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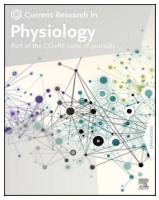

The story so far……- current opinion in the use and applications of interactive storytelling in physiology and clinical education

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A B S T R A C T

Physiology and clinical practice are subjects of study which demand integration of multiple sources of systems working knowledge and information on the performance of those systems to come to meaningful conclusions. This is made more complex by the interpretation and actions as a result of this conclusion having direct impact on the sum of the component systems, the human, thereby integrating significant social and psychological considerations into an already complex situation.

As higher education educators, it is a significant challenge to provide our learners with training and most importantly, practice, in these knowledge, skills and behaviours in the classroom. There has been a significant interest in recent years in providing active learning opportunities which allow learners to apply subject knowledge to multi-faceted, immersive, continuously evolving stories which reflect a graduate's professional aspirations. This review highlights practices from the literature of storytelling education which the higher education educator can utilise in promoting "meaning making" in the classroom. Here, the case for interactive storytelling in physiology and clinical education is argued, as well as presenting commonly utilised techniques and practices with which educators can embed storytelling into their pedagogy as well as highlighting future directions in this field.

1. Introduction

From the earliest records of human life on earth, there is evidence of storytelling as a method of the passing of information or experiences, from early cave paintings and etchings to nursery rhymes and fables up to the 21st century rise of vlogging and social media influencers. Our inclination toward stories is deeply ingrained in the structure and function of our brains. Whether we are listeners or storytellers, a narrative that profoundly resonates with us has the power to evoke emotions, cultivate trust, and stimulate genuine curiosity and empathy. As children, stories serve as a natural conduit for receiving information, and therefore, our brains become accustomed to recognising storytelling patterns, attributing meaning, and responding emotionally (Smith et al., 2017). Whether rooted in Greek mythology or in modern day novels of the lived experiences of the secondary education system for wizard's and witch's, stories captivate us because they tap into these fundamental cognitive processes (Garcia-et al., 2021). Stories that additionally encourage interaction transition a passive listener into an engaged participant, providing opportunities to actively process and seek understanding of their underlying meaning (Armstrong, 2020).

Interactive stories are effective educational tools that combine storytelling with interactive elements to engage students (Smed et al., 2021). They incorporate narrative structure, interactive features, feedback mechanisms, and consequences aligned with educational objectives to create a purposeful learning experience (Campos, 2017). The interactive story as an education tool also adheres to the concept of constructive alignment proposed by Biggs (2003), in that it allows students to attach meaning and application to their learning, achieving the learning outcomes of applied and integrative concepts which are difficult to achieve by lecturing (Biggs, 2003). In the context of higher education (and indeed in education more widely), this concept of storytelling to achieve learning outcomes by providing context to learners has been used widely without label for quite some time. Indeed, readers will now be recalling a moment from their education where the lecturer shared an experience from their professional practice or personal life which was related to the learning outcomes of the session. These interactions have the aim of humanising the learning and to emphasise the applications of the concepts being conveyed (Christodoulidi, 2023). There is limited literature as to the effectiveness of incorporating these experiences, through simply conveying stories or experiences, however there is a wealth of supporting literature in the student completion of stories through application of prior knowledge

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and learning, especially in health education, where this method of teaching by case study and problem based learning, is widespread, with entire curriculums based around its effectiveness (Herreid, 2011). Where the literature begins to become rare in health and science education, is the concept of "interactive stories", where the story of applied practice is taking place in real time, and learners use their prior experience and learning to "choose your own adventure", with branching scenarios which are adapted based on the learners choices. With graduate employers placing emphasis on wanting graduates to be problem solvers, have excellent communication skills and be able to develop interpersonal relationships (Khoo et al., 2020). Further, recent graduates have reported some of their largest training deficits from the undergraduate studies were in team working skills, flexibility and use of own initiative, amongst others (Sarkar et al., 2016). Our learning programme design must therefore "start with the end in mind", as Steele et al. (2020) suggests, with both the graduate employment market and student aspirations at its core (Steele et al., 2020). Interactive stories also provide students with learned experience to draw upon in their future careers in an exciting and, dare we say it, fun way for learners to develop skills in a safe environment before reaching their future graduate roles. There is a significant gap in the pedagogic literature in applying interactive stories in the education of sciences, with most evidence so far being in the area of health education. Charon (2006) explores interactive stories for nursing students, suggesting this as an effective modality in supporting both qualified and student nurses to explore and reflect on the realities of clinical practice (Charon, 2006). Having said that, Greenhalgh (2001) suggested that learners in the healthcare and medical professions are prone to dismiss stories based on them being viewed as non-scientific (Greenhalgh, 2001). Although seemingly widely accepted as a valid and exciting concept in educating future graduates, it remains to be seen as to the ideal model for the interactive story for application to physiology education.

