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Materialising Ecologies of Intelligences: Learning to design with and within more-than-human systems

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Abstract: Design is evolving from primarily human-centred approaches towards planetary concerns that re-centre more-than-human agency: a perspective that correlates with pressing ecological challenges emerging from global anthropogenic impacts. Against this backdrop, design education that equips graduates with the competencies to engage present and future complex socioecological challenges continue to develop. The authors discuss interconnected drivers that are shaping the wider field and advancing designers' roles before presenting a pedagogical model that supports design students to engage in academic-industry-community collaboration and forms of making to materialise complex systems and evolving epistemologies in accessible and tangible ways. The authors offer insights into how future educators and graduates might design with myriad forms of intelligence – ecological, human, technological - to navigate poly-crisis issues such as energy transitions and nature restoration. These graduate attributes are positioned as an agile material practice, capable of advancing design for regenerative and just climate futures.

Keywords: more-than-human; systems; ecologies; intelligences; pedagogy

1. Introduction

Increasingly, the field of design is expanding beyond traditional human-centred disciplinary-specific approaches to incorporate planetary perspectives that recognise the agency of more-than-human actors and the interdependence of ecological, technological and social systems. This transition aligns with pressing and complex socioecological challenges that define present realities of the Climate Era emerging from global anthropogenic impacts. Building on these developments, this paper examines the drivers reshaping design education and the evolving competencies required of future designers in the pursuit of regenerative and just futures. It foregrounds the role of collaborative, materially grounded pedagogies that equip students to make sense of complex systems and diverse forms of intelligence (ecological, human, technological).

The paper proceeds with a scope of context, which highlights how the Climate Era and more-than-human perspectives are informing curricular and pedagogical shifts. Following this, the authors present a case study from a Masters course that sets out a pedagogical model to support students to engage in academic–industry–community collaboration and design with multiple intelligences through the materialisation of more-than-human systems thinking, explored in this case in the context of equitable energy transitions. Through discussion and reflection, the authors highlight the opportunities and challenges associated with engaging multiple intelligences, drawing out insights for developing agile and ecologically attuned design practices. The paper concludes by outlining how this key learning has been harnessed and is informing future project models, framed as guidance for design educators seeking pedagogical models to address poly-critical issues and just climate futures.

2. Scope of Context

Within an increasingly globalised context driven by technological transformation, design graduates are entering a world of work shaped by a fourth (Correia de Barros, 2022), or some argue fifth (Ghobakhloo et al., 2023; Hasani et al., 2025; Rame et al., 2024), industrial revolution that is compounding ecological precarity. Anthropocentric impacts have become the dominant influence on Earth's systems, reshaping environments and ecosystems on a global scale and causing profound instability that demands urgent mitigation, adaptation and reparative action. This Climate Era is, however, driving an increased recognition of plurality and a paradigmatic shift in perspectives and practices toward the more-than-human and ecological citizenship (Gooding and Phillips, 2025), particularly within complex decision-making for transformational adaptation (Woiwode et al., 2021).

In response to the demands of emergent and systemic global-to-local challenges that are characterised as uncertain, unstable, poly, complex and wicked (Dorst, 2017, 2006), design practices that centre change-orientated approaches are evolving (Halbe, 2024; Silver and Ruokamo, 2025; Meyer and Norman, 2020). Research has documented the emergence of new design roles, practices and terminology (see for example Kessler and Rieger (2025) on practices for sustainability transitions, Rocha's (2021) design competencies framework; and Gooding et al. (2024) on evolving design language to drive responsible and inclusive approaches), which are becoming increasingly transdisciplinary in nature. What remains less researched, however, are capabilities that can enable design students to engage and design with more-than-human and multiple kinds of intelligences (ecological, human, technological) (Eriksson et al., 2023), which underpin expanded and plural ways of knowing and being in the world (Bridle, 2022; Escobar, 2018; Noel et al., 2023).

