Innovating Pedagogy 2024

Exploring new forms of teaching, learning and assessment, to guide educators and policy makers

Agnes Kukulska-Hulme, Alyssa Friend Wise, Tim Coughlan, Gautam Biswas, Carina Bossu, Sarah K. Burriss, Koula Charitonos, Scott A. Crossley, Noel Enyedy, Rebecca Ferguson, Elizabeth FitzGerald, Mark Gaved, Christothea Herodotou, Melanie Hundley, Catherine McTamaney, Ole Molvig, Emily Pendergrass, Lynn Ramey, Julia Sargent, Eileen Scanlon, Blaine E. Smith, Denise Whitelock

Open University Innovation Report 12

The Open University

VANDERBILT UNIVERSITY
LIVE
LEARNING INNOVATION INCUBATOR

Institute of Educational Technology, The Open University
Walton Hall, Milton Keynes, MK7 6AA, United Kingdom

Vanderbilt LIVE Learning Innovation Incubator, 1400 18th Ave S, Nashville, TN 37212, United States

ISBN 978-1-4730-4004-5

This report published 2024
First Innovating Pedagogy report published 2012

A full-text PDF version of this report is available to download from www.open.ac.uk/innovating

Edited and typeset by The Open University
Cover image generated with DALL.-E 3 by Dr Tim Coughlan

Picture credits:
Grateful acknowledgement is made to the following sources:

Page 9: Image by Solen Feyissa on Flickr

Page 13: Image by Mobile Arts for Peace project

Page 19: Image by Markus Spiske from Pexels https://www.pexels.com/photo/climate-people-street-crowd-2990610/

Page 25: Image generated by ChatGPT, OpenAI

Page 30: Image by Ars Electronica: Glow / Diederik P. Kingma, Prafulla Dhariwal; OpenAI

Page 34: Image generated by Stable Diffusion

Page 38: Image by Intelligent Texts for Enhanced Lifelong Learning

Page 41: Image by Zhiyucai from Wikimedia Commons.
https://commons.wikimedia.org/wiki/File:VR_student.png

Page 46: Image by Lynn Ramey

Page 52: Image by Vanderbilt University

Suggested citation:
Kukulska-Hulme, A., Wise, A.F., Coughlan, T., Biswas, G., Bossu, C., Burriss, S.K., Charitonos, K., Crossley, S.A., Enyedy, N., Ferguson, R., FitzGerald, E., Gaved, M., Herodotou, C., Hundley, M., McTamaney, C., Molvig, O., Pendergrass, E., Ramey, L., Sargent, J., Scanlon, E., Smith, B.E., & Whitelock, D. (2024). *Innovating Pedagogy 2024: Open University Innovation Report 12*. Milton Keynes: The Open University.

Contents

Executive summary

In this series of annual reports, we continue to explore new forms of teaching, learning, and assessment for an interactive world, to guide teachers and policy makers in productive innovation. This twelfth report proposes another ten innovations which are already in currency but have the potential to exert a greater influence on education. To produce the report, a group of academics at the Institute of Educational Technology at The Open University (UK) collaborated with researchers and practitioners from the LIVE Initiative at Vanderbilt University in the US. A wide range of pedagogical innovations were proposed by the authors and then, in a process of collective discussion of major themes and associated research, ten ideas were developed through multiple drafts and peer review, with reference to published studies and other sources from research and practice. They are summarised below.

1 Speculative worlds

Speculative pedagogies involve reimagining the present, past, or future to critique and change the status quo, benefiting marginalised groups who often feel underrepresented. Marginalised groups face barriers to education, exacerbated by poor health, exclusion, and lack of resources. Techniques like world-building in speculative fiction and technology design with these groups may help them to reshape their worlds. Individuals can try out actions and personas that they may not experience in their daily lives, traversing time, space and perspective. Technologies such as AI and VR/AR facilitate these creative processes. Using innovative fiction and film can enable integration of marginalised communities' cultural backgrounds into new virtual spaces, providing a sense of belonging. Redesigning everyday technology and urban environments can also make learning environments and cities more inclusive. Challenges to implementing the speculative worlds approach include digital exclusion, socioeconomic hurdles, and biases in AI models. Furthermore, careful consideration of accessibility and representation is required, to ensure broad participation. Nevertheless, speculative pedagogies offer ways for marginalised individuals to envision equitable futures, express their identities, and explore their roles in society.

2 Pedagogies of peace

Pedagogies of peace emphasise the role of schools and organisations in promoting societal harmony by addressing everyday and structural violence. Peace-promoting practices include education for peace, violence prevention, and community healing. Compassionate practices in classrooms, such as developing empathy, storytelling, and integrating diverse perspectives, can extend beyond school, fostering broader societal compassion and understanding. Restorative justice practices in education seek to repair relationships rather than punish, using methods like sequential circles to facilitate dialogue and healing. These practices enhance student-teacher relationships, reduce ethnic disparities, and help shift school culture from punitive to restorative. Global citizenship education extends peacebuilding efforts beyond local conflicts, encouraging students to understand their role in a global context. Historical models, such as Montessori's White Cross, and modern initiatives like Libraries Without Borders' 'Ideas Box', support this by providing trauma-informed care and educational resources in conflict zones. Challenges to implementing these practices include limited resources, political resistance, and misunderstanding their value. Despite these barriers, compassionate and restorative practices can build resilient, inclusive communities, making peace education a foundational element for other learning and societal harmony.

3 Climate action pedagogy

Climate action pedagogy equips educators and students to address climate change effectively by integrating environmental topics across curricula and fostering interdisciplinary learning. It emphasises creating a climate-conscious curriculum supported by scientific research and real-world examples. Hands-on experiences, such as outdoor learning and sustainability projects, foster environmental responsibility and awareness. However, climate change itself can disrupt these activities, necessitating adaptable teaching methods. Promoting climate literacy and awareness through films, discussions on climate justice, and interactive tools is crucial for building informed and proactive individuals. Empowering student advocacy is vital, encouraging students to engage in local environmental issues, propose solutions, and advocate for policy changes. An example includes McMaster University medical students advocating for climate-related education in their curriculum. Reflective practices, such as journals and multimedia projects, allow students to connect personally with climate action. Challenges include keeping the evolving curriculum up-to-date and managing climate anxiety among students. Schools must provide secure spaces for expressing these anxieties and cultivating optimistic perspectives. Through climate action pedagogy, educators can nurture environmentally conscious individuals ready to tackle climate change, promoting responsibility and sustainable future actions.

4 Learning in conversation with generative AI

Generative Artificial Intelligence (GenAI) tools like ChatGPT and Gemini simulate Socratic questioning, fostering dialogic learning by providing real-time answers and guidance. These AI systems can act as 24/7 virtual tutors, assisting students with academic tasks and immediate answers. While students appreciate this convenience, concerns about content accuracy, data privacy and potential misuse persist. GenAI's conversational features enhance interactive learning through immersive simulations and role-playing, aiding language acquisition, professional skills, and critical thinking. For example, Duolingo Roleplay allows language practice in real-life scenarios, and GenAI can simulate job interviews or medical diagnostics. GenAI helps teachers create educational resources through iterative prompting and critical evaluation, but it requires verification and adjustment. Challenges include varying student engagement levels and the need for AI literacy to ensure productive dialogue and critical assessment of AI responses which can sometimes produce incorrect or biased information. Unequal access to advanced GenAI models and privacy concerns must also be addressed. As GenAI evolves, it will continue to shape learning and engagement, necessitating ongoing evaluation and adaptation.

5 Talking AI ethics with young people

Digital technologies, including AI, significantly impact young people's lives, influencing family life, leisure, communication and education. Advocates stress the importance of centring children's rights in AI debates, emphasising their voices in AI tool development for education. The UNCRC's call for child engagement remains relevant, highlighting children's agency and frustration with inadequate digital designs. Children desire greater digital literacy to navigate technology effectively. Initiatives like the European Union's AI Act aim to establish ethical AI use in education, focusing on data privacy and ethical concerns. At the University of Technology in Sydney, a community consultation process has addressed ethical AI use in education, reflecting the community's values. In the US, educators have adapted the AI Bill of Rights for young audiences, encouraging policy critique and adaptation. Challenges include the rapid pace of AI development, variations in children's rights globally, and translating ethical discussions into action. This pedagogy underscores the need for a rights-based approach, emphasising children's participation, understanding, and advocacy in the digital environment, to ensure their voices are integral in shaping ethical AI practices.

6 AI-enhanced multimodal writing

The integration of generative AI in multimodal writing enhances educational practices by enabling diverse forms of expression such as images, videos, voice-overs and music alongside traditional text. Educators, exploring its potential through projects like advocating environmental changes, note a shift in thinking and planning required. Students benefit from AI's ability to quickly generate and revise multimodal compositions, although mastering prompt creation and revision becomes crucial. This approach fosters critical thinking and creativity, evident in classes where students use AI to reinterpret stories or create artworks, refining their prompts to AI iteratively. Barriers and challenges include access to AI tools and ethical concerns over algorithmic biases and copyright issues. Nonetheless, the use of AI expands creative possibilities and accelerates multimodal composition processes, prompting educators to emphasise reflective practices and ethical considerations in integrating AI into educational curricula. As AI technology evolves, it will continue to shape multimodal literacy, encouraging deeper engagement and ethical exploration in education.

7 Intelligent textbooks

With the advent of Artificial Intelligence (AI), intelligent texts have become 'smarter', enabling personalised forms of learning by tracking the behaviour of readers such as page navigation and dwell time (amount of time a reader spends on a page) and by adapting content in real time to meet the needs of the reader. Intelligent textbooks leverage AI to enhance learning experiences by integrating interactive features such as automated question answering and adaptive content delivery. These digital tools are evolving from traditional and digital texts, offering personalised learning paths and real-time feedback to optimise comprehension and engagement. Key benefits include improved learning efficiency and student satisfaction, particularly noted in fields like computer science where interactive elements support deeper understanding and skill development. Integrating these tools effectively into existing curricula can be challenging. Concerns include biases in AI-generated feedback and ensuring student data privacy. Despite these challenges, intelligent textbooks represent a transformative approach to education, poised to facilitate lifelong learning by fostering adaptive learning environments accessible to diverse learners worldwide, albeit with considerations for ethical AI use and cost-effective implementation.

8 Assessments through extended reality

Simulation-based learning replicates aspects of the real world, requiring learners to take actions, and making the consequences of these actions visible. Its use in assessment is growing. Assessments through extended reality (XR), including virtual reality (VR) and augmented reality (AR), involve using immersive simulations for evaluating and developing practical skills. XR enhances learning by providing a sense of presence and agency, crucial for testing procedural knowledge in complex scenarios like surgery or hazardous environments. These simulations allow for authentic assessments without real-world risks or logistical constraints. Industries from healthcare to vocational training are adopting XR for assessing skills like hazard recognition in construction or customer service in hospitality, leveraging realistic virtual environments. Design principles for XR assessments emphasise using multiple data sources for comprehensive evaluation, starting with low-stakes assessments to familiarise learners, and aligning tasks with learning outcomes. Potential barriers to uptake are equipment costs, space requirements, and motion sickness in virtual reality, which may affect accessibility and equity. Nevertheless, XR assessments promise to revolutionise education by offering detailed analytics and fostering reflective learning experiences beyond traditional assessment methods.

9 Immersive language and culture

Immersive language and culture is an approach that uses digital games and role-playing to offer students authentic learning experiences in historical contexts. These methods provide engaging platforms for language acquisition and cultural understanding. Students who are immersed in an authentic learning activity can be supported to develop the judgment to distinguish between reliable and unreliable information, the flexibility to develop innovative solutions and to work across cultural boundaries. Video games like *Brendan's Voyage* and *Operation LAPIS* immerse students in specific historical periods, teaching languages such as medieval French and Latin while integrating cultural elements like architecture and literature. Alternatively, *Reacting to the Past* employs role-playing scenarios, such as simulating the Paris Peace Conference or ancient Athens, to foster critical thinking and historical empathy among students. Challenges include the complexity of creating educational games that authentically reflect language and culture, as well as student difficulties in adapting to role-playing and debate. However, such immersive learning methods show promise in enhancing student engagement and retention, paving the way for more interactive and effective educational practices in language and cultural studies.

10 Exploring scientific models from the inside

Embodied learning seeks to expand the repertoire of resources students use to learn from their experiences in the world by incorporating how they move their bodies in space and how they interact with the physical environment around them. Extended reality (XR) technologies like virtual reality, augmented reality and mixed reality can be used to create immersive environments where students interact with digital representations of scientific phenomena, such as pollination dynamics or states of matter, overlaid onto real-world settings. This approach allows students to explore and manipulate scientific models firsthand, enhancing their understanding through experiential learning. Artificial Intelligence (AI) complements XR by analysing vast amounts of multimodal data from these interactions, including video, audio, and system logs, to provide insights into students' engagement and learning processes. This data-driven approach enables teachers to facilitate reflective discussions and personalised feedback, guiding students to deeper conceptual understanding. There are challenges such as cost, technical complexity, and privacy concerns. Nonetheless, there are educational benefits of XR and AI in making abstract concepts tangible and engaging, which underscore their transformative potential in education.

Introduction

We are pleased to share in this report the outcomes of another fruitful collaboration among a group of authors who have come together to identify a further set of powerful pedagogies that hold the promise of transformative change. It is again very clear that consideration of important contemporary societal issues can lead to richly educational experiences that provide opportunities to imagine a range of possible futures. Challenges such as the climate emergency, the proliferation of Artificial Intelligence (AI), and the fragility of social trust can motivate educators to seek out approaches that will engage their students, and in doing so, lay good foundations for the future.

Often combined with application of smart technologies, the latest ten proposed pedagogies further expand teachers' repertoires, potentially strengthening student engagement and success. In particular, extended reality (XR) – i.e., immersive technologies that blend the physical and virtual worlds – as well as AI permeate many of the innovations described in this year's report. Pedagogical approaches incorporating these technologies highlight the development of practical skills and knowledge, as well as deepening conceptual understanding through experiences that are highly absorbing. The experiences may be based around embodied learning, which involves physical movement, sensations and emotions induced by physical experiences. Both XR and AI are also technologies that can fire the imagination, motivating both teachers and learners to create, critique and evaluate. The drawbacks as well as advantages of these technologies are brought to light.

'Speculative worlds' in this report illustrates one approach that ignites the imagination, through using, critiquing or producing speculative fiction or engaging learners in technology design. This pedagogy can be a way to shake up preconceptions about how any fictional or real world can look or function. It can be especially beneficial for marginalised or minoritised groups of learners, enabling them to express their perspectives and to influence the design of future learning spaces or environments.

'Pedagogies of peace' and 'Climate action pedagogy' are similarly future-oriented, with a range of strategies that reflect a common desire to forge deeper relationships between education and important developments taking place in our world. At a time of excitement about AI but also concerns around its role and influence, it is reassuring to know that researchers are developing a new field of knowledge and practice where the central focus is AI for peace. This new field includes the study of relationships between AI, climate and conflict, and it is already clear that educators, technologists, data scientists, designers, engineers, and technology activists will all need to play their part[1].

Teachers' pedagogical choices for individual lessons, learning activities or projects may ultimately contribute to shaping new curricula, with a view to preparing students for future employment in emerging fields. The future-oriented pedagogies we have included in this report tend to emphasise compassion and care, a concern for justice, awareness of important global issues, and an orientation towards the notion of global citizenship – a perspective that recognises collective responsibility and the digitally-enabled networks that increasingly connect people across the world. These pedagogies may require, or simply benefit from, engagement with communities beyond a single school or institution. Digital networks could facilitate that engagement.

The growing role of AI shows up as a prominent theme throughout this report, with multiple angles on its integration in education. Many other organisations have published reports dedicated to this theme as a whole[2,3,4]. In our case, 'Learning in conversation with generative AI' emerged from initial proposals to look at the skills involved in devising effective prompts when interacting with generative AI (GenAI) tools such as ChatGPT, but it was soon situated within the broader perspective of interaction with teachers or tutors and the benefits of conversational learning. The approach embraces virtual tutors, interactive simulations, and the co-creation (together with AI) of educational resources.

Conversation is also the central focus of 'Talking AI ethics with young people', where the message is that it is crucial to prioritise young people's rights, voices and experiences in the design, development, and implementation of AI tools that they will use in education. Key concerns are young people's safety, privacy, and meaningful participation in the digital world. Co-design processes involving young people can address both the risks and opportunities presented by AI.

Digital communication is increasingly multimodal, which means that familiar processes such as writing are being transformed. The pedagogical approach outlined in 'AI enhanced multimodal writing' draws attention to how GenAI enhances the process of creating multimodal compositions and how it forces writers to think differently about the arguments they are formulating. It emphasises how AI tools can facilitate the integration of various modes of communication, such as images, sounds, texts and videos, for example to enable retelling of stories in different ways. This not only broadens the creative possibilities but also requires new skills in devising prompts for the AI, and critical reflection on the use of AI and on the process of composing. 'Intelligent textbooks' connect the processes of reading and writing. These textbooks help students generate knowledge by making reading processes more interactive, for instance by requiring learners to construct responses to AI generated questions and produce summaries of texts they have read.

The final batch of pedagogies described in this report is clustered around the use of extended reality and immersion[5]. The section on 'Assessments through extended reality' provides teachers with guidance on designing these types of assessments along with practical suggestions for implementation. Introduction of new forms of assessment can be difficult, but in subjects where real-world skills and procedures need to be practised and assessed XR offers clear benefits. Digital data generated in these situations can be used for detailed analysis, and potentially that can lead to improvements in teaching and learning. XR is also central to 'Exploring scientific models from the inside', where playful exploration of scientific models is facilitated through embodied learning, analysis of multimodal digital data traces of performed activities, and subsequent reflection. In 'Immersive language and culture', learning classical languages such as Ancient Greek or Latin and playful exploration of historical scenarios are enabled by actions, readings and debates in immersive video game environments. Such a pedagogy can also be enacted without the use of technology, in student-led game-based sessions in class or outside of class.

We hope you enjoy our twelfth report and look forward to your feedback!

