



Review

Advancing One Health education: integrative pedagogical approaches and their impacts on interdisciplinary learning



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ARTICLE INFO

Keywords:

One Health education
Interdisciplinary collaboration
Global health integration
Pedagogical approaches
Curriculum integration
Global partnerships

ABSTRACT

One Health is an integrative approach that emphasizes the interconnectedness of human, animal, and environmental health, advocating for collaborative, multidisciplinary efforts to address health challenges, particularly amid globalization and emerging threats. This paper examines the integration of One Health principles into global health education, highlighting the importance of interdisciplinary collaboration and innovative pedagogical approaches. It evaluates various teaching methods, including problem-based learning (PBL), team-based learning (TBL), simulation-based education (SBE), case-based learning (CBL), interdisciplinary workshops and seminars (IWS), and service-learning (SL), analyzing their strengths and weaknesses in fostering interdisciplinary understanding and practical application of One Health concepts. While these methods enhance learning by promoting critical thinking, collaboration, and real-world application, they also face challenges such as resource constraints, variability in group dynamics, and the complexity of assessing long-term learning outcomes. The paper also discusses the role of global partnerships, such as the Global One Health Research Partnership (GOHRP), in advancing One Health education through collaborative research and educational initiatives. Addressing challenges in curriculum integration and interdisciplinary collaboration is crucial for the effective implementation of One Health education, ensuring that future health professionals are equipped to tackle complex global health challenges.

1. Introduction

One Health is an integrative approach that recognizes the interdependence of human, animal, and environmental health [1]. This concept emphasizes the necessity for a collaborative, multidisciplinary effort to address health challenges that cross these domains. By fostering

communication and coordination among physicians, veterinarians, ecologists, and other professionals, One Health aims to develop comprehensive strategies for disease prevention, control, and management [1].

Global health focuses on health challenges that extend beyond national borders, necessitating international collaboration for effective

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solutions [2]. It seeks to reduce health disparities and enhance global health outcomes by implementing policies, conducting research, and developing interventions that address both infectious and non-communicable diseases [3]. The intersection of One Health and global health is vital, as both fields strive to tackle complex, interconnected health issues through collaborative and multidisciplinary approaches [4].

One Health is crucial in the context of globalization, where the movement of people, animals, and goods facilitates the spread of zoonotic diseases such as Ebola, Zika, and COVID-19, underscoring the need for integrated health strategies [5–8]. Challenges like antimicrobial resistance, food safety, and climate change further emphasize the interconnectedness of human, animal, and environmental health. The Food and Agriculture Organization (FAO) and initiatives like Reduce the Need for Antimicrobials on Farms for Sustainable Agrifood Systems Transformation (RENOFARM) support One Health by promoting sustainable agricultural practices and education, enhancing biosecurity, reducing antimicrobial use, and fostering collaboration among farmers, public-private sectors, and international bodies [9,10].

Integrating One Health into global health education enhances the understanding of these complex interconnections, leading to more effective and sustainable health policies and practices. This integration is essential for addressing current and future health challenges comprehensively [11,12]. Therefore, we drafted this paper to highlight the critical importance of integrating One Health principles into global health education and research to effectively address the interconnected health challenges posed by emerging infectious diseases, antimicrobial resistance, food safety, and climate change.

2. Integration of One Health principles into global health education

Educational institutions initially integrated One Health principles into their curricula through courses on zoonotic diseases and environmental health [13]. As One Health gained prominence, universities and medical schools introduced interdisciplinary courses encompassing human, animal, and environmental health [13,14]. The formation of the One Health commission and the One Health platform further integrated One Health into global academic and research institutions [15].

The Global One Health Research Partnership (GOHRP) is a collaborative network that includes Nanjing Agricultural University (NAU), University of California, Davis (UCD), Wageningen University and Research (WUR), and Massey University (MU). Originating from NAU's One Health Center established in 2014 with support from UCD, GOHRP leverages the strengths of its partners to advance interdisciplinary research and education (Table 1). The partnership focuses on cross-border issues such as zoonotic, animal, and plant diseases, environmental health, and food safety, while promoting exchanges, seminars, and international collaboration through transdisciplinary research programs.