Globally it is recognised that the wellbeing of humans and nature are ecologically entangled and that transformational adaptation to changing climates requires frameworks and approaches that operationalise this way of thinking within decision-making contexts (Díaz et al., 2019; Woiwode et al., 2021). Shifting mindsets in such contexts requires engagement firstly with diverse human knowledge systems, demanding designers to critically question the systematic marginalisation of place-based, traditional and local ecological ways of knowing (Nicenboim et al., 2024; Smith, 2012).

Towards honouring diverse ontologies, more-than-human design extends this plurality to multispecies perspectives. Beyond dominant neoliberal perspectives that frame non-human systems as resources, it is the radical interdependencies within living systems that designers must contend with (Tsing, 2015). Frameworks for operationalising design with and for multispecies justice are already evolving within urban planning and climate politics contexts (Fiuew et al., 2021; Latour, 2018). The ways in which designers undertake such activity in ethical and non-tokenistic ways, however, requires “critical and creative speculation that interweaves design with posthuman thinking” (Wakkary, 2021). This posthuman turn in design discourse requires conceptualisation from local, regional and global scales and suggests that planetary intelligence materialises as cognition across animal, plant and machine (Bridle, 2022). Artificial and technological intelligence adds another dimension to this plurality whereby generative systems pose an opportunity to invoke planetary networks of knowledge and learning (Nicenboim et al., 2023). By recognising machine intelligence also as participant, beyond simply material, and by questioning the systems of knowledge that feed such networks, designers may forge new alliances across plural perspectives (Giaccardi and Redstrom, 2020). Designers in these complex decision-making contexts can therefore be expected to grow their capabilities for interpreting and collaborating with plural perspectives and ways of knowing towards envisioning equitable climate futures that express multiple intelligences.

This shift can be traced in design curricular in higher education, which is becoming increasingly place-responsive (Lynch and Mannion, 2021), and which centres learning and teaching around accruing capabilities and competencies that are transferable to different kinds of contexts and challenges (Patel et al., 2024). Beyond disciplinary-specific design skills and techniques applied to problem-solving, and seeking singular solutions in linear ways, criticality is nurtured through studio-based learning (Lynas et al., 2013) that supports students to problematise reflexively and develop outcomes through iterative approaches to challenge-framing and reframing that proposes new questions and alternative design responses (Peeters et al., 2025). Furthermore, studio-based learning that seeks to reflect professional practice will often centre collaboration – internally between students in design teams and externally when engaging with project partners and stakeholders (both human and non-human) – as a key intended learning outcome. Whilst there is an emphasis on the value of multidisciplinary collaboration in design-led innovation, as global contexts for practice continue to grow more complex, collaboration needs to expand beyond the inclusion of multiple disciplines and become agile and porous to the inclusion of plural knowledge systems, materialised as multiple intelligences.

2.1 Responding to Contextual Shifts in Practice

To support this capacity-building for designing in multi-intelligent ways, the authors present and reflect on insights from a Masters course that supports students to design with and within complex more-than-human systems, framed as ecologies of intelligences. This framing has been shaped by the authors’ shared interests and practice, which intersect across social, transformation and material-led design. This includes, for example, research and teaching exploring culture-based climate action, vernacular materials and sustainable development to reimagine locally grounded futures (Author 1); social design practices relating to multi-stakeholder sustainable transitions and community-led landscape decision-making, exploring the role of participatory design across scales (Author 2); and the development of studio-based pedagogy that supports collaborative and professional design practices (Author 3). Together, the authors' shared and complementary interests lie in design's capacity to mediate relationships between people, place and planet. This positionality, as practice-based researchers and educators, situate these interests within both academic and community-based contexts, which affords research-led teaching and teaching-led research to take place. The following case study, therefore, emerges from their intertwined research and teaching practices, examining ways in which design education invites students to recognise and collaborate with the more-than-human, cultivate socioecological literacy and design for contextually responsive and responsible change.