References

1. Panic, B. and Arthur, P. (2024) *AI for Peace*. CRC Press. London.
2. Edmett, A., Ichaporia, N., Crompton, H., and Crichton, R. (2023) *Artificial intelligence and English language teaching: Preparing for the future*, The British Council. Available at: https://doi.org/10.57884/78ea-3c69 (Accessed 10 July 2024).
3. Giannini, S. (2023) *Generative AI and the future of education*, UNESCO. Available at: https://www.unesco.org/sdg4education2030/en/knowledge-hub/generative-ai-and-future-education (Accessed 19 July 2024).
4. World Economic Forum (2024) *Shaping the Future of Learning: The Role of AI in Education 4.0*. Insight report, April 2024. Available at: https://www.weforum.org/publications/shaping-the-future-of-learning-the-role-of-ai-in-education-4-0/ (Accessed 10 July 2024).
5. Jisc (2024) *Extended reality in learning and teaching report 2023/24*. Available at: https://www.jisc.ac.uk/reports/extended-reality-in-learning-and-teaching-report-2023-24 (Accessed 10 July 2024).

Speculative worlds

Imagining and designing for a more equitable future

Introduction

Speculative pedagogies involve reimagining the present, past, or future to better understand, critique, and work to change the status quo. Exciting innovations include world-building and its critique in speculative fiction with young people, and speculative technology design with marginalised and/or minoritised groups.

These approaches may be especially significant for students who have not seen themselves or their needs reflected in popular media, like fiction and film, dominant curriculum, or technology design. Speculative creation allows for students who have been marginalised (due to how they represent or identify their race, gender, sex, ethnicity, religion, beliefs, education, income, health status, disability, geographic location, and more, in often-intersecting ways) to re-shape the world around them. This is done in ways that dominant media, technology and curriculum might not allow for. Emerging and growing technologies like generative artificial intelligence (AI) and virtual and augmented reality (VR/AR) offer students new ways to build and explore these alternate worlds.

> Speculative worlds are evolving as technology offers new ways of predicting and building the world

For a large proportion of marginalised groups, access to education can be a real problem. They can be denied their right to access teaching and learning, either face-to-face or at a distance. The reason for this is higher incidence of poor mental and physical health, higher probability of being excluded from school, poor attainment/employment and a lack of 'study space' at home. Localised deprivation, special educational needs, and low socio-economic status are also factors. They are often left behind by national educational policies.

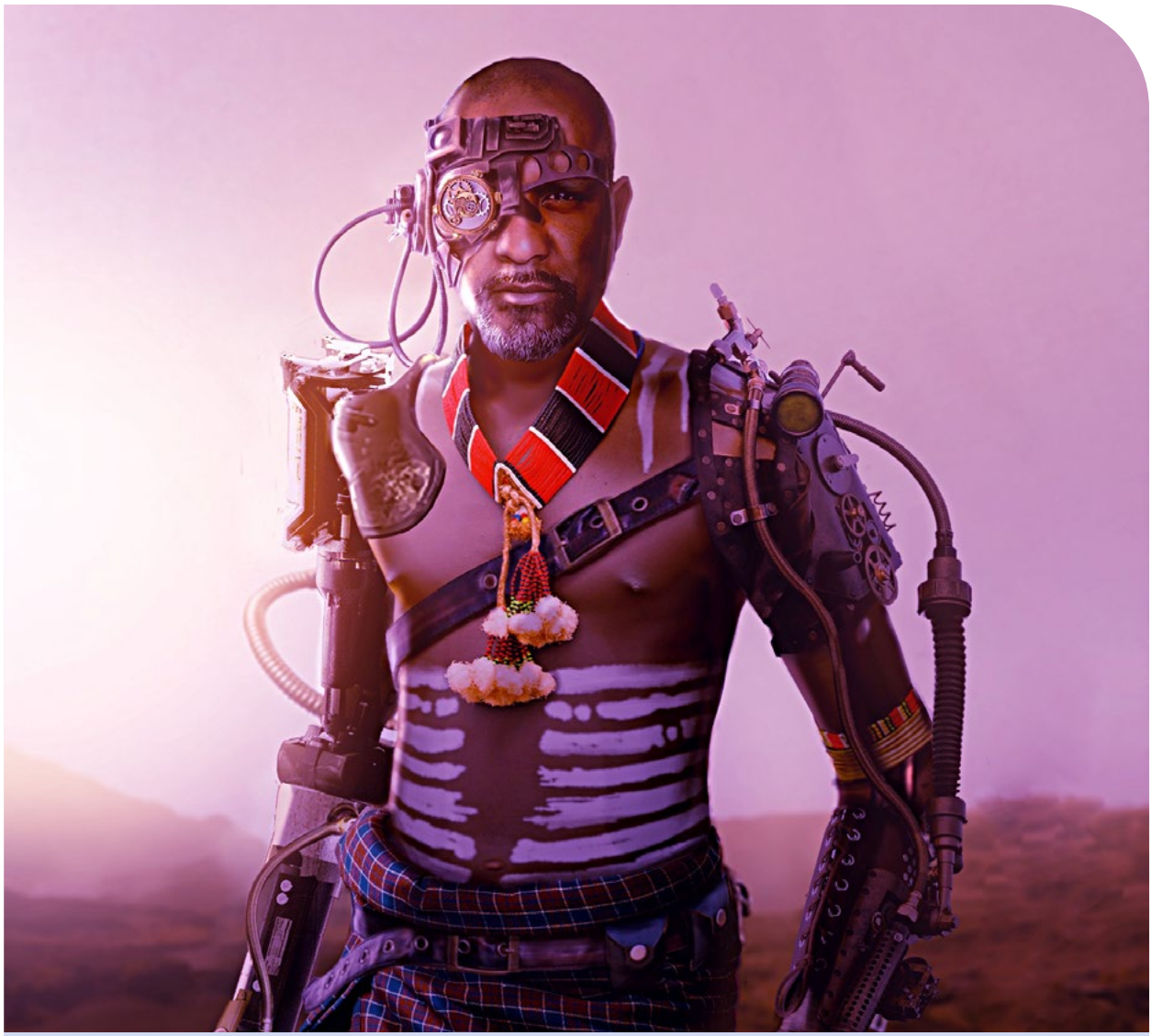
One way of addressing misrepresentation of marginalised students and their communities is the construction and use of innovative, ultra-modern worlds in fiction and film. This kind of creation can take the economic, cultural, social and historical background of marginalised communities and weave these into the creation of new real or virtual places. Those communities are able to have somewhere where they feel at home, and can access their right to education, amongst other human rights such as use of services and goods in a variety of domains.

This speculative approach to world-building in textual and visual media is currently seeing a surge in popularity and urgency as a form of pedagogy, especially in the context of the development and application of artificial intelligence (AI) and other advanced computational technologies like augmented and virtual reality (AR/VR). AI image and video generation tools can help bring speculative visions to life in vivid and shareable ways.

This was shown in the *Black Panther* films, where the fictional East African country of Wakanda and its people showed a futuristic view of these 'smart' cities, combined with historical, religious, cultural and social aspects of Wakandan life. For example, the fictional city Birnin Zana is considered by some to be a smart city; commerce-filled streets are car-free except for the infrequent bus-like shuttles. Maglev trains are seen around the city, with some Wakandan buildings having elements from African heritage, such as large hanging baskets, colourful brickwork and thatched roofs. The people themselves are technologically advanced. Their defences, languages and religious beliefs are diverse in nature and other cultural aspects such as art and clothing are also tailored to Wakanda.

Another speculative approach is to envision the redesign of technology and physical spaces that surround us. This might include efforts to create a 'smart city' – or world – virtually. It builds on game-based learning, where the graphics and economic, cultural, or social aspects of the game are a central part of the environment players find themselves in. This is an especially important realm of speculative design given that playable video game characters are still predominantly 'White', 'male' and 'adult.'[1] This pedagogical approach can mirror and/or bolster efforts in the physical world to design smart cities that leverage technology for more equitable futures, making cities more inclusive for the poor, the disabled, the elderly, and other vulnerable people[2]. Given that technology can also deepen inequities, it is crucial that marginalised communities have a voice in this design process.

Speculative worlds are evolving as technology offers new ways of predicting and building the world – with artificial intelligence, with virtual and augmented reality, and with new forms and modes of circulating texts with these technologies. For example, generative AI image tools may provide students with a way of designing characters to reflect a wide range of ages, races, genders and cultures. However, this process comes with its own risks, too, as generative AI can also reinforce stereotypes, generate false or misleading content, and may have been trained with illegally acquired content. Students and educators can examine, together, the risks and benefits of using these kinds of new technologies to create images and video of people and their worlds.



Serengeti Cyborg. Afrofuturism interpretation by Solen Feyissa

World-building in fiction and film: students as creators and critics

Scholars and educators have pointed to the ways that 'mainstream' speculative fiction can preserve and perpetuate dominant culture, erasing marginalised and minoritised communities. For example, these texts and films may use stereotypical tropes like the 'White savior' (e.g., as some have noted in *Black Panther*) or the 'exotic other.'[3] Asking students to examine these portrayals in existing films (like *Black Panther* or *The Matrix*) and novels, then re-imagine how they might want to tell their stories, can be a powerful experience. Educators have explored what it means to use Afrofuturist texts (expressing notions of Black identity, agency and freedom through art, creative works and activism) like *Black Panther* and young adult science fiction literature to encourage students' imagination in ways that have not typically been valued in schools.[4]

Speculation in this sense can include both making new art and critiquing existing media. Watching, reading and critiquing science fiction that speculates about the past, present, or future can open up alternative modes of textual analysis for students that seek to value texts – and student responses to them – beyond the largely White, male canon of 'traditional literature.' For example, students might interrogate representations in media sensations like *Watchmen*, *Star Trek* and *Westworld* using a tool like Davis's *Speculative Worlds of Color* website[3] to identify common tropes.

Redesigning everyday technology and the built environment

One application of this pedagogy asks students to design or redesign technology that impacts their lives. Another used 'Speculative Design Fictions' in an urban design context, asking students to think about their connections to urban spaces and think about the impact of technology on the design and experience of these spaces, ultimately producing a short film depicting students' responses. A group in the US held workshops with young people to think about how they would want to design AI to support collaborative learning, designing their own AI agent.[5]

In the virtual sphere, education researchers are creating AI-backed computer games for use in schools where students make choices to see how a story might play out, deciding whether a virtual community should have a car park or a garden and seeing the impact that might have on the neighbourhood. As part of the design process, researchers have asked students to give their feedback on what should happen in the game.[6] These research teams are working on emerging capabilities for educators themselves to design these experiences, tailoring the game to the learning standards and student content, without the need for coding expertise.

Challenges, barriers, limitations: Who gets to (re)design our world?

One major barrier to applying these pedagogies, particularly when AI and/or VR/AR is involved, is digital exclusion, and especially that which accompanies social, political, and economic exclusion that marginalised and minoritised communities may already face. With AI, the issue of bias in the AI models (and lack of access to the most current models) is important to consider. There may be persistent inequities in access to opportunities for consideration, due to inequitable access to education broadly and/or access to technology instruction, hardware and infrastructure.

There may be additional socioeconomic and governmental or political challenges to moving from speculation to enactment, sharing, or production of student creations or designs. For example, government agendas rarely state that building new smart cities is going to be a priority.

There is also the unwillingness of some marginalised communities – or individuals – to take part. Many of these may choose not to get involved in what might be seen as too advanced or revolutionary, with some reflecting on their colonial past, using this as a way of refusing to take part. This is a valid point and must be taken seriously.

Conclusions

The examples presented here are a snapshot of new trends, where educators are drawing on rich traditions to do new things with speculation, like using AI and AR/VR to re-make the world with students. Re-imagining and/or re-designing the world, our place in it, and the technologies and systems we are embedded in has offered misrepresented individuals ways of seeing themselves in virtual or real worlds, that otherwise might only reflect the identities, concerns, and needs of dominant groups. It also can be a blueprint for action; technologies designed theoretically may become reality. Especially in digital and virtual spaces, imagining new or different worlds might come without the high cost and other restrictions (social, physical) of creating them in everyday spaces. However, the technological access required for this particular kind of consideration may also be a barrier for widespread participation in places where the hardware – e.g., computers, AR/VR equipment, and infrastructure (such as high-speed internet) – is not available, like in parts of the Global South.

Speculative pedagogies, including imagining different future, past, and present worlds in fiction and film, designing everyday technology, and experimenting in virtual and game-based worlds, allow individuals to try out actions and personas that they may not experience in their daily lives, traversing time, space and perspective. Making speculative visual art can provide another avenue for people to express their fears and hopes for technology and the future. All of these strategies involve minimal technical expertise, offering a low-barrier-to-entry for deep, and deeply critical conversations about how we should live with – and build – our technology.

References

1. A study reporting on trends in video game character representation:

   Harrisson, A., Suyong Yi Jones, S., Marchessault, J., Pedraça, S., and Consalvo, M. (2020) 'The virtual census 2.0: a continued investigation on the representations of gender, race and age in videogames', *The 21st Annual Conference of the Association of Internet Researchers*, 27–31 October 2020. Available at: https://typeset.io/papers/the-virtual-census-2-0-a-continued-investigation-on-1e3u4fujhj (Accessed 27 June 2024).
2. An article on equity and smart cities from The Brookings Institution:

   Kharas, H. and Remes, J. (2018) 'Can smart cities be equitable?', *Brookings*. Available at: https://www.brookings.edu/articles/can-smart-cities-be-equitable/. (Accessed 27 June 2024)
3. A website with descriptions of common figures in speculative fiction:

   Jewel Davis (n.d.) *Speculative Worlds of Color: Highlighting common tropes, stereotypes, and biases found in speculative fiction and media*. Available at: https://jeweldavis.com/speculative-worlds-of-color. (Accessed 27 June 2024).
4. An article about social change and Afrofuturism:

   Jones, S. and Howard, N. R., (n.d) 'Traversing the Gaps: An Afrofuturist Approach to Social Change Through Dreaming in Science Fiction and STEM/Computer Science Education', *Journal of Futures Studies*. Available at: https://jfsdigital.org/traversing-the-gaps-an-afrofuturist-approach-to-social-change-through-dreaming-in-science-fiction-and-stem-computer-science-education/ (Accessed 27 June 2024).
5. A report on participatory design research with students, by authors from University of California Berkeley and University of Colorado Boulder:

   Chang, M. A., Philip, T. M., Cortez, A., McKoy, A., Sumner, T. and Penuel, W. R (2022) 'Engaging Youth in Envisioning Artificial Intelligence in Classrooms: Lessons Learned', *Rapid Community Reports Workshop Outcomes*. Available at: https://www.colorado.edu/research/ai-institute/sites/default/files/attached-files/chang_et_al._nov_2022.pdf (Accessed 27 June 2024).
6. Blog post describing feedback process for Food Justice computer game, from the EngageAI Institute:

   Humburg, M., McClain, J. and Walter, W. (2024) *Engaging Community Voices: Partnering with Girls Inc. to Make Better AI Games*. Available at: https://engageai.org/tag/partnerships/ (Accessed 27 June 2024).

Resources

- A series of YouTube videos, each one 1hr 30mins, talking about how different authors have used speculative worlds in their books:

  Worlds Of Speculative Fiction: Philosophical Themes by Gregory B. Sadler. Available at: https://www.youtube.com/playlist?list=PL4gvlOxpKKliuo3yYSBeOsrT-iSHvDRUb (Accessed 27 June 2024).
- A resource from the Black Perspectives website: ideas for bringing in Afrofuturism into schools:

  'Afrofuturism in the Classroom'. Available at: https://www.aaihs.org/afrofuturism-in-the-classroom/ (Accessed 27 June 2024).
- Website article from The National Museum of African American History and Culture about a Speculative Worlds exhibit:

  Speculative worlds. Available at: https://www.searchablemuseum.com/speculative-worlds (Accessed 27 June 2024).
- Website commentary about smart cities in Africa, fromThe Brookings Institution:

  Smart city initiatives in Africa. Eyerusalem Siba and Mariama Sow, November 1, 2017. Available at: https://www.brookings.edu/articles/smart-city-initiatives-in-africa (Accessed 27 June 2024)

Pedagogies of peace

Fostering peacebuilding in schools and society through relationship-centered practices

Mithila art – artistic output from the Mobile Arts for Peace project

Introduction

A pedagogy of peace foregrounds the responsibility of schools (and other organisations concerned with education, sports or communities) to influence society. Learning is impacted by threats of violence within individual classrooms, against communities, and across geopolitical boundaries. Everyday violence refers to routinised and often hidden forms of violence, such as discrimination on the grounds of gender or disability, while structural violence concerns the physical and psychosocial harms experienced by certain social groups due to the political, economic, and sociocultural organisation of societies. Peace promoting practices include education for peace, prevention of violence, enabling people to give expression to their experiences, and helping communities to heal from the effects of harm.

Pedagogies of peace may contribute to more cooperative coexistence across the planet by amplifying practices of compassion, tolerance, restorative justice, and global citizenship. UNESCO's *Recommendation on Peace, Human Rights and Sustainable Development* (2023) reminds us that peacebuilding takes place not only through international negotiations but also in education and in everyday life.

Compassionate practices in peace education

Developing empathy and compassion in the classroom can lead to the expression of empathy and compassion outside of the classroom. Supporting students to develop empathy and compassion for others can be done by helping them firstly to identify and articulate their own needs, and to find the obstacles to meeting those needs. In that way, they can be supported to better understand and respond to other people's needs, emotions and perspectives.

MacGill[2] and colleagues propose 'storying' as a key pedagogy in incorporating diverse perspectives that expand a shared understanding of culture, values, ethics and beliefs. Storying, which foregrounds respect, compassion and empathy as foundational to learning, relies on narrative to support learners in developing a deeper understanding of their relationships with each other. It involves storytelling and story performance. Telling and performing a story could be done through a variety of modes and media according to the teller's preferences. For example, experiences of conflict or discrimination could be presented as a sequence of journal entries, photographs, screenshots, drawings, videos, or through drama. Students can be invited to think about the ways in which different people are discriminated against in their school, organisation or community, and what could be done about it. The shared experience of diverse narratives offers learners multiple ways of acquiring and sharing knowledge and understanding, and it supports applied critical-thinking skills in imagining the resolution of conflicts presented in the narratives.

