Co-designing Encounters with AI in Education for Sustainable Development

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Abstract

This paper explores integrating generative AI into higher education using education for sustainable development (ESD) frameworks. Through workshops with 22 cross-disciplinary students at King's College London, participants used Microsoft Copilot to explore extreme heat challenges while critically reflecting on AI use. Key findings highlight the importance of facilitation in balancing critical reflection dimensions, the value of cross-disciplinary dialogue, and how sustainability-contextualised AI experiences helped students recognise cultural and geographical biases in AI models, though questions remain about lasting impacts on their learning practices.

1 Introduction

As higher education institutions begin to integrate generative AI into teaching and learning, there is a growing tension between AI's promised educational benefits and its problematic implications for sustainable development. Whilst AI tools offer new opportunities for student learning and research, they also pose significant challenges such as perpetuating systemic biases and inequalities (Bentley et al., 2020; Ferrara, 2024) or accelerating energy consumption through large-scale computing requirements (Nabavi et al., 2019). These challenges raise important questions about how to thoughtfully incorporate AI in ways that enhance rather than undermine education for sustainable development (ESD) principles.

This paper presents findings from a workshop series that brought together undergraduate and graduate students across disciplines at King's College London to explore the intersection of AI and ESD. Through structured co-design activities at two workshops, we investigated how students learned to frame critical questions around complex sustainability challenges whilst learning to use and critically engage with generative AI tools.

Our workshops engaged 22 students from across three faculties in collaborative learning experiences focused on extreme heat - a pressing sustainability challenge that crosses disciplinary boundaries. The workshop design emphasised three key learning outcomes: framing critical questions around complex sustainability challenges, explaining why sustainability principles matter in AI-enabled learning, and effectively communicating across subject areas. Activities included collaborative problem exploration using generative AI tools, interest-holder analysis, and cross-disciplinary dialogue on how different fields approach sustainability challenges. The workshops combined AI learning with ESD by having multidisciplinary student groups use Microsoft Copilot to investigate extreme heat themes whilst critically reflecting on AI's capabilities and limitations. Facilitation was essential in managing learning surrounding AI technology, extreme heat contexts, thematic exploration, and communicating across disciplines.

In this paper, we present our experiences and observations designing and delivering the workshops. Whilst students appreciated cross-disciplinary collaboration and often recognised cultural biases in AI, it remained unclear whether these insights would influence their future learning practices. AI learning tended to overshadow ESD learning outcomes, with many students leaving feedback contradictory to the intended learning outcomes. Students expressed interest in more concrete examination of AI's environmental impact and valued both the hands-on technology experience and interdisciplinary learning opportunities. We therefore end the paper with our reflections on future practice.

2 Literature Review

Education for sustainable development (ESD) is increasingly vital in preparing students to address complex global challenges (Zguir et al., 2021; Acosta Castellanos and Queiruga-Dios, 2022). We adopt UNESCO's (2017) ESD Framework for its holistic approach to sustainability dimensions and emphasis on transformative learning that engages values, behaviours, and competencies. Despite these benefits, the framework has been criticised for its grounding in Western epistemologies, potentially marginalising indigenous and global majority perspectives on sustainability (Barnhardt and Kawagley, 2005). Likewise, higher education institutions often struggle with translating the ESD learning objectives into specific educational methods, especially in predominately technical fields like engineering (Kopnina and Meijers, 2014). Moreover, critiques centred on the failure of ESD approaches to address contradictions between underlying economic growth paradigms and sustainability (Demaria et al., 2013), are increasingly urgent to address given the recent developments within the field of AI.

The debate over AI's environmental impact highlights the complexity involved. Kemene, Valkhof and Tladi (2024) noted that Microsoft's CO2 emissions have risen almost 30% since 2020 due to data centre expansion, whilst Google's greenhouse gas emissions in 2023 were almost 50% higher than in 2019. Likewise, Luccioni, as quoted in Calvert (2024) said that "switching from a nongenerative… AI approach to a generative one can use 30 to 40 times more energy for the exact same task." In contrast, Ritichie (2024) argued that although data centre energy use will grow, it represents 3% of projected global electricity demand growth through 2030. AI is also projected to help mitigate 5-10% of global emissions by 2030.