3. Case Study

The case study the authors present is drawn from a Masters programme that they co-deliver in The School of Innovation and Technology (SIT) at The Glasgow School of Art (GSA). For context, SIT encompasses a range of design and technologically driven disciplines, which includes, for example, product design, a number of design innovation specialist subjects (service, citizenship, transformation, environmental, interaction and circular economy), serious games and virtual reality, medical visualisation, heritage visualisation and sound for the moving image. Whilst covering a range of practices, the overarching ethos underpinning the School's philosophy and wider research portfolio combines theoretical and practical exploration of social and technological innovations and examines complex questions in fields such as healthcare, education and governance, situated within the interrelated urgent context of the climactic and ecological crisis. Graduates from the School have transitioned into a wide range of roles in industry and academia as well as joining design teams embedded across the public and third sector (such as the NHS, local and central Government and Police Scotland).

During the Masters of European Design (MEDes), final year students undertake "Creating Collaborative Futures", a 12-week studio-based course delivered in partnership with an external partner organisation. Previous collaborations have included Hitachi (2015), the Royal Bank of Scotland (2016-2018), Glasgow City Council's Centre for Civic Innovation (2019-2022) and New Commercial Arts (2023). The underpinning project model (Ross, 2018) provides a scaffold for students to gain insight into professional design practice, which, as opposed to a client-based relationship, centres on a reciprocal exchange of knowledge, practice and design responses to the co-created brief. This involves the students following a 3-phase design process: i) Explore and Envisage, ii) Prototype and Engage and iii) Communicate and Deliver. Each phase corresponds to systemic design-led approaches (Design Council, 2021) and methods learned and applied by the students to define new roles, responsibilities and ways of making that enable deep contextual awareness and expert collaboration (see Table 1).

To support this learning experience, a formation of "Project Leads" are assembled to anchor and integrate complementary areas of expertise: the Academic Lead (who co-develops the project brief, manages the project and undertakes assessment); Research Lead (who supports the student team to undertake ethical secondary and primary research and analysis); Social Design Lead (who supports the students to develop practices in design-led engagement, participation and prototyping); and Partner Lead (who co-develops the project brief and provides the student team with expert contextual knowledge and access to resources, stakeholders and places to situate the project). Over the 12-week period, as well as delivering key curriculum content, the Leads join the students for weekly reviews to provide routine feedback and feedforward.

Each year the project brief centres a social design challenge pertaining to people, place and planet. The 2024-25 cohort explored collective decision-making for the energy transition, a project developed in collaboration with innovation agency NESTA. The brief centred on the future of sustainable energy through harnessing “HACID” (Human and Artificial Collective Intelligence for Decision-making) technologies. The team’s goal was to deliver an energy blueprint, which would detail a range of complementary future system-scenarios supported by material and digital prototypes. The students envisioned a future energy system for 2035 that presented a neighbourhood cooperative model made tangible through designed physical touchpoints and devices to support complex decision-making and energy literacy. The students traced potential impact at different scales (person, public and planetary) and expanded upon NESTA’s “HACID” system to give equal agency to local ecological perspectives and knowledges (renamed in this project to “HAECID”: Human, Artificial and Ecological Collective Intelligence for Decision-making). The team defined this shift towards an “ecology of practice” as a dynamic eco-civic system where human, non-human and technological entities interact as interdependent agents. Unlike a traditional “community of practice”, which centres on human-centric collaboration and knowledge exchange, an ecology of practice integrates diverse life forces (biological, social, technological) into a living, adaptive system that amplifies situated and place-based knowledges required for equitable, ethical and inclusive renewable energy infrastructure.

Table 1 Creating Collaborative Futures Project Structure

Project Phase	**Design Process**	**Key Practices**	**Integration of Intelligences**
Phase 01 (weeks 1-4): explore and envisage	Collectively as a team: challenge framing; desk research; stakeholder engagement; analysis and sensemaking; identify design opportunities.	Mapping trends and drivers in energy transition decision-making to explore the current state and future opportunities.	Conducting secondary research under the themes of each intelligence (ecological, human, technological). Conducting primary research with stakeholders who each represent one of the intelligences, or intersections between them including: energy transition, community energy, environmental and collective intelligence experts.
Phase 02 (weeks 5-8): prototype and test	Individually by each team member: identifying scenarios;	Systems scenario mapping: identifying living entities, non-living infrastructures,	Mapping relevant ecological, human and technological entities and

	building concept prototypes; testing and iterating.	key decisions being made and the intelligences that exist with them.	infrastructure equally and identifying gaps and opportunities relating to the integration of different perspectives within energy transition decision-making. Developing speculative scenarios that represent system leverage points as opportunities to engage multiple intelligences in energy decision-making.
Phase 03 (weeks 9-12): communicate and deliver	Collectively as a team: collective system artefact refinement; implementing feedback and evaluation; outcome delivery.	Concept co-development with experts; future system blueprinting.	Prototyping products, services and interactions that intertwine plural intelligences at different "leverage points" to create system change across energy transition systems.