NAU's One Health Center, supported by UCD, plays a pivotal role in GOHRP, driving interdisciplinary research and education in China. UCD, a founding GOHRP member, leads in One Health education through its Global One Health initiative, emphasizing interdisciplinary research and outreach. From 2014 to 2023, UCD's Western Institute for Food Safety and Security (WIFSS) introduced One Health concepts to over 1000 students from 17 universities in Asia, significantly advancing research in zoonotic diseases, antimicrobial resistance, and food safety.

WUR addresses global health challenges through its Global One Health approach, integrating human, animal, plant, and ecosystem health with interconnected courses on health research, nutrition, food safety, and environmental interactions. MU implemented the Education into Action One Health program in Asia (2010–2017), offering online degrees in public and veterinary health with a focus on biosecurity, enhancing multi-agency cooperation and practitioner capacity to manage zoonotic diseases.

Table 1
Characteristics of GOHRP Universities' One Health initiatives.

University	Key initiative	Focus areas	Educational programs	Collaboration highlights
NAU	One Health Center established in 2014	Zoonotic diseases Animal and plant diseases Environmental health	Comprehensive programs integrating animal, human, and environmental health	International student and faculty exchanges; joint research projects
UCD	Global One Health initiative	Zoonotic diseases Antimicrobial resistance Food safety	Eighteen conferences involving 1000 students	Strong international collaborations; capacity building
WUR	Global One Health approach integrating human, animal, plant, and ecosystem health	Nutrition Food safety Environmental interactions	Four interconnected courses on Global One Health	Systems approach to antibiotic resistance; emerging diseases
MU	Education into Action One Health program in asia	Zoonotic diseases Biosecurity	Master of public health (biosecurity) and master of veterinary medicine (biosecurity)	Regional workshops; multi-agency cooperation enhancement

Abbreviations: NAU, Nanjing Agricultural University; UCD, University of California, Davis; WUR, Wageningen University and Research; MU, Massey University; GOHRP, Global One Health Research Partnership.

GOHRP universities exemplify the successful integration of One Health principles into their educational and research frameworks, serving as models for other institutions and highlighting the importance of One Health in advancing global health education and research (Fig. 1).

3. Strengths and weaknesses of different pedagogical approaches

Advancing One Health education requires innovative teaching methods to foster interdisciplinary learning and equip students to tackle complex health challenges (Table 2). Problem-based learning (PBL) is a student-centered approach where learners address real-world problems, such as zoonotic disease outbreaks, to enhance critical thinking, problem-solving, and collaboration [16,17]. PBL promotes interdisciplinary collaboration, crucial for a comprehensive understanding of One Health, by involving students from diverse disciplines in solving complex scenarios [18,19]. However, PBL's success relies heavily on student engagement and facilitator proficiency, with challenges in evaluating individual performance within groups. Effective facilitation, which includes transitioning from traditional teaching roles, is essential for positive outcomes, as it impacts student motivation and group dynamics [20]. Discrepancies in facilitator assessments and varying levels of student engagement further complicate the process, influencing the overall effectiveness of PBL [21,22].

Team-based learning (TBL) is an instructional approach designed to enhance collaborative skills by organizing students into diverse teams that work together throughout a course [23]. TBL fosters peer learning, interdisciplinary interaction, and emphasizes teamwork and communication across health sectors [24]. Its structured format includes regular assessments and feedback, supporting interdisciplinary collaboration. However, TBL's effectiveness is influenced by group dynamics, which can vary significantly and affect overall success [25]. Implementing TBL requires substantial preparation for designing team activities and assessments [26]. Challenges include unequal participation, where some students may dominate while others contribute less [27]. Despite these