In this piece, we explore current opinion on the place for interactive stories delivered to learners in higher education, with a specific focus on the applications to physiology and health professions education. We examine the literature for interactive stories as a method of incorporating relevant graduate skills which both graduates and their future employers desire, meeting applied and integrative learning outcomes and providing a starting point for the reader to integrate interactive stories into their own practice.

2. Bringing the workplace to the classroom: current methods

Across the Higher Education sector in the UK, academics strive to design their courses and programmes with the graduates' professional destinations in mind, laying down the gauntlet for designing teaching delivery methods which can transfer knowledge, skills and behaviours, but also allow learners to apply that knowledge in a "real world" setting. The prevailing methods of interactive storytelling that have evidence for their success in meeting these objectives are.

2.1. The "traditional" case study

Almost all STEM programmes, and certainly those in physiology, regularly incorporate the time tested "case study" as a method of testing students application of knowledge to a specific scenario. In other words "meaning-making". This traditional (usually paper-based format) method of teaching is simple to deploy and facilitate with limited technological resource (Herreid, 2011). There are however many formats this can take, with Herreid et al. (2021), discussing a number of formats which these can take, including the paper-based mentioned above, to audio clips, live cases with speakers, case studies using online polling software and student role playing cases (Herreid et al., 2021). Overall, in health subjects, these are well received and assessed as effective learning tools by students (Toogood, 2023; Seshan et al., 2021). These methods also allow students to take moments of reflection and research their answers in "slow time", allowing for a more considered and confident response to a problem or scenario. The length of these moments of reflection in interactive storytelling of all formats is a crucial element, greatly impacting the efficacy of learning experiences. Wu et al. (2022) observed that under time pressure, individuals would make simpler, repeated and more low cost decisions than when allowed unlimited time to solve a problem (Wu et al., 2022). This slowing of time in the interactive story may therefore allow students to respond to challenges more appropriately, effectively and confidently, after being able to better explore options from concepts and experiences from their learning. Having said that, this does also come with a lack of realism, as in most cases working with patients or participants, there often is a pressure (self-induced or otherwise) to respond quickly and professionally.

2.2. Simulation with simulated or live patients

Simulations involving both simulated and live patients represent a compelling use of interactive storytelling in education. By fusing the authenticity and intricacy of clinical scenarios with the captivating, narrative-driven approach of storytelling, simulations can provide a comprehensive learning experience that equips students to tackle real-world challenges. The integration enhances engagement, critical thinking, and skill development, rendering it an invaluable asset in fields requiring practical, empathetic, and adaptive professionals.

