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French Institutes of Technology (IUTs) as Laboratories for Climate-Aware Decision-Making

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Abstract
Climatic change is not merely a natural disaster but a crisis of collective judgment, exposing the challenges that governance and educational systems face in navigating uncertainty. Constrained by outdated predictive models and indicators derived from a historically stable world, educators often prioritize analytical calculation over the capacity to perceive connections, anticipate complexity, and imagine possibilities. Consequently, approaching action as a balance between analytical rigor and creative intuition becomes essential. French Institutes of Technology (IUTs, "U" for University) exemplify this approach: their strong local engagement and close ties with professional sectors support a pedagogy grounded in real-world challenges, where decision-making confronts uncertainty and complexity. Through a rigorous integration of theory and practice, IUTs cultivate undergraduate students capable of exercising discernment in unstable environments, avoiding the creation of "hemiplegic" decision-makers confined to a single mode of thought. This perspective highlights that hybridization of knowledge and practical skills offers a powerful means of responding to the intellectual, social, and political disorientation revealed by contemporary climate crises.
Keywords: Climatic change, Decision-making, France, Institutes of Technology (IUTs), Pedagogical innovation, Uncertainty, Undergraduate students
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1. Introduction

Climatic change is no longer a debated scientific hypothesis, except in certain fringe conspiracy circles; it is an observable reality evidenced by ecological disruptions that destabilize economies and profoundly reshape societies (Hui-Min *et al.*, 2021). Global average temperatures increased by 0.7°C during the twentieth century, and according to a report of the *United Nations Environment Programme*, even under optimistic scenarios, a rise of at least 2.5°C by 2100 appears unavoidable (Olhoff *et al.*, 2025). This trajectory manifests through a succession of droughts, floods, and population displacements, both more frequent and severe. These events expose the structural vulnerabilities of development models rooted in industrial productivism, which assumed predictability, abundant resources, and technical mastery over risk. They also underscore the growing inadequacy of local, national, and international governance systems to anticipate and manage uncertainty (McHugh *et al.*, 2021). Consequently, climatic change extends beyond environmental concerns, challenging cognitive frameworks, decision-making processes, and collective action strategies in a world increasingly marked by systemic unpredictability.

Addressing complex crises requires rethinking traditional decision-making tools and renewing both institutional and educational practices. In this context, French Institutes of Technology (IUTs) occupy a distinctive position

within higher education. Established in 1966 and affiliated with universities, these institutions provide undergraduate-level technological and professional training integrating academic instruction, applied skills, and local engagement—a model also reflected in Germany's *Fachhochschulen* and the Netherlands' *Hogescholen*. Their mission is to educate decision-makers capable of operating in complex industrial and commercial environments while fostering critical reflection on social, economic, and environmental transformations. IUTs serve as strategic sites for introducing students to systemic approaches to climate challenges, linking scientific knowledge, operational constraints, and societal responsibilities. They provide a robust framework for preparing future professionals to make decisions in contexts characterized by uncertainty, interdependent systems, and unpredictable crises. By emphasizing active, interdisciplinary, and experiential learning, IUTs cultivate graduates who navigate instability with discernment while contributing to the sustainable transformation of organizations and regions. In this way, they bridge theory and practice, developing competencies essential for adaptive, ethical, and informed action in a changing world.

Responding to climatic change cannot rely solely on technical or economic solutions. Effective responses demand a rethinking of decision-making rationality that emphasizes learning to act under uncertainty and recognizing complexity as a source of collective insight (Waisman, 2020). This integrative approach does not set science against ethics, or reason against intuition; rather, it seeks to combine them in informed, holistic action. Central challenges include rebuilding trust between institutions and citizens and coordinating diverse forms of intelligence toward the common good (Ostrom, 2015 [1990]). Within this framework, French IUTs provide strategic spaces for pedagogical experimentation, where students cultivate the critical skills necessary to understand, anticipate, and interpret climate impacts. Pedagogy becomes a laboratory for simulating complex situations, integrating hybrid knowledge, confronting diverse perspectives, and formulating effective responses to contemporary crises. These institutions also exemplify the vocational drift of French higher education, emphasizing employability, professional integration, and the development of skills directly applicable in the labor market, while highlighting the inequalities in access to work placements and professional experiences according to students' social and educational background (Bonnard, 2023).