Built into the project process was a design methodology that blended systems thinking (Meadows, 2008), speculative futures-focused design and causal-layered analysis (CLA) (Inayatullah, 2004 and Scupelli, 2021). The CLA framework unpacks complex issues in successive layers – moving from what is visible and often more tangible aspects of a given problem (behaviours, actions, relationships) towards what is more systemic, entrenched and tacit (societal structures, worldviews, cultures and myths). By moving analysis beyond empirical trends to interrogate cultural narratives and epistemological positioning and assumptions, CLA surfaces the deeper leverage points required for shaping transformative change.

The underpinning question of *how to design for renewable energy infrastructure decision-making in ways that centre collective and plural intelligences* was initially explored through methods of secondary and primary insight-gathering. This approach supported students to collaboratively collate, deliberate and define boundaries within energy transition decision-making, locate relevant infrastructures (non-living structures, institutions, organisations, polices, tools and technologies) and map these with the living inhabitants of such systems (including multi-species actors, groups, communities and roles). At a system-wide level, students collectively mapped the interrelationships between these layers of activity to uncover relational dynamics (Meadows, 2008) such as contradictions, tugs and pulls, trade-offs and compromises, and direct and indirect exchanges. In the context of the students' energy transition decision-making system analysis, they identified dynamic tensions that influenced subsequent design inquiry, namely: that limited energy literacy prevented communities from participating in energy transaction decisions, extending from personal decisions relating to how energy is produced and used regionally to decisions about where to locally install new energy technologies appropriately; an overreliance on technological intelligence through data-driven insights and energy usage monitoring (for example through smart meters); and that decisions relating to renewable energy technology installation typically did not equitably consider ecological insights or impacts at local and bioregional scales.

Using the CLA approach, each relationship was analysed though a set of behavioural lenses – the patterns of behaviours, systemic influences, and mental models (Scupelli, 2021) that shaped hierarchies of power and different decision-making goals (see Figures 1 and 2).

Figure 1 System-scenario mapping process, which includes identifying system entities, infrastructure, connections and relationships. Source: Oona O'Brian (2024).

