"Towards Innovative Continuous Training of Teachers Researchers in Morocco: A Conceptual Framework Integrating Design Thinking and Ethical Artificial Intelligence."

by Jana Publication & Research

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Abstract

The continuous training of teachers researchers in Morocco constitutes a fundamental lever for supporting the modernization of higher education in a context marked by reforms and initiatives described in our initial assessment (S. CHAOUI K.Derkaoui, 2025), notably the National Charter for Education and Training (1999), the Strategic Vision 2015-2030, Framework Law 51-17, and the ESRI 2030 Pact. Building on the identified challenges regarding pathway personalization, equity of access, and integration of advanced technologies, this contribution develops an innovative conceptual framework articulating Design Thinking and ethical artificial intelligence.

The methodology combines a systematic literature review on the joint application of Design Thinking and ethical artificial intelligence in education with a PESTEL analysis contextualizing the external factors impacting the Moroccan educational system. This approach enables the modeling of an integrated conceptual framework specifically adapted to the continuous training of Moroccan teachers-researchers.

The results demonstrate that the Design Thinking approach, which is human-centered and collaborative and enriched by the analytical and personalizing capabilities of ethical artificial intelligence, offers promising solutions for designing pathways that respect diversity while maintaining equity of access. This framework natively integrates ethical considerations "*ethics by design*" and adapts to the cultural and institutional specificities of the Moroccan context, while aligning with national guidelines.

This theoretical research establishes the essential conceptual foundations for developing an innovative continuous training program, thus paving the way for an empirical experimentation phase that will validate the effectiveness and relevance of this integrated approach in the specific context of Moroccan higher education.

Keywords: Design thinking; Ethical artificial intelligence; Pedagogical innovation; Training personalization; Technological ethics.

Résumé

La formation continue des enseignants-chercheurs au Maroc constitue un levier fondamental pour accompagner la modernisation de l'enseignement supérieur dans un contexte marqué par les réformes et les initiatives décrites dans notre diagnostic initial (S. CHAOUI K.Derkaoui, 2025), notamment la Charte Nationale de l'Éducation et de la Formation (1999), la Vision Stratégique 2015-2030, la Loi-cadre 51-17 et le Pacte ESRI 2030. Partant des défis identifiés en matière de personnalisation des parcours, d'équité d'accès et d'intégration des technologies avancées, cette contribution développe un cadre conceptuel innovant articulant Design Thinking et intelligence artificielle éthique.

La méthodologie combine une revue systématique de la littérature sur l'application conjointe du Design Thinking et de l'intelligence artificielle éthique en éducation et une analyse

PESTEL contextualisant les facteurs externes impactant le système éducatif marocain. Cette approche permet la modélisation d'un cadre conceptuel intégré spécifiquement adapté à la formation continue des enseignants-chercheurs marocains.

Les résultats démontrent que l'approche Design Thinking, centrée sur l'humain et collaborative, enrichie par les capacités analytiques et personnalisantes de l'intelligence artificielle éthique, offre des solutions prometteuses pour concevoir des parcours respectant la diversité tout en maintenant l'équité d'accès. Ce cadre intègre nativement les considérations éthiques ("ethics by design") et s'adapte aux spécificités culturelles et institutionnelles du contexte marocain, toiut en s'alignant avec les orientations nationales.

Cette recherche théorique établit les fondements conceptuels indispensables au développement d'un programme innovant de formation continue, préparant ainsi la phase d'expérimentation empirique qui permettra de valider l'efficacité et la pertinence de cette approche intégrée dans le contexte spécifique de l'enseignement supérieur marocain.

Mots-clés : Design thinking ; Intelligence artificielle éthique ; Innovation pédagogique, Personnalisation de la formation ; Éthique technologique.

1. Introduction: -

The modernization of higher education represents a strategic imperative for Morocco, positioned at the heart of major national reforms and modernization initiatives such as the National Charter for Education and Training (1999), the Strategic Vision 2015-2030, Framework-Law 51-17, and the ESRI 2030 Pact. Within this context of profound transformation, continuing training (CT) for teacher-researchers (TRs)[1] is identified as a fundamental lever to strengthen pedagogical and scientific competencies, ensure continuous adaptation to technological developments, and align training offerings with the country's socio-economic needs.

However, as revealed by our initial assessment (S. CHAOUI K.Derkaoui, 2025), despite institutional efforts and progress in structuring mechanisms, major challenges persist. These challenges notably include insufficient personalization of training pathways, inequalities in access to professional development opportunities, and still limited integration of advanced technologies in teaching practices. Moroccan TRs express the need for training programs better adapted to the specificities of their disciplines, their experience levels, and the increased requirements for digital competencies and distance teaching methods. This observation highlights a significant gap between the ambitious objectives of reforms and operational reality, necessitating the development of a robust and innovative conceptual framework—an indispensable prerequisite for designing effective training systems adapted to the real needs of TRs.

Building from these identified challenges, this theoretical contribution develops the conceptual foundations necessary for designing an innovative CT program. The main objective is to develop a novel conceptual framework that articulates two complementary

[1] In this article, the term "teacher-researcher (TRs)" is used in a gender-neutral sense.

approaches particularly relevant in the current context: design thinking (DT) and ethical artificial intelligence (AI). DT, through its collaborative and human-centered nature, offers an agile methodology for designing solutions tailored to real needs, while ethical AI, with its analytical and personalizing capabilities, promises to radically transform the effectiveness and accessibility of training while respecting ethical considerations related to the use of advanced technologies. This framework constitutes the theoretical and methodological foundation for the future engineering of a CT system specifically dedicated to Moroccan TRs.

The adopted methodology combines a systematic literature review on the joint application of DT and ethical AI in education with a PESTEL analysis contextualizing the macro-environmental factors impacting the Moroccan educational system. This holistic approach enables the modeling of an integrated conceptual framework that respects cultural and institutional specificities while building on international advances.

This study proposes to explore how the DT approach—human-centered and collaborative—enriched by the analytical and personalizing capabilities of ethical AI, could offer promising solutions for designing pathways adapted to the real needs of TRs, while respecting ethical issues related to the use of advanced technologies. The originality of this research lies in three major conceptual innovations: (1) the proposal of a theoretical specialization dedicated to TRs continuing training that integrates their dual pedagogical and scientific identity, (2) the native integration of ethics as a structuring principle "*ethics by design*" rather than as an external constraint, and (3) the cultural contextualization of the framework to Moroccan specificities as a fundamental design variable.

2. Literature Review and Theoretical Framework: - Foundations of Design Thinking, Contributions of Ethical Artificial Intelligence, Emerging Synergies, and Specificities of the Moroccan Context in Continuing Training.