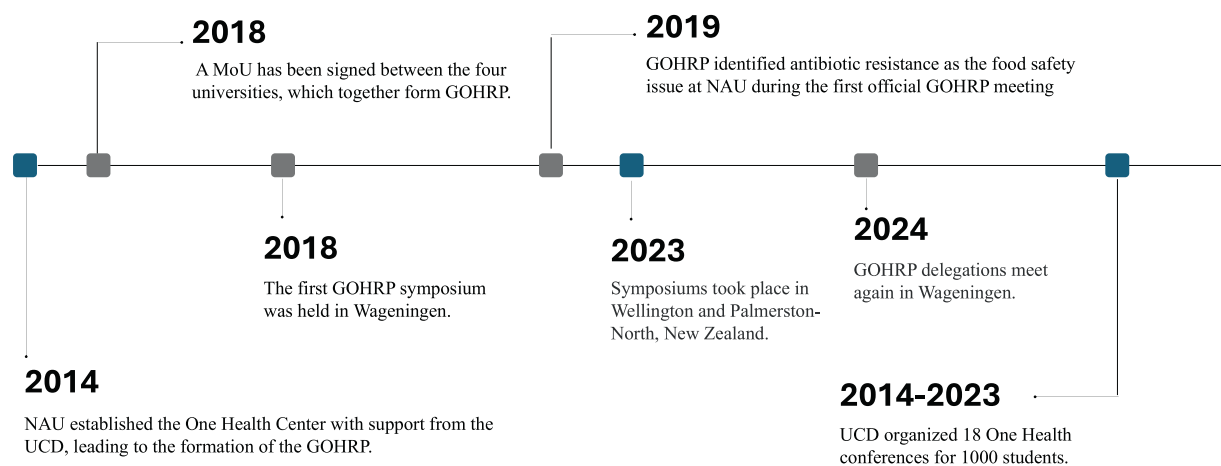


Fig. 1. Timeline of major events in the Global One Health Research Partnership (GOHRP). Abbreviations: NAU, Nanjing Agricultural University; UCD, University of California, Davis; GOHRP, Global One Health Research Partnership; MoU, Memorandum of Understanding.

Table 2
Strengths and weaknesses of pedagogical approaches in One Health education.

Pedagogical approach	Strengths	Weaknesses
Problem-based learning	Enhances critical thinking and collaboration Real-world problem-solving	Depends on student engagement Challenges in performance evaluation
Team-based learning	Fosters teamwork and interdisciplinary interaction Structured feedback	Requires significant preparation Variability in group dynamics
Simulation-based education	Provides hands-on, experiential learning Prepares for professional practice	Resource-intensive Requires skilled facilitators
Case-based learning	Applies theory to real-life cases Promotes deeper understanding	Time-consuming preparation Varies with instructor skill
Interdisciplinary workshops	Promotes interdisciplinary collaboration Diverse perspectives	Quality dependent on speakers Limited session duration
Service-learning	Real-world application Fosters civic responsibility	Complex coordination Difficult to measure long-term impact

challenges, TBL is a valuable strategy for fostering teamwork, communication, and interdisciplinary skills in a structured environment [28].

Simulation-based education (SBE) uses advanced simulations for hands-on learning, effective in One Health for scenarios like disease outbreaks and environmental assessments [29]. High-fidelity simulations enhance understanding of complex situations and prepare students for professional practice [30]. However, SBE is resource-intensive, requiring significant investment in technology and skilled facilitators, which can be a challenge for consistent implementation [31,32]. Its feasibility is limited in resource-constrained settings due to high costs and availability issues [33]. Effective integration into curricula requires careful planning to align with learning objectives, ensuring skills are applicable in real-world scenarios [34]. Strategic planning and resource allocation are essential to address these challenges and optimize SBE's benefits.

Case-based learning (CBL) involves examining specific cases, often related to recent or historical health crises, to apply theoretical knowledge to real-world situations, thereby enhancing understanding of One Health principles [35,36]. CBL in One Health covers topics like disease outbreaks, environmental contamination, and public health interventions. However, it demands significant time and effort to prepare

detailed case studies, posing a challenge for educators. The effectiveness of CBL also depends on the instructor's ability to facilitate discussions, which can vary with their experience [37]. Additionally, CBL may not engage all students equally, as it requires active participation and may not suit all learning styles [38].

Interdisciplinary workshops and seminars (IWS) engage students, faculty, and professionals from various fields to discuss One Health issues through guest lectures, panel discussions, and collaborative projects [39]. These sessions enhance understanding of the interconnectedness of human, animal, and environmental health and foster collaboration [40]. IWS provide diverse perspectives, networking opportunities, and can be tailored to address relevant One Health topics [41]. However, their effectiveness depends on the quality of speakers and organization, and the short duration may limit in-depth exploration. Additionally, geographic and financial constraints can restrict participation and inclusivity [42].

