Harnessing Generative Artificial Intelligence to Advance Education for Sustainable Development

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Abstract

In this paper we report on a study of the impact of the CoDesignS ESD AI Coach on academic and practitioner perspectives regarding the integration of Education for Sustainable Development (ESD) within teaching and curriculum design. Employing activity theory as the analytical framework, we investigate both the opportunities and limitations associated with the use of generative AI (GenAI) in educational contexts to support ESD.

Eighteen participants from a range of higher education (HE) institutions in the UK engaged in the research through a workshop setting. The cohort represented a breadth of disciplinary backgrounds, including engineering, medical sciences, sustainability and veterinary sciences.

The workshop introduced participants to concepts of sustainability and ESD, followed by the CoDesignS ESD Framework and its Role, Objective, Community, Key, Shape (ROCKS) method for effective prompting.

We employed a mixed-methods research design, incorporating pre-and-post surveys alongside focus groups. Discussion focused on the extent to which the tool enhanced or hindered participants' understanding of sustainability concepts, and how well it aligned with disciplinary expectations. Reflections also addressed the perceived relevance and accuracy of GenAI-generated content.

Survey data revealed that participants felt more confident and better equipped with resources to embed sustainability into their curriculum, and they reported increased assurance in using GenAI tools for curriculum development.

Based on focus group analysis, we conclude that the CoDesignS ESD AI Coach holds particular value as a prompt for idea generation. However, it should not be used in isolation. Those specialising in sustainability and curriculum design should guide its effective implementation.

Keywords: generative artificial intelligence, Education for Sustainable Development, higher education, learning design, curriculum design, sustainability

1. Introduction

1.1 Education for Sustainable Development: Addressing the Challenge

The urgency to embed Education for Sustainable Development (ESD) into global educational systems has never been greater. As global challenges related to climate change, biodiversity loss, social justice and sustainable development intensify, there is a growing imperative to equip educators and learners with the knowledge, skills and values necessary to foster a more sustainable future (Leal Filho et al., 2024). Encompassing a rich variety of practices, ESD is a holistic approach to examining critically 'the kind of society and planet that we would like and that can endure through time' (McCowan, 2023, p.18). Central to this urgent and global challenge is the need to both scale up and accelerate ESD's integration into curricula across the breadth of subject disciplines and within educational institutions at all levels.

This work takes the UNESCO definition of ESD, which also informed guidance produced for HE institutions by Advance HE and the Quality Assurance Agency (QAA): 'ESD empowers learners to take informed decisions and responsible actions for environmental integrity, economic viability and a just society, for present and future generations, while respecting cultural diversity. It is about lifelong learning, and is an integral part of quality education. ESD is holistic and transformational education which addresses learning content and outcomes, pedagogy and the learning environment. It achieves its purpose by transforming society' (AdvanceHE/QAA, 2021, p.8).

In essence, ESD encompasses three elements: (a) conceptual learning content – the Sustainable Development Goals (SDGs) and discipline-sustainability intersections; (b) pedagogy – active, student-centred, participatory and inter-disciplinary learning reflecting the complexities of sustainability challenges; and (c) learning outcomes – the transformative knowledge, skills, values and attributes needed for positive societal change towards a more sustainable world. To support the embedding of ESD principles into curricula, the CoDesignS ESD Framework (Price & White, 2025; White, Price & Hack, 2025; Varga-Atkins, Toro-Troconis & Ahmad, 2024; Toro-Troconis, Inzolia & Ahmad 2023; CoDesignS ESD, 2021) – an open-access, globally used model – provides educators with a structured approach. Three key pillars underpin it (Price & White, 2025; Ahmad, et al., 2023; UNESCO, 2017):

Pillar 1: Subject-relevant cognitive, socio-emotional and behavioural objectives for the SDGs.

For sustainability challenges to be addressed effectively, learning must take place within three domains: the Cognitive Domain (head) – to understand sustainability concepts and systems; the Socio-emotional Domain (heart) – to drive the social communication, collaboration and self-reflection skills that influence values and the motivation to act; and the Behavioural Domain (hands) – to bring about changes that result in actions to tackle sustainability challenges (Advance HE/QAA, 2021, Sipos, Battisti, & Grimm, 2008).

Pillar 2: Key competencies for sustainability (UNESCO, 2017).

These are categorised as ways of thinking, ways of practicing and ways of being, and they are the cross-cutting and context-independent skills and attributes needed to address complex sustainability challenges. The eight competencies are systems thinking, anticipatory competency, normative competency, strategic competency, collaboration competency, critical thinking competency, self-awareness competency and integrated problem-solving competency. Systems thinking, in particular, enables learners to make connections and identify interactions between the SDGs.

Pillars 3: Learner-centred, action-oriented and transformative pedagogies.

These are necessary to equip and empower learners with the motivation and competencies to act as change agents for a sustainable society. This 'learning by doing', or experiential learning, immerses the learner cognitively, emotionally and behaviourally, and it transforms and disrupts by changing the world view and ways of being in the world (White et al., 2025). Methods tend to be collaborative, relational, reflective, authentic, place-based, flexible and co-created (Nicholson & Vargas, 2021; Tasler & Dale, 2021).

The CoDesignS ESD Framework (CoDesignS ESD, 2021) provides a Toolkit Planner enabling a granular analysis of learning activities across curricula. Learning elements (including learning outcomes, domains, SDGs, activity types and competencies) can be mapped to analyse their distribution over the course of a programme and to identify gaps in the pillars. The framework provides a valuable tool for planning and designing curricula that embed ESD. However, a significant challenge is that buy-in to the notion of ESD and its alignment with transformative pedagogies has to come from the educator. In traditional contexts where transmissive styles of teaching dominate, and among educators who do not possess deep knowledge of sustainability challenges, creativity and idea generation to design new curricula may be stifled. One way forward is to leverage the power of generative AI to assist with the CoDesignS ESD Framework's implementation. This is justified on the basis of the current technological pace of development and its increased use in university learning and teaching (Leal Filho et al., 2024). At the same time, we are aware of the wider discourse identifying challenges in using generative AI.

Like any recent technology, AI is changing the process of teaching and learning in many ways. Generative AI presents both opportunities and significant challenges within HE. Research indicates that AI facilitates personalised and adaptive learning environments through features such as real-time feedback, tailored tutoring and automated assessments, thereby improving how content is delivered and making administrative processes more efficient (Attewell, 2025). Additionally, multiple studies highlight AI's potential in optimising resource allocation and supporting content creation and management across various organisational levels, including departmental, institutional and systemic frameworks (Attewell, 2025; Salas-Pilco, Xiao & Oshima, 2022).

At the same time, challenges arise from academic integrity and plagiarism (Kalniņa, Nīmante & Baranova, 2024), AI systems may deliver inaccurate, misleading or biased information due to limitations in training data (Al-Zahrani &

Alasmari, 2024), hallucinations (Zhai, Wibowo & Li, 2024), data privacy and security risks (Liew & Kamrozzaman, 2024). Scholars have highlighted gaps in faculty readiness and training, along with concerns over ethical issues such as bias, academic integrity and sensitivities to cultural or religious contexts (Bobula, 2024; Kamila & Jasrotia, 2023).

With this in mind, the CoDesignS ESD AI Coach (CoDesignS ESD AI, 2024) was developed as a digital enhancement to facilitate the framework's broader uptake. This AI-powered tool offers tailored guidance to educators, helping them align sustainability goals with disciplinary and institutional priorities.

In this study we aim to explore how the CoDesignS ESD AI Coach influences academic and practitioner attitudes towards embedding ESD in their teaching and professional practice. We also seek to identify areas where the AI Coach's guidance could be enhanced, especially in terms of sustainability principles, disciplinary relevance and curriculum design. Additionally, we evaluate the AI Coach's user interface to determine how enhancements might improve usability, functionality and overall user satisfaction.

1.2 Evaluating the Contribution of AI to Support ESD

The integration of ESD, digital tools such as the CoDesignS ESD AI Coach, and evolving curriculum design practices cannot be understood in isolation. These innovations interact within complex educational systems, where tools, rules, communities, roles and cultures shape how new practices are adopted and sustained. To analyse this complex integration of technology in education, sociotechnical systems have been previously employed to structure pedagogical approaches for a technology-driven world. They have been described as 'sociotechnical ensembles' (Bijker, 1997, p.128), which combine artefacts, human behaviour, social arrangements and meaning (Johnson & Verdicchio, 2017).

A systems approach has gained traction with academics and policymakers to address contemporary societal issues around sustainability, and systems thinking must be adopted as a new paradigm to enable transformational change (Voulvoulis et al., 2022). Thus, we adopt an activity theory lens (Engeström, 1987), providing a systems-based perspective to examine the complex interplay between the CoDesignS ESD Framework, the AI Coach and the broader context of ESD integration. In this research, we adopt activity theory's conceptual framework as applied to the introduction of GenAI in education (as used in Toro-Troconis, 2025) to explore the current challenges and opportunities associated with integrating AI to support ESD.