While this orientation responds to legitimate economic and institutional pressures, it also raises critical tension: the prioritization of market-ready technical skills may come at the expense of developing reflexive and critical capacities. Yet, these capacities are essential for engaging with climate-related challenges, which are inherently systemic, uncertain, and ethically complex. In this respect, the ability to question assumptions, navigate ambiguity, and integrate diverse forms of knowledge becomes as important as technical proficiency. Such perspective aligns with longstanding critiques in management education, which caution against an overly instrumental conception of knowledge that reduces learning to the application of standardized tools and techniques, thereby neglecting the development of *critical judgment* and *reflexivity* (Grey, 2004; Ghoshal, 2005). An imbalance of this kind suggests that vocationally oriented curricula, if insufficiently calibrated, may constrain the formation of climate-aware decision-makers capable of addressing long-term and interconnected environmental issues. The objective is to prepare undergraduates capable of transforming crises into meaningful collective initiatives that promote ethical decision-making, sustainable practices, and adaptive organizational and societal transformation in an increasingly uncertain, volatile, and interconnected world.

This article examines how university education—and more specifically the training provided within IUTs—contributes to reshaping decision-making processes in the context of climatic change. It advances the central hypothesis that contemporary environmental disruption should not be understood solely as an ecological crisis, but rather as a deeper crisis of the decision-making and educational frameworks inherited from industrial modernity. Consequently, preparing students to make decisions under conditions of uncertainty emerges as a major challenge—one that has remained insufficiently addressed for decades, despite early scholarly attention to this issue dating back to the 1960s (Lebraty, 1967). To support this argument, the article is organized into three parts. Firstly, it outlines the dynamics of planetary disruption and its social repercussions, showing how climate-related crises increasingly exceed the capacities of traditional governance structures. Secondly, it examines the epistemic and pedagogical limitations of dominant decision-making models, while highlighting the pivotal role that IUTs can play in fostering learning focused on complexity, intuition, and the ethics of action; to provide further clarity on the methodological stance and analytical choices underpinning this investigation, Box 1 presents the qualitative and interpretive approach adopted. Thirdly, the discussion identifies both the contributions and the limitations of these pedagogical approaches and opens avenues for future research on the education of decision-makers in a business context increasingly shaped by irreversible crises.

Box 1. Methodological Approach

The present study adopts a qualitative and interpretive research approach, which is particularly well suited to the analysis of sustainability-related challenges and decision-making processes in the context of climatic change. This methodological choice is justified by the exploratory nature of the research question, which seeks less to establish causal relationships than to examine how decision-making frameworks are reshaped through pedagogical practices in higher education. Qualitative methods are especially appropriate for investigating complex socio-environmental systems characterized by non-linearity, irreversibility, and strong interdependence among phenomena (Fulconis & Paché, 2018; Creswell & Poth, 2024). Empirically, the analysis builds on a structured review of academic literature addressing sustainability education and decision-making under conditions of uncertainty, complemented by a qualitative examination of pedagogical practices implemented within French IUTs, including learning and assessment situations, project-based learning, and programs dedicated to ecological transition. Consistent with a constructivist epistemological stance (Sterling, 2010), the methodological framework conceptualizes knowledge as *situated* and *co-constructed*, allowing decision-making education to be approached not merely as a process of skill acquisition, but as a transformative lever shaping students' representations, reflexivity, and capacity for action in the face of contemporary environmental crises.