This section provides a critical analysis of the main conceptual and methodological foundations employed within the framework of this research. It is structured around four complementary axes: (i) the principles and applications of DT in CT, (ii) the emerging contributions of ethical AI in instructional design, (iii) the potential convergences and synergies between these two approaches in the international literature, and (iv) the specificities of the Moroccan context illuminated by our initial assessment. This theoretical foundation aims to justify the development of the integrated conceptual framework presented in the following sections.

2.1. Design Thinking Applied to Continuing Training:

DT has established itself as an innovative methodological approach for solving complex problems, characterized by a user-centered orientation, collective creativity, and rapid iteration of solutions (Brown, 2010). Originally conceptualized by industrial designers and popularized by the IDEO[2] agency and Stanford d.school[3], DT has progressively entered the

[2]**IDEO**: Founded in 1991 in the United States, IDEO is an international design and innovation agency, widely recognized for having structured, disseminated, and popularized the Design Thinking methodology in both the professional world and the education sector. Notably, IDEO collaborated with Stanford's d.school to formalize

field of instructional design, where it emphasizes empathy and the active participation of all stakeholders (teachers, students, administrators) to design contextualized and relevant educational solutions (Razzouk & Shute, 2012).

2.1.1. Epistemology and Fundamental Principles of Design Thinking in Instructional Design:

The epistemology of DT is rooted in a pragmatist philosophy that prioritizes experimentation, continuous adaptation, and co-construction of knowledge. Unlike traditional pedagogical approaches based on the vertical transmission of knowledge, DT adopts a constructivist stance in which learning emerges from the dynamic interaction between actors, contexts, and the challenges to be solved (Johansson-Sköldberg et al., 2013). This epistemological orientation places empathy at the heart of the educational process, recognizing that any effective pedagogical innovation must begin with a thorough understanding of learners' real needs and the contextual constraints faced by instructors.

Integrated Methodological Architecture

The DT process is structured around five main stages, specifically adapted to the challenges of instructional design:

1. **Empathy:** This constitutes the foundational phase, aimed at deeply understanding the needs, motivations, and constraints of end users (continuing training professionals, learners, stakeholders). This stage employs sophisticated qualitative techniques: in-depth interviews, contextual observations, empathy mapping, and the construction of representative personas (Brown, 2008; Razzouk & Shute, 2012).

2. **Definition:** This phase aims to reformulate and synthesize the problem based on data collected during the empathy phase, precisely targeting the key issues, major obstacles, and real needs to be addressed. This involves drafting a "*point of view*" or "*problem statement*" to clarify the problem and contextualize it, thereby effectively guiding the subsequent stages of the design process (Tschimmel, s. d.) ; (Henriksen et al., 2017).

3. **Ideation:** This is the phase for collectively generating a range of potential solutions, fostering creativity, divergent thinking, and diversity of perspectives. This stage relies on brainstorming workshops, brainwriting techniques, and mind mapping, involving various stakeholders to multiply approaches and avoid conventional solutions (Carroll et al., 2010; Razzouk & Shute, 2012). The objective is to stimulate innovation through the free expression of ideas, without self-censorship (Liedtka, s. d.).

4. **Prototyping:** This involves designing models, mockups, simulations, or simplified versions of selected solutions, rapidly and cost-effectively. Prototyping enables the concrete

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the steps of the Design Thinking process a promote its use in solving complex problems, organizational innovation, and educational transformation. Brown, T. (2008). Design Thinking. Harvard Business Review, 86(6), 84–92; IDEO (2012)

[3] **Stanford d.school**: The Hasso Plattner Institute of Design at Stanford, founded in 2005, is internationally recognized for formalizing and disseminating Design Thinking in higher education. Stanford d.school (2018). An Introduction to Design Thinking Process Guide. Retrieved from https://dschool.stanford.edu/resources/design-thinking-bootleg.

materialization of ideas, visualization of pedagogical scenarios, testing of their coherence and feasibility, and identification of potential limitations or areas for improvement before larger-scale implementation (Henriksen et al., 2017; « Towards a Paradigm Shift in Education Practice », Noweski et al., 2012).

5. **Testing:** This final stage consists of experimenting with prototypes among target users, collecting their qualitative and quantitative feedback (through questionnaires, observations, or feedback interviews), then adjusting, improving, and refining solutions accordingly (Scheer & Noweski, s. d 2012, Carroll et al., 2010). Testing operates within an iterative logic, where lessons learned enable the revisiting of previous phases, when necessary, to ensure optimal alignment between the deployed solution and field needs (Liedtka, 2018; Johansson-Sköldberg et al., 2013).

The following diagram illustrates the five main stages of Design Thinking in a circular and iterative process:

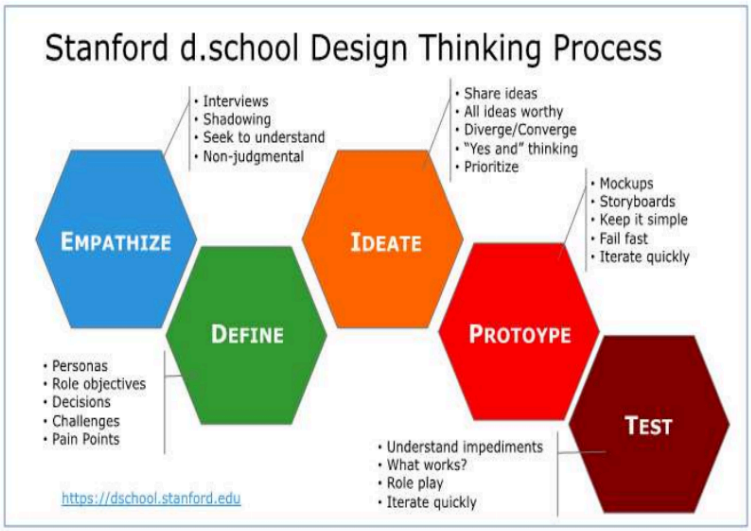

Figure 1: The five stages of Design Thinking in education (adapted from Henriksen et al., 2017; Razzouk & Shute, 2012; Stanford d.school).

This process, illustrated by a continuous cycle of exploration, creation, and experimentation, fosters adaptability and the continuous improvement of pedagogical approaches. According to Henriksen et al. (2017), empathy and problem definition constitute the immersion phase, ideation and prototyping fall under the creation phase, and testing belongs to the

implementation and adjustment phase. This model emphasizes the need to revisit these steps based on user feedback, giving DT its iterative and evolutionary dimension.

Thus, numerous authors (notably IDEO and Stanford d.school) synthesize this process into three major interdependent phases: inspiration (or immersion), ideation (or creation), and implementation (or realization), as shown in the following diagram:

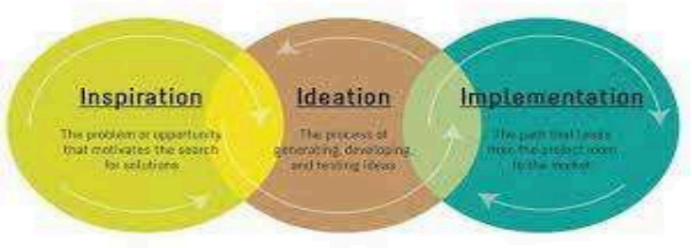

Figure 2: The three main phases of Design Thinking – Inspiration, Ideation, Implementation (adapted from IDEO, 2012; Brown, 2008; Stanford d.school, 2018).