However, rebound effects occur when energy savings associated with increases in AI efficiency are less than expected because of behaviour change. Additionally, geographical concentration of AI infrastructure creates localised strain and injustices, with communities in the Global South having to mobilise against data centre projects threatening their water access (Lehuedé, 2024). Galaz et al. (2021) cautioned that new systemic risks may emerge due to interactions between social, technical, ecological and political aspects.

Current research exploring generative AI and education tends not to confront this debate. Within engineering education literature, scholars argued that generative AI offers benefits such as personalised learning, simulations, and reduced faculty workload (Nikolic et al., 2023; Yeralan and Lee, 2023). These authors acknowledged ethical concerns including academic integrity risks, misinformation, and bias, arguing for responsible AI use. In the broader higher education field, a similar pattern can be observed. These approaches often fail to address the fundamental concerns surrounding AI's environmental footprint and political economy, with limited evaluation of learning outcomes related to holistic systems thinking competencies.

Our focus is on Education for Sustainable Development (ESD) learning objectives that address these gaps by exploring approaches that engage with learners' values and facilitate communication across disciplines. This multi-disciplinary approach equips students to understand the complex socio-technical systems in which AI operates. We draw on Bentley et al.'s (2023) Framework for Responsible AI Education because it emphasises promoting social justice, dialogue, inquiry-based learning, reflection, and contextualising AI. This Framework encourages learners to understand not only how to use AI responsibly but also to critically question its societal impacts.

3 Methodology

We adopted an action research methodology for this study, characterised by cycles of planning, action, observation and reflection within educational research (Stringer, 2008). However, in line with critical participatory action research (PAR), our approach differs from conventional action research by emphasising how educational institutions can become sites of transformative change through collective critical inquiry, connecting individual perspectives and practice to broader institutional structures (McTaggart et al., 2017). This approach aligns with Bentley et al.'s (2023) Responsible AI Education Framework, positioning education as fundamentally political and aiming to challenge structural inequalities in AI design and deployment.

Our methodology involved two phases of action research with different participant groups. The first phase focused on co-designing a workshop model and resources with a core group of practitioners and students; whereas, the second involved testing and iteration through two workshops with student participants.

3.1 Phase 1: Co-design with a core group of practitioners and students

In the first phase, we engaged a core group of practitioners and students selected purposefully at the outset. We invited academics and students with expertise in AI and/or sustainability, welcoming others who joined based on their interests later into the process. The academics involved in this research represent different departments (Informatics, Engineering, Global Health and Social Medicine, Digital Humanities), and education functions of the university. The student co-leads were likewise diverse, with undergraduate, postgraduate and postgraduate research levels represented.

We used co-design methods to collaboratively develop a workshop model and curriculum resources. We held four two-hour preparatory workshops, each designed by a different member of the team to encourage sharing of knowledge and expertise. Each workshop focused on a different theme: multidisciplinary exploration, learner personas, learning objectives, and drafting resources. Between workshops, we developed resources for review within the workshops.

3.2 Phase 2: Co-design with student participants through two workshop iterations

The workshops with students received ethical clearance LRS/DP-23/24-40766 from King's College London, with all participants providing informed consent. In the second phase, student participants engaged with the workshop materials and provided feedback at intervals on both the content and teaching and learning methods. Between the workshops, the core group reflected on the outcomes of the first workshop, and iterated certain design aspects and materials. Initially, 67 students signed up for the workshops, from which we randomly selected 30. For the first workshop, 14 ultimately participated, and the second workshop had 8 participants. Workshops were full-day events from 10am to 4pm, with participating students receiving a £50 gift voucher as compensation.

