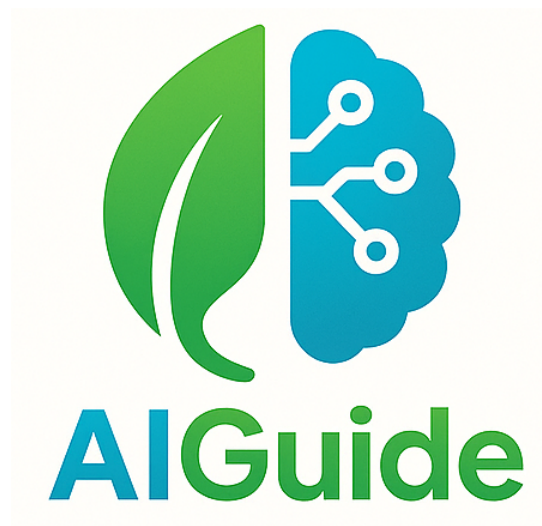




ONLINE COURSE CONTENT

MODULE 3: SYSTEMS AND INTERDISCIPLINARY THINKING

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Artificial Intelligence for Green Understanding, Insights & Decision Empowerment



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A. General Information

Module No	☐ Module1 ☐ Module2 ☒ Module3 ☐ Module4 ☐ Module5
Subtopic	Systems and interdisciplinary thinking
AI Literacy Component	AI-assisted systems mapping; interdisciplinary evidence integration
Decision Making Skills	Systems thinking and interdisciplinary reasoning
Teacher Learning Outcome	Use AI-supported systems for connecting environmental, technological, social and economic variables.
Student Transfer Outcome	Analyse green problems by using systems thinking
Possible AI Tools	Systems mapping tools; Miro AI; chatbots; climate data tools
AI Literacy Level	Medium
Estimated Duration	60 minutes

B. Content:

Highlights

1. Systems thinking provides a holistic framework for understanding how environmental, technological, social and economic variables interact within complex green problems, challenging reductionist, single-discipline approaches (Barile & Saviano, 2021).
2. Interdisciplinary reasoning integrates knowledge and methods from different disciplines, serving as a common denominator for shared understanding and more effective decision-making (Barile & Saviano, 2021).
3. AI-assisted systems mapping tools (e.g., Miro AI, causal-loop and stock-flow mapping tools) accelerate the construction and revision of visual system maps, making feedback loops and ripple effects visible to learners.
4. AI-supported interdisciplinary evidence integration tools such as System Pro and DeepReport map relationships across large bodies of literature, helping researchers and teachers bridge epistemic divides between fields (Coalter, 2023; Xu et al., 2025).
5. Layered outcomes: teaching staff learn to use AI-supported systems for connecting environmental, technological, social and economic variables; their students, in turn, learn to analyse green problems by using systems thinking.
6. This 60-minute session combines a concise conceptual input, a live AI-assisted systems-mapping demonstration, guided hands-on mapping of a green problem, and a transfer-design step for participants' own disciplines.

Introduction

Complex green challenges — climate change, resource depletion, biodiversity loss, energy transitions — rarely respect disciplinary boundaries. A decision about fertiliser policy affects drinking water quality and aquatic biodiversity; a decision about campus energy systems affects budgets, laboratory schedules and emissions. Interdisciplinary systems thinking is therefore increasingly recognised as an essential approach for addressing such multifaceted problems, because it integrates diverse disciplinary perspectives and fosters holistic understanding (Barile & Saviano, 2021; Voulvoulis et al., 2022).

For STEM teaching staff, this subtopic has a dual purpose. First, it develops your own capacity to use AI-supported systems for connecting environmental, technological, social and economic variables — the teacher learning outcome for Subtopic 3.6. Second, it prepares you to design learning experiences in which your students analyse green problems by using systems thinking — the student transfer outcome. The AI literacy components addressed are AI-assisted systems mapping and interdisciplinary evidence integration, at a medium AI literacy level, supported by tools such as systems mapping tools, Miro AI, chatbots and climate data tools.