Traditionally, the mainstay of medicine and health professions education programmes, the simulation using technological solutions to simulate patient interactions, signs or symptoms is becoming more prevalent in the life sciences and in a number of other disciplines. With the pressure on the higher education sector overall to provide "authentic assessment", representative tasks of those found in the graduate workplace, interactive simulations provide a powerful pedagogic tool to develop employability and professional skills as well as apply subject specific knowledge (Sotiriadou et al., 2020; Sokhanvar et al., 2021). These simulation type activities in health and science education can be incredibly realistic and high fidelity in their nature, or incredibly simple and "ad-hoc". The complexity of the simulation seemingly also has little impact on student achievement of learning outcomes from these sessions, with learners practising clinical skills observe little difference in student outcomes between low and high-fidelity simulations (Chandra et al., 2008). Having said that, Ahad et al. (2013) suggest that the level of prior knowledge of the learner may impact the outcomes, suggesting that students who are at a higher level of prior knowledge or experience, will gain more from higher fidelity and challenging realism than those who are novice (Ahad et al., 2013). There is also no reason that this type of education experience cannot be multi-disciplinary in more than the traditional sense. In line with this, live interactive storytelling may also benefit from incorporation of interprofessional education, a concept which is constructively aligned to training graduates for the workplace which (especially in healthcare and scientific professions) is multi-disciplinary by nature. In healthcare education settings, interprofessional education has students from a number of subjects work together to solve problems or manage scenarios (Gilbert et al., 2010). Not only does this method of interprofessional education provide opportunities for students of differing disciplines to learn the roles of one another in an integrated workplace and learn from one another with alternate viewpoints, it allows students to practice collaborative and interpersonal skills they will need in their future careers (Jorm et al., 2016). A recent systematic review of interprofessional education outcomes suggests that this method of interprofessional education improves interprofessional attitudes and perceptions and interprofessional knowledge and skills (Shuyi et al., 2024). Roe et al. (2024) recently demonstrated the benefits for medical students from this method of teaching, but also utilised the simulated patient (actor) experience in this, with Drama students gaining experience in acting the patient during live simulations (Roe et al., 2024).

2.3. "Choose your own adventure" as asynchronous activity

The "choose your own adventure" style, has been utilised in the gaming industry for some time now, and even longer in printed form, with major online streaming services also now utilising this type of interactive experience (Mansky, 2022). Indeed, the teaching academic of today has these tools to produce their own interactive story adventure in most virtual learning environments (VLE's) (Hensen et al., 2023), or indeed utilising the long standing friend of the lecturing academic, Microsoft PowerPoint® (Handoko et al., 2023). Having said that, evidence as to the efficacy to bring this interaction to the lecture theatre in large cohorts is lacking, especially in the sciences and in health professions. If we as academics see our lectures as a performance conducted in lecture theatres, this live action simulation in these environments seems the next logical step to bring those benefits of interactive learning to our students.

2.4. "Choose your own adventure" as synchronous activity

The live interactive theatre technique, as described by Wilson and Walker (2017), offers several educational advantages. The use of a student response system (SRS) allows students to actively participate in the live storyline by making decisions that influence the direction and outcome of the play. The integration of service user voices further enhances the authenticity and educational value of the learning experience, making it a potentially powerful tool for education (Wilson et al., 2017).

2.5. Immersive virtual environments

It is often difficult to provide this type of clinical experience for physiology and other STEM disciplines, through lack of placement opportunities, health and safety constraints or difficulties in incorporating these experiences into effective curriculum design (Jackson, 2015; Römgens et al., 2020). Indeed, during academic year 2021/2022, only 6% students were enrolled on sandwich placement courses in the UK (HESA and Agency, 2023). An emerging technology (at least in education settings) answering this challenge is the virtual environment, either through headset type technologies to mimic laboratories, workplaces or clinical settings (Barteit et al., 2021; Pellas et al., 2020). Indeed in a study of geology students completing either a desktop virtual field trip, virtual field trip and an actual field trip as part of the course, students perceived learning outcomes and experience was rated higher in the virtual field trip when compared to the actual field trip. Further, there was no difference in perceived learning outcomes between the desktop and virtual field trips (Zhao et al., 2020). Although the authors acknowledge that the experience gained in reality is vitally important and is much more rooted in social and behavioural norms (ie, there are more "moving parts" to the experience), the additive nature of these simulations to provide our students with real world experiences in a controlled environment is an exciting and promising concept. A "best of both worlds" prospect is the advent of the computer automated virtual environment or "CAVE", which can mimic real world environments and have physiological and psychological effects of moving through environments in reality, but in a safe and simulated environment (Chen et al., 2024) (see Fig. 1).