Data collection included a pre-workshop questionnaire assessing students' knowledge, skills, and attitudes regarding AI and sustainability. We also collected facilitators' observational notes, recorded debriefing sessions, student work in shared folders, and written feedback cards. All workshop data were thematically analysed according to stated learning outcomes. The core research team conducted an analysis workshop to review initial findings and reflect on the entire process, ultimately developing key recommendations based on this collaborative assessment.

4 Findings

4.1 Co-design process and outcomes

Preparatory Workshop 1 -- Multidisciplinary Exploration: This workshop established shared understanding across disciplines through creative activities including a paper doll exercise comparing human-created and AI-generated narratives about AI. This highlighted the value of contextualising AI and reflecting on its outputs, which tended to be simplistic and culturally homogenising. For example, Klyshbekova created a story about Emre, a researcher from Turkey who uses AI for language learning but develops an overreliance on it. In contrast, Microsoft Copilot produced a more simplistic narrative about Emre perfecting his English with ChatGPT.

The second activity asked each core group member to interpret AI in Emre's story from their disciplinary perspectives. For instance, Samuels focused on structural inequality whereas Dahlin reflected on infrastructure dependencies. In sharing these perspectives, we learned about each other's interests and saw how our perspectives articulated important aspects regardless of AI or sustainability expertise. For us as educators who confront colleagues' tendency to dismiss AI as outside their area, this simple activity highlighted how everyone has responsibilities relevant to shaping AI's societal impact.

Preparatory Workshop 2 -- Learner Personas: Our second goal was to determine target learner groups and meaningful learning outcomes. We created 'learning personas' to discuss what participants might wish to gain from future workshops and how to structure inclusive sessions accommodating different knowledge backgrounds. We focused on making the learning design accessible to first-year undergraduates who may not yet have strong disciplinary identities.

Preparatory Workshop 3 -- Learning Objectives: The third workshop took up the discussion of learning objectives, once we had a clearer idea of the students we were targeting. The team agreed on objectives that included enabling participants to *"frame complex challenges around AI and sustainability, drawing on perspectives from different contexts and academic subjects,"* and to *"articulate your own values and knowledge in a way that is respectful of others' knowledge and values."* However, we were not convinced the learning outcome phrasing would resonate with students, and these were later modified.

The team selected *"extreme heat"* as a thematic focus because it provided a concrete sustainability challenge intersecting with AI applications that each discipline could engage with. For example, Ciriello suggested activities around measuring human comfort, which Samuels noted could be interesting from a public health perspective. This provided confidence that we could develop resources addressing learning outcomes, though many had reservations.

Preparatory Workshop 4 -- Drafting Resources: This final workshop developed specific learning activities and materials. The team created a comprehensive workshop agenda structuring activities across a full day, beginning with introductions to extreme heat and AI, followed by problem-framing activities. Some proposed activities like "Use Gen AI as a discussion partner" were considered too complicated. Vogel advised that despite our co-design intention, we should provide a clear, well-scaffolded starting point to avoid confusion within the allotted time.

Following this workshop, the agenda was revised to improve activity flow, clarify instructions, balance independent and group work, and establish appropriate durations. A focus group discussion guide was developed but later reduced to a few reflection questions due to time constraints. Table 1 outlines the set of activities developed for the first student workshop. Changes to these activities are discussed in the next section.

Table 1: Descriptions of the Activities

Activity	Description
1: How does extreme heat interact with AI?	In this first activity, participants explored what extreme heat is, before going deeper into an extreme heat theme. They also explored the field of artificial intelligence (AI), and how AI may interact with, or be used to explore topics related to extreme heat.
2. Framing critical questions along an extreme heat theme using AI	This activity challenged participants to explore extreme heat's impacts on a chosen theme through research, critical question development, and group collaboration. Participants first studied resources using assigned materials and Microsoft Copilot, then independently formulated complex questions exploring knowledge gaps. Finally, groups shared insights, discussed the most compelling questions, and collectively selected one for further investigation during the workshop.
3. Interest holder needs and impacts	This activity guided participants to explore their question from diverse perspectives by having each group member adopt a different interest holder role. Participants first personalised their assigned role using generative AI to create a character with a name and face. They then shared these personified stakeholders with their group, discussing how each is affected by extreme heat, their involvement in addressing the challenge, and their specific needs.