Activity theory focuses on human agency and interactions with technology within cultural contexts (Engeström, 1987) and provides a valuable lens for understanding AI's transformative effects in the educational landscape. An activity theory model is defined by its unique 'Subject, Object, Division of Labour, Tools, Rules and the Community' that shape its operations (Bligh & Coyle, 2013, p.341; Engeström, 1987). It aids in providing a structured approach to identifying systemic tensions by examining inherent contradictions that can drive growth and transformation within the system (Engeström, 1987; Yamagata-Lynch, 2010) and which often act as catalysts for change and development.

Activity theory is particularly valuable for understanding how AI can drive transformative change within educational systems (Toro-Troconis, 2025). As follows, this framework offers critical insights into AI's structural impact by identifying and analysing the roles and interactions among key elements involved in its integration:

(1) Subject: Represents the individual engaged in the activity – typically a learner or academic.

(2) Object: Signifies the purpose or goal driving the activity, motivating the actions of the subject. In this context, the object is to introduce the use of GenAI to support integrating ESD into curricula.

(3) Tools: Signifies the resources or instruments that facilitate the interaction between the subject and the object. In this case, the use of the CoDesignS ESD AI Coach to support embedding ESD in curriculum design.

(4) Division of Labour: Involves the allocation of roles and responsibilities among participants within the system. In an educational environment, tasks are distributed among academics, professional staff and learners, each playing a specific role in the learning process.

(5) Rules: Includes the norms, guidelines and institutional policies that shape activity and govern how the subject interacts with the object. In this case, these may encompass ESD and GenAI guidelines, policies and standards.

(6) Community: Signifies all individuals and groups who share the same objective and contribute to the activity's success. In this case, the community may include educators involved in academic activities or supporting teacher training, learners, staff and university leadership groups, the global community and society.

The key elements involved in integrating GenAI to support integrating ESD into curricula have been mapped (Figure 1), aiming to identify potential systemic tensions or contradictions between different components of the activity theory model.

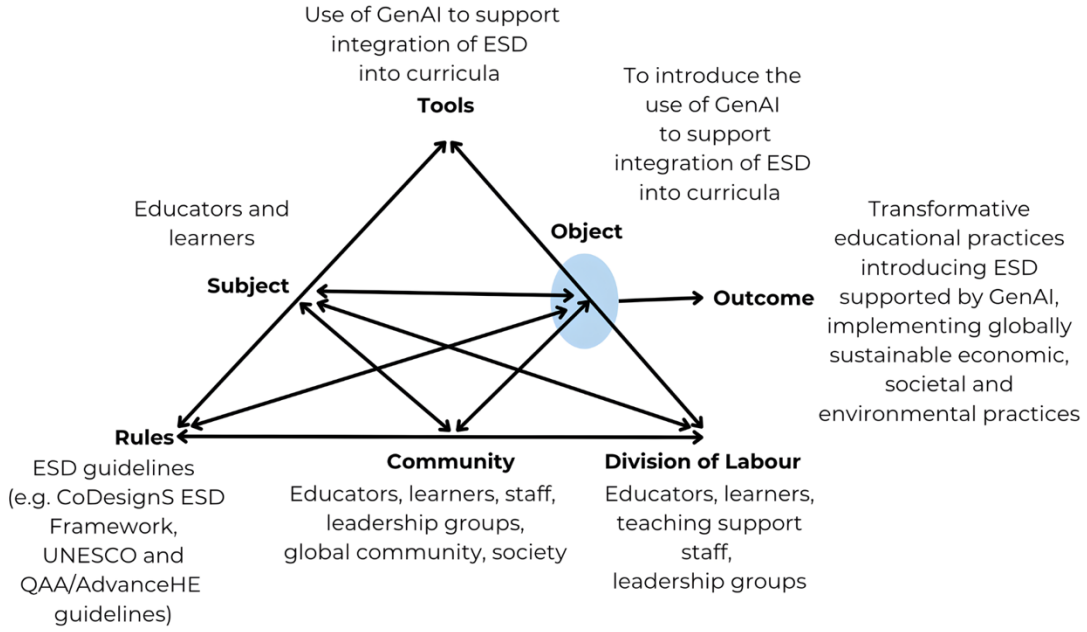

Figure 1. A modified activity theory model for integrating GenAI to support integration of ESD into curricula (adapted from Toro-Troconis, 2025)

2. Methods

This work, led by the Association for Learning Design and ESD (ALDESD, 2025), emerged from a collaborative effort involving experts from multiple institutions, several of whom had previously collaborated in the Learning Design and ESD Bootcamp that ALDESD delivered in partnership with UNESCO IESALC (Varga-Atkins et al., 2024). A pivotal moment in this initiative was the in-person workshop titled 'Harnessing AI to Advance Education for Sustainable Development' at the University of Cambridge in April 2025. This workshop laid the groundwork for the current research, introducing participants to key concepts related to sustainability, ESD and GenAI within the context of HE.

Following an initial exploration of active learning, creative pedagogies and interconnections with sustainability, participants engaged in examining the complex and evolving relationships between self, learners and place (Tasler & Dale, 2021). Building on these discussions, they applied the CoDesignS ESD and CoDesignS AI Frameworks (CoDesignS AI, 2024; CoDesignS ESD, 2021), with guidance from the beta version of the CoDesignS ESD AI Coach (2024), to reflect critically on and design transformative educational practices. The workshop represents a collaboration between ALDESD, King's College London, the University of Cambridge, Cambridge Zero and the University of Glasgow (ALDESD, 2025).

2.1 Representation of Activity Theory Elements during the Workshop

The workshop design's aim was to reflect the key elements of an activity theory model that included the following:

(1) Subject: The participants were academics from a diverse range of disciplines within HE institutions across the UK (presented in 2.2 Workshop participants)

(2) Object: The workshop's primary goal was to introduce and explore the use of the CoDesignS ESD AI Coach (CoDesignS ESD AI Coach, 2024) as a tool to support ESD's integration into curricula, and to gather feedback from participants on its usability and effectiveness.

(3) Tools: The mediating artifact facilitating the interaction between the subject and the object was the CoDesignS ESD AI Coach (CoDesignS ESD AI Coach, 2024), which served as both a resource and scaffold for curriculum design aligned with ESD principles.

(4) Division of Labour: Workshop facilitators provided guidance on how to access and engage with the CoDesignS ESD AI Coach. Participants were encouraged to work in groups, navigating the tool collaboratively.

(5) Rules: Participants were expected to engage with the tool by following the structured instructions provided. Group-based interaction was encouraged to stimulate dialogue and shared interpretation of the tool's outputs.

(6) Community: The workshop brought together a representative cohort of educators committed to embedding ESD within HE curricula.

2.2 Workshop Participants

Eighteen participants from a range of universities in the UK attended the workshop and consented to take part in the research, including representatives from the following:

(1) Anglia Ruskin University

(2) King's College London

(3) Manchester Metropolitan University

(4) Oxford Brookes University

(5) Royal Veterinary College

(6) The Open University

(7) University of Cambridge

(8) University of East Anglia

(9) University of Gloucestershire

(10) University of Hertfordshire

Workshop participants represented a diverse mix of professionals (Figure 2), including educational developers and learning technologists with discipline specialisms in engineering (34.5%), sustainability (21.4%), medical sciences (24.3%) and veterinary sciences (20%).

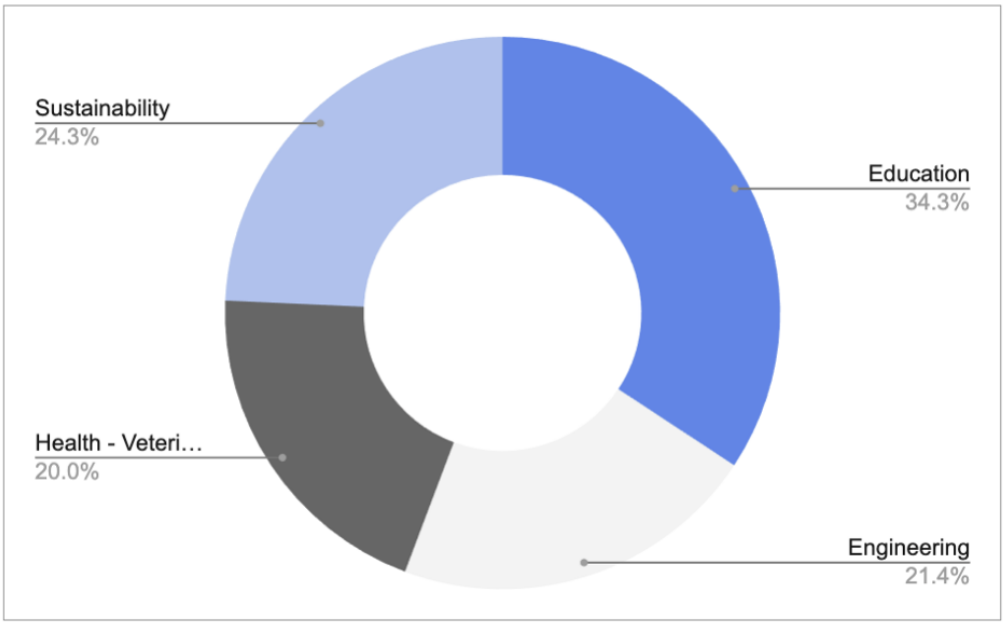

Figure 2. Disciplines represented by workshop participants

2.3 Workshop Delivery and Participant Engagement

The workshop was held in the afternoon and commenced with an introduction to sustainability and ESD. This was followed by an overview of the CoDesignS ESD Framework and the concept of transformative pedagogies, illustrated through practical examples. Participants were then introduced to the CoDesignS ESD AI Framework (CoDesignS ESD

AI, 2024), with a focus on the ROCKS method – a structured approach to crafting effective prompts for AI tools. ROCKS (Figure 3) stands for:

(1) Role – Define AI's role (e.g 'I am a curriculum designer')

(2) Objective – State the interaction's intended goal

(3) Community – Provide background and situational information

(4) Key – Specify the tone or style domain or expertise required

(5) Shape – Note the output's desired format

This approach to using AI is gaining traction in HE (Armstrong, 2025). This method supports users in writing more efficient and targeted prompts, enabling GenAI to generate higher-quality responses with fewer iterations (Toro-Troconis, 2025). This, in turn, contributes to reduced computational demand and energy consumption, aligning with the workshop's sustainability goals.