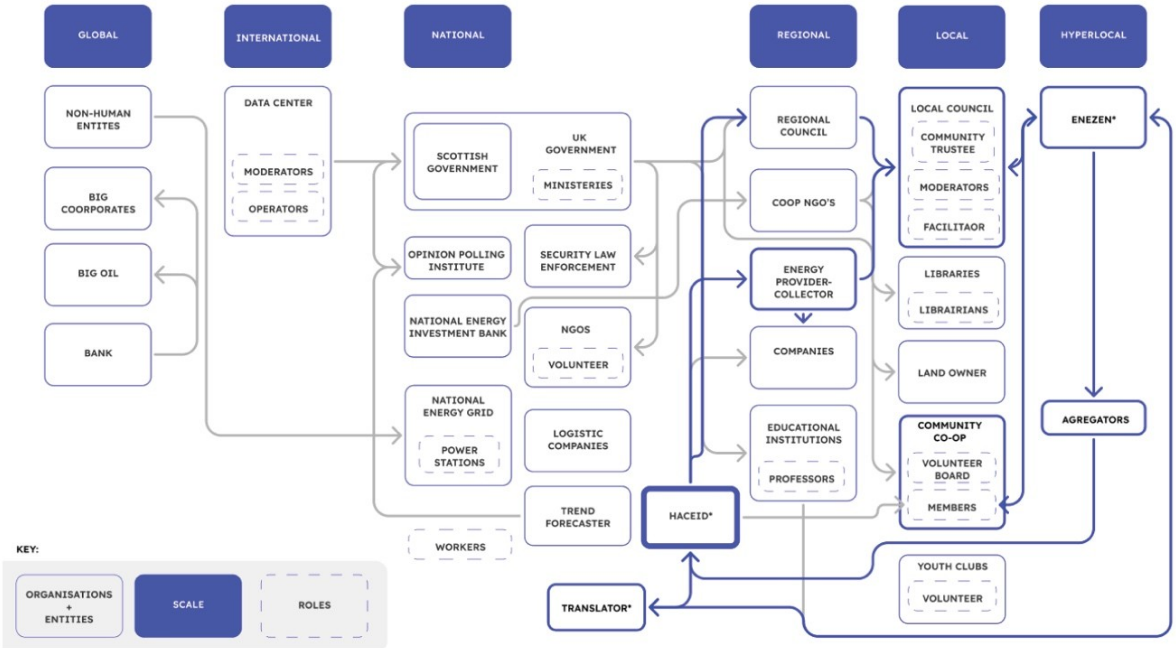

Figure 2 The team's refined system-scenario map, which explored system dynamics at different scales. Source: Oona O'Brian (2024).

Adopting then a speculative design perspective, the students each selected significant dynamics as leverage points (Meadow, 2008) from which to materialise preferable relationships between actors who expressed multiple intelligences. This involved the student's re-imagining new relationships between existing infrastructure and entities that valued ecological, human and technological perspectives and intelligences equally. This phase was conducted in collaboration with renewable energy and collective intelligence expects and resulted in the identification of opportunities to: support bottom-up citizen and community-level decision-making in Glasgow through increased energy system knowledge; integrating citizen science-led ecological knowledge within energy infrastructure decisions; and utilising technological systems to blend local insights with national-level energy data, connected to regional and national Scottish policy implementation and city plans for net zero transitions. These opportunities became system-scenarios from which to deepen an understanding of the various knowledges, values and worldviews of actors, and the settings for designing speculative products, services and experiences that re-imagined equitable decision-making with diverse ecologies of intelligence (Auger, 2013). Next, the students created a collective "Energy Blueprint" (see Figure 3), which placed each scenario into a future context of community-led energy decision-making – taking the form of an energy cooperative that uses "HACID" to determine the placement of renewable infrastructure, located in the Dennistoun area of Glasgow in 2035.

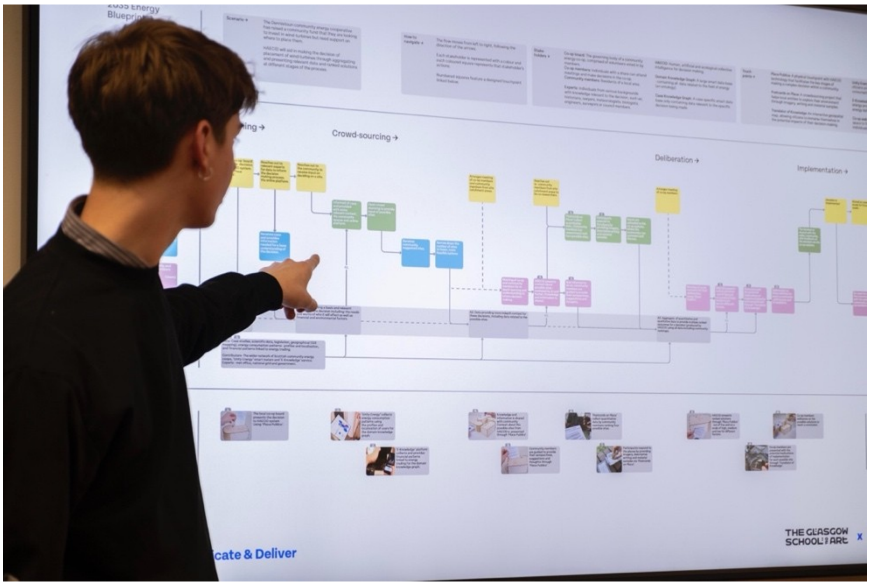

Figure 3 An "Energy Blueprint" mapping what community-led energy decision-making could look like in 2035. Source: Oona O'Brian (2024).