4. AI for sustainability dialogues	This activity prompted participants to reflect on how their discipline would approach their chosen question and evaluate AI's role in this process. Participants first individually considered their field's investigative methods (whether researching, analysing, experimenting, or other approaches) and assessed how generative AI might help or hinder these approaches.

4.2 Students' backgrounds and interests

Across both workshops, attitudes toward generative AI in education were predominantly positive (4 extremely positive, 10 positive out of 21 or 67%) or neutral (7 out of 21 or 33%). Participants reported moderate to high familiarity with AI, with more than half of participants using text-based generative AI tools daily or weekly. When asked if they use other types of generative AI, very few participants used them more than 'rarely.' About half of the participants reported feeling comfortable using generative AI tools. Regarding sustainability, familiarity was moderate to high, and interest in the intersection of AI and sustainability was generally positive with most participants 'somewhat likely' or 'very likely' to seek related information on their own. However, participants reported limited existing knowledge about this intersection.

Workshop participants signed up to learn about AI applications in education, sustainability efforts, to explore ethical considerations or to receive the shopping voucher. Key concerns about AI centred around academic integrity issues, with participants citing concerns about "peers using AI excessively in assignments," "loss of originality in content," inaccuracy in specialised fields like law, and challenges surrounding distinguishing between AI-generated and original student work.

4.3 Workshop outcomes

Workshops began with an introductory presentation covering key concepts of sustainability and AI, leading to activities that progressed from initial explorations of these concepts to more complex tasks in groups. Following an initial exploration of extreme heat, AI and how they interact, student then chose a theme to focus on (water infrastructure, food security, policy and regulation or health) in groups. This progression, whilst logical in design, failed to account for the level of the students and their existing knowledge, with some participants finding the introductory activities too simplistic. In the second workshop, we therefore asked students to pick a theme right away, and to explore extreme heat, AI and its interactions within the scope of the theme right away.

For the second activity, we asked participants to do some independent research on their chosen theme, with the goal of formulating critical questions that might help them to understand more about the parts of a complex challenge. Across both workshops, participants valued the time to independently research their chosen theme by reading literature we had pre-selected. In the second workshop, having begun exploring AI and their extreme heat theme straight away, participants reflected that the resources helped them to identify limitations in the outputs of generative AI. With one participant commenting:

> *AI can be helpful if we use it without much expectations. We can use it to generate some ideas to aid in our brainstorming process, but it might not be feasible to rely 100% on AI as the answers lack human voice and nuance. It also oversimplifies complex issues such as climate change.*

Moreover, a striking aspect of this activity was the evolution of critical questions as students moved from independent brainstorming supported by AI to a collective question created collaboratively with others. In the food security group, for instance, individual students initially posed questions such as *"how can AI help optimise crop yields during heatwaves?"* and *"What role does water scarcity play in exacerbating food insecurity during heatwaves?"* These questions, whilst valuable, tended to focus on a narrower or more disciplinarily focused aspect of the extreme heat theme, positioning the problem as one of predominantly relating to efficiency. Through group discussion, and with some groups continuing to use AI for refinement, groups created significantly more sophisticated questions:

> *How can AI-driven strategies ensure equitable adoption of climate-resilient agriculture in lower- and middle-income countries, considering extreme heat challenges and potential conflicts, while promoting food security and addressing funding disparities?*

This question, whilst much more complex in nature, integrates AI curiosity with social equity, geopolitical realities and resource allocation. A similar pattern emerged in the other groups as well. In the water group, individual questions such as *"which components of our water infrastructure are most vulnerable during extreme heat"* to a collective question that considered technology, infrastructure, and resilience: *"what innovative water technologies can be integrated into existing infrastructures to enhance resilience during extreme heat events?"* The process demonstrates the value of collaborative inquiry across disciplines, which AI is not yet positioned to replace.