Service-learning (SL) combines community service with academic coursework, enabling students to apply One Health principles in real-world contexts, such as zoonotic disease prevention, environmental health assessments, or food safety initiatives [43]. This approach fosters civic responsibility and practical learning but can be complex and time-consuming to coordinate, with variable quality of community engagement [44]. Measuring the impact of SL on student learning, particularly its long-term effects, is challenging due to issues like attribution, data collection, and evaluation of sustained behavioral changes [45]. Despite these challenges, SL remains a valuable method for enhancing student learning and community engagement [46].

4. Challenges in integration of One Health into global health education

Integrating One Health into global health education faces three primary challenges: insufficient interdisciplinary collaboration, institutional barriers, and regional disparities. First, the lack of interdisciplinary collaboration is a significant barrier. Many educational programs remain siloed, with separate curricula for medicine, veterinary science, environmental science, and public health, which limits interaction among students from different disciplines [47]. This segregation hinders the comprehensive understanding of the interconnectedness of human, animal, and environmental health that One Health aims to promote.

Second, institutional barriers further impede integration. A lack of structured interdisciplinary projects and limited opportunities for joint research restrict the practical application of One Health principles and the development of collaborative skills [48]. Departmental silos, competition for resources, and the scarcity of interdisciplinary faculty

discourage collaboration and reduce the depth of One Health education [49,50].

Third, regional disparities affect the implementation and quality of One Health education. Institutions in low- and middle-income countries often face resource constraints that limit the availability and quality of One Health programs and practical learning opportunities [51,52]. In contrast, high-income countries have better resources to support comprehensive curricula and research. Additionally, variations in national policies, governance structures, and language and cultural differences pose challenges to standardizing and disseminating One Health education globally [53].

5. Recommendations for enhancing the integration of One Health into global health education

To address the challenge of insufficient interdisciplinary collaboration, educational institutions should develop integrated curricula that promote collaboration among students in medicine, veterinary science, environmental science, and public health. Implementing joint courses, projects, and case studies will help bridge the gaps between these disciplines, fostering a holistic understanding of One Health. By encouraging students to work together on real-world problems, these initiatives can cultivate the interdisciplinary skills necessary for addressing complex health challenges.

Institutions must also enhance support for interdisciplinary initiatives by breaking down departmental barriers that hinder collaboration. This can be achieved by fostering interdisciplinary faculty development, encouraging joint research initiatives, and reallocating resources to support One Health projects. Establishing dedicated One Health centers or committees within institutions can facilitate cross-departmental communication and cooperation, ensuring that interdisciplinary approaches are embedded within the educational framework.

To ensure equitable access and standardization of One Health education, particularly in low- and middle-income countries, targeted support is essential. This includes resource allocation, capacity building, and the development of accessible educational materials tailored to diverse contexts. International collaboration and partnerships can aid in standardizing One Health education globally, while also accounting for cultural and language differences to ensure inclusivity and broad dissemination of One Health principles.

These recommendations aim to enhance the integration of One Health into global health education by addressing the key challenges of interdisciplinary collaboration, institutional barriers, and regional disparities. By implementing these strategies, educational institutions can foster a more cohesive and effective framework for One Health education, equipping future professionals with the skills and knowledge necessary to tackle global health challenges.

6. Summary

One Health is an integrative approach that underscores the interconnectedness of human, animal, and environmental health, advocating for collaborative, multidisciplinary efforts to address global challenges such as infectious diseases, antimicrobial resistance, food safety, and climate change. This paper explores the integration of One Health principles into global health education, evaluating pedagogical approaches like PBL, TBL, SBE, CBL, IWS, and SL for their effectiveness in fostering interdisciplinary learning. It also highlights the role of global partnerships, such as the GOHRP, in advancing education through collaborative initiatives. Key barriers identified include insufficient interdisciplinary collaboration, institutional obstacles, and regional disparities. The paper recommends strategies such as developing integrated curricula, fostering interdisciplinary faculty development, enhancing research collaboration, and ensuring equitable access to One Health education, particularly in low- and middle-income countries, to support more cohesive and effective educational frameworks.