2. Global Disruptions and Social Inequalities

The contemporary world, shaped by unchecked growth, is revealing its incoherence and self-destructive potential, a concern anticipated over fifty years ago in the Meadows Report for the Club of Rome (Meadows *et al.*, 1972). Rising average temperatures, driven by industry, transportation, and the pursuit of productivity, extend far beyond simple global warming, profoundly altering ecological and social equilibria (Graciela, 2023). Natural disasters are no longer rare anomalies or "*black swans*"—events considered by Taleb (2007) to be extremely improbable and unpredictable yet highly impactful—but increasingly predictable consequences of global disruption, in which seasonal cycles lose their regularity. Mild winters, torrential rains, and unprecedented droughts disrupt agricultural practices and threaten food security, while rising sea levels endanger densely populated regions. Asian megacities, including Dhaka, Kolkata, and Bangkok, exemplify urban vulnerability, where millions face confinement due to geographic and infrastructural constraints (Becker *et al.*, 2020). Globally, 95% of humanity occupies only 10% of the Earth's landmass (Planète des Humains, 2025). These dynamics illustrate the planet's saturation point under human pressures, interacting with economic and social fractures and exposing the inadequacy of governance at multiple scales (Zahnow *et al.*, 2025), signaling the urgent need to rethink systemic resilience and institutional capacities.

Climate deregulation permeates every aspect of life, generating uncontrollable chaos. Desertification threatens over a billion people, while melting Himalayan glaciers risk depriving hundreds of millions of water and agricultural resources by 2035 (AbdelRahman, 2023). Health crises are intensifying, with rising infectious diseases, water stress, and injuries from extreme events. Many governments, constrained by lobbying and short-term political calculations, fail to implement decisive reforms, leaving competition for critical resources such as water and arable land to drive geopolitical tensions (Vesa *et al.*, 2020; Marin, 2023). Climatic change thus exposes stark global inequalities: some populations amass wealth and power, while others endure famine and forced migration. In 2023, approximately 733 million people faced hunger, one in eleven worldwide and one in five in Africa (Food & Agriculture Organization, 2023). Worst-case projections suggest that 3.5 billion could experience food insecurity by 2050 (Institute for Economics & Peace, 2025). Current systems, focused on immediate individual gains, amplify collective vulnerability and risk societal collapse, as Diamond (2004) warned, when short-term self-interest consistently outweighs long-term sustainability. Environmental mismanagement, resource depletion, and inequality interact in ways that create feedback loops, intensifying crises and undermining social cohesion, and without proactive governance, equitable resource distribution, and resilient institutions, humanity risks repeating historical collapses on a planetary scale (see Richards *et al.* [2021] for an empirical causal loop analysis showing how environmental degradation, inequality, and institutional dysfunction reinforce systemic crises).

Vulnerability to climate crises is neither inevitable nor natural; it emerges from profoundly unequal social, political, and economic structures. For instance, female-headed rural households in low-income countries lose significantly more income during heatwaves and floods compared with male-headed households, illustrating how gender inequality and systemic discrimination compound climate impacts and reduce adaptive capacity (see Box 2). More generally, poor populations bear disproportionate burdens due to geographic exposure, systemic inequalities, corruption, limited information access, weak infrastructure, and marginalization in local planning

(Ngcamu, 2023). Cyclone Idai in Mozambique (2019) exemplifies these inequities: entire neighborhoods of Beira were devastated due to inadequate dikes and early warning systems, converting a recurrent and dramatic weather event into a major humanitarian disaster (United Nations Office for Disaster Risk Reduction, 2024). Unregulated urbanization, fragile healthcare systems, and low risk awareness exacerbate impacts, transforming climate events into socio-environmental catastrophes. Political inaction and profit-driven decision-making continue to undermine collective resilience, pushing the planet toward critical limits. Addressing this challenge requires an ethical, strategic, and operational shift: rethinking development models, reinforcing environmental justice, promoting civic education, and cultivating the capacity to "relearn how to decide." Such measures are essential to prevent the compounding of disasters and to foster adaptive, equitable, and sustainable responses capable of securing societal and ecological survival under unprecedented climatic uncertainty.