A panel discussion followed the framework presentation, featuring practitioners from both ESD and GenAI fields. The panel explored the opportunities and tensions involved in integrating GenAI technologies into curriculum design with sustainability in mind.

Figure 3. ROCKS method – CoDesignS ESD AI Framework (CoDesignS AI, 2024)

Following the panel discussion, participants were organised into four groups based on their academic disciplines as presented previously in Figure 2. They were then introduced to the CoDesignS ESD AI Coach, with clear instructions on how to access the tool by scanning a QR code and opening it in a web browser. Participants were guided to interact with the tool using the ROCKS method to structure their prompts effectively. This structured prompting approach enabled each group to explore curriculum design ideas tailored to their subject area, grounded in ESD principles.

Examples of prompts objectives were given to the groups:

Objective 1: Design an escape room activity.

Objective 2: Create a lesson plan.

Objective 3: Create an assessment rubric.

Objective 4: Design a small activity lasting 45 min (Supervision).

Objective 5: Re-write a lecture.

Objective 6: Design a Problem-Based Learning session for clinical education

Figure 4 presents the CoDesignS ESD AI Coach's interface, featuring a sample prompt constructed using the ROCKS method and the corresponding AI-generated response. The CoDesignS ESD AI Coach operated using ChatGPT-4.0 as

its underlying large language model. Working collaboratively, participants discussed the guidance the AI Coach provided, evaluating its relevance, clarity and potential for supporting sustainable curriculum design within their disciplinary context.

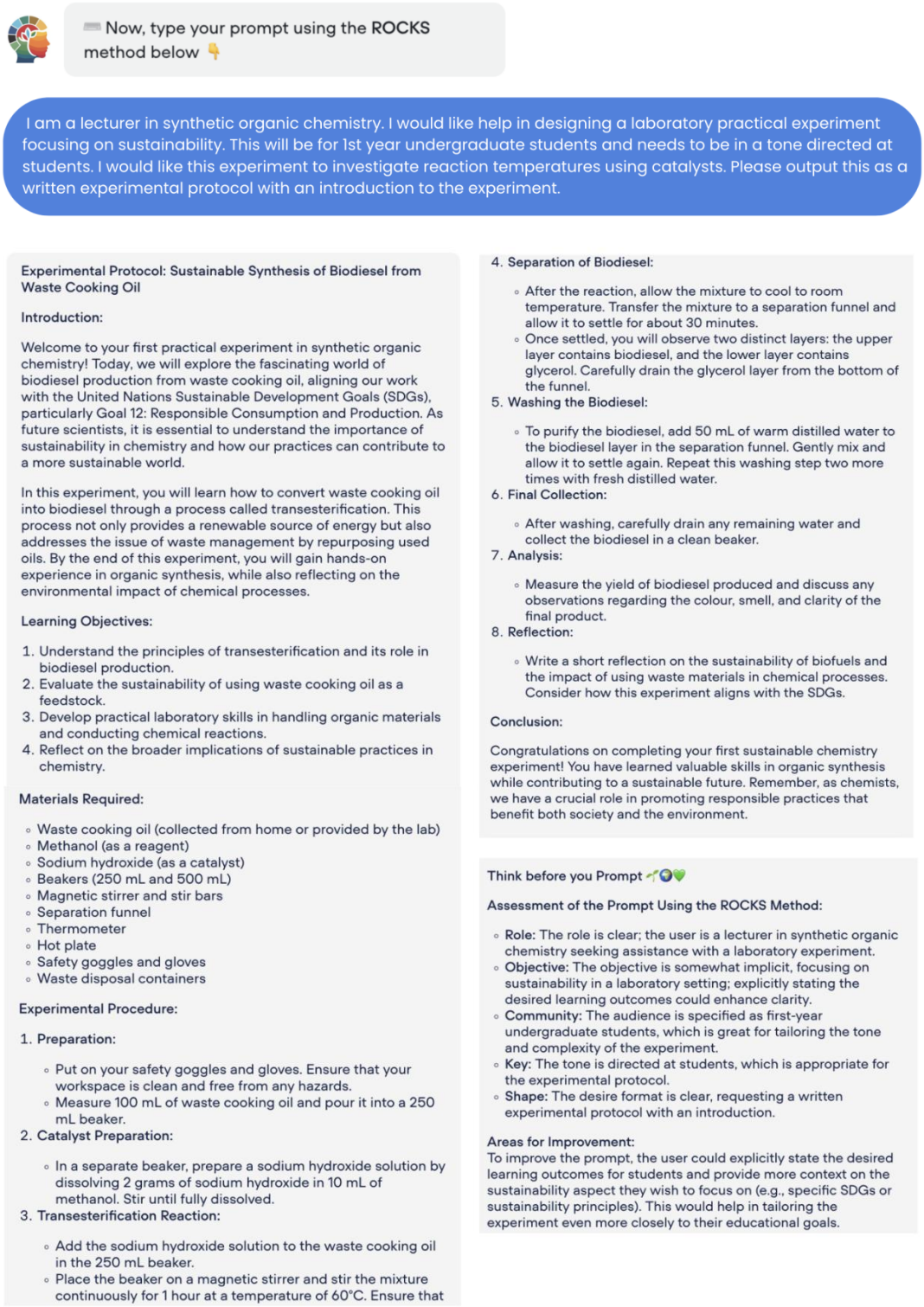

Figure 4. CoDesignS ESD AI Coach interface, featuring a sample prompt constructed using the ROCKS method and the corresponding Gen AI-generated response

Following engagement with the AI coach, each group was invited to reflect on their experience and summarise their feedback across three key thematic areas:

(1) Curriculum design

(2) Sustainability-related aspects

(3) Discipline-specific considerations

These reflections informed a broader evaluation of the tool's usability and pedagogical value. Feedback was captured on flip charts using a traffic light system for each group:

(1) Green sticky notes for positive insights

(2) Yellow for mixed or neutral feedback

(3) Amber for areas of concern or improvement

2.4 Evaluation

2.4.1 Workshop Reflections

Participant reflections were coded according to three key dimensions:

(1) Academic discipline, categorised as education, engineering, health and veterinary sciences, and sustainability;

(2) Thematic area, including curriculum design, sustainability-related aspects and discipline-specific considerations;

(3) Feedback sentiment, indicated by the colour-coding system used during the activity: green (positive), yellow (neutral or mixed) and amber (critical or less favourable) based on UCL Arena Centre for Research-based Education (n.d.).

2.4.2 Pre- and Post-Surveys

To assess attitudes towards using GenAI to support ESD's integration in curriculum design, participants were invited to complete a pre-workshop survey; the same survey was administered again, post-workshop. The pre- and post-workshop surveys included ten statements (Table 1) designed to assess participants' attitudes towards integrating ESD in curricula and the use of GenAI to support this process, both before and after the workshop, on a scale of 1 = Strongly disagree to 5 = Strongly agree.

Table 1. Pre- and Post-workshop survey questions

Questions	
Q1	I believe embedding sustainability concepts into curriculum design is important for my learners.
Q2	I feel motivated to integrate sustainability concepts into my teaching practice.
Q3	I see GenAI as a useful tool for guiding the process of embedding sustainability in curriculum design.
Q4	I trust GenAI to help me design engaging and relevant sustainability activities in my discipline (e.g. collaborative activities, lesson plans, formative assessments).
Q5	I'm open to exploring GenAI to innovate my curriculum design around sustainability in my subject.
Q6	I feel confident in my ability to embed sustainability concepts into my teaching.
Q7	I feel I have the resources to integrate sustainability concepts into my curriculum.
Q8	I have the necessary skills to design curriculum elements that include sustainability principles.
Q9	I feel confident using GenAI to support my curriculum design.
Q10	I have access to the support and guidance I need to use GenAI in education effectively.

Additionally, two focus groups were conducted following the workshop. Both sessions took place in person at the University of Cambridge. The discussions were audio-recorded and subsequently transcribed to support the analysis and coding of participants' responses. The guiding questions for these are provided in Appendix A. One group brought together eight academics with backgrounds in engineering and medicine, while the other comprised eight participants with expertise in sustainability and education.