CRedit authorship contribution statement

Chang Cai: Writing – original draft, Resources, Methodology, Conceptualization. **Yong-Sam Jung:** Conceptualization. **Richard Van Vleck Pereira:** Conceptualization. **Michael S.M. Brouwer:** Writing – review & editing, Conceptualization. **Junxia Song:** Methodology, Conceptualization. **Bennie Irve Osburn:** Writing – review & editing, Supervision, Conceptualization. **Joanna McKenzie:** Writing – review & editing, Conceptualization. **Wim H.M. van der Poel:** Writing – review & editing, Conceptualization. **Yingjuan Qian:** Writing – review & editing, Methodology, Conceptualization.

Declaration of competing interest

Chang Cai is the associate editor and Michael Brouwer is the editorial board member of *Science in One Health*. The authors have no other competing interest to disclose.

References

- [1] WHO, One Health High-Level Expert Panel Annual Report 2021, WHO, Geneva, Switzerland. <https://www.who.int/publications/m/item/one-health-high-level-expert-panel-annual-report-2021>, 2021 (accessed 15 July 2024).
- [2] J.P. Koplan, T.C. Bond, M.H. Merson, K.S. Reddy, M.H. Rodriguez, N.K. Sewankambo, et al., Towards a common definition of global health, *Lancet* 373 (9679) (2009) 1993–1995, [https://doi.org/10.1016/S0140-6736\(09\)60332-9](https://doi.org/10.1016/S0140-6736(09)60332-9).
- [3] L.P. Fried, M.E. Bentley, P. Buken, D.S. Burke, J.J. Frenk, M.J. Klag, et al., Global health is public health, *Lancet* 375 (9714) (2010) 535–537, [https://doi.org/10.1016/S0140-6736\(10\)60203-6](https://doi.org/10.1016/S0140-6736(10)60203-6).
- [4] E. Togami, C.B. Behraves, T.V. Dutcher, G.R. Hansen, L.J. King, K.M. Pelican, et al., Characterizing the One Health workforce to promote interdisciplinary, multisectoral approaches in global health problem-solving, *PLoS One* 18 (5) (2023) e0285705, <https://doi.org/10.1371/journal.pone.0285705>.
- [5] W.A. Gebreyes, J. Dupouy-Camet, M.J. Newport, C.J. Oliveira, L.S. Schlesinger, Y.M. Saif, et al., The global one health paradigm: challenges and opportunities for tackling infectious diseases at the human, animal, and environment interface in low-resource settings, *PLoS Neglected Trop. Dis.* 8 (11) (2014) e3257, <https://doi.org/10.1371/journal.pntd.0003257>.
- [6] M.N.F. Shaheen, The concept of one health applied to the problem of zoonotic diseases, *Rev. Med. Virol.* 32 (4) (2022) e2326, <https://doi.org/10.1002/rmv.2326>.
- [7] B. Courtney, K.C. Bond, C. Maher, Regulatory underpinnings of Global Health security: FDA's roles in preventing, detecting, and responding to global health threats, *Biosecur. Bioterror.* 12 (5) (2014) 239–246, <https://doi.org/10.1089/bsp.2014.0046>.