1. Systems Thinking as a Green Decision-Making Skill

Systems thinking provides a framework for understanding the interconnectedness of components within a system, enabling more effective problem-solving and decision-making (Barile & Saviano, 2021). Rather than isolating a single variable, the systems thinker asks how variables influence one another over time: Which feedback loops amplify or dampen change? Where are the delays between action and effect? Which stakeholders sit inside and outside the system boundary?

Key concepts that teaching staff should be able to explain and model include:

7. System boundary: the deliberate choice of what is inside and outside the analysis — e.g., does a campus energy analysis include commuting emissions?
8. Interconnections and causal links: the pathways through which one variable changes another — e.g., fertiliser use → nitrate leaching → water quality → biodiversity.
9. Feedback loops: reinforcing loops that accelerate change and balancing loops that stabilise a system — central to feedback-loop reasoning in sustainability education (Peretz, 2025).
10. Delays and unintended consequences: effects that emerge far from their causes in time or space, which linear thinking systematically misses.
11. Leverage points: places in a system where a small, well-placed intervention produces large change.

Systems thinking is pivotal for sustainability transformation because it enables understanding of the conditions that generate sustainability challenges and supports the development of integrated solutions (Voulvoulis et al., 2022). During the COVID-19 pandemic, for example, systems thinking was applied to manage complexity and guide decision-making across social, political and economic dimensions (Kusumastuti et al., 2020).

Diagram (embeddable image + text): The Iceberg Model and Meadows' 12 leverage points from the Donella Meadows Project's public Systems Thinking Resources page — <https://donellameadows.org/systems-thinking-resources/>.

2. Interdisciplinary Reasoning

Interdisciplinary reasoning is the complementary skill: integrating knowledge, methods and standards of evidence from different disciplines to address a shared problem. Systems thinking serves as a common denominator for interdisciplinary convergence, supporting the development of a shared vision across disciplines (Barile & Saviano, 2021). It challenges reductionist approaches by promoting holistic and integrative thinking, which is essential for addressing complex societal issues.

In higher education, this pairing has demonstrated concrete learning benefits. A pilot study in land economics showed that systems thinking enhances interdisciplinary learning outcomes by fostering perspective-taking, holistic thinking and belief-testing (Mathews et al., 2008). In public health education, systems thinking enabled students to grasp the interdisciplinary nature of health promotion and pandemic response (Shelley et al., 2022). In entrepreneurship education, it encourages students to consider social and environmental factors alongside economic goals, aligning with the United Nations Sustainable Development Goals (Gassol, 2025). Engineering projects likewise increasingly require systems thinking skills for managing and integrating multidisciplinary tasks (Kordova, 2020).

3. AI-Assisted Systems Mapping (AI Literacy Component 1)

Constructing a good system map by hand is slow, and the first draft is usually wrong in instructive ways. AI-assisted systems mapping tools lower this barrier. Visual collaboration platforms with AI features (such as Miro AI and comparable systems mapping tools) can generate a first-draft map of variables and causal links from a written problem description; teachers and students then critique, correct and extend the draft. This critique step is where the learning happens: deciding which AI-suggested links are plausible, which are missing, and which reflect bias or oversimplification directly exercises AI literacy competences of evaluating AI outputs and human–AI decision-making.

A typical AI-assisted mapping workflow for a green problem has five steps:

12. 1. Frame: write a one-paragraph problem statement naming environmental, technological, social and economic variables.
13. 2. Generate: prompt the AI tool (mapping tool or chatbot) to propose variables, causal links and feedback loops as a first-draft map.
14. 3. Interrogate: check each proposed link against evidence and disciplinary knowledge; mark uncertain links; add missing ones — climate data tools can supply real data to test assumptions.
15. 4. Identify leverage: use the corrected map to locate feedback loops and candidate leverage points for intervention.
16. 5. Decide and justify: make a human decision about the preferred intervention and justify it with reference to the map and the evidence — the AI supports, but does not make, the decision.

Courses designed around systems thinking in engineering and operations management already use experiential learning and visual-based mapping tools to cultivate critical thinking and interdisciplinary collaboration (Bubbar et al., 2024; Teo et al., 2023); AI assistance accelerates the mapping cycle so that more class time is spent on reasoning and less on drawing.