By aggregating expert input, local community knowledge and local environmental data, the system facilitates decisions that account for social needs, technological capabilities and ecological conditions. Within this system exists the five complementary prototypes (see Figure 4):

1. "Place Publics" prototyped a physical deliberation interface through which community members interact with "HAECID", enabling human perspectives to be combined with algorithmic analysis while acknowledging environmental impacts;
2. "Translator of Knowledge" employed an immersive extended-reality environment and geospatial mapping to communicate the ecological and social consequences of proposed infrastructure sites, translating complex technological outputs into accessible narratives that foreground environmental systems;
3. "Postcards on Place" mobilises citizens as co-researchers who document local landscapes through images, writing, and material samples, contributing situated ecological knowledge and non-human perspectives to energy decision-making processed;
4. "UnityEnergy" reimagines the smart metre as a participatory data interface, linking individual energy practices with collective knowledge graphs analysed by "HAECID";
5. and "E-Knowledge" aggregates national smart meter data to visualise household energy production, consumption and neighbourhood environmental impacts.

The form of the prototypes, which included material and digital components, mapping surfaces, touchpoints and interfaces and multi-sensorial environments, were intentionally selected to make abstract energy needs, perspectives and decisions tangible. These materialities act as mediating devices that foreground multiple intelligences by translating ecological signals, human experiences, and technological data into shared, deliberative forms.

Figure 4 A selection of system-scenario prototypes, which propose approaches to community-level decision-making for the energy transition. Source: Oona O'Brian (2024).

4. Insights and Discussion

Research and design outputs throughout the project process were co-developed with the Partner Lead and evolved through expert input sessions with their networks, which included other public innovation bodies and national data operators. Feedback and reflections were captured throughout the process and final reflections from all four Leads along with the student cohort were used to synthesise the following findings. These findings are framed as guidance for future educators seeking to develop pedagogical models that address poly-critical issues for just climate futures, and to propose future design roles and positions for those working collaboratively with myriad forms of intelligence – ecological, human, technological.

A deliberative and interrogatory approach was taken throughout the system-mapping phase of the project whereby different iterations of possible system configurations were considered. The students created an initial baseline view of the current “business as usual” (Sharpe et al., 2016) issues that prevented plural perspectives from being considered within energy transition decision-making, based upon primary and secondary research categories. From this perspective, the cohort were able to question what new values, mindsets and worldviews were required as leverage points (Davelaar, 2021; Woiwode et al., 2021) from which to reconfigure future decision-making structures. By engaging the Project Partner within this iterative process, different forms of intelligences were surfaced, reconsidered and validated through rigorous cycles of collaborative deliberation with expert representatives. This process involved considering various decision-making scenarios in which different voices and perspectives became dominant or marginalised, and through which different actor's underpinning needs and values required negotiation and rebalancing. Regarding decisions about the placement of renewable energy infrastructure, ecological needs and intelligences were identified as a consistently marginalised perspective, for example: the removal of biodiversity-supporting habitats to make way for large scale wind farm installation; the effects of turbines on migrating bird pathways; and the lack ongoing monitoring of renewable energy technologies on ecosystem health. To elevate these perspectives and values within the system, students proposed an evolution of the collective decision-making framework that would offer equal scale of influence to the ecological; evolving the "HACID" framework to a "HAECID" – Human, Artificial and Ecological Collective Intelligence for Decision-making.

By inviting learners to interrogate the values and worldviews of different systems actors within and across relationships in systems, the designer's role shifted; from one that primarily materialised artefacts and solutions, towards a materialisation of plural epistemologies through proposals that prioritised and facilitated negotiations between different ways of knowing. We therefore propose that learning processes that engage both collaborative and causal-layered systems mapping can provide learners and project partners with enhanced capabilities from which to locate and conceptualise, through deep reflexivity, and materialise plural needs and perspectives within the interrelation of multiple intelligences.