Beyond this process-oriented structure, DT is distinguished by the integration of specialized tools derived from design: learning journey maps, learner personas, pedagogical storyboards, which facilitate the co-construction of solutions and encourage the active engagement of all stakeholders (Liedtka, 2018). DT thus contrasts with linear and prescriptive pedagogical methods by emphasizing experimentation, reflexivity, and the right to make mistakes—elements essential for teachers' professional development and the transformation of educational practices (Carrol, 2014; Serrat & Simon, 2010).

2.1.2. Documented applications in higher education and relevance for the continuing training of teacher-researchers:

The integration of DT in higher education is now emerging as a strategic lever for pedagogical transformation and institutional innovation, particularly relevant for the continuing training of teacher-researchers. According to Kelley & Kelley (2013), this approach represents "*a learning orientation that encompasses active problem-solving and the mobilization of a person's capacity to create changes that have an impact.*" (Kelley & Kelley, 2013). The pioneering work of Stanford d.school and IDEO has established solid empirical foundations demonstrating the effectiveness of DT in higher education. (Brown, 2010 ; Lake et al., 2024).

Specific documented impacts

The scientific literature converges in identifying several dimensions of DT impact that are specifically relevant to TRs training:

The development of transferable skills is considered one of the most well-documented contributions. The application of DT promotes intrinsic motivation, creativity, critical thinking, complex problem-solving abilities, teamwork, and interdisciplinary collaboration (Bruton, 2011) ; (Dosi et al., 2018).These skills prove to be particularly crucial for TRs, who must reconcile scientific excellence with pedagogical innovation.

The strengthening of pedagogical innovation represents a second major area of impact. Scheer and Plattner (2011) establish that DT constitutes a particularly effective innovation process, promoting experiential learning and reflexivity. This approach fosters the emergence of new pedagogical practices, centered on experimentation and continuous adaptation.

The transformation of professional attitudes constitutes a third significant contribution. TRs exposed to DT develop greater autonomy, strengthen their collaborative and innovative capacities, while acquiring "*creative confidence*" that makes them more resilient in the face of uncertainty and institutional change. This is accompanied by a shift from a logic of disciplinary reproduction to one of continuous pedagogical creation and adaptation (Chung, 2014).

Concrete Applications in Continuing Training

In the specific field of CT for TRs, several application methods have been successfully tested: pedagogical co-design workshops that enable collective rethinking of practices (Carroll et al., 2010), the creation of pedagogical innovation laboratories—"*learning labs*"—that foster collective experimentation (Dosi et al., 2018), and integrated professional development programs. The University of Potsdam example illustrates these applications: Noweski et al. (2012) report that multidisciplinary teams of faculty members designed pedagogical modules centered on learners' real needs, significantly strengthening their capacity to innovate.

2.1.3. Methodological Potential for Innovation in Continuing Training:

Le DT met en avant un potentiel méthodologique considérable pour transformer les approches traditionnelles de FC des EC. Cette transformation s'opère à travers plusieurs dimensions innovantes.

DT presents considerable methodological potential for transforming traditional continuing training approaches for TRs. This transformation operates through several innovative dimensions.

Adaptive Personalization Paradigm

DT introduces a personalization paradigm that goes beyond traditional standardized approaches. The empathy stage enables precise identification of each TR's specific needs according to their discipline, level of experience, and professional development objectives. This individualized approach stands in stark contrast to the "*one-size-fits-all*" training programs (Tomlinson, 2014) that often characterize conventional institutional systems, proving particularly crucial in contexts like Morocco, where the diversity of profiles requires differentiated approaches (Chaoui & Derkaoui, 2025).

Innovation in Professional Learning Modalities

DT revolutionizes professional learning modalities by replacing transmissive approaches with experiential and collaborative methods. The ideation and prototyping phases transform TRs into co-creators of their own training programs, thereby developing their professional autonomy and fostering the emergence of innovative communities of practice (Carroll et al., 2010).

Methodological Challenges and Opening Toward Ethical Artificial Intelligence

Despite this exceptional potential, the effective integration of DT in CT requires overcoming several significant methodological challenges. Johansson-Sköldberg et al. (2013) identify that the adoption of prototyping and testing phases often remains insufficient, as these steps are perceived as the most complex to implement in a traditional educational context (Johansson-Sköldberg et al., 2013).

Moreover, the widespread adoption of DT also requires a transformation of institutional cultures and structured support for teaching teams (Liedtka, 2018). More fundamentally, several authors highlight the challenges associated with large-scale application of DT in complex institutional contexts. Liedtka (2018) identifies that systematic application of DT necessitates substantial resources in terms of time, training, and personalized support, particularly when managing diverse needs at scale. Similarly, Carlgren et al., (2016) observe that implementing DT in complex organizational environments encounters operational challenges related to the capacity for processing and analyzing large volumes of user data.

These convergent findings suggest that enriching DT with advanced technological approaches could optimize its efficiency and reach (Micheli et al., 2019), thus paving the way for integrating ethical AI as a strategic methodological complement to optimize personalization processes, needs analysis, and learning monitoring.

International literature converges in recognizing DT as a central driver of pedagogical innovation, capable of inspiring and transforming CT for TRs, provided it is carefully adapted to institutional realities and coordinated with advanced technological approaches to maximize its impact and widespread adoption in the specific context of Moroccan higher education.

In light of these considerations, this analysis of DT fundamentals naturally leads to examining its strategic technological complement: ethical AI and its applications in CT.

2.2. Ethical Artificial Intelligence in Education:

AI has established itself today as a major transformative technology in the field of CT, opening unprecedented perspectives in terms of personalization, optimization, and accessibility of learning systems. This technological revolution is part of a broader context of education digitalization, accelerated by contemporary societal changes and the specific challenges of higher education (« Artificial Intelligence in Education », 2020 ; Holmes et al., 2019 ; UNESCO, 2021). However, AI integration raises fundamental ethical questions that must be addressed proactively to ensure responsible and equitable development. In the specific context of CT for faculty members, ethical AI represents a potential lever to meet the growing needs for personalization, adaptability, and pedagogical effectiveness, provided it is deployed within a rigorous ethical framework that ensures transparency, equity, and respect for fundamental educational values.

2.2.1. State of the Art of Ethical AI Uses in Continuing Training:

The integration of ethical AI in CT systems is structured around several technological and pedagogical axes, each requiring a specific ethical approach to ensure responsible implementation that benefits all stakeholders.