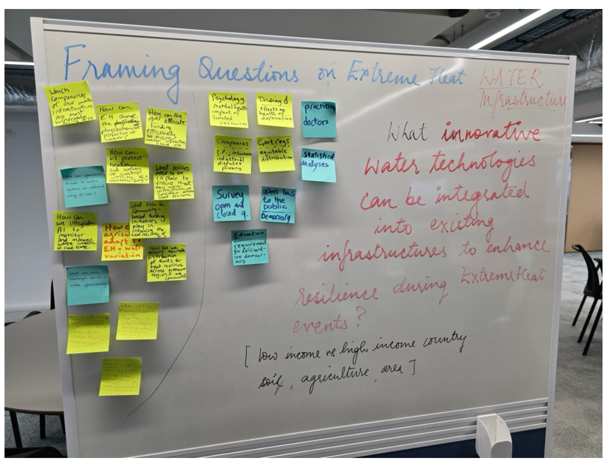

Figure 1 Example individual questions on post-its and combined complex question of a group

Following this, the workshop included two activities to explore their question first from the perspective of interest holders impacted by the complex challenge, and second by reflecting on how each disciplinary perspective may explore the challenge, and how AI might help or hinder this process. These activities were designed to help students reflect on their position relative to the challenge and communicate across disciplines. However, whilst most groups completed the activities, participants struggled to connect their disciplinary background and personal values to the equity issues in the complex challenge. One reason was that participants became overly focused on using AI to generate stories and images of their interest holder, creating a distraction. The stories generated frequently highlighted biases inherent in generative AI models. Furthermore, there was no reconvening phase where participants could collectively examine what aspects each disciplinary perspective addressed to identify blind spots or complementarities.

In the first workshop, this 'reconvening phase' involved groups filling in a power analysis matrix reflecting on their own power to influence aspects of AI and the complex challenge. This proved too complex, with only one group completing it. In the second workshop, we adopted an activity designed by Samuels to create public dialog cards, encouraging critical thinking in their own context. All groups completed this activity and developed ideas reflecting how they applied learning in ways they have power to influence. However, the collective examination of perspectives and blind spots could still be developed further.

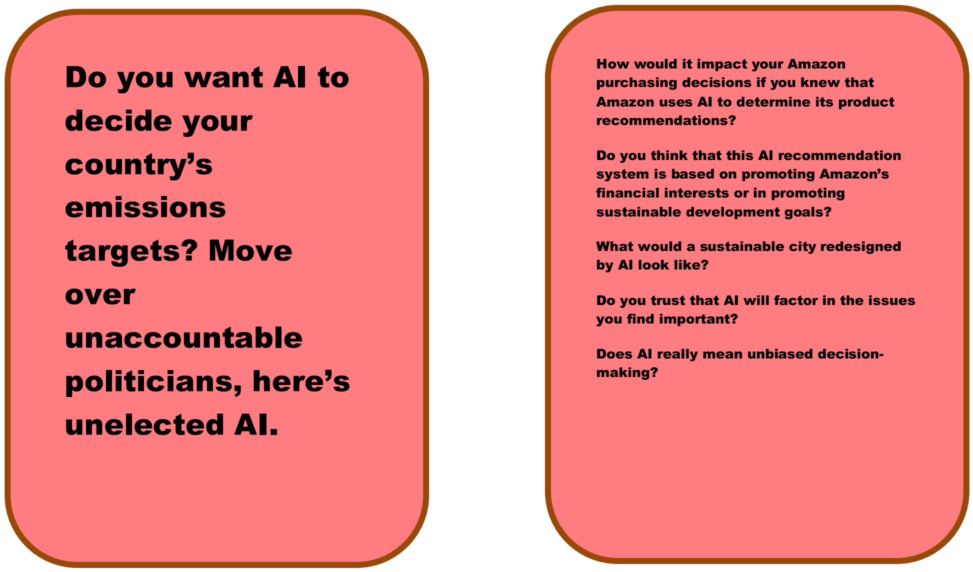

Figure 2: Example of a public dialogue card created by a participant group (formatting and spelling adjusted).