Box 2. Climate Vulnerability and Gender

A 2024 report by the Food & Agriculture Organization (FAO) found that female-headed rural households lose, on average, 8% more of their income during heat waves and 3% more during floods than male-headed households. These figures were derived from a survey of 100,000 rural households across 24 low- and middle-income countries. The report emphasizes the need for targeted strategies to address the vulnerabilities of rural households headed by women. According to the FAO Director-General, social differences related to location, wealth, gender, and age have a profound yet often overlooked effect on rural populations' vulnerability to climate impacts. Notably, the report found that most national climate adaptation plans fail to consider the specific needs of rural women and youth: of more than 4,000 proposals reviewed, only 6% explicitly mentioned women. The FAO further highlighted that, in many low-income countries, women face systemic discrimination in land ownership and decision-making over agricultural work. When climate-related declines in farm and livestock productivity force women to diversify their income sources, they often encounter barriers in accessing information, financing, and technology, compounding their vulnerability.

Source: Inspired by Food & Agriculture Organization (2024).

3. Educating Undergraduates for Ethical Action

Contemporary climate crises expose a profound collective failure in public decision-making, revealing the persistent difficulty institutions face in understanding uncertainty as anything more than an anomaly to be corrected. Decision-makers remain constrained by short-term priorities and rely on outdated economic indicators and forecasting models that fail to capture systemic complexity (Harris, 2021). Political action is often reduced to crisis communication designed to reassure the public, rather than encouraging experimentation, adaptability, or organizational agility. Bureaucratic structures focused on error avoidance exacerbate decision-making inertia and reinforce analytical biases: the comforting predictability of flawed models is preferred over the discomfort of intuitive judgment (Dimond *et al.*, 2025). Mintzberg's (1976) distinction between analytical and intuitive modes of managerial thinking highlights the limits of overreliance on rational, sequential planning at the expense of imagination and synthesis. **Rather than referring to a strict neurological divide, the distinction points to a functional asymmetry in decision-making, where calculative reasoning tends to dominate over interpretive and context-sensitive judgment.** This imbalance persists in many French IUT management programs, where knowledge acquisition often prioritizes modeling, quantification, and procedural reasoning, thereby producing decision-makers who may appear "*hemiplegic*" when confronted with complex, real-world challenges.

Pedagogical approaches developed within IUTs nonetheless offer opportunities to mitigate such asymmetry. Project-based learning, interdisciplinary modules, and the use of real-world case simulations encourage students to mobilize multiple forms of knowledge simultaneously, combining technical expertise with situated judgment and reflexive thinking. Empirical research on project-based learning shows that engaging students in real-world problems fosters the development of higher-order cognitive strategies, including critical thinking, collaboration, and reflective judgment, which cannot be achieved through traditional lecture-based instruction (Naseer *et al.*, 2025). Similarly, interdisciplinary education has been shown to cultivate the ability to integrate diverse knowledge domains and generate novel insights, reinforcing the cognitive flexibility required to address complex and systemic challenges (Spelt *et al.*, 2009). By confronting students with ambiguous and evolving problem situations, these pedagogical formats promote the articulation of analytical reasoning with experiential and interpretive forms of knowledge. Such hybridization aligns with research showing that analytical and creative processes are not opposed but mutually reinforcing in effective decision-making (Fulconis, 2004). Addressing this cognitive imbalance is therefore critical for developing leaders capable of navigating uncertainty with ethical, adaptive, and innovative strategies. In this perspective, educational

environments are not merely sites of knowledge transmission but play an active role in shaping the cognitive frameworks through which future decision-makers interpret complexity and act upon it.

Climatic change exposes a profound collective failure in public decision-making, revealing the persistent difficulty institutions face in understanding uncertainty as anything more than an anomaly to be corrected. Decision-makers remain constrained by short-term priorities and rely on outdated economic indicators and forecasting models that fail to capture systemic complexity (Harris, 2021). Political action is often reduced to crisis communication designed to reassure the public, rather than encouraging experimentation, adaptability, or organizational agility. Bureaucratic structures focused on error avoidance exacerbate decision-making inertia and reinforce analytical biases: the comforting predictability of flawed models is preferred over the discomfort of intuitive judgment (Dimond *et al.*, 2025). Mintzberg's (1976) distinction between the analytical left hemisphere and the creative and intuitive right hemisphere highlights how traditional management training overvalues rational, sequential planning at the expense of imagination. This imbalance persists in many French IUT management programs, where knowledge acquisition emphasizes modeling, producing decision-makers "*hemiplegic*" when confronted with real-world challenges. Yet decades of research demonstrate that calculation and creativity are inseparable and mutually reinforcing in effective decision-making (Fulconis, 2004). Addressing this cognitive imbalance is critical for developing leaders capable of navigating uncertainty with ethical, adaptive, and innovative strategies.