Literature in the CAVE applications for education is so far limited, but has provided experiences in clinical settings for simulation (Maftei et al., 2021) which has potential applications for healthcare professional training and providing work experience for students in other disciplines. de Back et al. (2020) provided learners with a collaborative learning experience in neuroanatomy, a subject which is challenging to convey as from a visual and spatial context (de Back et al., 2020). Learning gains (determined by correct scores in assessment) were significantly higher in the CAVE activity when compared to a textbook based alternative (de Back et al., 2020). Further, when separated by spatial abilities, students

Fig. 1. The Computer Automated Virtual Environment (CAVE) at Manchester Metropolitan University. This facility allows lecturers to place the learner in a virtual world to solve problems either individually or as a team. The figure depicts a scenario carried out by Nursing and Physiology students to triage and manage a virtual critical care patient as a team, with patient and wider clinical team interactions.

with lower spatial abilities saw higher learning gains than those with higher spatial ability, suggesting the CAVE is a potential tool in providing inclusive and accessible learning environments for all learners (de Back et al., 2020). Indeed, the present authors have used this method to provide Life Sciences undergraduate students with virtual experiences based on clinical settings our graduates often aspire to (Bagley and Kime, *unpublished observations*). Our observations suggest similar to de Back and colleagues, with students perceiving learning to be effective and allowing application of concepts in a relevant scenario. Having said that, in free text analysis of short surveys from learners, those who reported feeling "stressed" in some form, the perception of learning reduced, suggesting there may be an accessibility issue for some learners with these real world learning experiences becoming ineffectual due to the perception of induced stress.

2.6. The generative AI case study

Interactive case studies can harness the potential contribution of generative AI represent as an innovative application of interactive storytelling in education. There is an emerging body of work in the interactive case study using generative AI (Lee, 2024). Artificial intelligence systems can create unique and adaptive learning experiences by generating varied scenarios, adapting storylines, personalizing learning paths, providing immediate feedback, and adding realism and complexity to simulations.

This may provide an exciting future direction for the humble case study in science education, with students able to interact in real time with an ever-changing case based on their answers. The potential for generative AI format in this space may also go some way in reducing the potential bias of the session facilitator guiding the student experience (Brown et al., 2020; Mateo et al., 2020).

3. The case for interactive stories in physiology education

3.1. "Soft" skills vs "hard" skills

In science and clinical education, there has traditionally been an emphasis placed on knowledge and technical skill associated with the subject in curriculum design. "Other" or "soft" skills as they are sometimes referred to as, such as communication, emotional intelligence and reflective practice are now however recognised as fundamental in the training of the scientist and healthcare professional (Helliwell, 2016; Gibson et al., 2012). These are therefore often difficult for a graduate to effectively communicate their proficiency in these skills, as there is possibly no specific experience for them to call upon of utilising these.

Further, students often rate these skills as highly as their technical skill development, however there is often poor engagement in activities and sessions solely designed to train these skills (Demaria et al., 2018; Jorre de St et al., 2018). It is reasonable to hypothesise that interactive stories and storytelling methodologies in education may provide a specific case for graduates to call upon to build confidence, but also to more effectively reflect on experiences and knowledge application and therefore clearly communicate the skills they have acquired to a potential employer.

3.2. Putting the "human" in human physiology

With around 90% of physiology and bioscience graduates aiming for a career in the health professions or medicine upon graduation (Steele et al., 2020), graduates from our programmes may well be asked at interview questions pertaining to their principles of compassionate communication. This broad term of compassionate care refers to attributes and skills of empathy and compassion, active listening, understanding and handling difficult conversations or situations (Barker et al., 2023). Interactive stories may provide a "touch-point" for students, in the training of these skills, giving an overt and clear experience to call upon on in applying this in their practice (Jackson et al., 2022). Across the higher education sector, there is an ever growing emphasis on sense of belonging for both students and academics, being linked to student retention, motivation and satisfaction (Meehan et al., 2019; Pedler et al., 2022). Literature from nursing lecturers suggest storytelling in pedagogy practice may indeed promote a sense of belonging and community as a field of practice, something which is very relevant with a lot of discussion in the field of physiology in the UK (Stevenson-Cocks et al., 2023). Storytelling sessions for nursing students have been seen to promote a sense of belonging to their profession, but also to promote open conversation about students fears, anxieties and excitement about their future careers (ÖZaras et al., 2024); summarised by part of the title of this study, "I want to have stories too". Baldwin et al. (2017) also explored this concept of storytelling as a method of professional and personal role modelling with students, with academics drawing on their professional experience in a "safe zone" (Baldwin et al., 2017).