Overall, participant feedback was predominantly positive, with many highlighting the value of the workshop for their academic and professional development. There were many participants that maintained presumably uncritical positive attitudes towards AI: *"from a career perspective in today's world, people having the capacity of learning with AI and using AI is quite vital."* This response does not portray evidence of integrating sustainability principles into their view of AI. However, the workshop fostered a balanced understanding in many others, as one participant noted: *"both AI and sustainability are very important. AI represents the fourth industrial revolution. It's important that students are able to use it but are also aware of its limitations."* And some students mentioned greater concern of AI's environmental impacts: *"the most important thing that I leaned today was about the excessive energy demands of AI technologies."* The fourth learning outcome, communicating across subject areas, was most appreciated, with many students noting interdisciplinary exchange as a highlight.

5 Discussion and Conclusion

Our preparatory workshops and student workshops exploring education at the intersection of AI and ESD were developed for a pragmatic reason, as we were keen to work collaboratively on building curriculum resources that aligned with our values, responding to ESD concerns that we could use within our university. In doing this work, we have learned a great deal about finding balance in AI learning by engaging with the

Responsible AI Education Framework, providing insights into how students can engage with AI through an ESD lens using this approach. Ultimately, creating meaningful learning experiences that incorporate AI wand sustainability principles is a challenging balance to achieve. Additionally, generative AI was new and exciting when we held our workshops, and ongoing dialogue about what constitutes valuable learning as students gain more experience is necessary.

Future iterations could be strengthened by more explicitly connecting to ESD principles, emphasising critical thinking about sustainability through more "why" questions as suggested in the Responsible AI Education Framework (Bentley et al., 2023). We also questioned whether AI is necessary or appropriate to use as a means of learning in this context. Although generating images of interest holders were often the most immediate way in which participants noticed cultural bias, participants did not find generating the images beneficial to their learning. When questioned about the environmental costs of image generation, most participants seemed to agree it was not worth doing more than once.

In our team discussions, we also considered what implementation barriers might stand in the way of using these materials within our respective programmes further. We anticipate that student backgrounds will significantly influence how our workshop model would unfold in practice. For instance, those familiar with self-reflection and comfortable with complexity might engage more readily, whilst others may need extended scaffolding across multiple sessions rather than a one-off workshops. We also discussed the implications of our model for early-career educators who may lack confidence to help students make the connections between AI and sustainability. Educators of all levels of experience may also wonder what level of AI expertise they need to facilitate meaningful discussions. We recommend they approach this challenge by trying out the activities themselves first, preparing reflection prompts beforehand based on this experience. The sequencing of activities—beginning with guided, independent exploration moving to independent and then collaborative groupwork—seemed crucial, and which seems promising to replicate further, nevertheless.

Likewise, the multidisciplinary nature of these workshops was the standout highlight for participants, suggesting a need to maintain this aspect. However, embedding multidisciplinary education within our university is problematic for a few reasons. First relates to accreditation, and how many of our programmes do not have flexibility to accommodate learning outside of their curriculum – implying we would need to change the curricula. Additionally, our programmes do not accommodate experiential learning approaches well due to the high-stakes summative assessment structure we have. In which case, how might we create deliberate learning pathways that connect these learning experiences to learning in subsequent courses, ensuring these experiences build meaningfully upon one another rather than existing as isolated educational moments.