Reflecting on teachers' practices, Vandeyar[3] tracks the ways in which teachers shifted from a 'panicgogy' (a response arising from a sense of panic) to a pedagogy of compassion after the COVID-19 pandemic. The pedagogy emphasises compassionately engaging with diversity and 'instilling hope and sustainable peace' (pp. 2163). It illustrates how in many cases the cognitive dissonance created from a rapid shift to unfamiliar teaching settings increased teachers' curiosity for and compassion toward students' diverse learning contexts. As disparities by race, gender, geography and digital access grew starker, many teachers emphasised student mental health and resilience as a precursor for content learning. In such circumstances, teachers' compassionate practices could support students' perception of how welcomed, included and valued they felt in their learning settings. Likewise, Zaky's framework[1] emphasises the importance of teachers demonstrating compassion in their practice, including:

- developing connected relationships with students
- accommodating student needs
- reciprocating learning in ways that allow learners to be visible co-constructors of knowledge
- integrating diverse perspectives and processes in the classroom
- rationalising practices explicitly, especially for students who are from different cultural backgrounds
- developing learning activities that ask students to experience diverse perspectives for themselves.

Mindfulness practices, anti-bullying and tolerance lessons, and teachers' assessments of their own biases and abuses of power are all promising approaches. The online resource *Learning for Justice* offers free learning guides that support individual teacher development and classroom-based activities to address both systemic and interpersonal conflicts as well as research-based learning-plan building resources to develop school-specific activities.

> Developing empathy and compassion in the classroom can lead to the expression of empathy and compassion outside of the classroom

Restorative justice

A pedagogy of peace includes not only the opportunity to develop intentionally compassionate learning communities, but to assure justice when conflicts amongst learners arise. Practices of restorative justice seek to restore healthy relationships after an injury or offense. Rather than expelling or suspending students who have caused injury or offense, restorative practices focus on repairing relationships and helping the community to heal, in school and beyond the school. Researcher Jamee S. Carroll and her colleagues[4] detail classroom-based, whole-school and community-based models of restorative justice in urban schools, identifying both the promising outcomes of these practices and the importance of teacher training in implementing them. For example, in one classroom practice, a 'sequential circle' provides a structure for participants to speak, or to answer a

question, one at a time: a small object may be passed from person to person, indicating when it is someone's turn to speak without being interrupted. School settings in the US have expanded the use of these practices widely in the last five years, with positive impact. Restorative practices, when followed in a consistent manner, were shown to support greater positive relationships between teachers and students[5], decreased opportunity gaps among students of different ethnicities, and an increased perception of teachers as resources instead of obstacles to students' experiences at school.

These efforts coincide with efforts to increase a critical evaluation of school practices toward more inclusive practices. Restorative justice complements other efforts to recognise institutionalised patterns of inequity that lead to school conflict. Arguing that schools should move beyond simple conflict-resolution, Hajir and Kester[6] suggest *critical peace education* as a model that addresses both individual and structural conflicts. A critical stance foregrounds understanding the structural impediments to advancing peace education and it aims to empower learners as agents of change. Critical analysis could consider power dynamics as well as factors such as race, gender, disability, language, religion and geography.

Research into restorative justice models in school recommend long-term, trust-centered practices that facilitate buy-in from school stakeholders. Justice Circles (i.e., coming together as a community or group to explore an injustice) and restorative coaching show promise for both short-term and sustainable school culture interventions. As an alternative to zero-tolerance models, restorative justice practices focus on mediation rather than punishment. Promising innovations emphasise a multistep process of prevention, intervention, reintegration, asking students what happened, how they were affected, how they contributed, how others were affected, and what steps they need to take to repair harm.

Global citizenship

Global citizenship is an expanded view of restorative justice that allows teachers and learners to look beyond the conflicts of their own classrooms toward an impact on the global community. In implementing new practices for peace education and global citizenship, advocates have also looked to educational interventions for trauma-informed care. Global citizenship education foregrounds student understanding of their role within an integrated national, regional and global context. In these efforts, advocates have looked to historical educational interventions, especially in times of war, to propose new models of peace education. Montessori's proposed White Cross organisation, initially inspired by the aim to serve child survivors of war in the early twentieth century, has helped to inform crisis-care for learners living in violence today[1]. In other settings, survivors of genocide describe the benefit of explicit school-centered supports for forgiveness and peace education.

Berkowitz' PRIMED model of civic education, which includes a focus on the global community and individual efforts to become agents of peace, may build upon models of compassionate practice and restorative justice[2]. The model comprises Prioritisation of character education, Relationships in school and with external stakeholders, Intrinsic motivation, Modeling, Empowerment, and adopting a Developmental perspective.

Various organisations provide resources for teachers:

- The environmental charity Global Action Plan provides a teacher toolkit for implementation of global citizenship learning in school settings, including resources for developing students' awareness of sustainable development, ecological foot printing, climate change, global justice, and global impact of poverty and inequality.
- Childhood Education International, a US-based nonprofit, is a valuable clearinghouse for teacher and community development. AnjiPlay, a model that incorporates global citizenship preparation through play, emphasises the need for love, risk, joy, engagement, and reflection in early childhood learning. The model has been implemented throughout China in publicly funded early childhood centers and serves more than 14,000 children in settings that preserve the right of every child to self-directed, unguided and uninterrupted play.

- *Libraries Without Borders* has developed the 'Ideas Box,' pop-up media and learning centers that can be distributed in refugee contexts and to respond to internally-displaced learners in areas of political conflict. This easily adaptable system can be dispatched quickly to protect children's right to learn, and currently has programmes active throughout the countries of the middle east and northern Africa.

Challenges, barriers, limitations

Adopting impactful peace education practices is not without its challenges. Schools and teachers may question the value of these practices when faced with limited time and increased performance pressures for other academic goals. There is a risk of misunderstandings about 'pedagogies of peace' compared to social and emotional learning, conflict resolution, classroom management or other civic education models. Political challenges may arise to the inclusion of the embedded pedagogies in education for peace, as these pedagogical models include equity and justice centered practices that foreground the inclusion of diverse perspectives. In communities torn by violence, stakeholders may underestimate the potential for peace education practices or the immediate need for children's play, community and education. In these spaces, resources may be limited.

Conclusions

As the world community shrinks and global conflicts grow, educators will increasingly feel the impact of external conflicts within their classrooms. Compassionate practices show promise for supporting both individual resilience and positive classroom cultures. These practices begin with teacher education and self-assessment, and expand to support the development of healthy, relational climates in classrooms where learners access the most immediate impact. Restorative justice practices may strengthen classroom, school and community responses to long-standing disparities in access and opportunity. These practices expand beyond the school setting to incorporate local and community stakeholders, other nonprofits and the local judicial system, rebuilding communities toward restoration and justice and away from the inequities perpetuated by punitive policies. Global citizenship as a focus in the classroom may help to develop student capacity and support healing after trauma. As an immediate intervention, global citizenship practices can decrease the interruption of learning and defend the rights of children to play in communities struck by violence. While often undervalued or relegated to enrichment, pedagogies of peace are most impactful when they are foregrounded as a foundation on which other learning occurs.

References

1. A comprehensive review of the literature related to empathy and compassionate practices in classroom activities:

   Zaky, H. (2024) 'Adult education and empathy', *International Journal of Curriculum Development and Learning Measurement*, 5(1), pp. 1–18. Available at: https://doi.org/10.4018/ijcdlm.339913 (Accessed 26 June 2024).

2. A paper exploring the role of extended families as First Teachers in iTaukei and Indo-Fijian Early Childhood contexts in Fiji, using 'storying':

   MacGill, B. M., Jattan, S., Lal, D., Narain, B., Neill, B., Nayaca, T., Diamond, A., and Camaitoga, U. (2023) 'Ethics of care: Pedagogical encounters from Oceania', *Qualitative Research Journal*, 24(1), pp. 39–48. Available at: https://doi.org/10.1108/qrj-05-2023-0085 (Accessed 26 June 2024).

3. A qualitative case study into the ethics of care and compassionate teaching practices post-pandemic:

   Vandeyar, S. (2021) 'Educational transmogrification: From panicgogy to pedagogy of compassion', *Teaching in Higher Education*, 28(8), pp. 2160–2172. Available at: https://doi.org/10.1080/13562517.2021.1952568 (Accessed 26 June 2024).

4. A chapter highlighting three different levels of restorative justice within an urban, US-based school district, including teacher education, standalone classes and whole-school interventions:

   Carroll, J.S., Kaugers, A., and Grynch, J. (2022) 'Diverse Approaches for Implementing Restorative Practices in Schools in the US', In: Velez, G., Gavrielides, T. (eds) *Restorative Justice: Promoting Peace and Wellbeing*. Peace Psychology Book Series. Springer, Cham. Available at: https://doi.org/10.1007/978-3-031-13101-1_1 (Accessed 26 June 2024).

5. A study describing the impact on student empathy, respect and agency in school settings using restorative justice practice:

   Gregory, A., Clawson, K., Davis, A., and Gerewitz, J. (2015) 'The Promise of Restorative Practices to Transform Teacher-Student Relationships and Achieve Equity in School Discipline', *Journal of Educational and Psychological Consultation*, 25(4), pp. 325–353. Available at: https://doi.org/10.1080/10474412.2014.929950 (Accessed 26 June 2024).

6. An integrative review of practices and theories of peace education including an emphasis on decolonization as a foundation for critical peace education in theory and practice:

   Hajir, B., and Kester, K. (2020) 'Toward a decolonial praxis in critical peace education: Postcolonial Insights and Pedagogic Possibilities', *Studies in Philosophy and Education*, 39(5), pp. 515–532. Available at: https://doi.org/10.1007/s11217-020-09707-y (Accessed 26 June 2024).

Resources

- An historical study of Montessori's interventions for children in adversity or trauma, particularly from war-torn communities, that led to the White Cross, and a series of recommendations for implementing Montessori methods in trauma-informed practice:

  Phillips, B., O'Toole, C., McGilloway, S., and Phillips, S. (n.d.) 'Montessori, the White Cross and trauma-informed practice: Lessons for contemporary education', *Journal of Montessori Research*. Available at: https://eric.ed.gov/?id=EJ1345390 (Accessed 26 June 2024).
- A teacher-friendly guide for implementing a six-component framework for purposeful learning, virtue-based learning and healthy relationships in peace-education classrooms:

  Berkowitz, M. W. (2021) *PRIMED for character education: Six design principles for school improvement*. Routledge (Taylor & Francis Group).
- Teacher-and-leader-development institute with online resources for parents, teachers and other advocates of peace education:

  Primed. Center for Character & Citizenship. (n.d.). Available at: https://characterandcitizenship.org/primed (Accessed 26 June 2024).
- An online clearinghouse of peace education news, current events and teacher resources, centered in Lansing, Michigan, US, with resources available for a global audience:

  Peace Education Center (2024) *Welcome to the hub for Peace and Justice in the Greater Lansing Area!* (30 January). Available at: https://www.peaceedcenter.org/ (Accessed 26 June 2024).
- A free resource describing the theoretical foundations and implementation of restorative justice practices in K-12 school settings, including case studies and teacher development resources:

  We are Teachers. Available at: weareteachers.com/restorative-justice/ (Accessed 26 June 2024).
- A practice-as-research based arts-integrated approach for peacebuilding through education, with current sites in Indonesia, Kyrgyzstan, Nepal and Rwanda:

  Mobile Arts for Peace (MAP). (n.d.). Available at: https://map.lincoln.ac.uk/ (Accessed 26 June 2024).

  Podcast series from this project: https://map.lincoln.ac.uk/podcasts/ (Accessed 26 June 2024).
- A resource for curriculum and instruction for classroom teachers funded by the Southern Poverty Law Center, focused on the advancement of human rights through the dismantling of white supremacy and the strengthening of intersectional movements toward peace:

  Learning for Justice (n.d.). Available at: https://www.learningforjustice.org/ (Accessed 26 June 2024).
- UNESCO's Recommendation on Peace, Human Rights and Sustainable Development, was adopted by UNESCO's 194 Member States in November 2023. Its full title is as follows:

  Recommendation on Education for Peace and Human Rights, International Understanding, Cooperation, Fundamental Freedoms, Global Citizenship and Sustainable Development (2023). Available at: https://www.unesco.org/en/global-citizenship-peace-education/recommendation (Accessed 26 June 2024).

Climate action pedagogy

Empowering teachers and learners to take meaningful actions towards climate change

Introduction

Climate change is a reality that most of us have now experienced and learned about. Climate change refers to severe changes in global temperatures and weather patterns[1]. These changes can be caused by natural events such as the sun's activities, but in the last 200 years the majority of global climate change has been caused by human activity – also known as anthropogenic climate change[2].

There seems to be a sense that we might be running out of time to stop these changes taking place, and this can cause anxiety and distress in most people[3]. It is crucial that educational systems prepare teachers and learners for the urgent need to address environmental issues. By educating people about the causes and consequences of climate change, we can empower them to make informed decisions and take meaningful actions to mitigate its effects[4].

Recently, many pedagogical approaches have emerged as attempts to support teachers and learners to understand this phenomenon further, including planetary social pedagogy (see Resources), climate-kind pedagogy (see Resources), ecojustice pedagogy[4], becoming designers with Earth[2], climate action pedagogy[5] (elaborated below), and many more. The common goal of these educational approaches is to assist teachers and learners in integrating climate change principles into the curriculum.

Climate action pedagogy in practice

Climate action pedagogy (CAP) requires teachers to have multiple skills and knowledge so that they can engage students with the immediacy of the climate crisis, and create a curriculum that supports world problem solving, social innovation and societal transformation[5]. CAP is a vital approach to cultivating environmental awareness, inspiring sustainable behaviours, and empowering individuals to become agents of change in the fight against climate change. There are several approaches and strategies to help educators incorporate CAP into their teaching practices.

The climate is changing. So should we. Approaches are being developed to address this through education.

Create a climate-conscious curriculum

One approach to adopt CAP is by infusing climate change topics across various subjects and grade levels to promote interdisciplinary learning. This infusion should be supported by current scientific research, case studies, and real-world examples to illustrate the urgency and impact of climate change. There are many examples of such infusions in science disciplines, but also in arts, health education and even in language studies. Sriwijaya University in Indonesia has included climate change related topics into the curriculum of their Program in English Language Education. In the initial pilot, 20 preservice teachers explored climate change related topics within a semester-long creative writing course. Analyses of classroom discussions, reflective writing, and picture book projects indicated that the participants' awareness of climate change issues developed as they engaged with the projects that required their understanding of the global climate issues and connected them with their local contexts[4].

> outdoor education is uniquely positioned to witness the impacts of climate change first hand

Foster environmental care

Another approach that could help educators and learners to engage with CAP is by creating opportunities to foster care for the environment. This could be done by:

- facilitating hands-on experiences such as outdoor learning, gardening, or waste reduction projects to promote a sense of environmental responsibility
- organising field trips to sustainable facilities, renewable energy sites, or local ecosystem reserves to connect students with tangible examples of environmental conservation efforts
- encouraging students to take ownership of sustainability initiatives within the school/university community, such as recycling programmes or energy-saving campaigns.

However, some of these activities can be directly affected by climate change. Scott Jukes[6], promoting outdoor environmental education (OEE), highlights that outdoor education is uniquely positioned to witness the impacts of climate change first hand. He notes that the necessity to cancel fieldwork programs because of catastrophic bushfires, floods and other extreme weather events has significantly shaped the way fieldwork programs are conducted. But he also developed examples of practice where climate change education is delivered through OEE, which take advantage of pedagogic moments (i.e., opportunities where significant teaching and learning can occur) and offer curriculum development strategies for climate change education within OEE[6].

Promote climate literacy and awareness

Building capacity, developing literacy and raising awareness of educators and learners constitutes perhaps one of the most important approaches in CAP. It is only through building their capacity, literacy and awareness that teachers can make informed decisions about how to incorporate CAP into their practice. There are several teaching strategies that can be adopted and adapted to raise learners' awareness of climate change, including the use of films, documentaries and interactive tools. Teachers can also facilitate discussions on climate justice, equity and the disproportionate impact of environmental issues on marginalised communities. These activities have the potential to empower students to engage in dialogue, and to work on collaborative projects that foster awareness of global environmental challenges and promote the importance of collective action. However, it is important that these activities and resources are age-appropriate, as the reality of current and future global climate conditions can be stressful for learners and create climate anxiety[2]. Many online resources have been created to develop teachers' and learners' skills on climate change topics. An example of such resources is the freely available course on the OpenLearn platform titled *Supporting climate action through digital education*[7] developed by The Open University, UK.

Empower student advocacy

Empowering student advocacy in CAP is essential for fostering a sense of responsibility, agency and collective action in tackling one of the most pressing challenges of our time. By investing in students as advocates for climate action, we are nurturing a more informed, engaged and empowered society, ready to address the complexities of climate change. Ways in which teachers can promote student advocacy include encouraging students to research local environmental issues, propose solutions, and advocate for policy changes within their community. Teachers and educational institutions should support student-led initiatives, clubs, or campaigns focused on environmental activism, climate justice and sustainable practices. An example of student advocacy initiative was developed by a group of medical students at McMaster University in Ontario, Canada, where the students engaged in advocacy efforts to improve the education of medical students on the impacts of climate change and health[8]. The project consisted of an elective lecture series including two sessions with guest speakers and a three-part online component. Students also advocated for formal curricular change, involving the integration of a mandatory lecture on climate and health into McMaster's medical training curriculum[8].

Assess and reflect

This is an approach that can be used in combination with all the CAP approaches above as it gives the opportunities for teachers and learners to reflect on what they have learnt, and create opportunities for action and improvement. Teachers can encourage reflection through reflective journals entries, students' presentations, art projects, or multimedia creations that allow students to express their learnings and personal connections to climate action. For CAP to succeed, it is important to create a cycle of reflection and review, and to refine climate action pedagogy practices based on feedback, student engagement, and the evolving landscape of environmental challenges[2,3,7].

Challenges, barriers, limitations

Although important and timely, this pedagogy brings several challenges for teachers and their students. One of the challenges is that our responses to climate change and thus climate action, are constantly evolving[4]. As such, a challenge exists around continuously reviewing and refining the curriculum and teaching materials to encompass the evolving landscape of the changes, rather than creating a fixed curriculum. Keeping up with this evolving curriculum means frequently building teacher capacity, which is time consuming and adds to the already high workload of teachers.

Another challenge is related to how teachers and students respond to and process the facts and reality of a warming world. Emerging evidence indicates that a large number of young people around the world are feeling distress, fear and anguish associated with climate change and the consequences of ecological crises[2]. To support teachers and students, schools need to provide secure spaces for students to express anxieties and fears, fostering a foundation for cultivating optimistic perspectives for the future.