3.3. Applying knowledge: There isn't always a "perfect" answer ……

In all of our professional practice and in our personal lives, we can all recall an experience where there is no perfect option or path to choose, just the "least bad" based on the evidence we have in front of us and our critical appraisal. It is therefore important to prepare our graduates for this in their professional practice. By providing a perfect or "textbook" option as we regularly do in exam or assessment situations, one could argue we do not provide our students with experience of applying this skill of critical appraisal and acting quickly to resolve an issue. Interactive stories of scenarios with a piece of equipment breaking down in the lab with a participant waiting to go, a patient waiting to be discharged while balancing multiple other priorities or simply situations where there is a "least negative outcome" all may provide this experience of critical appraisal in a "real world" situation. Further, Attenborough and Abbott (2020) observed that these arduous, "rock and a hard place" type experiences also create a sense of subject specific identity in both academic staff and students, with nursing professionals seeing storytelling as a reinforcement of theory to practice and continuing connection with the profession (Attenborough et al., 2020).

3.4. The challenges in incorporating interactive stories in curriculum design

From the literature so far in the field of practical application of storytelling methods in higher education combined with the present authors experience of integrating these methods in their own teaching, it is clear that embedding interactive storytelling in physiology (and all other STEM subjects for that matter) comes with significant challenges to overcome.

Is this going to be on the exam?:

Students in STEM (and indeed across higher education) are generally very assessment outcome focussed (Rand, 2017; Winstone et al., 2022) and the phrase "is this going to be on the exam?" certainly not an unusual question for the reader of this review. Constructive alignment in incorporating interactive stories is therefore a very necessary consideration, whether interactive story sessions align with the assessment of a piece of learning or with the student aspirations and motivations upon graduation. Students enrolled on a medical programme improved their confidence after a simulation-type experience, with their feedback alluding to concepts of student motivations being aligned to use in future practice (Morris et al., 2020). Sierra (2020) conducted interactive story sessions with economics students, of whom 91% reporting the sessions to be useful as a teaching and learning method and 93% reporting a better understanding of the theoretical knowledge of the sessions (Sierra, 2020). Taken together, this suggests that interactive stories are a useful tool to foster a deep learning approach of theoretical concepts, but requires specific and overt signposting to the relevance of the interactive story to assessment or application.

How do I know that learning has actually occurred?:

As well as Sierra (2020) reporting student perception of learning efficacy through interactive stories, they also emphasise the importance of a thorough debrief with students to relate the experience to the learning outcomes. Debriefing is also conducted to highlight best practice, areas for improvement and as in physiology we often discuss potentially sensitive topics, to support participants who may be affected by the subject matter of the session (Peters et al., 2004).

But I don't have experience/technology:

A barrier for many in this space to incorporate in their practice is the use of learning technology, from both academics and students (Børte et al., 2023). This is an issue, but we and other colleagues in the literature have shown this is possible using simple technologies such as Microsoft Powerpoint® in a large lecture theatre setting (Meibauer et al., 2018; Vevox, 2024), in the form of live action sessions with live role play elements and large group discussion (Roe et al., 2024; Vevox, 2023). Indeed, the humble case study is a time-tested form of the interactive story and can be employed with little to no technology and as discussed earlier, this method has positive outcomes (Toogood, 2023; Seshan et al., 2021). Generative Artificial Intelligence (GenAI) may also provide experiences or short stories for use in education. Studies so far in this application in STEM and Healthcare are limited, but the use of GenAI has been studied to simply generate stories and act as a chatbot for students to interact with (Tlili et al., 2023), all the way to powering AI characters in virtual worlds (Ijaz et al., 2017).

4. Conclusions and future directions

Interactive storytelling in higher education is not a novel concept, and it has long been a cornerstone of learning at other educational levels. However, some university disciplines have embraced this approach more than others, likely because it is more overtly applicable to their field. That said, interactive storytelling has the potential to elevate the humble case study, which remains a staple across physiology and health education programmes worldwide.

For students, bridging the gap between theoretical knowledge and real-world application in physiology is a significant challenge. Interactive stories offer a compelling way to bring abstract concepts to life in a meaningful and applied context. Beyond academic learning, these methods may also foster a stronger sense of identity and belonging within the discipline—an issue currently under discussion among physiologists in the UK, much like it has been in the nursing profession.

