaluate the effectiveness of these technologies in improving attitudes and overall satisfaction with the learning experience.

While the use of digital technologies has proliferated in recent years, emphasis should also be placed on the alignment of educational needs with learning outcomes, as well as the essentials of digital competence associated with professional knowledge and skills. This is particularly important for the education of health professionals and their practical training in relation to the key concepts of sociocultural theory and situated learning, which also highlight the importance of both teachers and students in the design process for meeting the learning needs. A recent study reported on an integrated primary care education model that incorporates patient simulations within communities of practice. Additionally, recent work has explored the correlation between digital health competence profiles and the factors influencing health professionals' capabilities [16]. This further underscores the need for extensive research to fully harness the potential of educational technologies and innovations in the learning and training of healthcare professionals and managers.

Furthermore, the introduction of new technologies in health education should not solely focus on the technical aspects of digital tools, nor should their implementation be restricted to traditional topics. Patient simulations, disaster and health crisis scenarios, and digital education in healthcare settings are essential to address the evolving needs and challenges of public health. The use of new technologies in education should also encompass emerging topics in public health, such as pharmacoeconomics, a relatively new field in some countries around the world [17].

3. HEALTH PROMOTION AND SUSTAINABILITY

Health literacy is an important goal of public health [3, 18]. Implementation of effective and sustainable health promotion programmes also provides significant contributions to sustainable healthcare systems. Recent studies have reported promising potential of using social media in the promotion of health behavioral changes [19-21]. Other examples of digital technologies used in health promotion programmes include mobile apps, immersive virtual reality, and gamification [22-25]. Meanwhile, school-based health promotion programmes have been assessed in relation to various health outcomes [26, 27]. Recently, increasing studies have also investigated the sustainability of health promotion programmes [28, 29]. The success of health promotion programmes harnessing innovative tools and technologies will also rely on factors affecting programme sustainability, such as continued effects on health promotion, lasting impacts on health benefits, and continued implementation of programmes in the long run. Health literacy and technology competence are also one of the major factors to be considered. More research is needed to further examine the sustainability of technology-supported health promotion programmes.

While more studies are suggested for the use of innovative digital tools and GenAI in health education and promotion, attention should also be paid to addressing other major challenges, including issues arising from intellectual rights and the concepts of health disparities and equity. Considering the importance of programme sustainability and the necessity of sustaining health benefits after the initial implementation, it is critical that more studies should address challenges to the sustainability of health promotion programmes, such as limited resources, inadequate funding support, and unsatisfactory community engagement [3, 28, 30]. It is noteworthy that the development of technology and the emergence of artificial intelligence are intended to support our work in nature, while the core values and roles of humans remain indispensable, particularly in the context of education for sustainable health and development.

4. EDUCATION FOR SUSTAINABLE HEALTH AND DEVELOPMENT

Educational innovations and technologies should not be confined to applications in the education and training of health professionals. Equally important are their applications in the promotion of public health and the nurturing of socially responsible students to address global challenges for a sustainable future [31, 32]. This is especially significant when considering the worldwide ageing population, the prevalence of chronic conditions, and the deterioration of environmental sustainability [32]. In recent years, there have been fascinating advancements in the adoption of innovative approaches in education for a sustainable environment, particularly based on the pedagogy of systems thinking. This approach is critical for cultivating students with a comprehensive mindset to

visualize the complex interconnections between health and other systems [33-35]. Notably, poor education is associated with various public health issues [36]. Recent studies have highlighted the benefits of education on environmental issues and climate change, demonstrating how it can equip individuals with essential knowledge to address environmental threats, such as air and water pollution, and enhance students' engagement in maintaining a healthy environment [37-39]. Extensive efforts and collaborations are necessary to advance innovations and leverage new technologies in support of education for sustainable health and development. Public health education and policy research curricula should increasingly incorporate components related to the applications of artificial intelligence. Curriculum reforms should include the integration of major research findings and breakthroughs in artificial intelligence within public health, as well as instruction on its potential applications in health practice [40]. Specifically, the curriculum should focus on understanding how artificial intelligence can be applied in public health, such as disease prevention, infection control, and health management [41]. Moreover, the learning of artificial intelligence and technological applications is also advocated in other disciplines, including science and engineering, which are highly relevant to the development of technologies in relation to the promotion of health and improved environment. Moreover, aspects related to inclusion and equity, as well as innovations in the design of teaching resources for sustainability, warrant more investigation.

CONCLUSION

In the near future, an increasing number of studies are expected to explore the adoption of technologies and the development of innovative approaches in health education and promotion. Further research is needed to evaluate the effectiveness of emerging technologies and artificial intelligence in enhancing learning outcomes, including students' attitudes and satisfaction with the educational experience. Future efforts will also focus on the design and implementation of strategies to fully harness the potential of digital technologies and artificial intelligence, while simultaneously examining their efficiency and identifying barriers within technology-supported learning environments. In addition, more components related to applications of artificial intelligence should be included in the curriculum of public health education and policy research. In the context of applying emerging technologies, professional development of technology competence, health literacy, and capabilities of interdisciplinary collaborations are indispensable for the effective utilization of innovative tools and new technologies to genuinely support human connection and interaction in health education and promotion. More studies should address challenges to the sustainability of health promotion programmes, such as limited resources, inadequate funding support, and unsatisfactory community engagement. The advancement of technology and the rise of artificial intelligence are designed to support human efforts in addressing environmental and societal challenges. Nevertheless, the fundamental values and roles of humans remain essential, particularly in the realm of education aimed at promoting sustainable health and development. With the evolving societal landscapes and changing priorities in public health, periodic reviews of digital technologies and artificial intelligence in health profession training, health promotion, and education are important for moving towards sustainable healthcare and development in the long term.

AUTHORS' CONTRIBUTIONS

The author confirms sole responsibility for the following: Study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

ABBREVIATION

GenAI = Generative artificial intelligence

CONSENT FOR PUBLICATION

Not applicable.

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CONFLICT OF INTEREST

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