Conclusions

By integrating some of the practical strategies of CAP into teaching practices, educators can cultivate a generation of environmentally conscious individuals who are equipped to address the pressing challenges of climate change. Climate action pedagogy not only empowers students to become informed global citizens but also instils a sense of responsibility towards creating a sustainable future for all.

Teaching learners about climate change cannot simply be about giving them facts. CAP and other related pedagogical approaches can help students become more climate sensitive and agents of change. Learning and teaching approaches should enhance student abilities and confidence in demanding accountability of those who are in power and in participating in collective action to facilitate system and behavioural change in ways that are age and culturally appropriate.

References

1. United Nations website with information and helpful visuals about climate change:

   United Nations (n.d.) *What Is Climate Change?* Available at: https://www.un.org/en/climatechange/what-is-climate-change (Accessed 25 June 2024).

2. A paper about an account of a design inquiry for first year students that questions the realities, remit and structuring of design education, from within ecological and existential crises:

   Fountain, W., and Carleklev, S. (2023) 'Becoming designers with Earth: propositions for design education', in Derek Jones, Naz Borekci, Violeta Clemente, James Corazzo, Nicole Lotz, Liv Merete Nielsen, and Lesley-Ann Noel (eds.), *The 7th International Conference for Design Education Researchers, 29 November* – 1 December 2023, London, United Kingdom. Available at: https://doi.org/10.21606/drslxd.2024.069 (Accessed 25 June 2024).

3. A paper about a pedagogical model developed to enable hope-based pedagogy in Climate Change Education:

   Finnegan, W., and d'Abreu, C. (2024) 'The hope wheel: a model to enable hope-based pedagogy in Climate Change Education', *Frontiers in Psychology*. 15(1347392). Available at: https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2024.1347392/full (Accessed 25 June 2024).

4. A paper about integrating climate change related topics into English learning education curriculum:

   Silvhiany, S., Kurniawan, D., and Safrina, S. (2023) 'Climate change awareness in ELT: Ethnography in connected learning and ecojustice pedagogy', *Journal of English Language Teaching Innovations and Materials (Jeltim)*, 5(2), pp. 91–109. Available at: https://jurnal.untan.ac.id/index.php/JELTIM/article/view/63548 (Accessed 25 June 2024).

5. A paper that considers higher education's role in climate crisis, reflecting on the potential of action-oriented pedagogy. As a reflection on practice, the authors consider a new postgraduate course, Climate Crisis and Action (CCA):

   Leimbach, T., and Milstein, T. (2022) 'Learning to change: Climate action pedagogy', *Australian Journal of Adult Learning*, 62(3), pp.414–423. Available at: https://files.eric.ed.gov/fulltext/EJ1370386.pdf (Accessed 25 June 2024).

6. A chapter about the impact of climate change in outdoor environmental education and examples of practice where climate change education is delivered through OEE:

   Jukes, S. (2023) 'Responding to Climate Change Through Outdoor Environmental Education: Pedagogy for Confronting a Crisis', In: 'Learning to Confront Ecological Precarity', *International Explorations in Outdoor and Environmental Education*, 13, Springer, Cham. Available at: https://doi-org.libezproxy.open.ac.uk/10.1007/978-3-031-34200-4_11 (Accessed 25 June 2024).

7. A free course available in the OpenLearn platform about Supporting climate action through digital education:

   The Open University (2024) *Supporting climate action through digital education*. Available at: https://www.open.edu/openlearn/education-development/supporting-climate-action-through-digital-education/ (Accessed 25 June 2024).

8. A paper about a student-driven advocacy project about including climate change topics in the curriculum in a Canadian Medical school:

   Hansen, M., Rohn, S., Moglan, E., Sutton, W., and Olagunju, A. T. (2021) 'Promoting climate change issues in medical education: Lessons from a student-driven advocacy project in a Canadian Medical school', *The Journal of Climate Change and Health*, 3(100026). Available at: https://www.sciencedirect.com/science/article/pii/S2667278221000249 (Accessed 25 June 2024).

Resources

- A blog post on the Global Partnership for Education: Transforming Education titled 'Towards a pedagogy for climate action', written by Selby and Kagawa in 2022:

  Available at: https://www.globalpartnership.org/blog/towards-pedagogy-climate-action (Accessed 25 June 2024).
- A paper about a theory of planetary social pedagogy (PSP), which considers the kind of pedagogy that could support a transformation of the human conception of reality into a form that both recognises the connections and interactions between people, society, and the planet, and imparts an ethical orientation to action that strengthens the health and integrity of all entities:

  Salonen, A.O., Laininen, E., Hämäläinen, J. and Sterling, S. (2023) 'A Theory of Planetary Social Pedagogy', *Educational Theory*, 73, pp. 615–637. Available at: https://doi.org/10.1111/edth.12588 (Accessed 25 June 2024).
- A project report about creating a novel pedagogical framework designed to address the climate crisis through kindness and compassion for the planet and one another:

  Johnston, H. (2022) 'Developing a novel pedagogical framework: Climate-kind pedagogy'. Available at: https://sustain.ubc.ca/about/resources/developing-novel-pedagogical-framework-climate-kind-pedagogy (Accessed 25 June 2024).
- A report developed by the Commonwealth of Learning, which provides a road map for how ministers of education can climate-proof education systems, implement a green learning agenda that builds skills for blue and green economies, and promote education for climate action through policy development, resource allocation and effective implementation:

  Kwauk, C. (2022) 'Transforming Education for Climate Action: Report to Commonwealth Ministers of Education'. Available at: https://oasis.col.org/items/bf61e5a6-9d8d-474b-86a6-0085fdfeea51 (Accessed 25 June 2024).
- An expanded guide of fiction to engage your students in an imaginative exploration of the climate crisis. This guide, accessible online and as a PDF, includes lists of poems, short stories, novels, and films to consider reading and discussing with students, including, in some cases, questions for discussion:

  Outterson-Murphy, S. (2023) 'Climate Change Fiction for Students and Teachers' *Morningside Center for Teaching Social Responsibility*. Available at: https://www.morningsidecenter.org/teachable-moment/lessons/climate-change-fiction-students-and-teachers-0 (Accessed 25 June 2024).

Learning in conversation with Generative AI

A dialogic, real-time method of learning

Introduction

Generative Artificial Intelligence (GenAI) has taken the world by storm with applications such as ChatGPT and Gemini being released at a rapid rate. The style of communication and conversation with tools such as ChatGPT resembles Socratic questioning and dialogic teaching[1], with learners posing questions and asking for clarifications to the answers they receive, and the AI replying and further prompting them, thus engaging people in a dialogue through which they can learn.

GenAI chatbots are dialogue-based online systems that can receive requests or questions in the form of text (and increasingly images and spoken words) from users, called prompts, and generate human-like language responses. They can reply to questions and statements with a wide variety of outputs ranging from simple answers to generated stories, poems, essays and more, in real time in the form of a conversation with the person prompting them[2].

Generative AI as a 24/7 virtual tutor

The idea of having access to a 24/7 (always available) teacher that can help students with their studies is enticing. GenAI promises to do this through AI digital tutoring assistants or chatbots that can either answer student questions regarding a topic or pose questions to students to check their understanding of content.

University students seem enthused about the idea of having access to a virtual tutor assistant whenever they need it. They report benefits in terms of having real-time assistance, getting immediate answers to their questions and receiving support on how to do specific academic tasks. Yet, they are also found to be concerned about the privacy of their data when using such systems and the potential for misuse by other students (for example, cheating in assessed academic work). They would particularly welcome AI assistants that make use of institutional content rather than any content on the web[3] to address concerns about accuracy, quality and relevance to their studies.

One such system is the AI tutor of Khan Academy, Khanmigo, that gives students personalised support and guidance on maths, science and humanities. It suggests topics students can study and asks follow-up questions based on their responses to help them to identify mistakes and improve their understanding.

Such tools can promote personalised learning that responds to the learning needs of each individual. A student can ask GenAI for explanations at different levels of depth (e.g., 'Explain quantum mechanics in terms a 7th grader would understand') or related to their interests ('Explain the economics principle of supply and demand using examples from the music industry'). Students can also request that answers be given in a culturally relevant way, such as 'I'm a British-Iranian high school student studying poetry. I need to better understand how poets use comparisons. Can you give me some examples using poems by Hafez, which I used to hear when I was little?.'

> Even after using best-in-class models, the content created still needs human adjustments and checking

Conversing with Generative AI in simulation and role-play

Leveraging AI's conversational features, students can get immersed in interactive scenarios, practising and honing their skills within a safe, controlled setting. This approach is particularly effective for learning that requires interpersonal interaction, offering realistic contexts for language acquisition, medical diagnostics, and more.

A female student in a classroom pointing to an AI human-like robot in front of her

In language learning, AI-facilitated simulations let learners practise in various scenarios, such as ordering from a waiter in French at a Parisian café or discussing travel plans for the Great Wall of China with an explorer in Mandarin. This immersive practice can not only boost conversational fluency and listening skills but also introduces learners to the cultural nuances of language use, like the many different terms for 'straw' in Spanish used across Latin American countries. This is something that students can ask an AI chatbot to do, or they might use a specialised tool like Duolingo Roleplay which provides tailored conversational partners for this purpose. If a learner wants to go deeper culturally or historically, they can engage in immersive game-based problem-solving as described in the Immersive Language and Culture section of this report.

Simulation and role-playing with GenAI can also be useful for professional skill development; for example, preparing for job interviews, or medical diagnosis based on (simulated) patient interviews. By taking on various roles, GenAI can simulate different stakeholders in a variety of professional settings with different kinds of characteristics (e.g., secure an advantageous contract to produce snack bars with someone who takes a competing approach to negotiation), providing learners with a diverse range of interactive experiences. GenAI can also be helpful in taking on the role of an intellectual sparring partner, particularly in fields requiring robust argumentation like law, philosophy, and ethics. By challenging learners to defend their viewpoints, identify logical fallacies, and counter opposing arguments, GenAI can help them both improve a specific argument to be made and sharpen their critical thinking and debate skills.

Generative AI as a curriculum partner for teachers

GenAI also has the potential to become a collaborator for teachers in the production of educational resources and activities. This use of AI showcases how a dialogue between a teacher or course designer and AI can develop for supporting the creation of learning content such as lesson objectives, assessment rubrics and interactive activities. Important in doing so is careful, creative and iterative prompting of the AI and critical evaluation of the responses it generates both with respect to content veracity and inclusiveness of course designs.

To partner with AI in producing useful course resources, it is helpful to leverage known prompting strategies[4, 5] such as:

- providing detailed information about the learning context
- giving examples of the kinds of activities or materials you are looking for
- asking the AI to take on a persona (e.g., 'you are an expert curriculum developer...')
- splitting complex tasks into several smaller tasks
- providing recipe-like instructions of the steps the AI should follow
- adding key instructions at the end of a prompt.

It can be valuable to provide the AI with pedagogical principles to follow in its creations, for example designing for inclusivity, active learner engagement, and student collaboration. Specific prompts have also been developed to support educators in these tasks (for example, see the Github repository 'Prompts for Education'), such as a prompt for planning lessons or generating ideas for assignments.

Early evaluation of efforts to create curriculum with AI suggests that it can aid with brainstorming ideas, creating an outline, assessing adherence to specific writing guidance (such as readability and inclusive language)[6]. Yet, it is worth noting that GenAI outputs need to be verified by topic experts who can comment on how the prompts are designed, the quality of the materials produced and their suitability in teaching. Even after using best-in-class models, the content created still needs human adjustments and checking, ranging from small tweaks to wholesale regeneration to make it suitable for the learning context it is being designed for (e.g., online learning university, elementary classroom, science museum).

Challenges, barriers, limitations

While the possibilities for learning through dialogue with GenAI are diverse and exciting, there are also important challenges to note. Initially, students have shown varying levels of engagement; these range from rich in-depth learning conversations to simple requests to be given 'the answer'. Some students resist interaction, for example replying 'idk' ('I don't know') to all questions the chatbot asks. This highlights the need for guidance (for students and teachers) in AI literacy, including how to 'talk' to GenAI to foster productive dialogue and how to critically assess the GenAI's responses. The latter is crucial as GenAI models represent how things are talked about generally, not according to verified disciplinary knowledge. As a result, these models are known to produce 'hallucinations' – responses that sound believable but are actually incorrect or outdated. These same concerns are important for educators to be aware of and identify how to overcome; for example by instructing AI to answer using information from specific resources. GenAI responses may also oversimplify complex concepts or add irrelevant details to an explanation. Together, these create a danger of generating misconceptions and/or shallow learning. Research has also shown that people may tend to rely on AI, rather than learn from AI or work in collaboration with AI[7].

Another concern is the risk of perpetuating social biases in the training data, such as returning fewer examples of women and people of colour when asking about scientists who have made a difference in a given field[8, 9]. One example of a model built on a more diverse training set, including sources that have data from indigenous oral tradition, is Latimer.ai. Unequal access to the latest and most advanced GenAI models, which are generally not free, can also exacerbate educational inequalities giving some students or educators access to better tutors, curriculum partners, or simulators than others. Finally, privacy concerns surrounding the use and storage of student data by GenAI platforms must be addressed to safeguard students' personal information.

Conclusions

This pedagogy has potential to support students' critical questioning and argumentation skills. This will be increasingly important as GenAI generated information becomes more prevalent and requires a more critical stance. GenAI is expected to improve over time, presenting new and unanticipated capabilities. This may have different implications for how students learn and engage with GenAI outputs.

References

1. An overview of the Socratic approach and dialogic teaching:

   Prendergast, D. (2021) 'An investigation into the impact of dialogic teaching and Socratic questioning on the development of children's understanding of complex historical concepts'. Available at: https://durham-repository.worktribe.com/output/1140584 (Accessed 26 June 2024).

2. A brief overview of what ChatGPT is and how it can be used in education:

   University of Central Arkansas, Center for Excellence in Teaching and Academic Leadership (2024) 'Chat GPT: What is it?'. Available at: https://uca.edu/cetal/chat-gpt/#:~:text=One%20of%20the%20key%20features,stories%2C%20essays%2C%20and%20poems. (Accessed 26 June 2024).

3. University students' perceptions of using a GenAI digital assistant in their studies:

   Rienties, B., Domingue, J., Duttaroy, S., Herodotou, C., Tessarolo, F., and Whitelock, D. (2024) 'I would love this to be like an assistant, not the teacher: a voice of the customer perspective of what distance learning students want from an Artificial Intelligence Digital Assistant', *arXiv preprint arXiv:2403.15396*. Available at: https://arxiv.org/abs/2403.15396 (Accessed 26 June 2024).

4. A guide on how to create good prompts:

   Open AI developer platform (2024) *Prompt engineering*. Available at: https://platform.openai.com/docs/guides/prompt-engineering/six-strategie (Accessed 26 June 2024).

5. Some advanced techniques in prompt design and prompt engineering:

   Microsoft Azure (2024) *Prompt engineering techniques*. Available at: https://learn.microsoft.com/en-us/azure/ai-services/openai/concepts/advanced-prompt-engineering?pivots=programming-language-chat-completions (Accessed 26 June 2024).

6. A paper showing early findings from using GenAI in the design of an online course:

   Ullman, T., Bektik, D., Edwards, C., Herodutu, C., and Whitelock, D. (2024) 'Teaching with Generative AI: Moving Forward with Content Creation', EDEN 24 Annual Conference, Graz, Austria.

7. Research study examining how students interact with AI in relation to their learning agency:

   Darvishi, A., Khosravi, H., Sadiq, S., Gašević, D., and Siemens, G. (2023) 'Impact of AI assistance on student agency', *Computers & Education*, 210(104967). Available at: https://doi.org/10.1016/j.compedu.2023.104967 (Accessed 26 June 2024).

8. A paper discussing bias in large language models in stigmatised groups:

   Mei, K., Fereidooni, S., and Caliskan, A. (2023) 'Bias against 93 stigmatized groups in masked language models and downstream sentiment classification tasks', *Proceedings of the 2023 ACM Conference on Fairness, Accountability, and Transparency* (pp. 1699–1710).

9. A paper discussing bias in large language models in relation to queer people:

   Dhingra, H., Jayashanker, P., Moghe, S., and Strubell, E. (2023) 'Queer people are people first: Deconstructing sexual identity stereotypes in large language models', *arXiv Preprint*. Available at: https://arxiv.org/abs/2307.00101 (Accessed 26 June 2024).

Resources

- An example of a GenAI virtual tutor assistant called Khanmigo produced by Khan Academy:

  Available at: https://blog.khanacademy.org/parents-khanmigo/ (Accessed 26 June 2024).

- A video discussing how a GenAI virtual tutor works produced by the Khan Academy Chief Learning Officer Kristen DiCerbo and GSV Ventures VP Claire Zau:

  Available at: https://www.youtube.com/watch?v=h6QOR1nRgXI (Accessed 26 June 2024).

- A personalised language learning tool, Duolingo, that makes use of GenAI to support language learning:

  Available at: https://blog.duolingo.com/duolingo-max/ (Accessed 26 June 2024).

- A prompt library to turn GPT4, Claude, Gemini, Bing into tutors, feedback engines, negotiation simulators and more written by Dr Dr. Ethan Mollick and Dr. Lilach Mollick:

  Available at: https://www.moreusefulthings.com/student-exercises (Accessed 26 June 2024).

- Two papers that provide examples of prompts:

  Mollick, E., and Mollick, L. (2023) 'Assigning AI: Seven approaches for students, with prompts'. Available at: https://arxiv.org/abs/2306.10052 (Accessed 26 June 2024).

  Mollick, E., and Mollick, L. (2023) 'Using AI to Implement Effective Teaching Strategies in Classrooms: Five Strategies, Including Prompts', *The Wharton School Research Paper*. Available at: https://ssrn.com/abstract=4391243 (Accessed 26 June 2024).