Despite its promise, interactive storytelling remains underutilised in STEM education, with limited research assessing its effectiveness in improving learning outcomes. Future studies could investigate whether

storytelling-based approaches can.

a) Enhance students' ability to apply theoretical concepts to practice, potentially leading to improved academic engagement and performance.
b) Strengthen students' professional identity and sense of belonging within physiology, mirroring the effects observed in nursing and health education.

However, waiting for more research is not an excuse for inaction. As educators, we have the opportunity and responsibility to experiment with interactive storytelling in our own classrooms. We challenge you to integrate storytelling into your teaching, test its impact, gather student feedback, and refine your approach. Whether through case studies, Scenario-based drama, or digital simulations, storytelling can transform passive learning into active engagement.

All of us have stories from our professional experiences that could be meaningful for our students. Perhaps that unexpected equipment failure in the lab could become a tutorial discussion. How would your students respond? What choices would they make? The challenge is clear: start telling the stories, and let the learning unfold.

CRediT authorship contribution statement

Bagley L.: Conceptualization, Investigation, Writing – original draft, Writing – review & editing. **Wilson J.:** Conceptualization, Investigation, Writing – original draft, Writing – review & editing. **Kime A.:** Conceptualization, Investigation, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

No data was used for the research described in the article.

References

Ahad, S., et al., 2013. The effect of model fidelity on colonoscopic skills acquisition. A randomized controlled study. J. Surg. Educ. 70 (4), 522–527.
Armstrong, P.B., 2020. Stories and the Brain: the Neuroscience of Narrative. Johns Hopkins University Press.
Attenborough, J., Abbott, S., 2020. Using storytelling in nurse education: the experiences and views of lecturers in a higher education institution in the United Kingdom. Nurse Educ. Pract. 44, 102762.
Baldwin, A., et al., 2017. Reconciling professional identity: a grounded theory of nurse academics' role modelling for undergraduate students. Nurse Educ. Today 59, 1–5.
Barker, M.-E., Leach, K.T., Levett-Jones, T., 2023. Patient's views of empathic and compassionate healthcare interactions: a scoping review. Nurse Educ. Today, 105957.
Barteit, S., et al., 2021. Augmented, mixed, and virtual reality-based head-mounted devices for medical education: systematic review. JMIR Serious Games 9 (3), e29080.
Biggs, J., 2003. Aligning teaching and assessing to course objectives. International Conference on Teaching and Learning in Higher Education: New trend and innovations 2.
Børte, K., Nesje, K., Lillejord, S., 2023. Barriers to student active learning in higher education. Teach. High. Educ. 28 (3), 597–615.
Brown, M.E.L., et al., 2020. 'Too male, too pale, too stale': a qualitative exploration of student experiences of gender bias within medical education. BMJ Open 10 (8), e039092.
Campos, I., 2017. Interactive storytelling to teach news literacy to children. In: Interactive Storytelling. Springer International Publishing, Cham.
Chandra, Deven B., et al., 2008. Fiberoptic oral intubation: the effect of model fidelity on training for transfer to patient care. Anesthesiology 109 (6), 1007–1013.
Charon, R., 2006. The self-telling body. Narrat. Inq. 16, 191–200.
Chen, D., et al., 2024. Physiological and psychological responses to transitions between urban built and natural environments using the cave automated virtual environment. Landsc. Urban Plann. 241, 104919.
Christodoulidi, F., 2023. A pedagogy of vulnerability: its relevance to diversity teaching and 'humanising' higher education. Equity Educ. Soc. 0 (0), 27526461231185834.
de Back, T.T., et al., 2020. Benefits of immersive collaborative learning in CAVE-based virtual reality. International Journal of Educational Technology in Higher Education 17 (1), 51.
Demaria, M.C., Hodgson, Y., Czech, D.P., 2018. Perceptions of transferable skills among biomedical science students in the final-year of their degree: what are the implications for graduate employability? International Journal of Innovation in Science and Mathematics Education 26 (7).
Garcia-Pelegrin, E., Wilkins, C., Clayton, N.S., 2021. The ape that lived to tell the tale. The evolution of the art of storytelling and its relationship to mental time travel and theory of mind. Front. Psychol. 12, 755783.