Ethical Adaptive Learning Systems

Adaptive learning systems constitute one of the most documented and promising applications of AI in education. These platforms use machine learning algorithms to dynamically adjust content, pace, and teaching modalities based on each learner's performance, preferences, and identified gaps (Pane et al., 2015 ; Walkington & Bernacki, 2020). In the context of CT for TRs, these systems enable the provision of professional development modules precisely calibrated to individual skill development needs, whether in digital pedagogy, research methodologies, or cross-cutting skills. The ethical approach to these systems necessarily involves transparency of recommendation algorithms, respect for users' pedagogical autonomy, and the guarantee that adaptation does not lead to discrimination or confinement to limited pathways(Barocas & Selbst, 2016).

Responsible Intelligent Tutoring Systems

Intelligent Tutoring Systems (ITS) represent a second category of applications, offering individualized support similar to that of a human tutor. These systems use natural language processing and automated reasoning techniques to provide tailored explanations, identify conceptual gaps, and propose targeted remediation (Kulik & Fletcher, 2016 ; Ma et al., 2014). For TRs, these tools can facilitate learning new pedagogical skills or mastering complex technological tools. The ethical dimension of these systems lies in their ability to preserve the human relationship in learning, avoid dehumanization of education, and maintain a balance between automated assistance and human support.

Educational Analytics and Ethical Prediction

Predictive analysis and learning analytics constitute a third particularly relevant field of application. These approaches enable the collection, analysis, and interpretation of massive data on learners' interactions with training platforms, identifying behavioral and predictive patterns (Siemens & Baker, 2012; *Educational Technology & Society*, s. d.-a Papamitsiou & Economides, 2014). In the CT context, these analyses can help evaluate system effectiveness, identify participants at risk of dropping out early, and optimize pedagogical intervention strategies. The ethical use of these analyses requires informed user consent, rigorous protection of personal data, transparency regarding collection and analysis methods, and assurance that predictions do not lead to stigmatization (« Ethics and Learning Analytics », Prinsloo & Slade, 2017).

Virtual Assistants and Ethical Conversational Interfaces

Virtual assistants and educational chatbots offer a conversational interface for learner support, using natural language processing techniques (Winkler & Soellner, 2018 ; Smutny & Schreiberova, 2020). These tools can provide ongoing support for TRs, answering frequently asked questions, directing them to relevant resources, or facilitating access to administrative and pedagogical information. The ethical approach to these interfaces involves transparency about their artificial nature, respect for the confidentiality of exchanges, and ensuring that the responses provided are reliable, up-to-date, and culturally appropriate.

2.2.2. Existing Ethical Frameworks[4] and Potential for Responsible Personalization:

Reference Ethical Frameworks

Several international ethical frameworks currently structure the responsible development of AI in education. UNESCO (2021) proposes a comprehensive normative framework that prioritizes a human-centered approach, algorithmic transparency, equitable access, and personal data protection. This framework emphasizes the importance of maintaining human agency in educational processes and ensuring that AI serves to augment human capabilities rather than replace them.

The ethical framework proposed by Holmes et al. (2019) focuses on four fundamental principles: beneficence (maximizing educational benefits), non-maleficence (avoiding harm), autonomy (respecting learners' agency), and justice (ensuring equitable access and treatment). These principles provide a particularly relevant analytical framework for evaluating the ethicality of AI applications in CT for TRs.

Opportunities for Ethical Personalization

One of the most significant contributions of responsible AI in CT lies in its capacity to offer truly personalized learning experiences while respecting fundamental principles of equity, transparency, and autonomy. This responsible personalization operates at several levels:

[4] **Ethical framework:** An operational normative framework that structures the principles, rules, and procedures necessary for the development and responsible use of artificial intelligence in a specific domain. Distinguished from a conceptual framework by its practical and regulatory purpose (adapted from UNESCO, 2021; Holmes et al., 2019).

adapting content to individual prerequisites and objectives while respecting profile diversity, modulating learning pace without discrimination, and diversifying pedagogical modalities according to learning styles while avoiding stereotypes (Xie et al., 2019 ; Zawacki-Richter et al., 2019a).

The ethical individualization of pathways enables an effective response to the heterogeneity of TRs profiles, a major challenge in CT within higher education. AI systems can analyze prior competencies, identify specific gaps, and propose targeted training modules, thus optimizing pedagogical effectiveness and participant engagement, while ensuring that this personalization does not lead to discrimination or exclusion (Aleven et al., s. d. 2009).

Contextual Potential and Responsible Adaptation

Ethical scalability represents another major advantage, enabling the deployment of personalized training systems at large scale without proportional increase in human costs, while maintaining high ethical standards (Holmes & Luckin, 2016). Temporal and geographical accessibility constitutes a significant contribution, with responsible technologies enabling the provision of continuously available training, adapted to the professional constraints of TRs and the geographical specificities of institutions, without creating new forms of digital exclusion (UNESCO, 2021).

However, this dimension proves particularly critical in the Moroccan context, where our initial assessment highlighted persistent challenges related to temporal and geographical accessibility of CT programs, particularly for TRs from universities located in less advantaged regions (S. CHAOUI K.Derkaoui, 2025). Ethical AI thus offers promising solutions to overcome these identified structural obstacles, by proposing flexible, personalized, and decentralized training modalities that respect the cultural and institutional specificities of the Moroccan context.

2.2.3. Ethical Issues Specific to the Context of Continuing Training for Teacher-Researchers:

Critical Ethical Challenges

The integration of ethical AI in CT raises major challenges that require thorough critical analysis and rigorous management, particularly in the specific context of CT for TRs.

Algorithmic biases and equity issues constitute a central concern. AI systems, relying on potentially biased historical data, can reproduce or amplify existing inequalities in access to training or in skills assessment (Barocas & Selbst, 2016 ; Chouldechova, 2017). In the context of TRs training, these biases can affect the recognition of disciplinary competencies, favor certain pedagogical approaches over others, or discriminate based on gender, age, or institutional background.

Algorithmic transparency and explainability represent a major technical and ethical challenge. The complexity of algorithms and the "*black box*" nature of some systems make it difficult to understand the decisions made by AI, which can undermine user trust and professional acceptance (Holmes et al., 2019).

The digital divide represents a particularly pressing challenge in certain geographic and institutional contexts. Unequal access to technologies and digital skills risks deepening disparities if the introduction of AI is not accompanied by digital inclusion measures and appropriate training (UNESCO, 2021).

Technological dependence and educational sovereignty represent a major organizational risk. Institutions risk losing their pedagogical autonomy to external technological solutions, with implications for educational sovereignty and system sustainability (UNESCO, 2021 ; Williamson, 2017). This concern is all the more critical in contexts where national education systems seek to preserve their capacity to adapt to cultural specificities and national development objectives (Selwyn, 2019).