Talking AI ethics with young people

Affording children and young people their rights related to AI and education

Introduction

Digital technologies, including developments in artificial intelligence (AI) and automation, have brought many changes in the world. This is especially true for young people, many of whom are growing up in an increasingly digitally-enabled environment, with technologies being a key aspect of the ecosystem of their everyday lives. The impact is felt in all aspects of their family life, play and leisure activities, communication, and education. Over the years various concerns have been raised around children and young people's participation in digital spaces and use of digital tools. These have intensified following recent rapid developments and deployment of forms of AI due to a growing recognition of high commercial interests within industry, and associated evidence that points to children's long-standing protections being ignored online (e.g., rights to privacy)[1].

As a result, advocates have pushed towards centring children and young people's rights and interests in the current global debates around AI (e.g., work by 5Rights Foundation). Representing and addressing children's interests and rights in the emerging digital landscape is a pressing issue to consider. This pedagogy considers the criticality of foregrounding the voices of children and young people in the design, development and implementation of AI tools in education. It highlights a stronger emphasis on pedagogical practice involving talking to children about AI and understanding how children themselves might be able to approach such issues outlined above so they can participate equally, knowledgeably and safely. This pedagogy is about supporting children's 'lived experiences' and voices and ensuring that these occupy a prominent place in discussions and initiatives related to AI in Education.

More than an afterthought: Putting youth perspectives on AI ethics first

The United Nations Convention on the Rights of the Child (UNCRC)[2] in 1989 called for greater levels of child and youth engagement, and the opportunity for children and young people to have a voice. This is still highly relevant today. Children and young people's views on their digital lives matter, and they have a lot to say about the elements of the digital world they engage with. Children for example, gain agency, pleasure and value from the digital world but they get frustrated when digital design, provision and regulation fail to meet their needs[3]. Children not only have the right to express their views on such matters but also that their views are taken seriously by adults and are actioned in ways that change and improve children and young people's lives. For this reason, in the report 'Children and Young People's Voices' commissioned by the Digital Futures Commission and 5Rights Foundation, Mukherjee and Livingstone[3] stressed that children's interests and rights often come as an 'afterthought'. To address this issue, children's perspectives need to come first and be framed within a holistic rights-based framework informed by advances in childhood ethics and rights.

In a recent interview, Professor Sonia Livingstone, based at the London School of Economics[4], explained that there have been two main ways of addressing such issues: on the one hand, she says, it is about recognising the risks associated with children being exposed to materials and matters thought to be inappropriate and harmful to children. Examples may include pornography, deepfakes, exploitation, child trafficking, sexual violence, addiction, radicalisation and so on. On the other hand, it is about recognising the opportunities offered by digital technologies such as expanding and augmenting access to educational opportunities, offering opportunities to communicate with friends and family (near and distant) and so on.

In the same interview[4], Livingstone referred to children demanding greater digital literacy: *'they want to understand the technology better, they want to know how to sift truth from falsehood, they want to understand the business models. And they want their parents and teachers and others who might assist them to have those digital skills as well. Otherwise, they face a key barrier'*.

It is indeed critical to learn from children and young people's experiences of engaging with digital technologies, and to listen to what they want and expect from the key players who could make a difference to their (digital) lives. It is also about translating their ideas into meaningful action and advocacy work.

From talking to doing: Engaging with Ethics in AI and Education

Several initiatives are being taken worldwide to shape the regulatory environment and associated legislation, with the most important development the recently passed *Artificial Intelligence Act (AI Act)*, a European Union regulation on AI which aims to establish a common regulatory and legal framework for AI. Many initiatives also look to establish ethical principles for the adoption of AI in education[5], including the processes needed to understand and make pedagogical choices that are ethical, and to account for the ever-present possibility of unintended consequences.

An area of concern is related to generation and use of educational data where data, indicators and metrics are increasingly defining school and university cultures. Data has always been collected from children and young people in education settings and can offer valuable insights. However, the volume and types of data processed have grown exponentially in recent years. Young people have little choice and control over this, and they, their parents, and school/educators, are often unaware of the extent or purposes of this data processing within or beyond the education system. Therefore, children and young people's education data is a key area to focus on when engaging with ethics.

A relevant example is from an initiative at the University of Technology in Sydney (UTS)[6]. This involved a novel community consultation process at UTS, using the principles and methods of Deliberative Democracy to consult with the UTS community on the following question: *What principles should govern UTS use of analytics and artificial intelligence to improve teaching and learning for all, while minimising the possibility of harmful outcomes?*. The consultation process was implemented with UTS students, tutors and academics, and experts, who engaged in a series of five online workshops over several weeks. The outputs of the process offer a representative expression of the community's values, interests and concerns, in response to this brief, with an aim to influence how these technologies are being deployed responsibly in the university.

> Children and young people's views on their digital lives matter and have a lot to say about the elements of the digital world they engage with.

Another example is related to making national policies around AI more accessible and relevant to young people. One team of educators in the United States sought to redesign the White House's *Blueprint for an AI Bill of Rights* for and with younger audiences[7]. Students were asked to critically examine extant policies and ethical frameworks, and apply them to the ways that they use and are used by AI in their own daily lives. In their local context, this meant asking students to adapt a framework like the *Blueprint*, redesigning and/or remixing the text to suit their needs and creating art and text to feature rights that are most important to them. However, this same pedagogical approach may be applied in other contexts, with other local or national policies. It can also include involving students in collaboratively setting policies and expectations for use of technology in classrooms alongside educators.

Young people interact with 'Glow', an installation which generates photorealistic images of faces and allows various attributes of these to be altered.

Challenges, barriers, limitations

A main challenge is related to the nature of the fast-changing environment of AI in education. Those who are placed in a position of responsibility such as educators, parents and other caregivers, are often not able to respond knowledgeably, lacking the knowledge and capacity to assist young people themselves, so they too should be supported. This also applies to policy makers, who need to have the skills and knowledge to understand how to introduce a rights-based approach to digital environment they are regulating. An orchestrated approach should take place where industry, government and other key players must collaborate to offer accessible family- and child-friendly resources, designs and support (which may become obsolete rapidly given on-going developments).

Another challenge is the variations in terms of how children's rights are defined and protected worldwide, with major differences across national legislative frameworks. Many countries have enacted or are considering national legislation to protect children's rights, which will enable monitoring and enforcement of legislation and breaches when it comes to children's data. This means that technology companies operating at global levels need to work within diverse local frameworks and this will require substantial investment on their side in navigating such diverse frameworks. This may also affect efforts to encourage industry stakeholders to consider ethics and children's rights as they develop tools and content.

Finally, one challenge is related to moving from ideation about AI ethics/rights toward advocacy and change. It is easy to ask young people to dream about how they want their world to look, but much harder to translate that into action (like legal protections, meaningful opportunities). Barriers to translating talk to action include youth status (especially dependent upon geopolitical context) and corporate control of many AI tools and related documentation about how they work/were trained.

Conclusions

This pedagogy draws on a rights approach to children and young people's participation in the digital environment and necessitates action to mitigate risks, avoid harm and optimise opportunities for youth, including taking part in co-design processes. The pedagogy is phrased as an action (i.e., 'talking') to emphasise human action and values in determining how communities and their practices, socio-technical designs and systems, economic logics and political factors help or fail to serve children and young people's interests. It offers a practical step that may contribute towards realising children's rights in the digital environment.

This may be about 'reaching out' to young people and inviting them to the discussion, but more importantly it is about expanding and creating dialogic spaces, widening participation to such spaces, helping young people understand their rights, and providing an opportunity for them to engage with ethical decision-making and policy-setting with technologies that impact them. It is also about listening, and acting upon points raised by young people to reach a stronger understanding on how they negotiate the digital environment.

References

1. United Nations (2021) *Artificial Intelligence and Privacy, and children's privacy – Report of the Special Rapporteur of the right to privacy*, A/HRC/46/37. Available at: https://www.ohchr.org/en/documents/thematic-reports/ahrc4637-artificial-intelligence-and-privacy-and-childrens-privacy (Accessed 1 July 2024).
2. *UN Convention on the Rights of the Child*. Available at: https://www.unicef.org.uk/what-we-do/un-convention-child-rights/ (Accessed 1 July 2024).
3. Mukherjee, S. and Livingstone, S. (2020) 'Children and Young People's Voices', Digital Futures Commission. London: 5Rights Foundation. Available at: https://digitalfuturescommission.org.uk/wp-content/uploads/2020/10/Children-and-Young-Peoples-Voices.pdf (Accessed 1 July 2024).
4. Millwood Hargrave, A. (2024) 'Children's rights in the digital age', *InterMedia*, 52(1). Available at: https://iicintermedia.org/vol-52-issue-1/childrens-rights-in-the-digital-age/ (Accessed 1 July 2024).
5. Holmes, W., Porayska-Pomsta, K., Holstein, K., Sutherland, E., Baker, T., Buckingham Shum, S., Santos, O. C., Rodrigo, M. T., Cukurova, M., Bittencourt, I. I. and Koedinger, K. R. (2021) 'Ethics of AI in Education: Towards a Community-Wide Framework', *International Journal of Artificial Intelligence in Education*. Available at: https://doi.org/10.1007/s40593-021-00239-1 (Accessed 1 July 2024).
6. Buckingham Shum, S. (2022) 'What principles should govern UTS' use of analytics and artificial intelligence to improve teaching and learning for all, while minimising the possibility of harmful outcomes?' [Blog], 31 January 2022. Available at: https://simon.buckinghamshum.net/2022/01/deliberative-democracy-for-edtech-ethics/ (Accessed 1 July 2024).
7. Burriss, S.K. and EngageAI Staff. (2023) 'Redesigning an AI Bill of Rights For & With Young People', *EngageAI Institute Nexus Blog*. Available at: https://engageai.org/2023/10/18/redesigning-an-ai-bill-of-rights-for-with-young-people/ (Accessed 1 July 2024).

Resources

- Guidance for policy makers:

  Child Online Safety Global Toolkit. Available at: https://childonlinesafetytoolkit.org/ (Accessed 1 July 2024).
- 5Rights Foundation is a London-based non-governmental non-profit charitable organisation that works towards creating a digital environment fit for children and young people. The website includes resources published around three main areas of work: data and privacy, child-centred design and children's rights:

  5Rights Foundation. Available at: https://5rightsfoundation.com/ (Accessed 1 July 2024).
- Blog post by Gazal Shekhawat and Sonia Livingstone who call attention to the interests of children in the global AI arms race and provide five key sources of AI guidance:

  AI and children's rights: a guide to the transnational guidance. Available at: https://blogs.lse.ac.uk/parenting4digitalfuture/2023/11/08/ai-rights/ (Accessed 1 July 2024).
- European Union Artificial Intelligence act:

  EU AI Act: first regulation on artificial intelligence. Available at: https://www.europarl.europa.eu/topics/en/article/20230601STO93804/eu-ai-act-first-regulation-on-artificial-intelligence (Accessed 1 July 2024).
- Essays by various authors, published by 5Rights Foundation and Digital Futures Commission:

  Education Digital Futures: Critical, Regulatory, and Practical Reflections. Available at: https://educationdatafutures.digitalfuturescommission.org.uk/ (Accessed 1 July 2024).
- Curricular Resources from Day of AI:

  AI is for everyone. Available at: https://www.dayofai.org/teacher-pages/ai-blueprint-bill-of-rights (Accessed 1 July 2024).
- UNICEF's Manifesto:

  The Case for Better Governance of Children's Data: A Manifesto. Available at: https://www.unicef.org/globalinsight/media/1741/file/UNICEF%20Global%20Insight%20Data%20Governance%20Manifesto.pdf (Accessed 1 July 2024).
- A report report presenting the views and perspectives of young people on AI and its impact on children's rights:

  Chaudron, S. and Di Gioia, R., 'Artificial Intelligence and the Rights of the Child – Young people's views and perspectives', EUR 31094 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-53101-2, doi:10.2760/272950, JRC129099. Available at: https://publications.jrc.ec.europa.eu/repository/handle/JRC129099 (Accessed 1 July 2024).

AI-enhanced multimodal writing

Extending multimodal authoring and developing critical reflection

Introduction

As educators, we understand that meaning-making is not limited to one mode of expression; we sing, draw, speak, write, move, and gesture as we learn and communicate. Learners are more likely to understand new concepts when multiple modes of communication – sound, visuals, movement, and texts – are used. This perspective on learning and meaning-making is not new; however, digital technologies and generative AI (GenAI) have made possible the use of multiple modes for composing narrative, argument, explanation, interpretation, and other forms traditionally assigned to print texts. Generative AI, a form of artificial intelligence that can generate images, sounds, texts, videos, and other modes based on user prompts, is a tool that can support composers of multimodal texts.

Thinking differently about arguments

In a professional development activity, a group of teachers created a multimodal project arguing for a new way of dealing with refuse near a local riverbank, incorporating images, videos, voice-over commentaries, statistics, and music. They did this to see whether they could set a similar task for their students. The teachers explained that, while effective, this form of argument required them to think differently and they needed more time to complete the task. One of the teachers explained: 'I thought using image and sound in my essays would be easy, but I found that using those media required that I think and plan in ways I didn't when I wrote my usual essays.' The key message from this experience is that educators should consider the purpose, processes and tools, as well as new ways of working when they design learning tasks that allow learners to create multimodal compositions. New generative AI tools may be able to support both educators designing multimodal tasks and learners creating them.

The use of multiple modes of communication are already part of adolescents' out-of-school lives; they use video, image, text, sound, and animations to create stories and communicate. The New London Group[1] identified five modes of meaning-making:

1. oral and written language
2. still and moving images
3. music and sound effects
4. facial expression and body language
5. spatial layout and organisation of objects.

Previous technologies already afforded the combinations of these multiple modes to make meaning, but multimodal AI increases both production speed and access to those modes. Previous digital tools may have required some skill with the mode, such as artistic or musical skill in order to develop a new song, whereas new AI tools allow students with little skill in these areas to create. This speeds up both design and revision, making the modes more accessible. Nevertheless, the use of AI requires a new and more sophisticated set of skills as students consider how to prompt the AI and how the modes work together.

Multimodal composing includes the process of meaning-making across different modalities in digital formats, such as videos, collages, and soundscapes for immersive environments. These compositions incorporate more than one mode, so meaning is constructed within and across the modes. For example, consider the case of an elementary school student who wrote a story about finding a puppy. She included images of a skinny, hungry puppy in a box, accompanied by sad music. However, at the end, she included pictures of the puppy playing with toys, and happy, upbeat music. The images provide visual impact while the music adds emotional weight to the written words. The student writer used generative AI to create the images so that the reader could see what she was imagining. Using AI provided opportunities to create multiple layers of meaning in the story.

The student noted she had described the image she wanted, so that the AI could provide this image. She explained that she had to revise her image several times because the outputs the AI produced were not what she had imagined or the image of the puppy it created had too many legs. Additionally, both students and teachers identified prompt engineering and revising (the process of crafting prompts for the AI and amending them) as unexpectedly important parts of the composing process. As one teacher explained, 'I realised that I had to help my students learn how to write and revise prompts as part of multimodal composing with AI.'

Considering classroom use

Teacher planning and reasoning

Educators first need to determine their instructional goals for incorporating AI into multimodal writing tasks and what tools are available for students to use. They should also evaluate the critical and ethical use of the AI tools. As they incorporate AI in multimodal writing instruction, they should consider the task their students will be asked to complete, its instructional purpose, how the AI tool might support learning, and what other supports learners will need to use the AI tool in completing their task. The following questions provide helpful guidance:

Task

1. What are the skills embedded in the task? How might AI support the development of those skills?
2. What are the supports that students need to accomplish this task? Are these supports that AI might be able to provide?

Tools

3. What multimodal elements does AI provide? What supports might students need to use these elements effectively?
4. What ethical considerations need to be discussed in advance of using AI?

Reflection

5. Does AI support the communicative purpose of the task?
6. How might reflection on the composing process (e.g., revisions of prompts) illustrate student thinking?
7. How might the iterative process of revising the prompts and discussing their choices help students move beyond a simple use of AI as a tool for cutting corners or cheating, towards thinking of it as a tool to support their learning?

Recursive process of prompt writing and revising

Crafting a prompt for a composing task with AI is a component of the writing process. A prompt (the writer's text-based input for the AI) is a tool that writers carefully craft to achieve their intended results from the AI. For example, in a university class, undergraduate students might examine literature by using image and text. The students can use AI tools to create images that provide commentary about an intriguing aspect of the text. They can then reflect on how the AI-generated image might be improved and revise their initial prompt in order to create a better image.

Image generated by the prompt "Depict a mind trapped in a machine"

Following this pattern, a student analysed Ophelia, the AI character in *The Infinity Courts*[2], focusing on the character's motivation. His first prompt, 'Depict a mind trapped in a machine', produced an unsatisfactory output, so he amended his prompt to say, 'Depict an AI trapped and suffering inside a machine.' He revised his prompt multiple times to create an image that provided the commentary he wanted to make. The generative AI art tool allowed recursive critical thought and revision of his artwork, and the engineering of the prompt revealed the depth of his understanding of the AI character. For a different class, an engineering student designed a magical waste disposal system for the Harry Potter

Wizarding World using generative AI image creators to design the individual components and show what the unit looked like once installed at Hogwarts. He noted that he revised his prompts more than ten times for each piece. Capturing the prompts and revision choices as part of the assignment allowed the teacher to gain a better understanding of the students' thinking.

> the use of AI requires a new and more sophisticated set of skills as students consider how to prompt the AI and how the modes work together

Retelling and Remixing Stories

In another university class, students were asked to retell a story by creating a multimodal composition through the use of generative AI. Before composing, students learned that a retelling is a new version of a story that can include a variety of elements, such as updating the text for a new time period or setting; extending the text to involve new information, perspectives (genders, ethnicity, language, etc.), characters or settings; and/or remixing the genre of the original text and adding multiple modes to it (visuals, sounds, text, and movement). Students selected from a list of free AI tools for different modes (e.g., ChatGPT, Stable Diffusion, Craiyon, Riffusion, Kapwing). The teachers created short tutorials for how to use each tool, shared examples of remixes with AI, and integrated a workshop model for students to share their work.

A theme across the student experiences was how AI shaped the creative possibilities of the multimodal design. Some AI tools limited what the composers could create while others opened up new possibilities. One student felt she had to sacrifice her vision of creating a song because the free music generators did not provide the options she needed, including being able to download an entire song. She adapted by creating multiple short snippets of songs. Another student described how the AI took her in new directions that changed her final retelling of *Romeo and Juliet*. She originally thought AI would limit students' creativity, however, her experience made her realise that in fact the use of AI could boost creativity as it helped them experiment with different visions. Across both examples, students developed critical reflection as an aspect of the work they produced and in response to the multiple tools they used.