Gibson, S., Molloy, E., 2012. Professional skill development needs of newly graduated health professionals: a systematic literature review. Focus on Health Professional Education: A Multi-Professional Journal 13 (3), 71–83.
Gilbert, J.H., Yan, J., Hoffman, S.J., 2010. A WHO report: framework for action on interprofessional education and collaborative practice. J. Allied Health 39 (Suppl. 1), 196–197.
Greenhalgh, T., 2001. Storytelling should be targeted where it is known to have greatest added value. Med. Educ. 35 (9), 818–819.
Handoko, E., et al., 2023. Digital storytelling: an innovative teaching method for medical education. Prima Journal of Oral and Dental Sciences 6 (1), 18–25.
Helliwell, J.R., 2016. Skills for a Scientific Life. Crc Press.
Hensen, B., Kühlem, K., 2023. Collaborative learning in mixed reality using webxr and h5p. In: International Conference in Methodologies and Intelligent Systems for Techhnology Enhanced Learning. Springer.
Herreid, C.F., 2011. Case study teaching. N. Dir. Teach. Learn. 2011 (128), 31–40.
Herreid, C.F., et al., 2021. Survey of case study users during pandemic shift to remote instruction. Adv. Physiol. Educ. 45 (3), 620–625.
HESA, 2023. In: Agency, H.E.S. (Ed.), Higher Education Student Statistics: UK, 2021/22.
Ijaz, K., Bogdanovych, A., Trescak, T., 2017. Virtual worlds vs books and videos in history education. Interact. Learn. Environ. 25 (7), 904–929.
Jackson, D., 2015. Employability skill development in work-integrated learning: barriers and best practice. Stud. High Educ. 40 (2), 350–367.
Jackson, D., Tomlinson, M., 2022. The relative importance of work experience, extra-curricular and university-based activities on student employability. High Educ. Res. Dev. 41 (4), 1119–1135.
Jorm, C., et al., 2016. A large-scale mass casualty simulation to develop the non-technical skills medical students require for collaborative teamwork. BMC Med. Educ. 16 (1), 83.
Jorre de St Jorre, T., Oliver, B., 2018. Want students to engage? Contextualise graduate learning outcomes and assess for employability. High Educ. Res. Dev. 37 (1), 44–57.
Khoo, E., Zegwaard, K., Adam, A., 2020. Employer and academic staff perceptions of science and engineering graduate competencies. Australas. J. Eng. Educ. 25 (1), 103–118.
Lee, H., 2024. The rise of ChatGPT: exploring its potential in medical education. Anat. Sci. Educ. 17 (5), 926–931.
Maftei, L., Harty, C., 2021. Surprise: challenging design perceptions in immersive virtual reality environments? The case of designing a hospital project using a CAVE (Cave Automatic Virtual Environment). Archnet-IJAR: International Journal of Architectural Research 15 (3), 887–904.
Mansky, J., 2022. The Surprisingly Long History of 'Choose-Your-Own-Adventure'Stories, vol. 4. Smithsonian. com.
Mateo, C.M., Williams, D.R., 2020. More than words: a vision to address bias and reduce discrimination in the health professions learning environment. Acad. Med. 95 (12S).
Meehan, C., Howells, K., 2019. In search of the feeling of 'belonging' in higher education: undergraduate students transition into higher education. J. Furth. High. Educ. 43 (10), 1376–1390.
Meibauer, G., Aagaard Nøhr, A., 2018. Teaching experience: how to make and use PowerPoint-based interactive simulations for undergraduate IR teaching. J. Polit. Sci. Educ. 14 (1), 42–62.
Morris, M.C., Conroy, P., 2020. Development of a simulation-based sub-module in undergraduate medical education. Ir. J. Med. Sci. 189 (1), 389–394.
Özaras Öz, G., Çakmak, N.C.S., Günbayi, İ., 2024. "I want to have stories too." Nursing students' views on nursing identity and reasons for choosing nursing as a career: a qualitative study. Nurse Educ. Pract. 78, 104009.
Pedler, M.L., Willis, R., Nieuwoudt, J.E., 2022. A sense of belonging at university: student retention, motivation and enjoyment. J. Furth. High. Educ. 46 (3), 397–408.
Pellas, N., Dengel, A., Christopoulos, A., 2020. A scoping review of immersive virtual reality in STEM education. IEEE Transactions on Learning Technologies 13 (4), 748–761.
Peters, V.A.M., Vissers, G.A.N., 2004. A simple classification model for debriefing simulation games. Simulat. Gaming 35 (1), 70–84.
Rand, J., 2017. Misunderstandings and mismatches: the collective disillusionment of written summative assessment feedback. Res. Educ. 97 (1), 33–48.
Roe, S., et al., 2024. A cross-disciplinary approach to learning medical physiology and behavioral skills involving drama students performing as simulated patients. Adv. Physiol. Educ. 48 (2), 297–303.