Beyond its immediate impacts, climatic change is fundamentally epistemic: linear decision-making frameworks struggle to accommodate discontinuity and complexity (Vezér *et al.*, 2018). Lagadec (2015) emphasizes that hierarchical rigidity, fragmented responsibilities, and reliance on technocratic models impede responsiveness and hinder learning from past crises. Decision-makers, fearful of personal errors and constrained by institutional penalties, are reluctant to act boldly. However, in high-uncertainty contexts, resilience depends on adaptability, rapid exchange of information, and trust among stakeholders. Where centralized authority dominates, delegation is essential; where rigid norms prevail, intuition and interdisciplinary collaboration must guide action. The most resilient societies are not those with abundant material resources but those capable of mobilizing hybrid knowledge, integrating diverse expertise, and rapidly adjusting priorities (Miceli *et al.*, 2021). Navigating uncertainty effectively requires abandoning the illusion of absolute control, a shift that challenges traditional IUT teaching practices. By balancing analytical rigor with creativity and adaptive judgment, educational institutions can prepare students to transform uncertainty into opportunities for learning, innovation, and socially responsible, sustainable decision-making in an increasingly unpredictable world.

Refunding decision-making from a humanistic perspective entails cultural and ethical transformation, moving beyond resilience as mere shock absorption toward leveraging crises as opportunities for collective learning that valorize local and endogenous knowledge (Gill *et al.*, 2021). Institutional structures must evolve into ecosystems of shared intelligence, treating uncertainty as a lever for innovation and cooperation. Bureaucratic constraints, excessive fear of risk, and marginalization of intuition undermine decision-making effectiveness, even in early university education. Eneji *et al.* (2019) underline that environmental education can foster responsible behaviors, such as sustainable waste management, and cultivating civic engagement. These findings highlight the importance of integrating pedagogical approaches from the outset of higher education that develop technical competence, critical reasoning, and social responsibility. By enhancing students' discernment, creativity, and collaborative skills, universities can nurture ethical, effective decision-makers. In this context, the Bachelor of Technology (*Bachelor Universitaire de Technologie* [BUT] in French) reform of 2021, incorporating learning and assessment situations (*Situations d'Apprentissage et d'évaluation* [SAés] in French), represents a major shift, placing students in real-world, complex problems to strengthen technical expertise alongside critical awareness of environmental and social issues. Building on this approach, Bolou-Chiaravalli *et al.* (2022) emphasize the central role of reflexivity in SAé-based learning, highlighting how diversified pedagogical supports and the production of varied individual and collective "*traces*" enable students to critically analyze their own learning processes. Such structured reflexive design enhances alignment between learning outcomes and professional expectations, while fostering adaptive expertise in complex, uncertain environments.

Complementing the BUT reform, programs such as ecological transition for sustainable development (or TEDS) integrate ecological transition, applied experience, and ethical reflection to cultivate environmental citizenship among future decision-makers. By linking academic knowledge, fieldwork, and ethical reasoning, these programs empower students to mobilize social capital, critically evaluate environmental risks, and contribute to sustainable organizational and societal transformation. Hasan & Bahauddin (2014) argue that environmental degradation is less a matter of knowledge deficiency than of insufficient civic awareness of collective responsibility. Similarly, Angelaki *et al.* (2024) demonstrate that integrating sustainability issues into