Challenges, barriers, limitations

While AI is an exciting new type of digital tool, there are challenges and potential barriers to its use. Most AI tools require consistent, reliable online access. Not all schools and students can access reliable, affordable internet connections, potentially extending the existing digital divide. Additionally, there are potential ethical issues as there may be biases in the algorithms that the novice users of the AI are not aware of or cannot control. The AIs may not provide information for their data selection process or what corpus of work they were trained on to create the works they produce.

If AI does not provide the provenance of its images, there is a potential for copyright issues. AI can infringe on digital copyrights of human artists by undercutting their work or using it without authorisation[3]. If an AI creates an image in response to the prompt 'create a painting in the style of' a famous or working artist, or 'write a short story in the style of J. K. Rowling', it could create potential ethical issues for those working artists and writers.

Conclusions

Generative AI offers a great many multimodal communication options, enabling authors to produce multimodal pieces more quickly and expand their meaning-making. Multimodal AI tools allow authors to focus on the product rather than the technical skills needed for specific multimedia elements. Multimodal composing with AI requires reflection and critique on both process and product as authors engage with incorporating a new composing tool. As generative AI continues to develop, authors will continue to find ways to achieve their creative vision within the confines of the tool as well as critically examine the ethical implication of AI use. The ethical use of this new innovation requires teachers and learners to explore, create, critique, and reflect on the process of composing and the product. This cycle of exploration and reflection will develop users as more critical and adaptable practitioners of generative multimodal AI, allowing for new composing possibilities.

References

1. A classic article on multiliteracies, from The New London Group:

   Cazden, C., Cope, B., Fairclough, N., Gee, J. et al. (1996) 'A pedagogy of multiliteracies: Designing social futures', *Harvard Educational Review*, 66(1), pp. 60–92. Available at: https://www.sfu.ca/~decaste/newlondon.htm (Accessed 4 July 2024).
2. A science fiction/fantasy book:

   Bowman, A. D. (2021) *The Infinity Courts*. Simon & Schuster.
3. An article on the Ars Technica website:

   Edwards, B. (2024) 'Billie Eilish, Pearl Jam, 200 artists say AI poses existential threat to their livelihoods', *Ars Technica*. Available at: https://arstechnica.com/information-technology/2024/04/billie-eilish-pearl-jam-200-artists-say-ai-poses-existential-threat-to-their-livelihoods/ (Accessed 4 July 2024).

Resources

- A free AI video creation platform:

  Kapwing. Available at: https://www.kapwing.com/6540f8469e9045e0bd5db2e0/studio/editor (Accessed 4 July 2024).
- A free AI art creation tool:

  Stable Diffision Online. Available at: https://stablediffusionweb.com/#ai-image-generator (Accessed 4 July 2024).
- An example of AI generating incorrect images – Gemini AI producing historical inaccuracies:

  'Google's hidden AI diversity prompts lead to outcry over historically inaccurate images', Article by Benj Edwards on *Ars Technica*. Available at: https://arstechnica.com/information-technology/2024/02/googles-hidden-ai-diversity-prompts-lead-to-outcry-over-historically-inaccurate-images/ (4 July 2024).
- Demo of AI Song Generating Tool, from a team in San Francisco:

  Riffusion – Create any music you imagine. Available at: https://www.riffusion.com (Accessed 4 July 2024).

Intelligent textbooks

Making reading engaging, 'smart' and comprehensive

Introduction

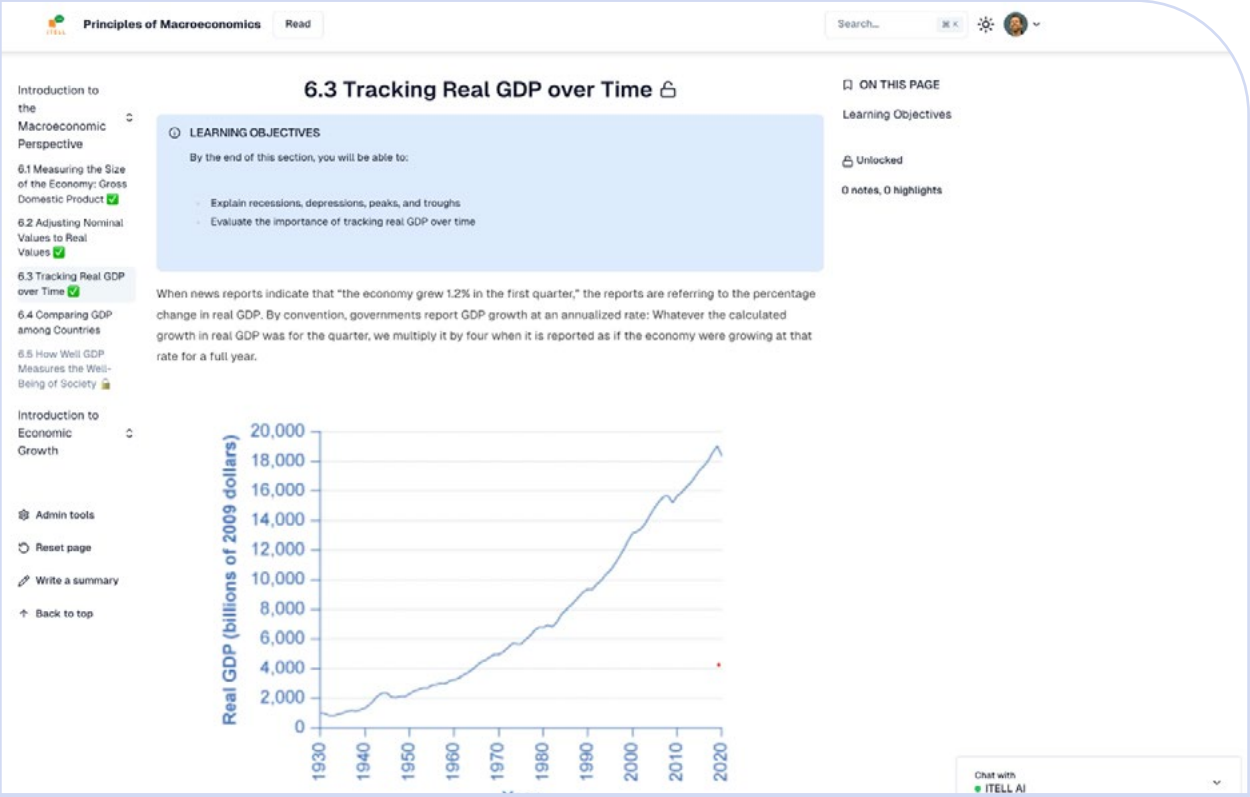
Intelligent textbooks are digital or web-based books that combine content reading with interactive elements such as automatic question answering. Such online books can ask readers questions to prompt deep learning in a section highlighted by the reader[1]. With the advent of Artificial intelligence (AI), intelligent texts have become 'smarter', enabling personalised forms of learning by tracking the behaviour of readers such as page navigation and dwell time (amount of time a reader spends on a page) and by adapting content in real time to meet the needs of the reader such as raising questions about the content. Intelligent textbooks also allow for greater interactivity and engagement between the reader and the text through generative exercises that help learners generate knowledge and ideas. They have great promise in making education and training more accessible, affordable, efficient, and adaptable to individual learning needs[2].

The use of intelligent textbooks is timely. Over the last two decades, a shift from using printed textbooks to adopting digital textbooks has been observed. Digital textbooks became interactive by using technologies such as multimedia, digital glossaries, self-assessments, and social annotation. They became more widely used, especially following the shift to online learning due to COVID-19. As a result, learners are more willing to study online and are more knowledgeable about how to use digital tools and content[3].

Generation Effects

An important theoretical basis for intelligent textbooks is 'generation effects', which demonstrate that remembering improves when ideas are generated by a person's mind rather than simply reading about them[4]. Studies have found that generation effects are a stable construct in learning[5] and that generating ideas, as compared to passively processing ideas, can increase learning[6].

Intelligent textbooks, as compared to traditional paper texts and digital texts, can help students generate knowledge while reading by making the reading processes interactive. The simplest approach is for intelligent texts to support 'read to write' approaches to learning (reading and analysing exemplary texts in preparation for writing). However, intelligent textbooks with these supports have only recently become feasible with the advent of large language models (LLMs) that can read text and provide opportunities for AI generated feedback and dialogues. For example, the intelligent Textbooks for Enhanced Lifelong Learning (iTELL) framework generates intelligent texts that require learners to construct responses to AI generated questions and produce summaries of the texts that they have read. Students are given the opportunity to revise their responses based on AI generated feedback, providing opportunities for deliberate practice. Within iTELL, learners can also use a 'think aloud' protocol to explain their understanding of text using self-explanation dialogues that are prompted and mediated by generative AI. In this way, iTELL transforms reading into an interactive learning experience[7].



Screenshot of the iTELL interface

A few studies have been published about student experiences with intelligent textbooks. For instance, business students used an interactive and adaptive digital textbook for three semesters and assessed its impact on their learning experience[8]. The textbook could track topics mastered by students and suggest areas that need further practice. It also offered students reports documenting progress. Students reported satisfaction with using the textbook and indicated that it helped them master their class work. They also found the textbook to be more favourable than hardcopy textbooks due to the adaptive features that helped them understand key concepts. Recent studies with iTELL also indicate increased efficiency in learning. For example, iTELL asks students to generate 'constructed responses' (i.e., short answers to short questions) for segments of texts based on questions automatically derived from Generative AI. The constructed responses are automatically scored used LLMs, and feedback is provided to users immediately. Over 80% of students using iTELL reported that the constructed responses were relevant and helped with learning. The top student responses indicated that the automatically generated constructed responses were informative, helpful, and supportive[9].

A recent study with iTELL in an introductory computer science class demonstrates the potential for intelligent textbooks to increase learning gains over digital texts[10]. The intelligent text was developed from an introductory programming textbook. The version of iTELL required students to complete constructed response items and summaries, both of which were scored automatically by LLMs that provided qualitative feedback to students. Within the class, 121 students elected to use the iTELL version of the textbook and 356 used a digital text. Survey results indicated that students using iTELL responded positively to the constructed response and summary items and felt both items helped them learn. An analysis of scores between pre-tests and post-tests for students that used iTELL and those that did not showed small learning gains for the iTELL students.

> remembering improves when ideas are generated by a person's mind rather than simply reading about them

Challenges, barriers, limitations

While intelligent textbooks are a reality, there is much work to be done to bring them into the educational landscape. A major challenge is their integration in the current teaching practice in ways that are reflective of possible biases and meet existing learning objectives and curricula. For example, students should become aware of concerns related to textbooks such as the limited number of languages available, constraining the development of intelligent textbooks in under-resourced languages, and biases in the human data used to train models behind textbooks. An example is AI bias toward the writing of non-native speakers (NNS) of English. Because intelligent textbooks often focus on having readers generate knowledge, ideas produced by NNS may receive differential feedback from that of native speakers. That feedback may be biased or less accurate and provide lower scores to NNS. Furthermore, student privacy is an issue if intelligent textbooks rely on industrial LLMs like ChatGPT, where student data is processed and shared by commercial entities.

Another concern is the amount of data needed to train LLMs to provide accurate feedback to users. As an example, the summary feedback models in iTELL were trained with over 15,000 summaries from around 50 source texts that had been hand-scored by experts. The constructed response model in iTELL was trained with over 25,000 questions and answers from around 450 sources. More specialised intelligent textbooks will require specific datasets to train models, which may be cost-prohibitive. Context-specific adaptation may also prove difficult in some areas. For instance, current LLMs are not efficient at processing maths word problems (maths problems described in words) or interpreting figures, graphs, and tables. This makes adapting a mathematics textbook into an intelligent framework difficult.

Another important issue is the cost of developing intelligent textbooks and their maintenance. These costs include for example, developing material (unless the material is open-source), constructing an interface, training AI models, and integrating content. The cost incurred can be substantial and will likely require support from commercial enterprises. This probably means that many intelligent textbook frameworks will be proprietary, making analysis of the systems difficult, including the reliability of their educational features and the validation of their AI interactions and learning potential.

Conclusions

The potential to make reading material interactive and enhance learning through the use of strategies known to increase text comprehension and skill development will lead many organisations to adopt intelligent textbooks. As the use of AI is changing how people work, intelligent textbooks that integrate AI will become important tools to support learning at school as well as learning beyond schooling. Learners will need to develop new skills – reskill or upskill – throughout their professional lives when they complete formal education. Intelligent textbooks can play a key role in making education and training more accessible, affordable, efficient, and adaptable.

References

1. A short description of the history of intelligent books in the AI magazine:

   Brusilovsky, P., Sosnovsky, S., and Thaker, K. (2022) 'The Return of Intelligent Textbooks', *AI Magazine*, 43, pp. 337–340. Available at: https://doi.org/10.1002/aaai.12061 (Accessed 27 June 2024).
2. A paper presenting the potential for interactivity in digital texts:

   Clinton-Lisell, V., Seipel, B., Gilpin, S., and Litzinger, C. (2021) 'Interactive features of E-texts' effects on learning: a systematic review and meta-analysis', *Interactive Learning Environments*, pp. 1–16.
3. An overview of the effect COVID had on the adoption of digital texts from a consultancy firm:

   Seaman, J. E., and Seaman, J. (2020) 'Digital Texts in the Time of COVID: Educational Resources in U.S. Higher Education', *Bay View Analytics*. Available at: https://eric.ed.gov/?q=higher+education+changes+in+the+u.s.&ff1=dtysince_2019&id=ED616838 (Accessed 27 June 2024).
4. A study introducing generation effects:

   Slamecka, N. J., and Graf, P. (1978) 'The generation effect: Delineation of a phenomenon', *Journal of Experimental Psychology: Human Learning and Memory*, 4(6), pp. 592–604. Available at: https://doi.org/10.1037/0278-7393.4.6.592 (Accessed 27 June 2024).
5. A study discussing generation effects in learning:

   Chen, O., Kalyuga, S., and Sweller, J. (2015) 'The worked example effect, the generation effect, and element interactivity', *Journal of Educational Psychology*, 107(3), pp. 689–704. Available at: https://doi.org/10.1037/edu0000018 (Accessed 27 June 2024).
6. A paper that compares generation to simple reading:

   McCurdy, M. P., Viechtbauer, W., Sklenar, A. M., Frankenstein, A. N., and Leshikar, E. D. (2020) 'Theories of the generation effect and the impact of generation constraint: A meta-analytic review', *Psychonomic Bulletin & Review*, 27(6), pp. 1139–1165. Available at: https://doi.org/10.3758/s13423-020-01762-3 (Accessed 27 June 2024).
7. An article introducing iTELL and summarisation interactivity:

   Morris, W., Crossley, S., Holmes, L., Ou, Chaohua, Dascalu, M., and McNamara, D. (2024) 'Formative Feedback on Student-Authored Summaries in Intelligent Textbooks using Large Language Models', *Journal of Artificial Intelligence in Education*. Available at: https://doi.org/10.1007/s40593-024-00395-0 (Accessed 27 June 2024).
8. A case study of using intelligent textbooks with university students in the US:

   Sun, Q., Norman, T. J., and Abdourazakou, Y. (2018) 'Perceived value of interactive digital textbook and adaptive learning: Implications on student learning effectiveness', *Journal of Education for Business*, 93(7), pp. 323–331.
9. A case study examining student perspectives using an intelligent textbook in the US:

   Morris, W., Choi, J., Holmes, L., Gupta, V., and Crossley, S. A. (in press). Automatic Question Generation and Constructed Response Scoring in Intelligent Texts. *Proceedings of the 17th International Conference on Educational Data Mining (EDM). Atlanta, GA*.
10. An experimental study comparing student achievements when using an intelligent textbook:

    Crossley, S. A., Choi, J. S., Morris, W., Holmes, L., Joyner, D. and Gupta, V. (in press). Using Intelligent Texts in A Computer Science Classroom: Findings from an iTELL Deployment. *Proceedings of the 17th International Conference on Educational Data Mining (EDM). Atlanta, GA*.

Resources

- A short video about iTELL: Intelligent Textbooks for Enhanced Lifelong Learning produced by the AI institute for adult learning and online education:

  iTELL Demo. Available at: https://www.youtube.com/watch?v=YZXVQjSDZtI (Accessed 27 June 2024).
- A short video of an example of how intelligent textbooks have been developed and used at the Rice University in Houston, Texas:

  Revolutionizing learning with free "intelligent" textbooks. Available at: https://www.youtube.com/watch?v=XqTiS8VmYQg (Accessed 27 June 2024).

Assessments through extended reality

Harnessing immersion to demonstrate and develop skills

Extended reality creates new forms of interactive activities which generate rich data on procedural knowledge and learners' abilities

Introduction

Simulation-based learning replicates aspects of the real world, requiring learners to take actions and making the consequences of these actions visible. This can allow practical skills to be developed and demonstrated without real-world constraints or risks. Simulation is already an important part of training in areas such as healthcare and aviation.

Extended reality (XR) – encompassing techniques such as virtual reality (VR) and augmented reality (AR) – increases opportunities for immersion, which is understood as the combination of an increased sense of presence (the feeling of 'being there') and of agency (having control over our actions and being able to manipulate the environment). In diverse industries, companies such as Hilton (hospitality), DHL (logistics), Volkswagen (automobile manufacture) and Rolls Royce (aerospace) are making use of XR simulations as part of workplace training. As greater immersion enhances the sense of agency, immersive simulations are particularly suited to testing and gaining feedback on procedural knowledge – how to do a particular task well, such as flying a plane, responding to an emergency or performing surgery.[1]

Assessment is key to learning, and assessing procedural competences is a core goal of many learning activities. It is increasingly recognised that XR could fulfil the growing desire for authentic assessments that test what someone can do and how well they can do it. This offers a radical alternative to traditional written assignments[2]. It can address difficulties with other ways of assessing performance in the real world, such as a lack of repeatability or availability of a particular scenario on demand, or the need for a specific physical environment, equipment or people, which are all limited resources.

Simulation provides important potential for assessment of competences where there may be serious consequences for real-world failure, or situations which are difficult to find or create for the purposes of assessment. In a simulation, formative and summative assessment can occur without these consequences, but emphasising the related learning points, testing skill levels and decision-making abilities.