4.1 Establishing design challenges as interrelated scenarios allows for relational solution-building

Using the system-scale and speculative "HAECID" map, in which values and needs were allocated to multispecies and organisational actors, localised decision-making challenges could be identified. By "zooming in" to relational tensions within the map, such as specific trade-off points between the value systems of actors, as outlined within the case study description, the student cohort framed these areas as scenarios from which to develop design solutions.

Each system-scenario, of which there were five, was understood to be both a discrete problem area and an interconnected system leverage point. Through continued reflexive practice within studio-based deliberation and Partner Lead engagement, each solution evolved beyond disciplinary boundaries and with consideration for its system-wide consequences. This process ensured that each scenario operated as a lens from which to frame and reframe the wider system challenges (Peeters et al., 2025), and question how different perspectives could be amplified through more symbiotic relationships.

The result was a set of discrete speculative design solutions, introduced above, that proposed criteria and mechanisms for collecting and interpreting ecological, technological and human intelligences while interweaving this plurality (Hill et al., 2021) into a wider system of equitable decision-making. Understanding scenarios from which to frame design solutions as interconnected system lenses, in this context, allowed learners to engage in both material and system-level solution development simultaneously. During this phase, designer roles again shifted into technical systems modellers, whereby individual relationships between actors could be scrutinised and fine-tuned through design prototypes.

4.2 Designing an ecology of intelligence

Broadening perspectives to ecological and technological intelligences shaped both the design process and the resulting suite of design outcomes, which collectively support future energy planning across multiple scales: household, community, neighbourhood and regional levels. Rather than centring the design of these system interventions solely on human needs, the student team developed hybrid socio-ecologic-technical artefacts that mediated relationships between human experiences, environmental processes, indicators and signals (such as habitat conditions or species presence) and machine learning. For example, prototypes such as "Place Publics" and "Translator of Knowledge" were designed not only to collect human observations but also to translate and centralise ecological data and algorithmic outputs into insights that communities could engage with and deliberate on. In this way, "HACID" was not treated as a computational tool but as an active non-human participant in proposed future decision-making processes to inform community-level energy planning. Furthermore, the students reflected on how the initial "HACID" framework acted as a "helpful constraint" to ground their early propositions, but through designing connections across distributed forms of intelligences, found the need to evolve this to "HAECID" to better reflect how, in their words, "human, living and technological entities interact as interdependent agents". Through their secondary and primary research, the students reflected on the challenges of locating contextualised ecological data and the limitations of existing decision-making infrastructures that account for more-than-human perspectives. Seeking to give this input equal weight alongside human observation and lived experience, and technological data motivated the design of participatory mechanisms such as "Postcards on Place", where citizens become co-researchers with nature to document landscapes and local species. At a house-level, the "UnityEnergy" and "E-Knowledge" prototypes support the development of energy literacy and responsibility through incentivising forms of data inputs.

4.3 Locating and situating ecological intelligence requires contextual partners and place-based material sites

As referred to above, challenges were met when attempting to locate and design with ecological intelligences, in particular the identification of relevant non-human species and their needs and interests. To engage with ecological non-human perspectives and needs, the students required access to relevant datasets and, due to the dynamic nature of shifting ecological systems, could only conceptualise non-human perspectives in relation to specific geographic places. In response, a local site in Glasgow was selected as a place-based case study due to access and engagement opportunities. Through this place-based lens, students were better able to consider non-human actors through direct observation however still struggled to identify the data required to represent multispecies needs with compelling evidence within a collective intelligence model and to determine the value and knowledge systems required to interpret this. This signalled a general gap surrounding accessible place-based ecological datasets.

When extrapolating different decision-making processes through the system and scenario prototypes, finer detail could be discussed only when a place-context was introduced, for example when considering energy infrastructure in a specific city or neighbourhood. When different species, geographical topology and local cultural heritage were integrated within the design criteria, students were far more likely to situate the ecological intelligence within their outcomes and recalibrate the wider systems conditions required to accommodate ecological needs. This capability extended to the physical materialisation of speculative artefacts for collecting and processing data relating to multispecies participants, such as tools for citizen-science inputs and the artificial intelligence required to process and negotiate multiple place-based values and needs across regional and national scales.