undergraduate ICT curricula significantly enhances students' environmental awareness, positive attitudes towards sustainability, and readiness to engage in sustainable practices, highlighting the potential of targeted educational interventions to foster active, responsible, and ethically informed citizens. The TEDS initiative aligns with this view, promoting systemic understanding, ethical decision-making, and interdisciplinary collaboration (see Box 3). Rapid adoption of these pedagogical innovations is essential: without it, structural inertia and persistent governance failures may allow climate and social crises to reach irreversible thresholds, compromising sustainable development and collective action. By integrating real-world problem-solving, ethical reflection, and civic engagement into higher education, French IUTs offer a model for preparing future professionals capable of transforming crises into informed, responsible, and constructive interventions. These reforms highlight the potential of education to equip decision-makers with the competencies necessary to navigate uncertainty, foster resilience, and contribute meaningfully to a rapidly changing global context.

Pedagogical innovations in French IUTs, particularly through the SAé program, reveal a structural tension in management education under conditions of profound uncertainty, as highlighted by climate-linked geopolitical crises. While project-based learning, interdisciplinary modules, and sustainability-oriented initiatives, including TEDS, encourage the integration of analytical reasoning with situated judgment, their outcomes remain uneven across institutions. Implementation depends heavily on local dynamics, faculty discretion, and resource availability, producing heterogeneous results in terms of learning objectives, assessment methods, and the depth of interdisciplinary integration (Belmekki, 2024). Moreover, the absence of institutional mechanisms to coordinate curricula may risk perpetuating fragmentation: learning objectives can be inconsistently articulated across programs, assessment standards may vary, and opportunities to share interdisciplinary approaches remain limited. Consequently, innovative pedagogical practices might not fully translate into coherent frameworks capable of systematically fostering adaptive expertise and ethical decision-making under uncertainty. Addressing this limitation requires moving beyond isolated experiments toward coordinated structures that align learning objectives, assessment strategies, and interdisciplinary integration while preserving contextual flexibility. By fostering reflexivity, collaborative problem-solving, and the integration of diverse knowledge forms within structured yet adaptable frameworks, IUTs position students to navigate complexity, critically engage with socio-environmental challenges, and convert uncertainty into actionable insight.

Box 3. Training undergraduate students in the ecological transition for sustainable development

In accordance with the objectives outlined in the Climate, Biodiversity, and Ecological Transition Plan for Higher Education and Research, and to ensure coherence and alignment across programs, a core set of knowledge and skills related to the ecological transition for sustainable development must be defined and shared among higher education stakeholders. Consistent with the recommendations of the report submitted by Jean Jouzel, climatologist and former IPCC vice-chair, and Jean-Luc Abbadie, ecologist and professor at Sorbonne University, every undergraduate student should acquire a foundation of comprehensive, cross-cutting, and multidisciplinary knowledge and competencies prior to graduation. To support this, a framework document is proposed to help institutions identify existing courses that provide this training or to develop new modules where needed. Each higher education institution can then use this framework to design a training program tailored to its mission and the specific needs of its student population, allowing for adaptation, enrichment, and contextualization while ensuring that all graduates acquire the essential skills and understanding required to engage in sustainable development and ecological transition challenges.

Source: Adapted from Ministère de l'Enseignement Supérieur, de la Recherche et de l'Espace (2023).

4. Discussion and Conclusion

French IUTs function as genuine pedagogical laboratories in which learning extends well beyond technical proficiency to engage directly with the multiple dimensions of uncertainty. Students are routinely confronted with complex, incomplete, and sometimes contradictory situations that require them to mobilize analytical reasoning, ethical judgment, and the capacity to integrate heterogeneous forms of knowledge. Learning and assessment situations play a pivotal role in this process, as errors are reframed as pedagogical resources and failure becomes a catalyst for collective and critical reflection. For instance, Barbot & Reydet (2024) show that SAés can effectively function as research-based learning environments, engaging large cohorts of students in projects related to ecological transition and sustainable development. Training students to operate under uncertainty, and to view experimentation as a genuine "*factor of freedom*" (Thomas *et al.*, 2021), involves cultivating sensitivity to weak signals, anticipating unforeseen developments, and collaborating within diverse epistemic networks. In a context defined by accelerating ecological and social transformations, future decision-

makers can no longer rely exclusively on standardized models or linear planning tools. Instead, they must learn to confront unpredictability, adapt to situational variability, engage with plural perspectives, and transform crises into opportunities for responsible and informed action. From this standpoint, IUTs provide a distinctive environment for experiencing decision-making within an unstable and deeply interconnected world, fostering graduates who combine technical competence with ethical awareness, reflexivity, and creative problem-solving capacities suited to complex societal and environmental challenges.