The sense of presence that comes from increased immersion can allow assessment of whether someone can perform in a facsimile of a real situation, where environmental or affective elements, such as navigating a complex physical space, time pressure, or managing interpersonal interactions can be made more realistic. For example, activities to assess and develop soft skills in hospitality can be undertaken in a realistic virtual simulation of the actual hotel environment, complete with guests that present challenging situations which need to be responded to by working with colleagues.

Where is this useful?

Examples of assessments through XR show reasons to use immersive approaches and provide insights into appropriate design. Medical teaching has been an early adopter of VR and AR, with demonstrations of this being used to assess proficiency and differentiate levels of skill in some procedures. Researchers have shown for example that VR can be used to distinguish novice and expert skill in neurosurgeons by capturing data on how they complete complex motor skills-based tasks in a virtual environment[3].

There has been substantial interest in VR-based training for health and safety. It is recognised, for example, that many construction workers are not able to identify and manage hazards, with potentially serious consequences. VR offers the opportunity to practise and assess these skills away from the dangers of a real-world construction site but with the benefits of feeling as if you are present in a real setting[3]. Simulations can capture data on whether a person can correctly identify hazards in a simulacrum (representation) of a workplace, such as a chemical laboratory or factory, and if the person can act appropriately to resolve or avoid these hazards.

Other examples involve capturing and assessing data on the operation of complicated and potentially dangerous machinery, such as cranes or lathes[4].

A whole range of further vocational subjects, where a simulation of the work environment can be produced including relevant objects, actors and decision points, offer opportunities for students to be assessed on their ability to respond to situations. The Sheffield College in the UK chose Animal Care, Catering, and Carpentry and Joinery courses as subjects in which to trial VR-based assessments. In each case, a virtual resource was built based around an actual environment using 360 degree photos. For example, in the animal care resource, students virtually navigate around the room at the college that contains animal enclosures and a walk-in fridge area, interact with enclosures and other objects, and answer questions to test their knowledge[5].

> assessing procedural competences is a core goal of many learning activities

By reducing reliance on reading and writing, some assessments in XR can also be designed to be completed regardless of the language proficiency of the student. The Augmented Assessment project (see Resources) is exploring how these assessments can be more inclusive of migrants studying in schools when compared to assessments with written questions and answers. For example, the students' mathematical or scientific understanding can be demonstrated through interaction with virtual objects.

Designing assessments with XR

While further research and development is needed, some initial principles for the design of assessment using XR could include:

- **Use multiple assessment methods and data sources to understand different dimensions of learning and performance**: Many forms of analytical data can be identified, logged and analysed to assess skills and procedural knowledge through

activities in XR. Features such as the time taken, amount of work completed successfully, or adherence to modelled behaviours can be logged and analysed. Decisions made during the simulation, and how the person communicates with others, might also be captured and assessed. This can be combined with observations or review by assessors to provide richer understanding and reflection. External to the data collected through the simulation, quizzes can test understanding and post-simulation activities can encourage reflection and identify ways to improve. It can also be valuable to test knowledge at a later date, well after the initial simulation activity, to check for retention[4]. Through a combination of these data sources the assessment can offer rich understanding that can be hard to gather through other means.

- **Start with formative or low stakes assessments**: Learners have expressed more positive views of VR in low stakes or formative assessment, where the novelty and challenge supports new forms of feedback but cannot impact negatively on their grades[5]. If the assessment is summative and carries weight for passing the course, then it will be particularly important to offer inductions and chances to develop experience in advance[3].
- **Align the assessment purpose and measures**: Research suggests that using existing VR-based games to assess competencies such as emotional intelligence or working at heights is problematic[7]. In any novel assessment it is important to think carefully about the alignment of the assessment tasks and measures with expected learning outcomes.

Barriers and potential solutions for equitable assessment

VR experiences using headsets and other hardware can create a strong sense of immersion, but they raise barriers for some people and pose risks for new inequities to emerge when using them in assessment:

- People who are more susceptible to motion sickness and with less experience of VR are more likely to suffer from 'VR sickness', which could result in reduced performance or aversion to taking part. However, VR sickness occurs when motions in the virtual space do not match physical movement, such as moving over a large virtual distance by pressing a joystick direction[6]. Activities in smaller spaces where the user can move naturally are less likely to cause symptoms.
- Some report other forms of discomfort such as eye strain or headaches from extended use of headsets[1]. Ensuring proper fitting, comfortable equipment, and limiting the length of time a person is expected to wear a headset is therefore recommended.
- The costs of headsets have reduced substantially in recent years with models available for a similar price to a smartphones or laptop. But as an additional device, cost is still a potential barrier and only a small minority own their own headset.
- A minimum clear space of 2 by 2 metres is suggested for each user. Limited space may reduce performance and create risks where people are unaware of their surroundings.

Standard computer or mobile XR experiences also exist, so in some cases it may not be necessary to use specialist hardware to take part in an XR-based assessment. These could also be offered as an alternative assessment method where barriers do exist.

Conclusions

Assessments through XR can address the challenge of achieving more authentic assessments by simulating situations that are difficult to achieve reliably or safely in the real world. It is attractive to think that assessments can be based on detailed analytical data and allow in-depth analysis, reflection, and potentially repetition. There remain uncertainties about the extent to which headset-based VR will become mainstream and can support equitable assessment, but where VR is available for learning it will become increasingly important to think about how to embed assessment effectively.

References

1. A widely cited framework for immersive learning:

   Makransky, G., and Petersen, G. B. (2021) 'The cognitive affective model of immersive learning (CAMIL): A theoretical research-based model of learning in immersive virtual reality', *Educational Psychology Review*, 33(3), pp. 937–958.
2. A paper exploring frameworks for assessments in VR and AR, along with an evaluation of an example in laboratory safety which uses multiple types of data to assess students:

   Udeozor, C., Chan, P., Russo Abegão, F. and Glassey, J. (2023) 'Game-based assessment framework for virtual reality, augmented reality and digital game-based learning', *International Journal of Educational Technology in Higher Education*, 20(1), pp. 36.
3. A review of research on VR training across subject areas:

   Abich IV, J., Parker, J., Murphy, J.S. and Eudy, M. (2021) 'A review of the evidence for training effectiveness with virtual reality technology', *Virtual Reality*, 25(4), pp. 919–933.
4. A review of research on VR training in health and safety applications which identifies different ways in which learning was assessed:

   Toyoda, R., Russo-Abegão, F., and Glassey, J. (2022) 'VR-based health and safety training in various high-risk engineering industries: a literature review', *International Journal of Educational Technology in Higher Education*, 19(1), pp. 42.
5. Report on pilot studies of VR in summative assessments in vocational learning:

   The Sheffield College, NCFE. (2023) *An investigation into the use of virtual reality on assessment*. Available at: https://www.ncfe.org.uk/media/nq3afg0n/final-report-the-sheffield-college.pdf (Accessed 24 June 2024).
6. Paper reviewing research on the causes of VR sickness:

   Chang, E., Kim, H.T. and Yoo, B. (2020) 'Virtual reality sickness: a review of causes and measurements', *International Journal of Human–Computer Interaction*, 36(17), pp. 1658–1682.
7. Study exploring the use of VR games to assess competencies with mixed results, suggesting next steps for valid XR assessments:

   Sanchez, D.R., Weiner, E. and Van Zelderen, A. (2022) 'Virtual reality assessments (VRAs): exploring the reliability and validity of evaluations in VR', *International Journal of Selection and Assessment*, 30(1), pp. 103–125.

Resources

- Summary of current trends around virtual reality and the metaverse for training employees:

  What does virtual reality and the metaverse mean for training? Blog post by Scott Likens and Andrea Mower from PwC.

  Available at: https://www.pwc.com/us/en/tech-effect/emerging-tech/virtual-reality-study.html (Accessed 24 June 2024).
- A list of examples of how companies use virtual reality in training, describing features such as how learning is assessed and feedback given:

  Available at: https://www.vrowl.io/the-22-best-examples-of-how-companies-use-virtual-reality-for-training/ (Accessed 24 June 2024).
- Augmented Assessment: Resources from a European Union funded project exploring how augmented reality assessments could be beneficial for migrants:

  Available at: https://augmented-assessment.eu/ (Accessed 24 June 2024).
- Drawing on a UK-based survey with responses from across 110 educational institutions, Jisc's Extended reality in learning and teaching report 2023/24 describes the growth in applications of XR in tertiary education but also outlines current challenges experienced by educators:

  Available at: https://repository.jisc.ac.uk/9534/1/extended-reality-in-learning-and-teaching-report-2023-24.pdf (Accessed 24 June 2024).
- A set of standards and guidance from the Association for Simulated Practice in Healthcare (ASPiH), guided by evidence on simulation-based learning and emphasising the appropriate use of assessment within this:

  Available at: https://aspih.org.uk/standards-2/ (Accessed 24 June 2024).

Immersive language and culture

Using games to step back in time for authentic learning experiences

Introduction

Students often benefit from opportunities to develop and apply their learning in authentic settings. Language students can progress quickly when they are immersed in a setting where everyone is using their target language. Field trips can also support lessons about historical periods and diverse cultures. However, providing authentic experience of an ancient language or culture is challenging. Immersive language and culture provides game-based opportunities for extended investigation of and roleplay within historic scenarios. This can be done through video-game-based experiences or through structured sessions of live-action role play.

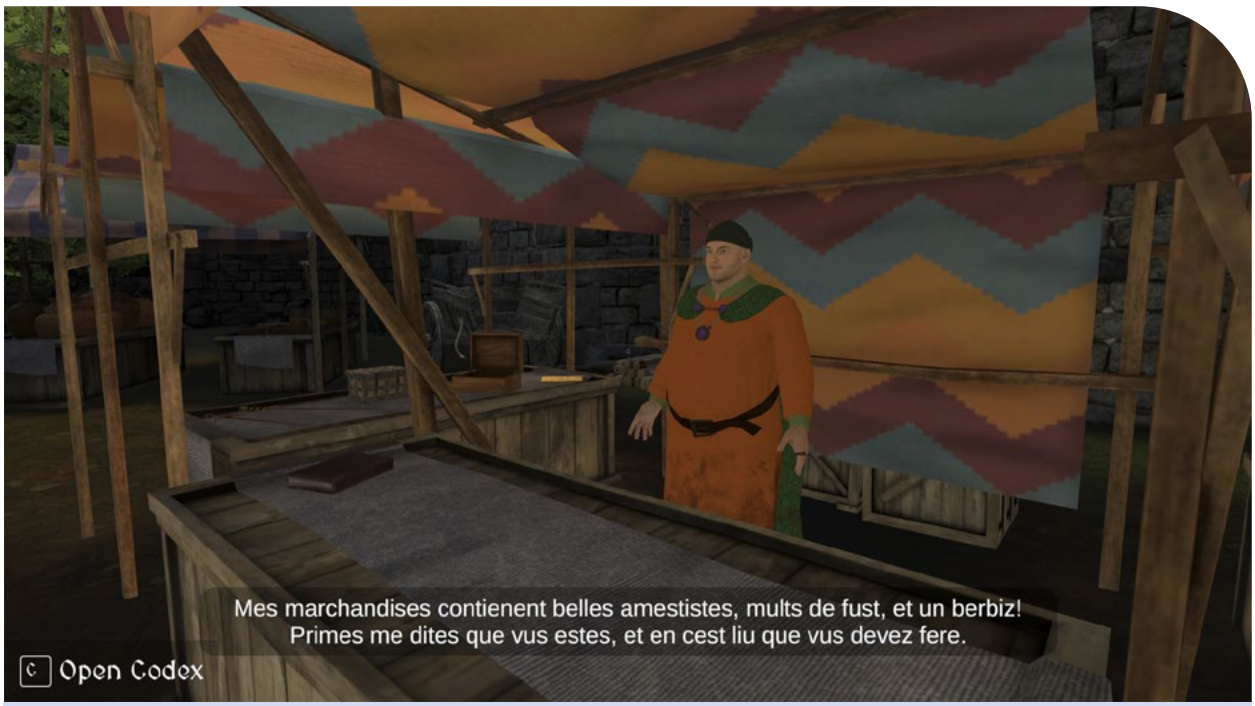
Authentic learning

Immersive language and culture draws on the strengths of authentic learning. This is an approach to learning-by-doing that prompts students to find solutions to complex problems in multi-disciplinary settings. Students who are immersed in an authentic learning activity can be supported to develop the judgment to distinguish between reliable and unreliable information, the ability to recognise patterns in unfamiliar contexts, the flexibility to develop innovative solutions and to work across cultural boundaries[1]. Some features of authentic learning include sustained investigations, the challenge of drawing on multiple sources and perspectives, and opportunities to seek out multiple interpretations and work towards a variety of outcomes. This can be achieved in real-world settings but, in the case of past languages and cultures, students can benefit from the use of digital immersive video game environments, or an approach known as Reacting to the Past.

Video games and immersive learning

As access to digital technology has become more widespread, virtual language learning has become increasingly popular. Propelled by the need to teach in online environments due to COVID lockdowns, virtual learning has become increasingly mainstream[2]. Language-learning software and apps, from Rosetta Stone and Duolingo to the software included with textbooks, have become an increasingly common part of learning a language. Many language-learning programs do not attempt to provide an authentic cultural environment, but function more like flashcards for the learner. The use of commercial entertainment industry video games to learn languages has provided an informal way (now sometimes formalised in language classrooms) of connecting sensory perceptions with unfamiliar languages, and these opportunities can be provided simply by changing the language in which the commercial game is installed.

However, this technique is not possible for 'dead' and endangered languages such as Latin or medieval French. Furthermore, to achieve the goal of language learning within a cultural context, the immersive environment must mirror the world of the target language and culture. For example, a modern kitchen table in a US-based game set in the 21st century would not be an appropriate table to include in a medieval court environment. Likewise, the vocabulary used in an off-the-shelf video game like *Assassin's Creed* applies only to a specific set of conquest and conflict situations, leaving many gaps for those who will be working with ancient and medieval literature – for example, vocabulary relating to rich religious experiences and interpersonal relationships.



The codex can be consulted at any point to help the player converse in Anglo-Norman with the merchant in the game "Brendan's Voyage" by Lynn Ramey and Jacob Abel.

Game scholars have uncovered and established the powerful links between learning and play[3]. Using off-the-shelf games can be effective, but these games usually lack linguistic and cultural input that would make them authentic learning environments. In other words, playing a popular game like *Fortnite* in English may teach some new vocabulary, but it offers little awareness of any anglophone culture. Much more valuable[3] are instructor- (or student-) produced games as well as game play systems designed specifically to promote learning the target language and culture. These have been shown to be effective – for example, students who played a 3D-immersive game related to an essay topic subsequently crafted richer second-language narratives than those who did not use those environments[4,5].

Brendan's Voyage is an example of an innovative use of video game design in support of learning and teaching dead languages and assessing the outcomes. The game, an adaptation of the medieval text *The Voyage of Saint Brendan the Abbot* teaches players to speak, read and write the Anglo-Norman dialect of medieval French.

The entire experience is infused with architecture, art and literature appropriate to 12th-century Europe, meaning players also learn about the culture, politics and aesthetics of the period. For instance, a player is coached by a magical codex (an ancient manuscript text in book form) through the language skills needed to interact with a merchant. The codex can be consulted at any point to help the player converse in Anglo-Norman with the merchant.

Using a game to provide learners with an immersive experience offers a variety of advantages. Game-based learning can help students to bypass the anxiety and lack of self-confidence that can be experienced when starting to learn a language. Any mistakes can be attributed to the in-game character rather than the student. The game also provides opportunities to communicate in medieval French, rather than being limited to the study of grammar and translation. Interacting in the game world emphasises how the language relates to the activity, context, and culture in which it was developed.

A similar approach is applied in *Operation LAPIS*[5], a two-year interactive adventure in which Latin learners develop skills in speaking, reading, and translating as they role-play as Romans. The game environment is used to foster engagement – it also provides a way of supporting a gradual shift from instructor-led learning to self-study, with students using the CODEX (a set of web-based language resources) as a resource to support their decisions about in-game interactions and how to proceed with their adventure. As they do this, the teacher can provide feedback and guidance on areas such as language use, problem-solving techniques and quality of background research.

Unlike *Brendan's Voyage*, *Operation LAPIS* is not set in a single game environment but uses a range of online tools and resources. However, an immersive language and culture approach can also be adopted without the use of technology, using a form of live-action role-playing game known as Reacting to the Past.

Reacting to the Past

Reacting to the Past[6] consists of complex games in which students are assigned roles to explore an historic topic. Class sessions are run by learners, with educators advising and guiding them, as well as assessing both oral and written work. The intention is to draw students into the past, to encourage them to engage with big ideas, and to develop their intellectual and academic skills. For example, a class of students might take on the roles of countries' representatives at the 1919 Paris Peace Conference, working to develop a treaty that establishes the terms of peace after the World War. This requires them to carry out research to establish what their countries' visions and priorities are, and then negotiate with others in topical sub-committees to recommend a course of action of the leaders who will determine the final treaty. In another class, a group of students might take on roles in ancient Athens, in a time following military defeat and rebellion. The newly restored democracy is unstable, and students will debate topics such a democracy, oligarchy, imperialism, women's rights and immigration – debates informed by the use of classical texts including Plato's *Republic*.

The Reacting Consortium currently has more than 75 games on offer, covering subjects including politics, religion, economics and STEM. Each of these comes with a student gamebook, which describes the historical context, explains the game premise, introduces the central debates and sets out the rules. An instructor manual includes handouts and gives instructions on running the game – how many students it is designed for and how long it will last. Role sheets are supplied for the students, so they can find out what their individual goals are and which strategies they can use. There are also companion texts, including readings from primary sources.

Some role-playing games – such as *Monumental Consequence* (in which students consider whether art is ever worth dying for) – can be played in less than an hour and could provide an introduction to Reacting for both students and educators. Others can play out over weeks or months. *Athens 403BCE*, described above, is one of the larger scale games and can run for as many as 15 sessions with roles for up to 50 students. *Versailles 1919*, the Paris Peace Conference game, takes around eight sessions and can run with as few as ten students.