- [8] T.R. Kelly, W.B. Karesh, C.K. Johnson, K.V. Gilardi, S.J. Anthony, T. Goldstein, et al., One Health proof of concept: bringing a transdisciplinary approach to surveillance for zoonotic viruses at the human-wild animal interface, *Prev. Vet. Med.* 137 (Pt B) (2017) 112–118, <https://doi.org/10.1016/j.prevetmed.2016.11.023>.
- [9] E. Boutrif, Institutions involved in food safety: food and agriculture organization of the united nations (FAO), in: Y. Motarjemi (Ed.), *Encyclopedia of Food Safety*, Academic Press, Waltham, 2014, pp. 354–358.
- [10] FAO, Reduce the Need for Antimicrobials on Farms for Sustainable Agrifood Systems Transformation, FAO, Rome, Italy. <https://www.fao.org/antimicrobial-resistance/background/fao-role/renofarm/en/>, 2024 (accessed 30 July 2024).
- [11] M. Barrett, T. Bouley, A. Stoertz, R. Stoertz, Integrating a One Health approach in education to address global health and sustainability challenges, *Front. Ecol. Environ.* 9 (2011) 239–245, <https://doi.org/10.1890/090159>.
- [12] E. Haxton, A. Lindberg, K. Troell, K.J. Redican, One Health education meets science, *Infect. Ecol. Epidemiol.* 5 (2015) 30264, <https://doi.org/10.3402/iee.v5.30264>.
- [13] L. Docherty, P.L. Foley, Survey of One Health programs in U.S. medical schools and development of a novel one health elective for medical students, *One Health* 12 (2021) 100231, <https://doi.org/10.1016/j.onehlt.2021.100231>.
- [14] L.H. Kahn, 'One medicine - one health' interview with Ronald M. Davis, MD, president of the American medical association, 14 may 2008, *Vet. Ital.* 45 (1) (2009) 19–21.
- [15] C. Stroud, B. Kaplan, J.E. Logan, G.C. Gray, One Health training, research, and outreach in North America, *Infect. Ecol. Epidemiol.* 6 (2016) 33680, <https://doi.org/10.3402/iee.v6.33680>.
- [16] C.E. Hmelo-Silver, Problem-based learning: what and how do students learn? *Educ. Psychol. Rev.* 16 (3) (2004) 235–266, <https://doi.org/10.1023/B:EDPR.0000034022.16470.f3>.
- [17] J. Beringer, Application of problem based learning through research investigation, *J. Geogr. High Educ.* 31 (3) (2007) 445–457, <https://doi.org/10.1080/03098260701514033>.
- [18] A.W. Bartlow, T. Vickers, Solving the mystery of an outbreak using the one health concept, *Am. Biol. Teach.* 82 (1) (2020) 30–36, <https://doi.org/10.1525/abt.2020.82.1.30>.
- [19] F. Mustaffa-Kamal, I.N.F. Shafie, S.Z. Zakariah, W.N.S.W.M. Sanusi, Z. Omar, A. Azahar, et al., Effectiveness of field simulation approach for problem-based