Professional Acceptance and Transformation of Practices

The social and professional acceptance of AI by TRs constitutes a major organizational challenge. Resistance may arise from fears related to the replacement of human trainers, the dehumanization of training, or the undermining of traditional pedagogical expertise (Zawacki-Richter et al., 2019). The ethical adoption of AI therefore requires transparent change management, clear communication about the objectives and limitations of these technologies, and a guarantee that AI enhances rather than replaces human expertise.

At the conclusion of this analysis, while ethical AI offers promising prospects for the personalization and optimization of CT for TRs, its effective integration requires a thoughtful, transparent, and contextualized approach. Recent research converges in recommending hybrid systems where ethical AI serves as a tool supporting pedagogy and human guidance rather than a substitute for the educational relationship (UNESCO, 2021; Holmes et al., 2019).

Thus, this analysis of the contributions and challenges of ethical AI in CT subsequently prepares the ground for analyzing conceptual synergies between these two complementary approaches.

2.3. Design Thinking (DT) – Ethical AI Convergence: Emerging Conceptual Synergies:

The articulation between DT and ethical AI represents an emerging field of conceptual innovation that is generating growing interest in international academic literature, particularly in the educational sector where the need for flexible, personalized, and ethically responsible pedagogical approaches is becoming increasingly imperative (Holmes et al., 2019 ; UNESCO, 2021). This convergence is part of a broader dynamic of transformation in pedagogical practices and opens unprecedented perspectives for designing training systems that are simultaneously human-centered, technologically advanced, and ethically grounded.

2.3.1. Theoretical and Methodological Hybridizations in International Literature

Scientific literature highlights a progressive convergence between DT and ethical AI, based on epistemological and methodological complementarities that transform traditional approaches to pedagogical innovation (Shneiderman, 2020 ; Zawacki-Richter et al., 2019b). This hybridization is structured around four major axes of conceptual synergy.

Epistemological Convergence: The Human-Centered Approach as a Common Ethical Foundation

The first axis of convergence lies in a shared epistemological orientation toward a human-centered approach, enriched with an explicit ethical dimension. DT, through its empathetic philosophy, places the user at the heart of the design process, while ethical AI seeks to personalize the experience while respecting the fundamental rights and dignity of each user (Brown, 2008; Luckin et al., 2016; UNESCO, 2021). This convergence enables the design of learning systems that combine empathetic understanding of needs, real-time technological adaptation, and adherence to fundamental ethical principles.

Methodological Hybridization: Ethical Iteration and Responsible Continuous Improvement

A second axis concerns the hybridization of iterative processes of continuous improvement with integrated ethical evaluation mechanisms. DT favors a cyclical approach of testing, evaluation, and adjustment, while ethical AI enables continuous performance optimization while maintaining high ethical standards (Henriksen et al., 2017; Floridi et al., 2018). This complementarity facilitates the creation of ethically controlled feedback loops, combining human intuition, big data analysis, and ongoing ethical vigilance.

Creative Synergy: Ethical Augmentation of Collective Creativity

A third domain focuses on the ethical augmentation of collective human creativity through AI's technological capabilities. This synergy enables the emergence of "*ethically augmented creativity*", where AI's generative capabilities enrich human creative processes while maintaining rigorous ethical standards and preserving participants' creative agency (Liedtka, 2018; Chen et al., 2020).

Analytical Convergence: Ethically Augmented Empathy

A fourth axis concerns the ethical use of data analysis to deepen empathetic understanding of users. Ethical AI can process considerable volumes of behavioral data while guaranteeing privacy protection and informed consent (Siemens & Baker, 2012; Prinsloo & Slade, 2017), enabling "*ethically augmented empathy*" that offers a more comprehensive understanding of learners' needs while respecting their fundamental rights.

2.3.2. Existing Conceptual Models and Their Limitations:

A systematic analysis of international literature highlights the existence of formalized theoretical models and the emergence of conceptual trends that structure, to varying degrees, the relationship between DT and ethical AI. This analysis rigorously distinguishes established frameworks from emerging syntheses.

Formalized Theoretical Models

The "*Human-Centered AI Design*" model developed by Shneiderman (2020, 2022) constitutes the most formalized and empirically tested framework. It structures the process around four phases: empathetic understanding of needs, definition of ethically aligned AI objectives, iterative design of hybrid solutions, and continuous evaluation including ethical dimensions.

This model has been the subject of documented applications in several educational contexts (Shneiderman, 2022).

The "*Human-in-the-Loop AI*" concept, formalized by Luckin et al. (2016), constitutes an established system architecture where humans intervene at each stage within a logic of reinforced ethical control. This model finds concrete applications in intelligent tutoring systems and adaptive learning platforms (Luckin et al., 2016).

Emerging Conceptual Trends

Recent literature emphasizes a convergence toward enriching each stage of DT with specific AI tools (Amershi et al., 2019; Holmes et al., 2019). This emerging trend, which we conceptualize as "*ethically integrated AI-DT*", manifests through various experiments: empathy augmented by responsible sentiment analysis, ideation assisted by transparent generative algorithms, prototyping accelerated by copyright-respecting tools, and testing optimized by ethical educational analytics.

The adaptation of the "*Ethics by Design*" principle, inspired by the work of Floridi et al. (2018) and the "*Privacy by Design*" concept (Cavoukian, s. d. 2009), explores the proactive integration of ethical considerations from the design stage.

Critical Analysis of Existing Limitations

Our critical analysis of these models in light of the literature and our research context identifies several limitations. On one hand, several authors highlight the challenges of cultural adaptation of models developed in Western contexts (Selwyn, 2019; UNESCO, 2021). On the other hand, as documented by Jobin et al. (2019), ethical integration often remains superficial in current approaches (Jobin et al., 2019)..

Our specific analysis reveals three major limitations of existing models:

1. A lack of contextual specificity for CT of TRs and their particular needs;
2. Insufficiently operational ethical integration that does not translate into concrete processes and tools;
3. An absence of cultural considerations for non-Western contexts such as Morocco.

2.3.3. Identified Theoretical Gap and Original Research Positioning:

Despite significant advances in the articulation between DT and AI, critical analysis of the literature reveals a multidimensional theoretical gap that justifies the development of an original conceptual framework.

Conceptual and Ethical Gap

The absence of theoretical frameworks specifically designed for the CT of TRs that natively integrate ethical dimensions constitutes the main gap. Existing models, while relevant, have been primarily developed for initial training contexts or professional development in sectors other than higher education. This specificity of the higher education faculty audience, with their dual pedagogical and scientific identity (S. CHAOUI K.Derkaoui, 2025), necessitates an

adapted conceptual approach that takes into account their particular professional development needs (Maurines & Marzin-Janvier, 2021).

Methodological and Contextual Gap

Methodologically, the analysis demonstrates a gap between sophisticated theoretical frameworks and concrete operationalization, particularly for constrained institutional contexts. The geographical concentration of research on Western contexts does not allow for understanding the specificities of educational systems in non-Western countries.