The focus groups explored participants' experiences engaging with the CoDesignS ESD AI Coach, examining its effectiveness across multiple dimensions. Discussions centred on how the tool supported or challenged participants' understanding of sustainability concepts, and whether it provided new insights or reinforced existing knowledge. Participants also reflected on the AI-generated responses' the relevance and accuracy from a disciplinary perspective, considering whether the outputs aligned with the specific practices, and expectations of their academic fields.

A key area of discussion involved the clarity with which sustainability and SDG-related concepts were integrated into the GenAI's responses. Participants discussed whether these elements were easily identifiable and meaningfully embedded within the content. The groups also considered the role of prompting – particularly the use of the ROCKS method – and how their interactions with the AI Coach deepened their understanding of how structured prompts influence GenAI outputs' quality and efficiency. This conversation was closely tied to discussions about environmental impact, recognising that more effective prompting can reduce the number of interactions needed and therefore help lower the energy consumption associated with GenAI use.

Participants also evaluated the CoDesignS ESD AI Coach in terms of its support for curriculum design. They discussed the practicality and applicability of the AI's suggestions, including how feasible they would be to implement within real educational contexts. Finally, participants shared ideas for how the AI Coach's design, functionality and usability could be enhanced to support interdisciplinary engagement better and promote sustainability-oriented teaching practices.

Two researchers, who were part of the workshop organising committee, facilitated the focus groups. It is important to acknowledge the potential for researcher bias because members of the project team facilitated the focus groups. Although careful measures were taken to foster a neutral, inclusive and open atmosphere for dialogue, the possibility remained that participants, whether consciously or unconsciously, may have tailored their responses to align with perceived expectations or to present the intervention in a more favourable light. To mitigate this risk, facilitators clearly communicated that all feedback, whether positive, critical or mixed, was both welcomed and essential to the CoDesignS ESD AI Coach's iterative refinement.

Two researchers analysed anonymised transcripts using the Data-TAVS Toolkit (2021). They analysed focus group data using Saldaña's (2016) qualitative coding methods, combining open and thematic coding. Initially, they coded participant responses using a SWOT approach (Strengths, Weaknesses, Opportunities, Threats) to assess the responses' tone. This was followed by pattern coding, which grouped related ideas into broader themes. Key themes that emerged included sustainability literacy, disciplinary relevance, curriculum design support and user experience. A summary of key codes is provided in Figure 5.

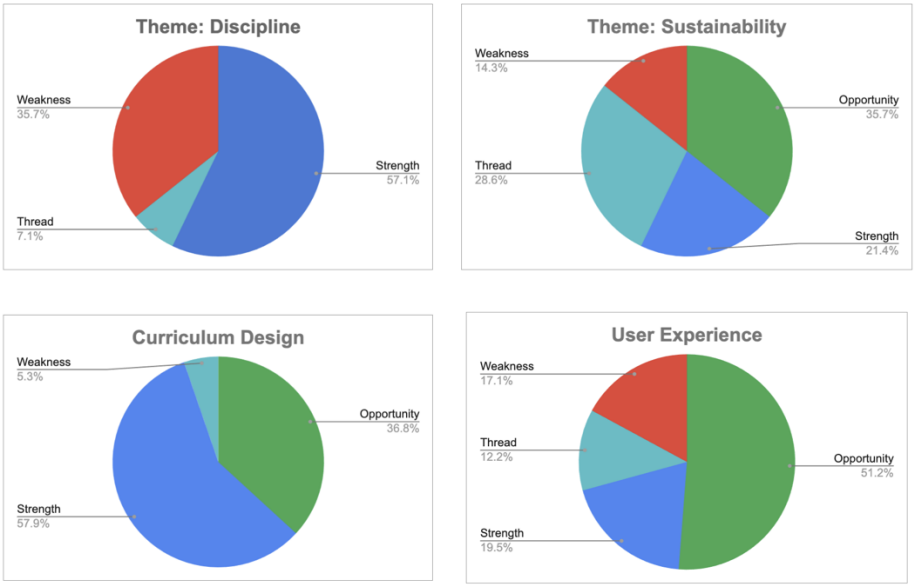

Figure 5. Focus Groups - key themes and SWOT analysis using the Data-TAVS Toolkit (2021)

The study was conducted in accordance with a research protocol approved by the Research Integrity and Ethics Committee at King's College London (Application reference: MRA-23/24-43065). Data collection was carried out in April 2025.

3. Results

3.1 Workshop Reflections

The responses recorded on flipcharts using colour-coded sticky notes were analysed to explore disciplinary differences across three key areas: curriculum design, sustainability-related aspects and discipline-specific considerations. The coding allowed for identification of key themes and patterns in the feedback, highlighting both perceived benefits and challenges associated with the CoDesignS ESD AI Coach and the broader integration of ESD principles (see Figure 6).

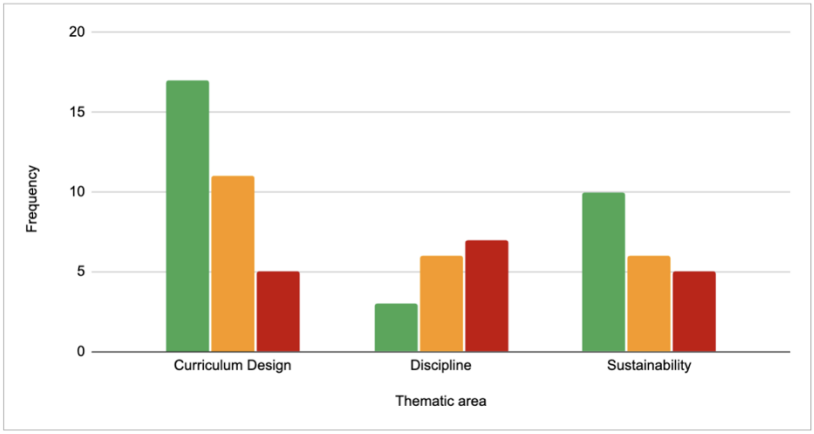

Figure 6. Feedback according to thematic area with feedback sentiment (green, yellow and red)

Participants from Engineering disciplines frequently highlighted the alignment between sustainability concepts and existing disciplinary frameworks, particularly in relation to innovation, systems thinking and real-world application. The integration of sustainability into curriculum design was seen as feasible and relevant, with several comments noting that the AI Coach provided clear and actionable guidance. Participants from the Sustainability and Education groups also emphasised the AI Coach's usefulness in supporting curriculum innovation. They recognised the tool for helping articulate sustainability concepts in a structured and accessible way as well as for offering a scaffold to integrate SDGs into teaching practices.

Despite general support for the tool, several discipline-specific challenges emerged. The Discipline-specific considerations category revealed the greatest number of concerns, especially among participants from Education and Health and Veterinary Sciences. These included difficulties in mapping ESD concepts onto traditional disciplinary content, concerns about institutional constraints and uncertainty about how sustainability values align with professional competencies or accreditation requirements.

In the Health and Veterinary Sciences group, comments pointed to perceived barriers in applying sustainability concepts in clinical or scientific contexts. Participants raised questions about SDGs' relevance and applicability in highly regulated or evidence-based fields. Interestingly, while the Sustainability group expressed strong engagement with the tool and its aims, they also offered critical reflections across all categories.

3.2 Pre- and Post-surveys

Eighteen participants completed the pre-survey, and seventeen completed the post-survey; the results are shown in Figure 7. Box shading represents the frequency (percentage) of response, and a dot represents the mode (most frequent response). There is very high agreement with statements 1 and 2, before and after the workshop, reflecting an ongoing strong commitment to sustainability in curriculum design and teaching practice. The mode for statements 3 and 7 shows a positive modal shift, in relation to the perception of GenAI being a useful tool to aid curriculum design and engaging activities. Similarly, a modal increase for statement 9 suggests that participants developed confidence in using GenAI to guide curriculum design. Regarding statements 4, 5, 8 and 9 – while the modes are no different – the frequency shading again reflects a positive shift. The sample size is too small to suggest that the changes may be significant; however, these encouraging results indicate increased openness to, and use of, GenAI for embedding GenAI into sustainability teaching.