Short video (approx. 4 min): Miro's official Mind Map tutorial (with the AI segment at 02:22): https://www.youtube.com/watch?v=1_AnKWuAZ4Q — for the live-demonstration paragraph and the 60-minute session plan's 15-25 min segment.

4. Anatomy of an effective mapping prompt

A well-structured prompt to a mapping tool or chatbot names four things: who the AI should act as (*role*), what it should do (*task*), the background it needs (*context*), and how the answer should be organised (*expected output*). Making these components explicit gives you a first draft you can critique on the terms you set — and lets students learn the pattern by seeing it applied, not only by being told about it.

Colour key: Role Task Context Expected output

Example 1 — Initial mapping prompt

You are an environmental systems analyst supporting a STEM class. Create a causal map for a watershed where intensive agriculture, drinking-water supply and aquatic biodiversity interact. List variables (environmental, technological, social, economic), causal links with direction (+/-), and possible feedback loops.

Example 2 — Follow-up prompt for critical evaluation

Identify which of these links are most uncertain given the causal map above and typical watershed evidence, and for each, state one type of evidence that would confirm or refute it.

Notice that Example 2 inherits the *role* from Example 1: once a role is set at the start of a session, it does not need to be repeated in each follow-up prompt. Teachers can use this template as a starting checklist — if a segment is missing, the prompt is probably underspecified.

5. Interdisciplinary Evidence Integration (AI Literacy Component 2)

The second AI literacy component concerns evidence: complex green problems require integrating findings from several literatures at once, which quickly exceeds what any individual can read. AI tools for evidence mapping address this. System Pro analyses search results from PubMed to create maps of evidence-based relationships in health and life sciences, summarising abstracts and providing citations, thereby expediting literature review and improving the discoverability of interdisciplinary research topics (Coalter, 2023). DeepReport uses concept co-occurrence graphs to extract insights from a vast array of publications, integrating up-to-date academic databases and visualising dynamic relationships between concepts (Xu et al., 2025).

AI frameworks are also enhancing interdisciplinary collaboration in engineering projects through data analysis, decision support and real-time optimisation (Kuchibhatla et al., 2025), and in medicine through AI-enabled integration of multimodal CT/MRI imaging and 3D printing (Zhou et al., 2025). More broadly, AI can help overcome cognitive challenges in interdisciplinary research by bridging epistemic divides and managing large bodies of literature — while raising its own safety and ethical concerns (Baum, 2021).

Critical evaluation remains essential. In healthcare, AI faces translational challenges such as replicating trials, reporting patient harms and varying performance across clinical settings (Coiera & Liu, 2022). Teaching staff should model this scepticism: AI-generated evidence maps are starting points for verification, not substitutes for reading key sources.

6. Bringing Systems Thinking into STEM Teaching

Systems thinking is increasingly integrated into sustainability education through feedback-loop reasoning, conceptual modelling and inquiry-based learning that connect scientific and social systems (Peretz, 2025). Educational frameworks that combine systems thinking with system dynamics and technology assessment prepare students to analyse socio-technical systems and anticipate long-term impacts (Eichentopf & Kasperidus, 2025). Project-based learning environments benefit from computer-based modelling and simulations that promote higher-order, holistic thinking (Bellam, 2023).

Implementation is not automatic. It requires careful alignment of teaching methods, learning activities and assessments with intended learning outcomes (Bellam, 2023), and fostering interdisciplinary collaboration can be difficult given entrenched disciplinary boundaries and differing methodologies (Barile & Saviano, 2021). A pragmatic strategy for a single course is to introduce one recurring green problem, revisit its system map as the course progresses, and let students take increasing ownership of the mapping and the evidence base.

Responsible AI use should be woven through: be transparent with students about where AI is used; treat AI-suggested causal links and literature summaries as claims to verify; discuss data privacy and bias; and note the environmental footprint of AI itself as part of the system being analysed (Toto et al., 2025; Sanieva, 2024).