Original Positioning and Innovative Contribution

In response to these gaps, this research positions itself originally along three axes of contribution:

Conceptual Originality

Our approach proposes an integrated conceptual framework specifically designed for CT of TRs articulating the specificities of their dual professional identity with the potential offered by DT-AI convergence. This approach surpasses existing models by explicitly integrating the research and pedagogical innovation dimensions that characterize the TRs profession (Vatin, 2020), placing ethics at the heart of the design process.

Methodological Originality

Methodologically, our research adopts an "*integrated ethics by design*" approach that closely involves Moroccan TRs in all phases of system design and evaluation. This collaborative approach ensures that proposed solutions address real needs while natively integrating ethical, cultural, and institutional considerations.

Contextual Originality

Contextually, this research constitutes, to our knowledge, the first systematic attempt to apply DT-AI convergence specifically to CT of TRs in the Moroccan context. This geographical and cultural originality enriches international literature by documenting how these innovative approaches can be adapted to different institutional and cultural contexts.

It is precisely within this ethical perspective that our work is situated, aiming to develop an innovative conceptual framework for CT of Moroccan TRs, that articulates DT and the ethical use of AI. This methodological approach, human-centered and collaborative through DT, enriched by the analytical and personalization capabilities of responsible AI, will enable the design of training programs adapted to the real needs of faculty while respecting fundamental ethical principles and the specificities of the Moroccan context.

This analysis of conceptual synergies between DT and ethical AI establishes the necessary theoretical foundations for examining Moroccan contextual specificities that will directly guide the construction of our innovative conceptual framework.

2.4. Contextualization and Grounding in the Initial Diagnosis:

This section establishes the direct articulation between the theoretical foundations of DT-Ethical AI convergence and the empirical specificities of the Moroccan context revealed by our initial diagnosis (S. CHAOUI K. Derkaoui, 2025). This contextualization aims to demonstrate how the identified challenges constitute specific conceptual needs that directly guide the construction of our innovative theoretical framework.

2.4.1. Theoretical Implications of the Initial Diagnosis:

Our conceptual framework is anchored in the empirical findings of our comprehensive diagnosis, which highlight operational challenges that, beyond their practical nature, constitute conceptual needs not addressed by existing models in the international literature.

From Profile Heterogeneity to the Need for Ethical Personalization

The diagnosis revealed significant diversity among Moroccan TRs profiles in terms of disciplines, experience, and professional development needs. This heterogeneity constitutes a major theoretical challenge for standardized approaches and conceptually justifies the integration of ethical AI personalization capabilities with empathetic DT methods. The inadequacy of "*one-size-fits-all*" approaches (Tomlinson, 2014) identified has led to the emergence of a conceptual need for adaptive models that respect diversity while maintaining equity (S. CHAOUI K. Derkaoui, 2025, pp. 766-767).

From Access Inequalities to the Need for Technological Distributive Justice

The identified geographical and institutional disparities present conceptual challenges related to access equity and distributive justice in CT. These findings theoretically justify the integration of advanced technological solutions within a human-centered design process, aimed at developing training modalities that transcend geographical constraints without creating new forms of digital exclusion (S. CHAOUI K. Derkaoui, 2025, pp. 771-772).

From Cultural Resistance to the Need for Participatory Acceptability

The resistance to innovation identified highlights theoretical issues related to the social and professional acceptability of educational technologies. These findings underscore the conceptual necessity of a participatory and empathetic approach that respects professional and cultural values while promoting responsible innovation (S. CHAOUI K. Derkaoui, 2025, pp. 769, 774).

Thematic Continuity: From Challenge Identification to Conceptual Solution Proposals

This thematic articulation illustrates the direct methodological continuity between our empirical diagnosis and our theoretical construction. Each major challenge identified in the diagnosis finds a specific conceptual response in our framework, as synthesized in the following table:

Table 1: Correspondence between diagnosed challenges and conceptual solutions of the DT-Ethical AI framework [5].

Challenges identified in initial diagnosis	Proposed conceptual solutions	DT-Ethical AI articulation mechanisms	Theoretical justification
Personalization challenges (S. CHAOUI K.Derkaoui, 2025, pp. 766-767)	DT- Ethical AI approach for adaptation to individual needs	Augmented empathy + responsible adaptive algorithms	DT, through its empathy phase, enables identification of each student's specific needs, while ethical AI provides personalized adaptation capabilities at scale, respecting diversity while maintaining equity.
Accessibility constraints (S. CHAOUI K.Derkaoui, 2025, pp. 771-772)	Ethical and flexible technological solutions	Inclusive prototyping + geographically accessible AI	Integration enables the development of training modalities that transcend geographical constraints without creating new forms of digital exclusion, combining technological flexibility with inclusive design processes.
Resistance to innovation (S. CHAOUI K.Derkaoui, 2025, pp. 769, 774)	Participatory and empathetic Design Thinking process	Collaborative co-design + technological acceptability	DT's collaborative approach promotes acceptability by respecting professional and cultural values, presenting AI as a tool for capability enhancement rather than substitution.
Equity issues	Native integration of ethical principles in design	Ethics by design + algorithmic distributive justice	Transforming ethics from an afterthought into a structuring principle ensures that distributive justice and equity become essential foundations of the conceptual framework.

2.4.2. Specific Conceptual Needs Revealed by the Moroccan Context:

A thorough analysis of the Moroccan context for CT of TRs in higher education highlights specific conceptual needs that directly inform the construction of our innovative conceptual framework.

Conceptual Need for Cultural and Linguistic Adaptation

The Moroccan context, characterized by institutional multilingualism (Arabic, French, English) and strong cultural specificities, reveals a conceptual need to integrate linguistic and cultural diversity into design processes. This need theoretically justifies the development of an ethical DT-AI approach that natively incorporates dimensions of cultural adaptation.

Conceptual Need for Educational and Technological Sovereignty

The specificities of the Moroccan educational system, engaged in profound reforms while preserving its cultural identity, reveal a conceptual need to maintain educational sovereignty

[5] Source: authors

in the face of standardized technological solutions. This need justifies the participatory approach of DT to co-construct ethical AI solutions tailored to national objectives.

Conceptual Need to Optimize Limited Resources

The identified budgetary and technological constraints highlight the conceptual need for efficiency and optimization of available resources. This need justifies integrating the automation and scalability capabilities of ethical AI into a resource-efficient design process.

Conceptual Need for Tradition-Modernity Articulation

The Moroccan context, characterized by the coexistence of established pedagogical traditions and aspirations for modernization, indicates a conceptual need for harmonious articulation between educational heritage and technological innovation. This need justifies an approach that respects traditional educational values while integrating the potential of advanced technologies.

2.4.3. Positioning the conceptual framework in direct continuity with diagnostic work:

Our conceptual framework positions itself in direct and logical continuity with the empirical findings of the initial diagnosis, transforming the identified challenges into structuring theoretical and methodological orientations.