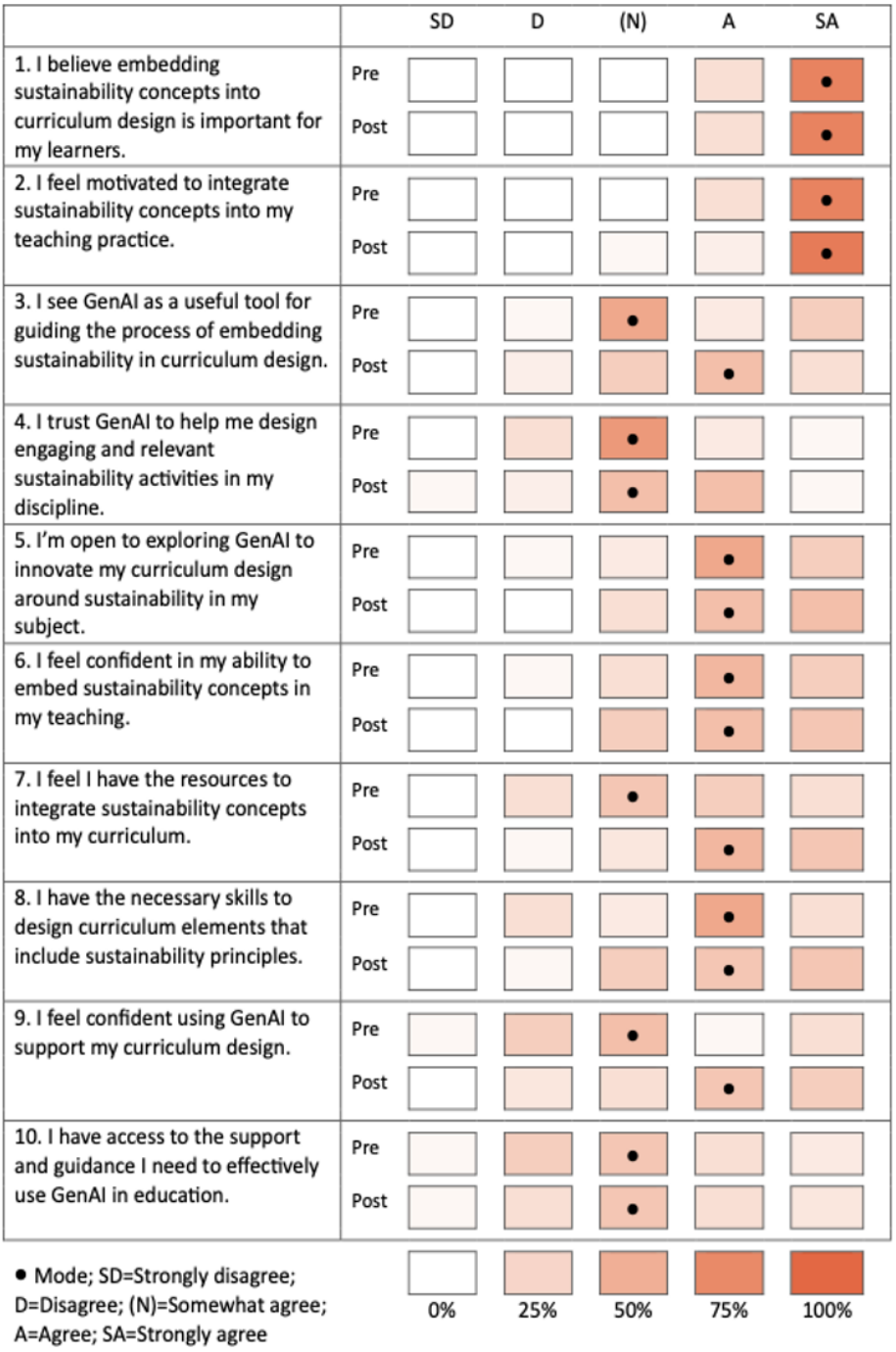

Figure 7. Pre- and Post-survey results

3.3 Focus Groups

Based on qualitative data from the focus groups, the main findings were categorised into four key themes: Curriculum Design, Sustainability, Discipline and User Experience, framed using a SWOT approach (see Tables 2–5).

3.3.1 Curriculum Design

Participants responded positively to the CoDesignS ESD AI Coach's potential to support curriculum design, especially for those newer to ESD or pedagogical planning (Table 2). The tool was valued for offering practical outputs such as structured activities and module outlines, while also introducing broader pedagogical approaches. Participants stated:

'The feedback I got from the, you know, on the rocks, was extremely valid and very well put together.'

'I think it was really good to bring in general kind of pedagogy concepts and activities and suggesting diversified ways of doing stuff. I thought that was really strong.'

'I really like the ROCKS. I mean, some of the ideas in ROCKS are things that you kind of think about when trying to create a question. But actually having a sort of step by step of the things you need to think about are good.'

Participants also emphasised the tool's value as a collaborative aid, something that could support shared planning, academic development and idea exchange, participants said:

'I think it would be really useful to use in conversation with colleagues.'

'And I think it's really the strength of the tool to be used in a collaborative fashion. I could see how I could use that for educational, for academic development, but you know, based on group work and exchanging views.'

However, some limitations were noted. For example, the AI Coach struggled to generate academic references, and its outputs occasionally lacked the depth needed for more complex or institution-specific planning.

'When I prompted it to give me the references, it couldn't do that and it just shut down.'

While the current version may not yet fully align with all transformational agendas, such as decolonisation or decarbonisation, participants saw strong potential for the tool to support values-based, reflective and innovative curriculum design, particularly when used as a starting point for further dialogue and development.

Table 2. Curriculum Design – SWOT

Strengths	Weaknesses
● The CoDesignS ESD AI Coach acts as an accessible entry point for educators new to ESD or curriculum planning. ● Provides practical outputs, such as structured module outlines and activity ideas. ● Encourages creative and critical pedagogical thinking (e.g. escape rooms, SDG-aligned strategies). ● Speeds up ideation and planning, supporting time-constrained educators.	● Perceived overemphasis on SDGs (e.g. appearing in every weekly plan) can be overwhelming. ● Outputs can be overly generic or misaligned with institutional processes. ● Curriculum specialists hesitant to recommend broadly due to depth limitations.
Opportunities	**Threats**
● Can be developed to promote transformative pedagogy, including systems thinking, graduate attributes and reflective practice. ● Potential integration with QAA/Advance HE frameworks. ● Serves as a foundation for more interactive curriculum co-design and values-based planning.	● Lacks current integration of broader transformation agendas such as decolonisation, decarbonisation and democratisation. ● Risk of reinforcing existing content norms rather than challenging pedagogical assumptions.

3.3.2 Sustainability

Many participants saw the CoDesignS ESD AI Coach as a powerful enabler for embedding sustainability across the curriculum, offering accessible and context-aware content linked to the SDGs. By lowering the barrier to entry, it supports educators at both the course and institutional level to engage meaningfully with sustainability themes.

'What that enables is, there's no excuse for anybody to, not to embed sustainability. So that's really good and that could make a difference and ripple outwards.'

Participants appreciated the tool's potential as a discussion aid, particularly in collaborative settings where it could help teams identify existing sustainability practices and explore further opportunities.

'I think it'd be really useful to use it if you're doing a session where you are working with colleagues and you are supporting them to, draw out what they already do, for instance, but then you could use it to take it one step further. To explore what more they could do and use it as a discussion tool.'

However, ethical concerns emerged around the environmental cost of using AI itself, creating a tension between the tool's sustainability message and the resource intensity behind it.

'But I am slightly challenged by using something that is so carbon and water intensive.'

'I feel quite tempted by everybody being able to embed sustainability in a curriculum, but I'm not sure ethically I can stand by the environmental impact it generates.'

These reflections highlight both the opportunity and complexity of using AI in sustainability education. While the AI Coach can help drive curricular change and raise awareness of sustainability issues, participants also called for greater transparency and responsibility in how its own environmental footprint is acknowledged and addressed (Table 3).

Table 3. Sustainability – SWOT

Strengths	Weaknesses
● The CoDesignS ESD AI Coach offers relevant, context-specific sustainability content tailored to disciplines. ● Clearly maps learning design outputs to SDGs. ● Supports both course-level and department-level sustainability efforts.	● The emphasis on technical or environmental aspects (e.g. carbon footprint) within the response can be improved. ● Risk of oversimplification of complex sustainability narratives.
Opportunities	**Threats**
● Can act as a decision-support tool for embedding sustainability into strategic educational planning. ● Helps educators identify existing alignment with SDGs, reducing resistance. ● Adds value by raising awareness of the environmental costs of AI itself.	● Ethical contradiction in promoting sustainability using AI tools with high carbon and water footprints. ● Risk of user disillusionment or scepticism if environmental impacts are not transparently addressed.

3.3.3 Discipline

Participants recognised the value of the CoDesignS ESD AI Coach in supporting disciplinary engagement with sustainability, particularly for early-career academics or those less familiar with ESD principles (Table 4). The tool helped users begin to connect sustainability with subject content and pedagogical design across diverse fields.

'As a tool I think it's quite valuable. I'm working on [a] postdoc programme. Most of them will become academics tomorrow. They don't necessarily have the knowledge about how to prepare a lecture, how to integrate all SDGs in the content they're creating. So I think it will be quite useful.'

However, a common critique was that the tool lacked sufficient disciplinary depth, often producing outputs that felt too simplistic or generic for certain academic fields' complexity.

'In paediatric health, it did a lovely structure, but equally a little bit what you were saying it was a bit simple.'

'In a lab setting, it didn't have any figures or anything like that. The detail was a bit too simple for the discipline.'

'I said, I'm a course leader for a history degree and I want to completely redesign my course so that it embeds SDGs, and then it just gave me really, really vague module titles, which were just unrealistic.'

While the AI Coach encouraged cross-disciplinary thinking and sparked useful reflection**,** participants emphasised the need for stronger alignment with subject-specific standards, benchmarks and levels of academic rigour. There is clear potential for the tool to evolve into a discipline-responsive support mechanism, helping staff align with accreditation frameworks and enhance both disciplinary and sustainability literacy. For this potential to be fully realised, the AI Coach must balance accessibility with disciplinary credibility, ensuring its value is consistent across academic fields' full spectrum.