In conclusion, while our approach demonstrated promising potential for integrating AI education with ESD principles, significant work remains to balance technical skill development with critical reflection. The workshop format established a foundation for this integration, but requires refinement to ensure that sustainability competencies are not overshadowed by the novelty of AI tools. Future iterations should focus on extending reflection time, strengthening connections between personal values and systemic challenges, and more explicitly addressing questions of AI necessity and impact within sustainability contexts.

6 References

Acosta Castellanos PM and Queiruga-Dios A (2022) From environmental education to education for sustainable development in higher education: a systematic review. *International Journal of Sustainability in Higher Education* 23(3): 622-644.

Barnhardt R and Kawagley AO (2005) Indigenous knowledge systems and Alaska Native ways of knowing. *Anthropology & education quarterly* 36(1): 8-23.

Bentley C, Aicardi C, Poveda S, et al. (2023) A Framework for Responsible AI Education. *Available at SSRN*.

Bentley C, Ashton K, Martin B, et al. (2020) Including women in AI-enabled smart cities: Developing gender-inclusive AI policy and practice in the Asia-Pacific region. *AI for Social Good*. APRU.

Calvert B (2024) *AI already uses as much energy as a small country. It's only the beginning.* Available at: https://www.vox.com/climate/2024/3/28/24111721/climate-ai-tech-energy-demand-rising (accessed 28/04/2025).

Demaria F, Schneider F, Sekulova F, et al. (2013) What is degrowth? From an activist slogan to a social movement. *Environmental values* 22(2): 191-215.

Ferrara E (2024) Fairness and Bias in Artificial Intelligence: A Brief Survey of Sources, Impacts, and Mitigation Strategies. *Sci* 6(1): 3.

Galaz V, Centeno MA, Callahan PW, et al. (2021) Artificial intelligence, systemic risks, and sustainability. *Technology in society* 67: 101741.

Kemeni E, Valkhof B and Greene-Dewasmes G (2024) *AI and energy: Will AI help reduce emissions or increase power demand? Here's what to know*. Available at: https://www.weforum.org/stories/2024/07/generative-ai-energy-emissions/ (accessed 28/04/2025).

Kopnina H and Meijers F (2014) Education for sustainable development (ESD) exploring theoretical and practical challenges. *International Journal of Sustainability in Higher Education* 15(2): 188-207.

Lehuedé S (2024) An elemental ethics for artificial intelligence: water as resistance within AI's value chain. *AI & SOCIETY*. 1-14.

McTaggart R, Nixon R and Kemmis S (2017) Critical participatory action research. *The Palgrave international handbook of action research*. 21-35.

Nabavi E, Daniell KA, Williams ET, et al. (2019) AI for sustainability: a changing landscape. *Artificial intelligence—for better or worse. Future Leaders*. 157-176.

Nikolic S, Daniel S, Haque R, et al. (2023) ChatGPT versus engineering education assessment: a multidisciplinary and multi-institutional benchmarking and analysis of this generative artificial intelligence tool to investigate assessment integrity. *European Journal of Engineering Education* 48(4): 559-614.

Ritchie H (2024) *What's the impact of artificial intelligence on energy demand?* Available at: https://www.sustainabilitybynumbers.com/p/ai-energy-demand (accessed 28/04/2025).

Stringer ET (2008) *Action research in education.* Pearson Prentice Hall Upper Saddle River, NJ.

UNESCO (2017) Education for Sustainable Development Goals: Learning Objectives. Reportno. Report Number|, Date. Place Published|: Institution|.

Yeralan S and Lee LA (2023) Generative AI: Challenges to higher education. *Sustainable Engineering and Innovation* 5(2): 107-116.

Zguir MF, Dubis S and Koç M (2021) Embedding Education for Sustainable Development (ESD) and SDGs values in curriculum: A comparative review on Qatar, Singapore and New Zealand. *Journal of Cleaner Production* 319: 128534.