Methodological continuity: from empirical analysis to contextualized theorization

The initial diagnosis adopted a rigorous methodological approach combining in-depth literature review, official documentary analysis of institutional and strategic sources, and application of a SWOT matrix for systemic evaluation of the context. Our conceptual framework extends this analytical approach by integrating these documentary and diagnostic data into an original theoretical construction that respects Moroccan contextual specificities while building on the international advances identified in the literature.

This methodological continuity ensures that our theoretical construction remains anchored in a solid empirical understanding of the Moroccan context, avoiding the pitfalls of a purely theoretical or decontextualized approach. The in-depth documentary analysis and SWOT matrix conducted in the initial diagnosis enabled precise identification of the strengths, weaknesses, opportunities, and threats of the CT system for TRs, constituting the robust empirical foundation upon which the design of our innovative conceptual framework is based.

It follows from this analysis that this direct continuity between our initial diagnosis and the developed conceptual framework transforms empirical findings into structuring theoretical orientations. Our framework constitutes a contextualized theoretical response to the identified challenges, paving the way for the detailed methodological development that will enable these conceptual foundations to be transformed into an innovative, ethical, and operational CT system adapted to the Moroccan context.

3- Methodology for constructing the conceptual framework: - constructivist-pragmatic approach, systematic review, and contextualized theoretical engineering.

The construction of an innovative conceptual framework that articulates DT and ethical AI for the CT of TRs in Morocco requires a rigorous methodology adapted to the specificities of the studied context. This section presents the methodological approach adopted, which rests on three complementary pillars: a constructivist-pragmatic epistemological positioning that guides the entire approach, a systematic literature review that establishes the scientific foundations, and contextualized theoretical engineering that enables adaptation to Moroccan field realities.

3.1. Epistemological positioning: constructivist-pragmatic paradigm:

3.1.1 Epistemological justification for the constructivist-pragmatic choice:

This research is situated within a constructivist-pragmatic paradigm (Creswell et al., 2016) ; (Lincoln et al., 1985), recognizing that knowledge is constructed through the interaction between the researcher, field actors, and the investigation context. This epistemological positioning proves particularly relevant for our study object, which aims to design an innovative framework adapted to the cultural, institutional, and technological specificities of the Moroccan context.

Constructivism guides our approach by recognizing that the reality of CT for TRs is socially constructed, influenced by the representations, practices, and interactions of the stakeholders involved. This perspective leads us to pay particular attention to the meanings that Moroccan TRs attribute to their training needs, their pedagogical practices, and their relationship with educational technologies, as highlighted in our initial diagnosis (Chaoui & Derkaoui, 2025).

The pragmatic dimension of our positioning (Dewey, s. d., 1938 ; Johnson & Onwuegbuzie, 2004) directs our research toward the production of actionable and contextually relevant knowledge. This orientation justifies our methodological choice to adopt a research-development approach (Gravemeijer et al., s. d., 2006), aimed at developing an operational conceptual framework directly usable by field actors, in coherence with the very philosophy of DT, which privileges action and experimentation.

3.1.2. Methodological implications of the constructivist-pragmatic approach:

This dual epistemological anchoring translates into four major methodological implications that structure our entire research approach:

• **The primacy of contextualization:** The model has value only if it responds to the specificities of the Moroccan context of CT for TRs, integrating the constraints, resources, and values specific to this system. This contextualization is not limited to superficial adaptation but constitutes a structuring principle that influences the very conception of the theoretical framework.

• **The dialectical articulation between theory and practice:** The conceptual framework aims to equip the future design of real systems while being informed by theories and international literature. This dialectical articulation allows us to avoid two opposing pitfalls: a purely theoretical framework disconnected from field realities, or a strictly empirical approach without solid conceptual foundations.

• **Methodological triangulation:** To strengthen the validity of theorization, we combine systematic literature review, contextual analysis, and participatory modeling (Denzin, 2017 ; Yin, s. d. 2018). This approach allows us to cross-reference different data sources and analysis methods to guarantee the robustness of our conclusions.

• **Participatory involvement of stakeholders:** Although the research is theoretical in nature, it integrates into its approach the voices, expectations, and representations of Moroccan TRs, gathered during the initial diagnosis. This active participation is materialized through consultation, validation, and adjustment mechanisms throughout the theoretical construction process.

3.1.3. Articulation with the specificities of DT and ethical AI:

Our constructivist-pragmatic epistemology presents natural conceptual affinities with the approaches we seek to articulate, creating overall methodological coherence that reinforces the validity of our approach.

The DT, through its empathetic and collaborative nature, naturally fits into a constructivist logic that values the co-construction of solutions with end users. Moreover, the iterative approach of DT, structured around empathy-definition-ideation-prototyping-testing cycles, corresponds perfectly to our constructivist-pragmatic approach, which privileges continuous improvement and contextual adaptation.

The ethical approach to AI also aligns with our epistemological positioning through our commitment to an "*ethics by design*" approach that integrates ethical considerations from the design phase rather than as an external constraint. This approach corresponds to our constructivist epistemology, which recognizes that values and ethical principles must structure theoretical construction from its origin, and to our pragmatic orientation, which evaluates the effectiveness of solutions not only according to technical criteria but also according to their compliance with fundamental ethical principles.

3.2. Systematic Literature Review: Protocol, Corpus and Critical Analysis

3.2.1. Literature Search Protocol and Selection Criteria (Inclusion/Exclusion):

The systematic literature review constitutes the theoretical and empirical foundation of this research, aiming to identify, analyze, and synthesize existing knowledge on the convergence between DT and ethical AI in educational contexts. This review follows the PRISMA[6] methodological guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses, (Moher et al., 2009)) to ensure the transparency and reproducibility of the process.

[6] **PRISMA** (Preferred Reporting Items for Systematic Reviews and Meta-Analyses): Internationally recognized methodological standard developed by a consortium of researchers under the leadership of Moher et al. (2009) to improve the quality, transparency, and reproducibility of systematic reviews and meta-analyses. This protocol establishes a checklist of 27 specific items and a standardized flow diagram that guide each step of the process: defining inclusion/exclusion criteria, literature search strategy, study selection process, quality assessment of sources, and synthesis of results. Its adoption in this research ensures the methodological rigor of our systematic review on the Design Thinking-Artificial Intelligence convergence in education, thereby strengthening the validity and credibility of our conclusions.

Our literature search strategy was based on a multi-step approach combining:

• A systematic search in major international academic databases: Web of Science, Scopus, ERIC (Education Resources Information Center), IEEE Xplore, ACM Digital Library, and PsycINFO, supplemented by Cairn and Google Scholar for French-language publications.
• An exploration of references cited in relevant articles (*snowballing technique*).
• A consultation of key institutional reports (UNESCO, OECD, CSEFRS).