- learning that incorporates the one health concept, *J. Vet. Med. Educ.* 51 (3) (2024) 405–411, <https://doi.org/10.3138/jvme-2022-0132>.
- [20] P.J. Olmesdahl, D.M. Manning, Impact of training on PBL facilitators, *Med. Educ.* 33 (10) (1999) 753–755, <https://doi.org/10.1046/j.1365-2923.1999.00530.x>.
- [21] J. McHarg, E.J. Kay, L.R. Coombes, Students' engagement with their group in a problem-based learning curriculum, *Eur. J. Dent. Educ.* 16 (1) (2012) e106–e110, <https://doi.org/10.1111/j.1600-0579.2011.00682.x>.
- [22] C.F. Whitfield, S.X. Xie, Correlation of problem-based learning facilitators' scores with student performance on written exams, *Adv. Health Sci. Educ. Theory Pract.* 7 (1) (2002) 41–51, <https://doi.org/10.1023/a:1014522513526>.
- [23] J. Mott, S. Peuker, Achieving high functioning teams using team based learning in flipped classrooms, in: *2015 ASEE Annual Conference & Exposition, Seattle, Washington*, 2015, pp. 26.143.1–2626.12.
- [24] K. Nishiwaki, A. Kawase, T. Wada, H. Yagi, N. Kawasaki, E. Ito, et al., [Team-based learning (TBL) in the interdisciplinary lecture], *Yakugaku Zasshi* 134 (2) (2014) 171–177, <https://doi.org/10.1248/yakushi.13-00231-1>.
- [25] J.M. Tucker, M.P. Brewster, Evaluating the effectiveness of team-based learning in undergraduate criminal justice courses, *J. Crim. Justice Educ. JCJE* 26 (4) (2015) 446–470, <https://doi.org/10.1080/10511253.2015.1052000>.
- [26] A. Burgess, C. van Diggele, C. Roberts, C. Mellis, Team-based learning: design, facilitation and participation, *BMC Med. Educ.* 20 (Suppl 2) (2020) 461, <https://doi.org/10.1186/s12909-020-02287-y>.
- [27] S.L. Sibbald, A. John-Baptiste, M. Speechley, Navigating the complexities of evaluating team-based learning in the graduate classroom, *Pedagogy in Health Promotion* 5 (4) (2019) 254–260, <https://doi.org/10.1177/2373379918819533>.
- [28] C.-Y. Cheng, S.-R. Liou, H.-M. Tsai, C.-H. Chang, The effects of Team-Based Learning on learning behaviors in the maternal-child nursing course, *Nurse Educ. Today* 34 (1) (2014) 25–30, <https://doi.org/10.1016/j.nedt.2013.03.013>.
- [29] T. Rutherford-Hemming, A. Herrington, L. Newsome, The use of simulation-based education with new graduate nurses in emergency department and acute care settings: a scoping review, *J. Cont. Educ. Nurs.* 53 (7) (2022) 301–306, <https://doi.org/10.3928/00220124-20220603-05>.
- [30] I.W. Ma, M.E. Brindle, P.E. Ronskley, D.L. Lorenzetti, R.S. Sauve, W.A. Ghali, Use of simulation-based education to improve outcomes of central venous catheterization: a systematic review and meta-analysis, *Acad. Med.* 86 (9) (2011) 1137–1147, <https://doi.org/10.1097/ACM.0b013e318226a204>.
- [31] Aldridge Matthew, J.S. Galbreath, P. Steed, Bridging the realism gap: using 'low-fidelity' simulation for high quality training, *Int. J. Healthcare Simulation* 2 (Supplement 1) (2022), <https://doi.org/10.54531/enyn6442>.
- [32] L.J. Nayahangan, E. Thinggaard, F. Khan, A. Gustafsson, A.M. Morcke, A. Dubrowski, et al., A view from the top: a qualitative exploration of top-level health care leaders' perceptions on the implementation of simulation-based education in postgraduate medical education, *Med. Educ.* 58 (4) (2024) 415–429, <https://doi.org/10.1111/medu.15248>.
- [33] E. Sanseau, A. Thomas, E. Jacob-Files, A. Calhoun, S. Romero, S. Kant, Feasibility of a low-fidelity pediatric simulation-based continuing education curriculum in rural Alaska, *Cureus* 12 (5) (2020) e8288, <https://doi.org/10.7759/cureus.8288>.
- [34] J. Astbury, J. Ferguson, J. Silverthorne, S. Willis, E. Schafheutle, High-fidelity simulation-based education in pre-registration healthcare programmes: a systematic review of reviews to inform collaborative and interprofessional best practice, *J. Interprof. Care* 35 (4) (2021) 622–632, <https://doi.org/10.1080/13561820.2020.1762551>.
- [35] J.E. Thistlethwaite, D. Davies, S. Ekeocha, J.M. Kidd, C. MacDougall, P. Matthews, et al., The effectiveness of case-based learning in health professional education. A BEME systematic review: BEME Guide No. 23, *Med. Teach.* 34 (6) (2012) e421–e444, <https://doi.org/10.3109/0142159X.2012.680939>.