Providing place-based boundaries within system and scenario development was therefore understood as a core component to enable plural perspectives and knowledge systems to be situated within more-than-human decision-making. Ecological intelligence, in particular, requires local and intercultural nuance whereby place-based boundaries provide the lens from which to understand multiple intelligences across scales.

The four Project Leads (Academic, Research, Social Design, Partner) reflected upon the need for an evolved model of collaboration to establish equal weighting of multiple intelligences; one that would involve a contextual place partnership to ensure ecological intelligences can be located and materialised from project inception (Figure 5). This recommendation has been adopted within the next iteration of the Creating Collaborative Futures course, in which multi-intelligence decision-making for nature restoration is explored through collaborating with both a technologically-centred UK innovation Partner Lead, Catapult Satellite Applications, and a Contextual Lead engaging in place-based development implementation, Loch Lomond and the Trossachs National Park. Future research questions will critique this model's ability to enhance more equitable understandings of ecological, alongside human and technological, intelligences and support learners to explore evolving design roles that seek to operationalise and translate plural epistemologies through value-based frameworks.

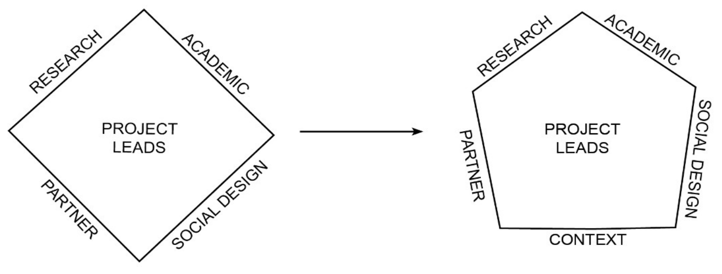

Figure 5 Evolution of the Formation of the Project Leads to include a Context Lead. Source: Authors own (2025).

However, whilst this case study demonstrates the pedagogical value of place-based and multi-partner collaboration, it also surfaces sector-wide structural constraints within design education. Developing and sustaining contextual partnerships requires significant time, coordination and long-term relationship building, and expanding briefs to encompass ecological intelligences also introduces complex ethical considerations around sourcing environmental data and engaging with human, non-human and more-than-human stakeholders. Located within an increasingly impact-driven funding environment, the authors acknowledge challenges design educators may face in embedding such complexity. Institutional support structures are therefore required to facilitate research-teaching linkages, collaboration and partnership development, and to value transdisciplinary ways of working as core rather than supplementary. Such capacity and budgetary constraints risk limiting the widespread adoption of pedagogies oriented towards ecologies of intelligences, even as their relevance to climate-responsive practice becomes more urgent.

5. Conclusion

This paper has outlined how design education is shifting in response to the Climate Era's complex and poly-critical challenges, toward plural epistemologies and more-than-human concerns. The case study demonstrated how collaborative and materially grounded pedagogies can operationalise these theoretical shifts. By reframing design challenges as interconnected system-scenarios, explored and designed within materially, the students evolved their design practice to engage with and respond to the complex and interdependent nature of multiple intelligences.

Reflecting on the case study model, the authors conclude that engaging with multiple intelligences for decision-making requires situated, place-based grounding and, where possible, expanded partnerships that honour local contexts and multispecies relations. However, in parallel to highlighting the affordances of such partnerships, the authors also recognise sector-wide adoption challenges for educators, which are compounded by limitations in capacity and budgetary constraints.

The case study presented here, therefore, offers an adaptable model for design educators seeking to cultivate capacities for working within, what the authors refer to as, ecologies of intelligences, where ecological, human and technological perspectives are negotiated equitably and future design roles offer value by materialising different ways of knowing. This model reflects broader curricular transitions toward place-responsiveness, and transdisciplinary collaboration in projects that are situated in large-scale multifaceted challenge areas. As the field continues to evolve, such models will be essential for preparing graduates to contribute meaningfully to regenerative and just climate futures in which design decentres and mediates relationships across people, place and planet.

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