> Immersive language and culture draws on the strengths of authentic learning

Challenges, barriers, limitations

A recent study[7] looked at the experience of running a Reacting game three times with classes of undergraduates and graduates. The students found some aspects challenging, particularly giving oral presentations, and engaging in debates. They also found it difficult to understand and summarise research and to critique arguments. Overall, though, they found the experience valuable. They reported that it not only helped them to strengthen skills and knowledge but also to identify areas where they had previously been weak. They also felt it prompted them to learn the material better than they would have done in other circumstances, and they believed that they would retain it better because the experience was so memorable.

Almost a decade ago, Julie Sykes and Jonathon Reinhardt anticipated an explosion of purpose-built games for language learning in authentic contexts, noting that it is 'critical that researchers and practitioners evaluate and, in many cases, participate in the creation of these games'[8]. However, immersive language-learning games created with researchers have not yet become mainstream or widely available. Perhaps due to the complexities of game production, studies have focused on games produced for entertainment (most commonly, multi-player role-playing games) that are co-opted into a classroom setting to be played in a target language.

Conclusions

Immersive and game-based learning methods provide a rich, engaging way for students to learn languages and understand historical and cultural contexts. By integrating digital game environments and live-action role-playing, these educational techniques allow students to dive deep into historical and cultural settings, enhancing their learning experience and retention. Games like *Brendan's Voyage* and *Operation LAPIS* exemplify innovative approaches that not only teach language skills but also imbue students with a deeper appreciation of historical cultures and practices. Despite challenges such as the complexity of creating authentic game-based learning tools, the potential for immersive educational experiences is vast, promising a more dynamic and effective approach to learning languages and exploring cultures. As virtual reality and augmented reality technologies advance, immersive learning environments could become dramatically enhanced, offering an even deeper level of immersion and interaction. Immersive pedagogies are likely to become widely adopted across the curriculum.

References

1. A paper that explains and exemplifies authentic learning:

   Lombardi, M.M. and Oblinger, D.G. (2007) 'Authentic learning for the 21st century: An overview', *Educause Learning Initiative*, 1(2007), pp. 1–12. Available at: https://library.educause.edu/resources/2007/1/authentic-learning-for-the-21st-century-an-overview (Accessed 27 June 2024).

2. A web page setting out some consequences of the COVID-19 pandemic:

   Li, C. and Lalani, F. (2020) 'The COVID-19 pandemic has changed education forever. This is how', *World Economic Forum*, April 29, 2020. Available at: https://www.weforum.org/agenda/2020/04/coronavirus-education-global-covid19-online-digital-learning/ (Accessed 27 June 2024).

3. A book about video games in education:

   Gee, J.P. (2003) *What video games have to teach us about learning and literacy*. Palgrave Macmillan, New York.

4. A journal article reporting using an interactive fiction game to teach German vocabulary, reading, and culture to university students:

   Neville, D.O., Shelton, B.E., and McInnis, B. (2009) 'Cybertext redux: using digital game-based learning to teach L2 vocabulary, reading, and culture', *Computer Assisted Language Learning*, 22(5), pp.409–424.

5. A magazine article describing the Operation LAPIS game and how it is used in teaching:

   Slota, S.T., Ballestrini, K., and Pearsall, M. (2013) 'Learning through *Operation LAPIS*: A game-based approach to the language classroom', *The Language Educator*, October, pp.36–38.

6. A journal article discussing the pedagogy of Reacting to the Past:

   Lamontagne, K. (2020) 'When the Past is the Classroom: Merging 'Reacting to the Past' and Experiential Education', *Impact: The Journal of the Center for Interdisciplinary Teaching & Learning*, 9(2), pp.9–17.

7. A journal article reflecting on the value of immersive, experiential active learning:

   Richardson, D.S., Bledsoe, R.S., and Manning, K. (2023) 'Pushing Active Learning to the Extreme: Is It Worth It?', *College Teaching*, 71(1), pp. 9–17.

8. A book chapter on digital games in language teaching and learning:

   Reinhardt, J., and Sykes, J.M. (2012) 'Conceptualizing digital game-mediated L2 learning and pedagogy: Game-enhanced and game-based research and practice', in *Digital games in language learning and teaching* (pp. 32–49). London: Palgrave Macmillan UK.

Resources

- A short video introduction to the *Brendan's Voyage* video game, designed to teach Anglo-Norman language and culture:

  Brendan's Voyage. Available at: https://www.youtube.com/watch?v=-3pVVCzQfP8&ab_channel=LR (Accessed 27 June 2024).

- Resources on Reacting to the Past:

  Reacting to the Past. Available at: https://reacting.barnard.edu/ – browse the games, sign up for an event (they tend to be in the US), join the community and/or sign up for the newsletter (Accessed 27 June 2024).

  Reacting Consortium. Resources from a consortium of institutions and instructors 'united by the belief that imagination, inquiry, and engagement are essential features of teaching and learning'. Available at: https://reactingconsortium.org/ (Accessed 27 June 2024).

- An article by Nicolas Trépanier about teaching history with video games, from the Newsmagazine of the American Historical Association:

  The Assassin's Perspective: Teaching History with Video Games. May 1, 2014. Available at: https://www.historians.org/perspectives-article/the-assassins-perspective-teaching-history-with-video-games-may-2014/ (Accessed 27 June 2024).

- Barnard and Columbia undergraduates play *Defining a Nation: India on the Eve of Independence, 1945* at Barnard College (5-minute video):

  Reacting to the past: The student perspective. Available at: https://www.youtube.com/watch?v=_U6L9ERzw0U&ab_channel=ReactingtothePast (Accessed 27 June 2024).

- Students—with costumes and trumpet in hand—assume roles in the Athenian Assembly to debate issues as Athens reconstructs after the Peloponnesian War (2-minute video).

  Reacting to the Past FYS142 Class Visit. Available at: https://www.youtube.com/watch?v=clO0uvCgwlM&ab_channel=SmithCollege (Accessed 27 June 2024).

Exploring scientific models from the inside

Rich embodied experiences supported by extended reality and AI

Introduction

The value of hands-on activities in science, manipulatives in maths (concrete objects showing concepts), and embodied empathy in literature (experiencing a character's world) clearly demonstrates how real-world experiences can enhance learning. An embodied learning approach seeks to expand the repertoire of resources students use to learn from their experiences in the world by incorporating how they move their bodies in space and how they interact with the physical environment around them. This approach is particularly powerful for understanding scientific models, allowing students to experience them first-hand 'from the inside.' Pedagogically, such learning is more robust when followed by reflective activities, helping to anchor abstract concepts in tangible experiences. However, the complexity of embodied exploration can hinder effective reflection. Teachers need useful digital data traces to help students focus on key moments of insight and difficulty, facilitating a deeper understanding of the phenomenon being modelled.

> these environments are novel because they provide playful first-hand explorations of scientific models

Two emerging technical trends are set to enhance student learning of models in classrooms. The first is extended reality (XR) technologies, which include virtual reality (VR), augmented reality (AR), and mixed reality (MR). These technologies blend physical surroundings with digital elements, transforming interactions with technology and learning methods. The second trend is the significant growth in artificial intelligence (AI) capabilities, which can now process extremely large sets of data from multiple modalities.

The merging of XR and AI holds promise for evolving and refining educational strategies and tools for model learning by increasing the responsiveness and adaptability of XR-based learning environments and supporting AI-enhanced interpretation of the full spectrum of human sensory information available in these environments. With guidance and support from teachers, such digitally enhanced experiences can help students move from direct experiences to conceptual understanding of scientific and other models that might otherwise remain ungrounded or misunderstood.

Immersion in models through extended reality

A common theme among XR environments is immersing students in a digitally enhanced experience that can be used as a springboard for more powerful understandings. VR strives for sensory immersion to help users suspend disbelief and engage in the digital world as if it were real. AR overlays digital information onto the physical world, enhancing real-world experiences with interactive and contextual digital elements. MR combines the physical and digital worlds, supporting interactive actions and sensory immersion in dynamic ways.

- **In MR**, physical movements and interactions with real objects are mirrored by their digital counterparts in a simulated environment. For example, to learn about the complex relationships between bees and flowers in pollination, students can move their bodies around in the physical space of a classroom while seeing virtual bees moving where they move in a virtual garden.[1] This integration is visually achieved by overlaying digital elements onto a live video feed that captures real-world phenomena. These virtual representations can be viewed on devices ranging from handheld smartphones to large-scale projections on walls and screens.

- **In more extensive MR setups**, the system tracks user movement within a physical space to display digital information in the context of a scenario being enacted and to enable interactions with virtual entities positioned in specific real-world locations. For example, in the pollination scenario, students can see where different kinds of flowers are placed in specific locations in the virtual garden and move their bee to interact with them by moving their body in physical space. Importantly, the system is tracking and responsive to multiple bees' actions at once, allowing students to experience the complex dynamics of the system and engage in teamwork strategies to optimise pollination and maximise the health of the garden. Room-sized space-based MR systems have been successful at enabling students to learn about various types of models from the inside, including biological systems such as animal foraging [2], physical science concepts such as states of matter[3], and geological concepts related to celestial entities found in outer space[4].

Pedagogically, these environments are novel because they provide playful first-hand explorations of scientific models. For example, the STEP (Science through Technology Enhanced Play) project[5] has students pretend to become parts of a scientific system they want to study. Digging deeper into the case of pollination, children learn by becoming bees and exploring a digital flower patch together. In one implementation, they enter a gymnasium and see a video feed of themselves walking around the room, but everywhere they go, a bee in the virtual space follows them (based on an array of sensors placed around the room). In certain locations around the room, there are virtual flowers that only appear when students are next to them. The students-as-bees collect nectar, which can vary in quantity and quality. The bees bring this nectar back to the hive and begin to discuss how best to organise to collect the most nectar before winter comes and it is all gone. Eventually, they discover that depending on their foraging activity, certain flowers get pollinated, or not, and therefore live or die.

The most recent version of the STEP environment is programmable by students. They can choose to add new agents (e.g., birds as predators) or explore edge-case interactions (e.g., program the bees to all go to the 'best' flower or to distribute themselves to all the flowers). Moving back and forth between being an agent within a model and reflecting on/programming this model balances the 'diving in' and 'stepping out' that Edith Ackerman describes as powerful for constructing deep understanding of experiences[6]. Particularly powerful in this case is the way that taking the role of modeler allows students to tell a story about a place that is personally and culturally meaningful. For instance, students in urban areas may explore the effects on the flower-bee system when new building developments are created with and without green rooftops. Such a student-led approach to modelling is a powerful new form of 'computational inquiry' (often learning through simulations) that allows students to control, and see the effects of changing the 'rules of the game', rather than simply learning a constrained set of rules that have been pre-programmed into a system. Data visualisation then serves as a critical tool for teachers to recognise and interpret key moments of discovery and/or confusion among students and use these for reflective discussions that can lead to further experimentation with the model.

AI-processing of data from multiple modalities

Embodied learning data, which captures student interactions in a three-dimensional space and time, presents a complex challenge to represent and interpret due to its multimodal, dynamic nature. Unlike traditional educational data, which often focuses primarily on language or digital interactions, embodied learning data encompasses a wide range of both verbal and non-verbal information and movements through space. Strategic sensors placed in XR embodied learning environments collect vast amounts of data in multiple modalities, including streaming video, sound (commonly speech), positioning data, and system logs from the modelling environment.

This data represents aspects of learners' movements, attention focus, emotional states, and digital interactions, which are essential for a comprehensive understanding of students' learning and problem-solving activities. However, managing and analysing this diverse data is complex and requires sophisticated computational tools and approaches.

Interaction Analysis (IA) is a key method used by educational researchers to extract insights from video data of embodied and other learning interactions[7]. IA examines human interactions in context, revealing the subtle dynamics necessary to understand collaborative, embodied learning environments. However, IA is labour-intensive and requires significant human effort. An interdisciplinary team of learning sciences and computer science researchers at Vanderbilt and Indiana universities has been exploiting recent advances in artificial intelligence (AI) and multimodal learning analytics (MMLA) to augment – but not supplant – human analysis and help support the generation of useful insights for students, teachers, and researchers. These technologies are being used to help provide a deeper understanding of learner engagement in embodied modelling activities, enabling teachers to gain a richer grasp of their students' learning process and offer personalised feedback and support for reflection.

For example, a timeline visualisation has been developed that integrates information across multiple data modalities to bring together information about what learners said (from the audio stream), where they were looking (from the video stream), what they were doing (from the system data logs), and how they were feeling (again based on information extracted from the video stream). This timeline can enhance teachers' understanding of how students interact with each other and their environment over time, allowing them to facilitate better reflective discussions of the students' embodied modelling experiences.

Embodied Model Learning in the Classroom with Timeline supporting Interactivity Analyses. This includes elements such as transcription of each individuals' contributions, gaze, and emotions.

To effectively analyse cases of embodied model learning, AI-based algorithms document the evolving states in XR environments, tracking and interpreting student engagement with scientific processes both individually and in groups. The classroom teacher actively guides students, helping them relate their activities to the modelled phenomena. The AI-driven timeline visualisation combines system log data on movements and interactions, gaze data to understand attention shifts, and video-derived emotional expressions. This comprehensive visualisation format provides clear, compelling insights for teachers and researchers, highlighting key moments of insight and difficulty. For example, the timeline may show a student's period of confusion or expression of frustration when they did not get the attention of other students to help them complete a task, offering teachers valuable information to guide further interactions. The visualisation can also serve as a tool for reviewing, recognising and interpreting key moments of discovery among students, which can be linked to their evolving understanding of the scientific content being studied. Teachers use these insights to facilitate meaningful discussions, supporting reflection and advancing the students' learning processes.

Challenges, barriers, limitations

Despite the potential of XR and AI to revolutionise embodied model learning there are ongoing challenges to address. First, high-quality XR and AI technologies require significant financial investment and technical expertise, which can be a barrier for many schools. Second, teachers must devote substantial time to understand the complementary elements of pedagogy and data representations of learning activity; the use of AI in analysis may also lead to a 'black box' effect where data-insight are either regarded with suspicion or too unquestionably relied upon. Third, collecting and analysing multimodal data raises concerns about student privacy and data security, necessitating careful protocols and ethical guidelines. Finally, questions of equity, both in terms of which students have access to these advanced technologies and in what ways they feel empowered to engage with them, are important to address in ensuring that the benefits of novel pedagogies are distributed fairly.

Conclusions

The integration of XR and AI technologies to support students in learning about models from the inside, represents a powerful approach to enhancing student learning by providing rich, embodied experiences and reflective opportunities. This approach can help students better understand complex scientific models by allowing them both to experience these models firsthand and become the designers of them. Teachers, supported by AI-driven data visualisations, can gain deeper insights into student learning processes and facilitate more effective reflective discussions to advance learning. Despite the challenges and barriers, the potential benefits of these technologies in making abstract concepts more accessible and engaging make them a valuable addition to modern educational practices.

References

1. Short conference paper from the STEP project:

   Danish, J., Enyedy, N., Humburg, M., Saleh, A., Dahn, M., Lee, C., and Georgen, C. (2018) 'STEP-Bees and the role of collective embodiment in supporting learning within a system', in J. Kay and R. Luckin (Eds.) *ICLS 2018 Proceedings: International conference of the learning sciences*, pp. 1249–1250. Available at: https://repository.isls.org/bitstream/1/600/1/272.pdf (Accessed 4 July 2024).

2. A conference paper describing several projects:

   Moher, T., Slotta, J. D., Acosta, A., Cober, R., Dasgupta, C., Fong, C., … and Peppler, K. (2015). *Knowledge construction in the instrumented classroom: Supporting student investigations of their physical learning environment*. pp. 631–638. CSCL 2015 Proceedings. International Society of the Learning Sciences, Inc. Available at: https://repository.isls.org/handle/1/449 (Accessed 3 July 2024).

3. A conference paper from the STEP project:

   Enyedy, N., Danish, J., DeLiema, D., Saleh, A., Lee, C., Morris, N., and Illum, R. (2017) 'Social affordances of mixed reality learning environments: a case from the Science through Technology Enhanced Play project (STEP)', *Papers from Hawaii International Conference on System Sciences 2017*. Available at: https://scholarspace.manoa.hawaii.edu/items/28ac995d-1cfe-4f03-b9e9-7915522896fa (Accessed 4 July 2024).

4. Journal article:

   Lindgren, R., and Johnson-Glenberg, M. (2013) 'Emboldened by embodiment: Six precepts for research on embodied learning and mixed reality', *Educational Researcher*, 42(8), pp. 445–452.

5. Journal article:

   Enyedy, N., Danish, J. A., Delacruz, G., and Kumar, M. (2012) 'Learning physics through play in an augmented reality environment', *International Journal of Computer-Supported Collaborative Learning*, 7, pp. 347–378.

6. A conceptual piece in a book chapter describing the value of students' ability to see things from different perspectives in creating deep understanding:

   Ackermann, E. (2012) 'Perspective-taking and object construction: Two keys to learning', in Y=. B. Kafai and M. Resnick (eds.) *Constructionism in Practice*, pp. 25–35. New York: Routledge.

7. Book chapter:

   Hall, R., and Stevens, R. (2015) 'Interaction analysis approaches to knowledge in use', in A. A. diSessa, M. Levin and N. J. S. Brown (eds.) *Knowledge and Interaction*, pp. 88–124. Routledge.

Resources

- STEP project website:

  Science through Technology Enhanced Play (STEP). GEM-STEP Example Models. Available at: https://embodiedplay.org/gem-step_examples/ (Accessed 4 July 2024).

- Short article on GenAI and XR, discussing the application of the AI approach to XR learning:

  Levine, E. (2024) 'The Next Frontier in Education: How generative AI and XR will evolve the world of learning in the next decade', *Qualcomm* blog post, 15 May. Available at: https://www.qualcomm.com/news/onq/2024/05/the-next-frontier-in-education-how-generative-ai-and-xr-evolve-learning (Accessed 4 July 2024).

- Feature article on several different applications of GenAI and XR (e.g., 'Imagine learning about the history of ancient Rome, not from a textbook but standing in the Curia of Pompey next to Julius Caesar surrounded by angry senators, moments before the knives come out'):

  J. Hutson (2023) 'Reinventing education through generative AI and XR', *Research Features*. Available at: https://researchfeatures.com/reinventing-education-generative-ai-xr/ (Accessed 4 July 2024).

Innovating Pedagogy 2024

Exploring new forms of teaching, learning and assessment, to guide educators and policy makers

Open University Innovation Report 12