Table 4. Discipline – SWOT

Strengths	Weaknesses
● The CoDesignS ESD AI Coach sparks reflection on how ESD can relate to varied subject areas (engineering, medicine, marketing). ● Useful for early-career staff or those unfamiliar with ESD. ● Encourages cross-disciplinary engagement with sustainability thinking.	● Most frequent criticism: suggestions often too generic or lacking disciplinary depth. ● Less effective in highly specialised or regulated fields (e.g. law, history, chemistry). ● Lacks alignment with discipline-specific standards or benchmarks.
Opportunities	Threats
● Potential to support learner use of AI in academic disciplines. ● Can help academic staff align with professional standards, such as accreditation criteria. ● Opportunity to aid in staff upskilling in both disciplinary and sustainability literacy.	● Tool may unintentionally favour certain disciplines, reducing cross-sector relevance. ● Uneven uptake due to differing ESD literacy levels across academic staff. ● Risks undermining credibility in fields requiring high rigour or evidence-based content.

3.3.4 User experience

Participants, particularly those new to AI-supported tools, appreciated the CoDesignS ESD AI Coach's ease of access and intuitive interface. The ROCKS method was highlighted as a helpful guide in crafting more effective prompts, enabling users to articulate their design needs better.

Despite a generally positive introduction to the tool, users noted some functional limitations that affected the overall experience. The AI Coach struggled with iterative improvement and integrating new user input into its previous outputs, which limited its effectiveness as a responsive co-design partner.

'I think the feedback on the prompting was very useful. Yes. But once I tried to take that first set of feedback on board and refine my prompt accordingly, I got very similar feedback again. So, it wasn't the kind of continuous improvement type experience.'

'So then I gave it another prompt to give me statistics related to it, which it did, but it didn't then integrate automatically into the slides it had already designed for me.'

Participants saw these limitations in the AI Coach's beta version, such as the inability to retain memory across prompts or automatically build on earlier outputs, as barriers to a dynamic and consultative AI experience. They envisioned future versions evolving into more collaborative tools, capable of group engagement and environmental transparency. The summary is presented in Table 5.

Overall, while participants welcomed the AI Coach as an engaging entry point, long-term adoption will depend on improving its responsiveness, integration capabilities and support for iterative learning.

Table 5. User experience – SWOT

Strengths	Weaknesses
● The ROCKS method was valued for helping users generate clearer, more targeted prompts. ● Easy-to-use interface supported engagement, especially for users new to AI tools. ● Perceived as beneficial for both staff and learners; helps introduce AI literacy and environmental awareness.	● Beta version had limitations: lack of memory and inability to integrate feedback. ● Some users experienced frustration with task completion limits or multi-step interactions.
Opportunities	Threats
● Participants suggested evolving into a consultative tool or 'AI coach' model. ● Potential for collaborative features (e.g. group prompts, shared design outputs). ● Could offer environmental feedback (e.g. token usage, energy consumption) to reinforce sustainability.	● 'SDG fatigue' noted – repetitive inclusion of SDGs in every response may deter adoption. ● Concerns about bias, intellectual property, and data privacy in institutional settings. ● Limited iterative responsiveness in its current form may hinder long-term usability.

4. Discussion

The analysis revealed that while curriculum design and sustainability integration are broadly welcomed, there is some tension in aligning ESD principles with specific disciplinary norms and pedagogical approaches, a phenomenon that White and Priest (2025) identified. Engineering, for instance, showed fewer concerns in this area, possibly due to a natural fit between ESD and engineering problem-solving models (Calvo et al., 2024; Ramirez-Mendoz et al., 2020). In contrast, Education and Health disciplines identified more structural or conceptual barriers, signalling the need for more tailored or context-sensitive support (Almazan et al., 2024). Overall, the feedback highlights a recognition of the CoDesignS ESD AI Coach's value and potential in advancing ESD integration. Feedback also underlines concern around discipline-responsive adaptation. Numerous publications provide examples of the integration of ESD in the 'problematic' disciplines, such as Suharto, Yusuf & Wahyuda (2025) for veterinary science, Almazan et al. (2024) for education and healthcare, and Calvo et al. (2024) for engineering. Still, there is clearly a continuing need to raise awareness of these, and this is probably outside the AI Coach's scope.

Based on the analysis, several key tensions have been identified within the CoDesignS ESD AI Coach's activity theory model (Figure 8). These tensions emerge across multiple elements of the model, as conceptualised by activity theory, which includes the subject, tools, object, community, rules and division of labour.

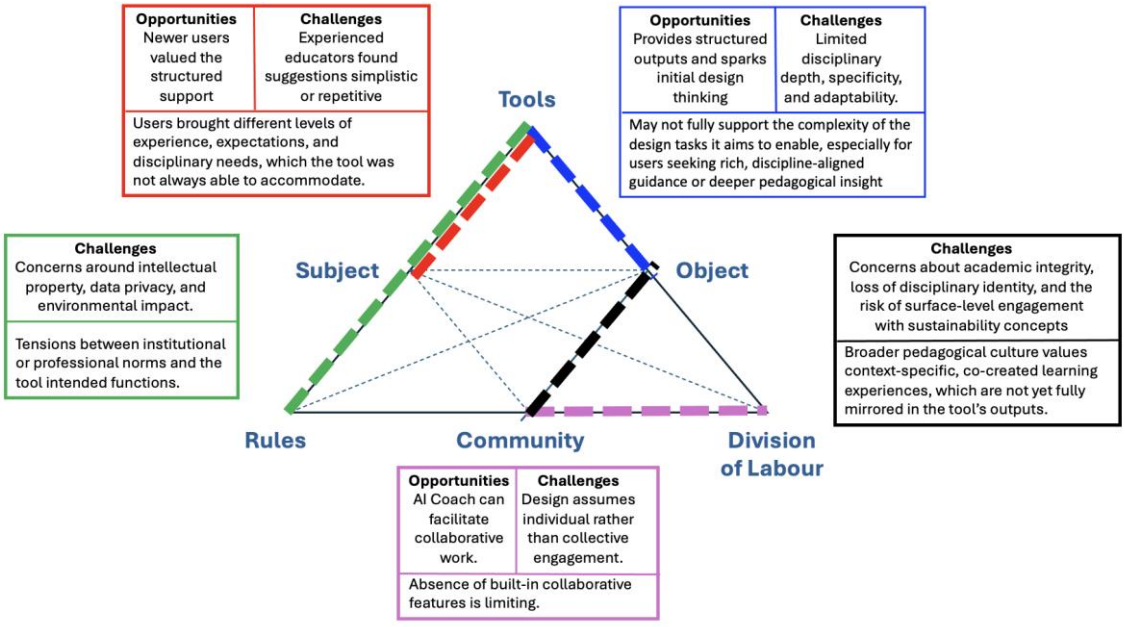

Figure 8. Opportunities and challenges identified within the modified activity theory model for integrating GenAI to support integration of ESD into curricula (adapted from Toro-Troconis, 2025)

4.1 Tools vs. Object

A central tension lies between the AI Coach as a tool and its intended object – to support ESD's meaningful integration into curriculum design. While the tool effectively provides structured outputs and sparks initial design thinking, many users reported that its disciplinary depth, specificity and adaptability were limited. This mismatch suggests the tool may not fully support the complexity of the design tasks it aims to enable, especially for users seeking rich, discipline-aligned guidance or deeper pedagogical insight.

At the same time, the AI Coach offers several important affordances. It acts as an accessible entry point for educators unfamiliar with ESD, encourages cross-disciplinary engagement and supports creative ideation through tools such as the ROCKS framework. The future challenge is to evolve the Coach beyond a generic design assistant into a consultative partner in curriculum transformation.

4.2 Subject vs. Tool

Although in general the participants expressed an overall positive user experience, tension was between the user (subject) – an academic, educational developer or practitioner – and the AI Coach as the mediating artifact. Users brought different levels of experience, expectations and disciplinary needs, which the tool was not always able to

accommodate. For example, experienced educators found the suggestions too simplistic or repetitive, while newer users valued the structured support. This suggests the beta version of the tool used during the workshop lacks adaptive scaffolding to meet users at varying levels of expertise.

Nevertheless, the Coach offered several meaningful affordances: it served as an accessible entry point for AI literacy, supported collaborative curriculum development and helped raise awareness of ESD and sustainability-linked design thinking.

4.3 Rules vs. Tools

A further tension emerges between the institutional or professional norms (rules) and how the CoDesignS ESD AI Coach functions. Participants raised concerns around intellectual property, data privacy and environmental impact, with some hesitant to embrace the tool fully due to these unresolved ethical and practical issues (UNEP, 2024). This creates a conflict between the rules guiding responsible practice and the tool's current limitations, particularly regarding transparency and sustainability.

At the same time, the AI Coach presents affordances that could help institutions manage these very challenges. For example, it offers opportunities to raise awareness of AI's environmental footprint, potentially sparking conversations around sustainable digital practices and promoting careful and efficient prompt engineering (Toro-Troconis 2025). Its accessible design supports responsible experimentation, allowing staff to engage with AI literacy in a controlled, reflective manner. Many institutions are tackling issues around intellectual property and data privacy by developing guidelines and establishing policies for the ethical use of AI (Yang & Beil, 2024).

4.4 Community vs. Division of Labour

The division of labour in the academic context – who is responsible for curriculum design, ESD integration and technology adoption – is not always clearly defined or supported (Gough & Kemp, 2025). While the AI Coach could serve as a facilitator for collaborative work, many participants noted that the current design assumes individual rather than collective engagement. The absence of built-in collaborative features or coaching pathways limits its use within a community-oriented setting, where curriculum design is often shared across teams.