Such distinctive positioning—still uncommon within most European higher education systems—supports a pedagogy firmly anchored in action and professional realities. Throughout three years of study, students participate in numerous concrete projects that are frequently interdisciplinary and closely connected to local territories, exposing them to novel problems that demand the continuous articulation of theory and practice. Unlike traditional university curricula, which often prioritize knowledge accumulation and standardized evaluation methods, French IUTs emphasize autonomous decision-making, systems thinking, and the ability to act effectively under institutional, technical, and temporal constraints. This pedagogical orientation transforms the effects of climatic change and contemporary crises into structured learning opportunities that foster innovation, cooperation, and resilience. Graduates—many of whom pursue advanced studies in MBA programs—emerge better prepared to confront uncertainty with clarity, responsibility, and confidence, while systematically integrating social, environmental, and ethical considerations into their professional judgments. By cultivating experimentation, reflective practice, and informed intuition alongside analytical rigor, the IUT model equips students to design solutions that are both effective and equitable. In doing so, it strengthens their capacity to convert crises into meaningful, sustainable collective projects, bridging theory and practice in a "disruptive" world.

Several concrete initiatives already demonstrate how this form of engaged pedagogy is implemented in practice. At the Thionville–Yutz IUT in eastern France, a comprehensive sustainable campus strategy has resulted in the award of the *Ecocampus* label, a national framework designed to recognize and structure the environmental commitments of higher education institutions. This initiative actively mobilizes students, faculty, and administrative staff around applied projects addressing biodiversity protection, sustainable mobility, waste reduction, and the mitigation of the campus's energy footprint. The projects draw directly on competencies developed in coursework and are reinforced through partnerships with local public institutions and territorial stakeholders, thereby strengthening the link between academic learning and civic engagement (IUT Thionville–Yutz, 2025). Similarly, the Senart–Fontainebleau IUT near Paris has developed a dynamic portfolio of competitions, calls for projects, and collective initiatives centered on ecological transition. Activities such as sustainable construction challenges and water-management events mobilize more than one hundred students annually across multiple disciplines, culminating in the presentation of concrete proposals to professional juries (IUT Sénart–Fontainebleau, 2023). The two cases illustrate how embedding real-world ecological projects within curricula anchors climate issues in tangible learning situations while fostering innovation, interdisciplinarity, and sustained student engagement.

Beyond promising experiments, several research avenues warrant further exploration to better understand the role of IUTs in training decision-makers under conditions of climate uncertainty and to assess the transferability of this model within European higher education systems. In June 2022, the European Union formally adopted recommendations making education for the ecological transition a priority at all levels of education, encouraging Member States to integrate sustainability-related knowledge and skills into curricula, mobilize ecological resources and infrastructure, and ensure that all learners acquire these competencies throughout their educational trajectories (Mulà & Tilbury, 2023). Firstly, longitudinal research is needed to evaluate the long-term impact of pedagogical approaches such as project-based learning, decision-making simulations, and territorial partnerships on graduates' professional trajectories, particularly regarding adaptability, ethical reasoning, and complex problem-solving capacities. Secondly, comparative studies between French IUTs and equivalent applied higher education institutions across Europe would help identify the institutional, cultural, and organizational conditions that support effective sustainability-oriented pedagogy. Thirdly, empirical investigations should examine how students integrate intuition, creativity, and analytical rigor in decision-making processes, drawing on mixed qualitative and quantitative methodologies across diverse educational contexts. Together, these research avenues would contribute to strengthening the evidence base for education as a lever of sustainable and ethical transformation.

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