7. 60-Minute Professional Development Session Plan (Workshop for Teaching Staff)

Note on the session structure. The 60-minute plan below describes a professional development (PD) session delivered to STEM higher-education teaching staff — the "participants" in the table are the teachers themselves, not the students in their courses. The session is designed as a synchronous, workshop-style experience (face-to-face or online), in which participants work through AI-supported forecasting, resource-use analysis and a weighted decision matrix as learners, using the same tools and dataset they will later adapt for their own STEM courses. It is not a self-paced e-learning module, nor a lesson plan to be delivered directly to STEM students.

The plan therefore operates at two levels. At the PD level, it is what teaching staff experience during the workshop; at the classroom level, it becomes the blueprint that teachers adapt for their own students. The transfer step is supported in the sections that follow: Section C provides a guideline for constructing an equivalent real-life case in the teacher's own discipline, and Section D provides a design guideline and student activity card for use with STEM higher-education students. Where the table refers to "participants", "teams" and "the case dataset", these refer to the teaching-staff learners in the PD session; the parallel student-facing materials are those developed via Sections C and D.

Time	Segment	Description
0–5 min	Welcome and framing	Present the layered outcomes: staff will use AI-supported systems mapping to connect environmental, technological, social and economic variables; their students will analyse green problems using systems thinking.
5–15 min	Mini-lecture	Core concepts: system boundaries, causal links, feedback loops, delays, leverage points; interdisciplinary reasoning as the integrating skill; where AI fits (systems mapping; evidence integration).
15–25 min	Live demonstration	Facilitator uses Miro AI (or another systems mapping tool / chatbot) to generate a first-draft map of a green problem, then visibly critiques and corrects it, thinking aloud about which AI-proposed links to accept, question or reject.
25–40 min	Guided hands-on mapping	In pairs or small groups, participants map a shared green scenario (e.g., campus energy transition), following the five-step workflow: frame, generate, interrogate, identify leverage, decide and justify.
40–50 min	Transfer design	Each participant sketches how they would adapt the mapping activity to their own discipline and drafts one real-life example and one student activity idea (see Sections C and D).

50–60 min	Debrief and reflection	Groups share leverage points found and AI outputs they rejected; discussion of responsible AI use; participants note one action for their next course.
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C. Real Life Example

Copenhagen Smart City AI Initiative – Integrated Urban Sustainability

The Copenhagen Smart City AI Initiative is one of the clearest real-world demonstrations of systems and interdisciplinary thinking supported by AI. The city integrated adaptive AI systems — IoT multi-system integration with machine learning optimisation of traffic, energy, waste and water — together with citizen-facing sustainability engagement platforms. Crucially, city administrators moved from siloed departmental analysis to integrated cross-sector green decisions made with AI dashboards that connect traffic, energy, waste and water data in one view.

This is systems thinking made operational: a decision about traffic routing is evaluated together with its effects on energy demand, air quality and waste logistics, rather than in isolation. It is also interdisciplinary in the human sense — city engineers, administrators and planners developed AI literacy in multi-system urban analytics, while citizens developed environmental data awareness through public-facing platforms.

The reported results illustrate why the approach matters: Copenhagen achieved a 55% CO₂ reduction against a 50% target, was on track for its carbon-neutrality ambition, and recorded measurable improvements in traffic flow, energy efficiency in municipal buildings and recycling rates. The initiative is globally recognised and offers a replicable smart-city model, with Copenhagen Climate Plan public documents making it adaptable to smart cities, urban sustainability and environmental policy modules.

Discussion prompts for the PD session: Which environmental, technological, social and economic variables are connected in this case? Which feedback loops can you identify (e.g., better dashboards → better decisions → more trusted data → wider adoption)? Where was the leverage point that produced results beyond target? What role did humans keep in the decision loop?