Despite these limitations, the AI Coach offers important affordances that could support more distributed and shared approaches to educational development. Its clear and structured outputs can serve as a starting point for group dialogue, helping teams surface assumptions, critique ideas and co-develop learning designs. Participants also saw its value as a discussion tool in academic development contexts, where it can prompt reflection on existing practices and stimulate new thinking around sustainability and pedagogy.

4.5 Community vs. Object

The educational community's shared goal of embedding ESD meaningfully can clash with the perceived standardisation or generic nature of GenAI-generated content. This raises concerns about academic integrity, loss of disciplinary identity and the risk of surface-level engagement with sustainability concepts. The broader pedagogical culture values context-specific, co-created learning experiences, which are not yet fully mirrored in the tool's outputs (White et al., 2025).

However, the CoDesignS ESD AI Coach also supports creative ideation and can introduce new pedagogical strategies, such as escape rooms, systems thinking activities or SDG-aligned reflections that educators may not have previously considered. It offers an accessible entry point into ESD, helping those unfamiliar with sustainability principles begin to integrate them into learning design. Additionally, the AI Coach can act as a reflective and discursive tool, encouraging educators to engage critically with its suggestions and adapt them for localised and collaborative use.

5. Conclusion and Recommendations

This research has significantly contributed to the emerging field of using GenAI to advance ESD. Central to this exploration have been the CoDesignS ESD framework and the CoDesignS ESD AI Coach, which together served as both tools and conceptual lenses for investigating how educators perceive and approach the integration of ESD principles into curriculum and teaching design.

The research was underpinned by activity theory, which provided a robust framework to analyse the complex interplay between various components of the teaching and learning environment. In particular, it allowed for the identification of tensions and affordances within the system – examining the relationships among the subject (educators and learners), object (goal of embedding ESD), tools (CoDesignS ESD AI Coach), community, rules, division of labour and outcomes. This theoretical lens revealed that while the CoDesignS ESD AI Coach introduced new opportunities for innovation, its effectiveness was contingent upon the broader learning ecosystem in which it was deployed.

One of the key insights is that the CoDesignS ESD AI Coach should not be implemented as a standalone tool. Instead, it offers the greatest value when embedded within a supported and collaborative learning and professional development experience (Mula et al., 2017). Its primary affordance is its capacity to act as a catalyst for idea generation, providing a low-barrier entry point for educators to begin thinking critically and creatively about how to embed ESD into their practice. However, these AI-generated ideas are not final products. They should serve as springboards for deeper professional dialogue and peer learning.

To maximise the CoDesignS ESD AI Coach's potential, it should be deployed in contexts where users have access to ongoing mentorship and expert input, particularly from specialists in sustainability education and curriculum design. This support is crucial in helping educators interpret, contextualise and improve the suggestions the AI Coach generates, ensuring alignment with institutional goals, pedagogical best practices and learners' diverse needs (Baughan, Price & Longhurst, 2025).

Despite some of the challenges associated with the CoDesignS ESD AI Coach, such as concerns over relevance, context-sensitivity and critical evaluation, the AI Coach's affordances are notable. It lowers the threshold for engagement with ESD, especially for educators who may be new to the field or unsure where to begin. It also helps democratise access to knowledge and strategies for ESD, offering a consistent and scalable means to seed ideas and prompt reflection.

To support the CoDesignS ESD AI Coach's effective and responsible use, we offer the following recommendations for institutions and practitioners considering its implementation:

(1) Use the AI Coach as an Ideation Tool

Encourage educators to view the CoDesignS ESD AI Coach's outputs as starting points. Human expertise remains essential in ensuring contextual relevance and pedagogical soundness.

(2) Adopt the ROCKS Framework for Critical Engagement

Incorporate the ROCKS method (CoDesignS AI, 2024) to help users craft effective prompts, reducing unnecessary processing.

(3) Integrate into Professional Development and Communities of Practice

The CoDesignS ESD AI Coach is particularly effective when used in training settings. It can support academic development by helping staff begin to embed ESD into their teaching practice.

(4) Provide Ongoing Expert Support

Ensure that users have access to subject-matter experts and learning designers who can provide feedback, guide refinement and support implementation.

By embedding the CoDesignS ESD AI Coach within a co-designed, reflective and supportive professional learning ecosystem, institutions can leverage GenAI not as a replacement for human creativity or pedagogical judgment but as a powerful augmentation tool, one that fosters innovation and capacity in advancing education for sustainable development.

6. Availability of Data and Materials

Anonymised data are available on request.

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References

Advance HE/QAA. (2021). *Education for Sustainable Development Guidance*. Retrieved from: https://www.qaa.ac.uk/quality-code/education-for-sustainable-development and https://www.advance-he.ac.uk/knowledge-hub/education-sustainable-development-guidance

Ahmad, N., Toro-Troconis, M., Ibahrine, M., Armour, R., Tait, V., Reedy, K., Malevicius, R., Dale, V., Tasler, N., & Inzolia, Y. (2023). CoDesignS Education for Sustainable Development: A Framework for Embedding Education for Sustainable Development in Curriculum Design. *Sustainability, 15*(23), 16460. https://doi.org/10.3390/su152316460

ALDESD. (2025). *Harnessing AI to advance Education for Sustainable Development*. Workshop. April. Retrieved from: https://aldesd.org/workshop/

Al-Zahrani, A. M., & Alasmari, T. M. (2024). Exploring the impact of artificial intelligence on higher education: The dynamics of ethical, social, and educational implications. *Humanities and Social Sciences Communications, 11*, Article 912. https://doi.org/10.1057/s41599-024-03432-4

Almazan, Joseph U., Manabat, April, Kavashev, Zulyar, Smagulova, Meruyert, Colet, Paolo C., Balay-odao, Ejercito Mangawa, Nurmagambetova, Ainetta, Bolla, Srinivasa Rao, Syzdykova, Alma, Dauletkaliyeva, Zhaniya, & Cruz, Jonas P. (2024). Sustainability in Education and Healthcare field: An Integrative Review of Factors, Barriers, and the Path Forward for Informed Practices. *Health Professions Education, 10*(4), Article 3. https://doi.org/10.55890/2452-3011.1299

Armstrong, A. (2025, May 15). Think before you prompt: Reduce your AI carbon footprint with ROCKS. *#ALTC blog.* Retrieved from: https://altc.alt.ac.uk/blog/2025/05/think-before-you-prompt-reduce-your-ai-carbon-footprint-with-rocks/

Attewell, S. (2025). *How is artificial intelligence actually being used in higher education*? Wonkhe. Retrieved from: https://wonkhe.com/blogs/how-is-artificial-intelligence-actually-being-used-in-higher-education/

Baughan, P., Price, E.A.C., & Longhurst J.W.S. (2025). Professional Development for All: Enabling Advocates for Education for Sustainable Development. In: White, R.M., Kemp, S., Price, E.A.C. and Longhurst, J.M.S. (eds) *Perspectives and Practices of Education for Sustainable Development. A Critical Guide for Higher Education*. pp 211-228. Routledge, London and New York. https://doi.org/10.4324/9781003451563-4

Bijker, W. E. (1997). *Of Bicycles, Bakelites, and Bulbs: Toward A Theory Of Sociotechnical Change*. Cambridge, MA: MIT Press.

Bobula, M. (2024). Generative artificial intelligence (AI) in higher education: a comprehensive review of challenges, opportunities, and implications. *Journal of Learning Development in Higher Education,* (30). https://doi.org/10.47408/jldhe.vi30.1137

Bligh, B., & Coyle, D. (2013). Re-mediating classroom activity with a non-linear, multi-display presentation tool. *Computers and Education, 63*, p 337357. https://doi.org/10.1016/j.compedu.2013.01.001

Calvo, I., Carrascal, E., Gonz ález, J. M., Armentia, A., Gil-Garc á, J. M., Barambones, O., Basogain, X., Tazo-Herran, I., & Api ñaniz, E. (2024). A Methodology to Introduce Sustainable Development Goals in Engineering Degrees by Means of Multidisciplinary Projects. *Education Sciences, 14*(6), 583. https://doi.org/10.3390/educsci14060583

CoDesignS AI. (2024). *CoDesignS AI Framework*. Retrieved from: https://aldesd.org/7574-2/

CoDesignS ESD. (2021). *CoDesignS ESD Framework and Toolkit.* Retrieved from: https://codesignsesd.org/

CoDesignS ESD AI Coach. (2024). *CoDesignS ESD AI Coach.* Retrieved from: https://codesignsesd.org/codesigns-ai-coach/

Data-TAVS. (2021). *Data Analysis, Triangulation and Visualisations (DATA-TAVs) TOOLKIT*. Retrieved from: https://mariatorotroconis.wordpress.com/data-analysis-triangulation-and-visualisations-data-tavs-toolkit/

Engestr öm, Y. (1987). *Learning by Expanding: An Activity-Theoretical Approach to Developmental Research, Orienta-Konsultit Oy, Helsinki*. Retrieved from: http://lchc.ucsd.edu/mca/Paper/Engestrom/Learning-by-Expanding.pdf