- [36] S. Forsgren, T. Christensen, A. Hedemalm, Evaluation of the case method in nursing education, *Nurse Educ. Pract.* 14 (2) (2014) 164–169, <https://doi.org/10.1016/j.nepr.2013.08.003>.
- [37] S.F. McLean, Case-based learning and its application in medical and health-care fields: a review of worldwide literature, *J. Med. Educ. Curric. Dev.* 3 (2016), <https://doi.org/10.4137/JMECD.S20377>.
- [38] K. Brown, M. Commandant, A. Kartolo, C. Rowed, A. Stanek, H. Sultan, et al., Case based learning teaching methodology in undergraduate health sciences, *Interdisciplinary J. Health Sci.* 2 (2) (2016) 48–66, <https://doi.org/10.18192/riss-ijhs.v2i2.1521>.
- [39] S. Sibbald, L. El-Aloul, J. Shelley, Education of future public health professionals through integrated workshops, *Pedagogy in Health Promotion* 8 (4) (2022) 297–308, <https://doi.org/10.1177/23733799221103203>.
- [40] K.M. Errecaborde, K.W. Macy, A. Pekol, S. Perez, M.K. O'Brien, I. Allen, et al., Factors that enable effective One Health collaborations - a scoping review of the literature, *PLoS One* 14 (12) (2019) e0224660, <https://doi.org/10.1371/journal.pone.0224660>.
- [41] C.R. Vicente, F. Jacobs, D.S. de Carvalho, K. Chhaganlal, R.B. de Carvalho, S.M. Raboni, et al., Creating a platform to enable collaborative learning in one health: the joint initiative for teaching and learning on global health challenges and one health experience, *One Health* 12 (2021) 100245, <https://doi.org/10.1016/j.onehlt.2021.100245>.
- [42] S.L. Herzig Van Wees, M. Målqvist, R. Irwin, Achieving the SDGs through interdisciplinary research in global health, *Scand. J. Publ. Health* 47 (8) (2019) 793–795, <https://doi.org/10.1177/1403494818812637>.
- [43] S. Sabo, J. de Zapien, N. Teufel-Shone, C. Rosales, L. Bergsma, D. Taren, Service learning: a vehicle for building health equity and eliminating health disparities, *Am. J. Publ. Health* 105 (Suppl 1) (2015) S38–S43, <https://doi.org/10.2105/AJPH.2014.302364>, Suppl 1.
- [44] S.B. Kruger, M.M. Nel, G.J. van Zyl, Implementing and Managing Community-Based Education and Service Learning in Undergraduate Health Sciences Programmes: Students' Perspectives, 2015, <https://doi.org/10.7196/AJHPE.333>.
- [45] N.L. Staus, J.H. Falk, A. Price, R.H. Tai, L.D. Dierking, Measuring the long-term effects of informal science education experiences: challenges and potential solutions, *Disciplinary and Interdisciplinary Science Education Research* 3 (1) (2021) 3, <https://doi.org/10.1186/s43031-021-00031-0>.
- [46] B. Moely, V. Ilustre, The impact of service-learning course characteristics on university students' learning outcomes, *Mich. J. Community Serv. Learn.* 21 (2014) 5–16.
- [47] M.S. Wilkes, P.A. Conrad, J.N. Winer, One health-one education: medical and veterinary inter-professional training, *J. Vet. Med. Educ.* 46 (1) (2019) 14–20, <https://doi.org/10.3138/jvme-1116-171r>.
- [48] C. Masters, V.O.T. Baker, H. Jodon, Multidisciplinary, team-based learning: the simulated interdisciplinary to multidisciplinary progressive-level education (SIMPLE©) approach, *Clin. Simulation in Nursing* 9 (5) (2013), <https://doi.org/10.1016/j.ecns.2011.11.007>.
- [49] J.B. Gibson, Bridging the divide: collaborative practice between faculty and student services staff — findings from a doctoral study, *Int. J. Leader. Learn.* 22 (2) (2022) 287–318, <https://doi.org/10.29173/ijll27>.
- [50] C.M. Sá, 'Interdisciplinary strategies' in U.S. research universities, *High Educ.* 55 (5) (2008) 537–552, <https://doi.org/10.1007/s10734-007-9073-5>.
- [51] S. Frehywot, Y. Vovides, Z. Talib, N. Mikhail, H. Ross, H. Wohltjen, et al., E-learning in medical education in resource constrained low- and middle-income countries, *Hum. Resour. Health* 11 (2013) 4, <https://doi.org/10.1186/1478-4491-11-4>.
- [52] M. Gupta, S. Marsden, T. Oluka, R. Sharma, H. Lucas, Lessons learned from implementing E-learning for the education of health professionals in resource-constrained countries, *Electron. J. e Learn.* 15 (2017) 144–155.
- [53] M. Hitziger, R. Esposito, M. Canali, M. Aragrande, B. Häslar, S. Rüegg, Knowledge integration in One Health policy formulation, implementation and evaluation, *Bull. World Health Organ.* 96 (2018) 211–218, <https://doi.org/10.2471/BLT.17.202705>.