Activity Guideline: Prepare a Real-Life Example for Your Own Subject Area

After examining the Copenhagen case, each participant prepares one real-life example from their own discipline in which systems thinking (ideally AI-supported) changed or could change

a green decision. Use the following guideline (approximately 15–20 minutes, individually or in discipline pairs):

17. Step 1 – Select (3 min): choose a real case, dataset, project or news event from your field where environmental, technological, social and economic variables interact (e.g., materials selection in engineering, land-use change in biology, data-centre siting in computer science).
18. Step 2 – Map the system (5 min): list 6–10 key variables and sketch the causal links and at least one feedback loop; note the system boundary you chose and why.
19. Step 3 – Add the AI dimension (4 min): identify where an AI tool (systems mapping tool, Miro AI, chatbot, climate data tool) could support the analysis — and where its output would need critical verification.
20. Step 4 – Frame the decision (3 min): state the green decision at stake, the stakeholders involved, and one leverage point your map reveals.
21. Step 5 – Share (5 min): present the example to a colleague from a different discipline and refine it based on their questions — an interdisciplinary check on your framing.

Quality check: the example is authentic to your discipline; it connects at least three of the four variable types (environmental, technological, social, economic); it contains a visible feedback loop; and it identifies both an AI contribution and a human decision component.

D. Interactive Learning Activity

Student Learning Activity Card: Mapping the Ripple Effects – A Watershed Systems Challenge

1. Activity Identification

Module / Unit	Module 3 – Subtopic 3.6 Systems and interdisciplinary thinking
Activity Code	M3-A6
Activity Title	Mapping the Ripple Effects – A Watershed Systems Challenge
Developing Partner	EGE
Recommended Duration	60 minutes (in-class) + optional homework extension
Delivery Mode	In-class Online synchronous Online asynchronous Blended
Student Grouping	Individual Pair Small group (3–4) Whole class
STEM Context / Discipline	Adaptable: environmental science, civil/agricultural engineering, biology, chemistry, data science, energy systems

2. Pedagogical Design

Learning Objective(s)	By the end of this activity, students will be able to: 1. Construct an AI-assisted system map connecting environmental,
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	technological, social and economic variables of a green problem. 2. Critically evaluate AI-generated causal links and justify a green decision using systems thinking.
Target AI Literacy Competence	Understanding AI concepts Using AI tools critically Evaluating AI outputs Human-AI decision-making Ethical/responsible AI use
Green Decision-Making Focus	Climate change Energy Materials/resources Biodiversity Waste/circularity Water Other: _____
Prerequisite Knowledge	Basic familiarity with the course discipline; introductory understanding of causal relationships; no prior systems-mapping experience required.
Key Concepts / Keywords	Systems thinking; feedback loop; system boundary; leverage point; AI-assisted systems mapping; interdisciplinary evidence integration; watershed; nitrate leaching; green decision-making.

3. Student Task Design

Student Scenario / Challenge	A regional authority must decide how to regulate fertiliser use in a watershed where agriculture, drinking water supply and aquatic biodiversity interact: “How do agricultural practices, water policy and biodiversity interact in this watershed, and which intervention offers the best leverage?” Students act as an interdisciplinary advisory team.
Student Instructions	Step 1 – Engage: read the one-page watershed brief and, as a group, list the environmental, technological, social and economic variables involved. Step 2 – Explore: prompt an AI systems mapping tool (e.g., Miro AI) or a chatbot to generate a first-draft system map; compare it with your own variable list. Step 3 – Explain: correct the map — accept, revise or reject each AI-proposed link; identify at least one reinforcing and one balancing feedback loop; verify two key links with a climate/water data tool or a source. Step 4 – Extend: identify a leverage point and formulate a recommended intervention, noting effects that ripple into other parts of the system. Step 5 – Evaluate: see part 5, Assessment and Evidence.
Input Materials	Dataset (regional water-quality data) Case text (watershed brief) Article Image/video Policy document (fertiliser regulation excerpt) Other: _____
Expected Student Output	Short report Decision matrix Presentation Poster/infographic Reflection Discussion post Other: _____
Student Deliverable Format	One exported system map (image or board link); a half-page decision justification (max 300 words); 3-minute group presentation of the map and recommendation.