Gough, G., & Kemp, S. (2025). Education for Sustainable Development; Curriculum Design, Content and Challenges. In: White, R.M., Kemp, S., Price, E.A.C. and Longhurst, J.M.S. (eds) *Perspectives and Practices of Education for*

Sustainable Development. A Critical Guide for Higher Education. pp 87-107. Routledge, London and New York. https://doi.org/10.4324/9781003451563-5

Johnson, D. G., & Verdicchio, M. (2017). Reframing AI discourse. *Minds and Machines, 27*(4), 575-590. https://doi.org/10.1007/s11023-017-9417-6

Kalniņa, D., Nīmante, D., & Baranova, S. (2024). Artificial intelligence for higher education: Benefits and challenges for pre-service teachers. *Frontiers in Education, 9*. https://doi.org/10.3389/feduc.2024.1501819

Kamila, M. K., & Jasrotia, S. S. (2023). Ethical issues in the development of artificial intelligence: Recognizing the risks. *International Journal of Ethics and Systems, 41*(1), 45-63. https://doi.org/10.1108/IJOES-05-2023-0107

Leal Filho, W., Ribeiro, P. C. C., Mazutti, J., Lange Salvia, A., Bonato Marcolin, C., Lima Silva Borsatto, J. M., & Viera Trevisan, L. (2024). Using artificial intelligence to implement the UN sustainable development goals at higher education institutions. *International Journal of Sustainable Development & World Ecology, 31*(6), 726-745. https://doi.org/10.1080/13504509.2024.2327584

Liew, A. L. X., & Kamrozzaman, N. A. (2024). The challenges of higher education students face in using artificial intelligence (AI) against their learning experiences. *Open Journal of Social Sciences, 12*, 362-387. https://doi.org/10.4236/jss.2024.1210025

McCowan, T. (2023). Tertiary Education and the Sustainability Agenda. *Centre for Global Higher Education Working Paper series*. Working Paper 90. Centre for Global Higher Education, University of Oxford, Oxford. Retrieved from: https://www.researchcghe.org/publication/tertiary-education-and-the-sustainability-agenda/

Mula, I., Tilbury, D., Ryan, A., Mader, M., Dlouhá, J., Mader, C., Benayas, J., Dlouhý, J., & Alba, D. (2017). Catalysing change in Higher Education for Sustainable Development: a review of professional development initiatives for university educators. *International Journal of Sustainability in Higher Education, 18*(5), 798-820. https://doi.org/10.1108/IJSHE-03-2017-0043

Nicholson, D. T., & Vargas, V. (2021). Design Principles for Assessment of Sustainability Teaching. In: Baughan, P. (Ed.) *Assessment and Feedback in a Post-Pandemic Era: A Time for Learning and Inclusion.* York: AdvanceHE, 183-195.

Price, E.A.C., & White, R.M. (2025). Education for Sustainable Development: Definitions, Debates and Design. In: White, R.M., Kemp, S., Price, E.A.C. & Longhurst, J.W.S. (eds) *Perspectives and Practices of Education for Sustainable Development: A Critical Guide for Higher Education*. Routledge, London.

Ramirez-Mendoza, R.A., Morales-Menendez, R., Melchor-Martinez, E.M., Iqbal, H.M.N., Parra-Arroyo, L., Vargas-Martínez, A., & Parra-Saldivar, R. (2020). Incorporating the sustainable development goals in engineering education. *International Journal on Interactive Design and Manufacturing, 14*, 739-745. https://doi.org/10.1007/s12008-020-00661-0

Saldaña, J. (2016). *The Coding Manual for Qualitative Researchers*. Sage Publications Ltd.

Salas-Pilco, S. Z., Xiao, K., & Oshima, J. (2022). Artificial intelligence and new technologies in inclusive education for minority students: A systematic review. *Sustainability, 14*(20), 13572. https://doi.org/10.3390/su142013572

Sipos, Y., Battisti, B., & Grimm, K. (2008). Achieving transformative sustainability learning: Engaging head, hands and heart. *International Journal of Sustainability in Higher Education, 9*(1), 68-86. https://doi.org/10.1108/14676370810842193

Suharto, R. H., Yusuf, B., & Wahyuda, A. A. P. J. (2025). Veterinary education and sustainable development goals: A perspective from professional students in Indonesia. *Open veterinary journal, 15*(10), 4997-5008. https://doi.org/10.5455/OVJ.2025.v15.i10.18

Tasler, N., & Dale, V. H. M. (2021). Learners, teachers and places: A conceptual framework for creative pedagogies. *Journal of Perspectives in Applied Academic Practice, 9*(1), 2-7. https://doi.org/10.14297/jpaap.v9i1.450

Toro-Troconis. M. (2025). The Role of AI Shaping Educational Practices: An Activity System View. UNESCO Mahatma Gandhi Institute of Education for Peace and Sustainable Development (MGIEP). *BlueDot Magazine. Issue XVIII AI for Learner Flourishing*. Retrieved from: https://mgiep.unesco.org/article/bd18-the-role-of-ai-in-shaping-educational-practices-an-activity-systemview

Toro-Troconis, M. (2025, May 15). *Think before you prompt: Reduce your AI carbon footprint with ROCKS* [Blog post]. ALT. Retrieved from: https://altc.alt.ac.uk/blog/2025/05/think-before-you-prompt-reduce-your-ai-carbon-footprint-with-rocks/

Toro-Troconis, M., Inzolia, Y., & Ahmad, N. (2023). Exploring Attitudes towards Embedding Education for Sustainable Development in Curriculum Design. *International Journal of Higher Education, 12*(4), 42-54. https://doi.org/10.5430/ijhe.v12n4p42

UCL Arena Centre for Research-based Education. (n.d.). *Evaluating your teaching* [PDF]. UCL. Retrieved from: https://www.ucl.ac.uk/teaching-learning/sites/teaching-learning/files/teaching_toolkits_downloads_evaluating_teaching.pdf

UNESCO. (2017). *Education for Sustainable Development Goals: Learning objectives*. Retrieved from: https://doi.org/10.54675/CGBA9153

UNEP. (2024). *Navigating New Horizons: A global foresight report on planetary health and human wellbeing. Nairobi*, pp 28-31. Retrieved from: https://wedocs.unep.org/20.500.11822/45890

Varga-Atkins, T., Toro-Troconis, M., & Ahmad N. (2024). Advances of Learning Design in Education for Sustainable Development: Experiences from the Learning Design and ESD Bootcamp 2022. Special issue of the *Open Scholarship of Teaching and Learning Journal*.

Voulvoulis, N., Giakoumis, T., Hunt, C., Kioupi, V., Petrou, N., Souliotis, I., Vaghela, C., & Wan Rosely, W. I. H. binti. (2022). Systems thinking as a paradigm shift for sustainability transformation. *Global Environmental Change, 75*, 102544. https://doi.org/10.1016/j.gloenvcha.2022.102544

White, R.M., Price, E.A.C., & Hack, C. (2025). Critical Pedagogies to Engage Heart, Hand and Head in Education for Sustainable Development. In: White, R.M., Kemp, S., Price, E.A.C. and Longhurst, J.W.S. (eds) *Perspectives and Practices of Education for Sustainable Development: A Critical Guide for Higher Education*. Pp 108-128. Routledge, London and New York. https://doi.org/10.4324/9781003451563-4

White, R.M., & Preist, C. (2025). Education for Sustainable Development: From Disciplinary to Transdisciplinary Approaches. In: White, R.M., Kemp, S., Price, E.A.C. and Longhurst, J.M.S. (eds) *Perspectives and Practices of Education for Sustainable Development. A Critical Guide for Higher education*. pp 59-86. Routledge, London and New York. https://doi.org/10.4324/9781003451563-4

Yamagata-Lynch, L. C. (2010). *Activity Systems Analysis Methods*. Boston, MA, Springer. Retrieved from: https://doi.org/10.1007/978-1-4419-6321-5

Yang, E., & Beil, C. (2024). Ensuring data privacy in AI/ML implementation. *New Directions for Higher Education, 2024*(207), 63-78. https://doi.org/10.1002/he.20509

Zhai, C., Wibowo, S., & Li, L. D. (2024). The effects of over-reliance on AI dialogue systems on students' cognitive abilities: A systematic review. *Smart Learning Environments, 11*, 28. https://doi.org/10.1186/s40561-024-00316-7

Appendix A

Focus Groups Guiding Questions

(1) In what ways did the CoDesignS AI Coach support or challenge your understanding of sustainability concepts?

(2) How did you find the CoDesignS AI Coach responses from a discipline point of view? Were the answers accurate in relation to your discipline?

(3) How did you find the CoDesignS AI Coach responses from a sustainability point of view? Were the answers clear? Were you able to identify where in the response provided sustainability and SDG concepts were embedded?

(4) In what ways did the CoDesignS AI Coach support or challenge your understanding of prompting techniques and the environmental impact associated with it? What else can the Coach do to support environmental awareness?

(5) How did you find the CoDesignS AI Coach responses from a curriculum design point of view? Were the answers accurate and feasible to implement?

(6) Overall, how did you find the user experience when interacting with the CoDesignS ESD AI Coach?

(7) What else would you like to see reflected in the design/user experience of the CoDesignS ESD AI Coach?