Römgens, I., Scoupe, R., Beausaert, S., 2020. Unraveling the concept of employability, bringing together research on employability in higher education and the workplace. Stud. High Educ. 45 (12), 2588–2603.
Sarkar, M., et al., 2016. Graduate employability: views of recent science graduates and employers. International Journal of Innovation in Science and Mathematics Education 24, 31–48.
Seshan, V., et al., 2021. Case study analysis as an effective teaching strategy: perceptions of undergraduate nursing students from a middle eastern country. SAGE Open Nurs 7, 23779608211059265.
Shuyi, A.T., et al., 2024. Effectiveness of interprofessional education for medical and nursing professionals and students on interprofessional educational outcomes: a systematic review. Nurse Educ. Pract. 74, 103864.
Sierra, J., 2020. The potential of simulations for developing multiple learning outcomes: the student perspective. Int. J. Manag. Educ. 18 (1), 100361.
Smed, J., Skult, N., Skult, P., 2021. Handbook on Interactive Storytelling. John Wiley & Sons.
Smith, D., et al., 2017. Cooperation and the evolution of hunter-gatherer storytelling. Nat. Commun. 8 (1), 1853.
Sokhanvar, Z., Salehi, K., Sokhanvar, F., 2021. Advantages of authentic assessment for improving the learning experience and employability skills of higher education students: a systematic literature review. Stud. Educ. Eval. 70, 101030.
Sotiriadou, P., et al., 2020. The role of authentic assessment to preserve academic integrity and promote skill development and employability. Stud. High Educ. 45 (11), 2132–2148.
Steele, K.J., et al., 2020. Start with the end in mind: using student career aspirations and employment data to inform curriculum design for physiology undergraduate degree programs. Adv. Physiol. Educ. 44 (4), 697–701.
Stevenson-Cocks, H., et al., 2023. “What Is Physiology?” – Interview Insights Straight from the Physiologists’ Mouths. In: Physiology 2023. Harrogate, UK.
Tlili, A., et al., 2023. What if the devil is my guardian angel: ChatGPT as a case study of using chatbots in education. Smart Learning Environments 10 (1), 15.
Toogood, C., 2023. Supporting students to engage with case studies: a model of engagement principles. Educ. Rev. 1–15.
Vevox, 2023. Vevox Pedagogy Series: ’Once upon a Time: Using Vevox for Interactive Storytelling. YouTube [Webinar]. Available from: https://youtu.be/1m-Srr93HhE?si=xdmSiwpNMf600gC.
Vevox, 2024. Bringing the Workplace to the Lecture Theatre Using Vevox. YouTube [Video]Available from: https://youtu.be/eHY-4SRgXCg?si=b7QbvZdTLT4aXKir.
Wilson, J., Walker, S., 2017. Turning a crisis into an interactive drama: an introductory paper of a ‘clickers theatre’ in nurse education. Nurse Educ. Today 51, 109–111.
Winstone, N.E., Boud, D., 2022. The need to disentangle assessment and feedback in higher education. Stud. High Educ. 47 (3), 656–667.
Wu, C.M., et al., 2022. Time pressure changes how people explore and respond to uncertainty. Sci. Rep. 12 (1), 4122.
Zhao, J., et al., 2020. Learning in the field: comparison of desktop, immersive virtual reality, and actual field trips for place-based STEM education. In: 2020 IEEE Conference on Virtual Reality and 3D User Interfaces (VR).