4. AI Use and Green Decision-Making

Suggested AI Tool(s)	Miro AI or another systems mapping tool; a general-purpose chatbot for link brainstorming; a climate/water data tool for verification.
AI Prompt / Interaction Guidance	Sample prompt: “Create a causal map for a watershed where intensive agriculture, drinking-water supply and aquatic biodiversity interact. List variables (environmental, technological, social, economic), causal links with direction (+/-), and possible feedback loops.” Follow-up prompt: “Which of these links are most uncertain, and what evidence would confirm or refute them?”
Critical Evaluation Requirement	Students must check AI output for: accuracy bias source quality uncertainty environmental relevance ethical implications
Human Decision Component	After correcting the AI map, the group must itself choose one intervention (e.g., buffer strips, fertiliser caps, precision-agriculture incentives), rank it against one alternative in a simple decision matrix, and justify the choice using the map and verified evidence. The AI proposes; the team decides.
Responsible AI / Ethics Note	Be transparent about AI use in the deliverable; AI-proposed causal links may be hallucinated or biased toward well-published contexts; local data may be under-represented; avoid entering personal or sensitive data into AI tools; note that AI use itself has an environmental footprint.

5. Assessment and Evidence

Assessment Method	Checklist Rubric Peer feedback Teacher feedback Self-reflection Quiz
Assessment Criteria	1. Relevance to green decision-making 2. Critical use/evaluation of AI (links accepted, revised, rejected — with reasons) 3. Evidence-based reasoning (verified links, cited sources) 4. Clarity of final decision/output (leverage point and justification)
Evidence to Be Collected	Student output (map + justification) Screenshots/log of AI interaction Reflection form Attendance/participation record Teacher observation notes
Success Indicator	At least 70% of groups submit a corrected system map containing at least two feedback loops and justify their recommended intervention with verified evidence.
Feedback Questions	1. What did AI help you understand about the system? 2. What AI output did you question or reject, and why? 3. How did your final decision change after evaluation?

6. Implementation Notes

Teacher Preparation	Prepare the one-page watershed brief and dataset excerpt; test the mapping tool with institutional accounts; prepare one pre-generated AI map as backup; review the sample prompts.
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Timing Plan	Introduction: 10 min Task: 30 min Discussion: 12 min Reflection: 8 min
Accessibility / Inclusion Notes	Provide the brief in advance; allow paper-based mapping as an alternative; mix disciplines/backgrounds within groups; assign rotating roles (mapper, sceptic, evidence-checker, presenter).
Possible Risks	AI tool access or licensing problems; superficial acceptance of AI-generated maps; groups getting lost in map complexity.
Mitigation / Backup Plan	Provide printed pre-generated AI maps for offline critique; cap maps at 12 variables; facilitator circulates with challenge questions.
Extension / Follow-up	Homework: transfer the same five-step workflow to a green problem from the students' own sub-discipline and bring the map to the next class; links forward to Module 3 assessment tasks.

Activity Guideline: Design Your Own Interactive Learning Activity

Each participant (or discipline team) now designs one interactive learning activity for their own subject area, using the AIGUIDE Student Learning Activity Card Template (WP3-A2) exactly as structured above. Suggested workflow (approximately 20–30 minutes in-session, completed afterwards):

22. 1. Anchor: start from the real-life example you prepared in Section C — it becomes the student scenario/challenge.
23. 2. Complete the card in order: Activity Identification → Pedagogical Design → Student Task Design → AI Use and Green Decision-Making → Assessment and Evidence → Implementation Notes. Keep instructions concrete and sequenced (Engage, Explore, Explain, Extend, Evaluate).
24. 3. Keep the systems-thinking core: students must map interconnections across environmental, technological, social and economic variables, identify at least one feedback loop, and make a justified human decision after critically evaluating AI output.
25. 4. Plan for failure modes: specify a backup for AI access problems and a strategy against superficial AI use.
26. 5. Peer-review: exchange cards with a colleague from another discipline and check the card against the Partner Completion Checklist (activity written for students; clear AI–green link; concrete instructions; transparent AI use; explicit output and evidence; implementable without further explanation; accessibility, timing and backup considered).

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