The search equations combined terms related to the three main axes:

• Design Thinking: "design thinking", "human-centered design", "design-based learning";
• Ethical AI: "ethical artificial intelligence", "responsible AI", "AI ethics", "machine learning", "intelligent tutoring systems", "adaptive learning";
• Educational contexts: "education", "higher education", "teacher training", "professional development", "continuing education".

The inclusion criteria were:

• Publications between 2015 and 2025 (with particular attention to recent publications);
• Languages: English and French;
• Peer-reviewed publications (scientific articles, book chapters, conference proceedings);
• Direct thematic relevance to our three research axes;
• Preference for studies with a strong empirical or theoretical dimension.

The exclusion criteria allowed for the elimination of non-academic publications, research addressing only a single concept without integration, purely technical applications with no pedagogical dimension, and non-educational contexts.

3.2.2. Corpus Construction and Analysis:

The selection process follows a funnel approach: initial selection based on titles and keywords (N≈800), filtering on abstracts according to defined criteria (N≈200), full reading and methodological quality assessment (N≈50), resulting in the constitution of the final corpus for in-depth analysis (N≈30).

Thematic analysis (Braun & Clarke, 2006) enables the identification of existing models, recurring challenges, best practices, and conceptual gaps, ultimately serving as the basis for constructing the conceptual framework. This analysis is organized around five main themes: theoretical convergences, empirical applications, ethical challenges, contextual factors, and identified gaps.

Having established the state of theoretical knowledge through this systematic literature review, it is now appropriate to analyze the contextual specificities of the Moroccan field in order to adapt this knowledge to local realities.

3.3. Contextual Analysis: PESTEL grid

3.3.1. Methodological Justification and Adaptation to the Moroccan Context:

The PESTEL analysis (Political, Economic, Sociocultural, Technological, Environmental, Legal) is a strategic analysis tool that allows examination of the macro-environmental factors influencing pedagogical innovation in Moroccan higher education (Aguilar, 1967 ; « Smmut-Bonnici & Galea», 2015). This contextual analysis is essential for adapting the conceptual framework to the specificities of the Moroccan context and for anticipating the conditions necessary for its effective and ethical implementation.

The choice of the PESTEL framework is justified by its ability to provide a holistic view of the systemic variables impacting pedagogical innovation, which is particularly relevant in a context of institutional transformation such as Morocco. The following figure presents the structure of this analysis framework as adapted to the specific challenges of our research:

Figure 3: PESTEL analysis grid for evaluating macro-environmental factors influencing the integration of Design Thinking and Artificial Intelligence in continuing training in Morocco.

3.3.2. Investigation process and sources used:

The investigation process is primarily based on the exploitation and enhancement of our preliminary diagnosis (S. CHAOUI K. Derkaoui, 2025), supplemented by systematic analysis of recent primary sources: legislative texts (Framework Law 51-17, implementing decrees), institutional reports from the CSEFRS[7], strategic documents from the Ministry of Higher Education, and OECD and UNESCO reports on higher education in Morocco.

[7] **CSEFRS** (Higher Council for Education, Training and Scientific Research): A Moroccan constitutional consultative institution created in 2014 (in accordance with Article 168 of the 2011 Constitution), succeeding the Higher Council for Education (CSE). The CSEFRS

This in-depth documentary analysis enables the identification of major trends, structural constraints, and institutional levers that influence pedagogical innovation in the Moroccan context, ensuring the empirical grounding of our conceptual framework.

3.3.3. Integration of Factors Specific to Continuing Training:

The PESTEL analysis specifically integrates dimensions inherent to CT for TRs according to six axes:

- Political Dimension: This dimension focuses on examining political orientations (National Charter for Education and Training 1999, Strategical Vision 2015-2030, Framework-Law 51-17, ESRI Pact 2030), governance mechanisms, and institutional stability, building on the results of our preliminary diagnosis concerning the strong political commitment identified (Chaoui & Derkaoui, 2025, pp. 770-771). It aims to understand how governmental decisions and priorities create a favorable or constraining environment for pedagogical innovation and the integration of new technological approaches in CT.

- Economic Dimension: This dimension involves evaluating financial resources allocated to higher education, CT funding mechanisms, and budgetary constraints identified in our previous analysis. It enables analysis of the economic viability of deploying innovative solutions combining DT and AI, as well as the financing models necessary to ensure sustainability and equitable accessibility of the proposed systems.

- Sociocultural Dimension: This dimension involves examining cultural representations of pedagogical innovation and resistance to change documented in our diagnosis (Chaoui & Derkaoui, 2025, pp. 769, 774), societal expectations regarding higher education, and Moroccan cultural specificities. It aims to identify factors of social and cultural acceptability for technological and pedagogical innovations, as well as the support strategies necessary to promote adoption by TRs and overcome identified resistance.

- Technological Dimension: This dimension involves evaluating available technological infrastructure, the digital maturity level of institutions, and implementation conditions for AI-based solutions. It enables determination of technical prerequisites, necessary investments, and technological deployment strategies adapted to Moroccan realities—a sine qua non condition for successful AI integration in training systems.

- Environmental Dimension: This dimension concerns analyzing issues related to the sustainability of digital training systems, the environmental impact of AI technologies (energy consumption, carbon footprint), and the integration of sustainable development goals into educational strategies. It aims to ensure that the proposed pedagogical innovation operates within an environmentally responsible framework, particularly relevant given Morocco's commitments to ecological transition.

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plays a central role in the development, evaluation, and monitoring of public policies related to education, training, and scientific research. It is notably the architect of the 2015-2030 Strategic Vision and contributed to the development of Framework Law 51-17, which are fundamental references for contemporary reforms in Moroccan higher education. In the context of this research, the CSEFRS serves as the reference institutional body for the validation, support, and strategic guidance of pedagogical innovations in the continuing training of teacher-researchers in Morocco.

- Legal Dimension: This dimension focuses on examining the regulatory framework for higher education, legal obligations regarding CT, compliance of systems with national and international laws, as well as crucial issues of data protection and privacy related to AI use in education. It ensures that the proposed conceptual framework complies with Moroccan and international legal requirements (GDPR[8], educational data sovereignty)—essential conditions for responsible and sustainable innovation.

This contextual PESTEL analysis, combined with insights from the literature review, constitutes the empirical and theoretical foundation upon which the engineering of the conceptual framework presented hereafter is based.

3.4. Contextualized Theoretical Engineering: Guiding Principles

3.4.1. Logic of Conceptual Framework Construction:

The construction of the integrated conceptual framework relies on an iterative modeling methodology that synthesizes contributions from the literature review and contextual analysis. Inspired by participatory design approaches (Sanders & Stappers, 2008), this approach aims to develop a model articulating DT and ethical AI specifically adapted to the Moroccan context. The process has favored a continuous improvement logic, alternating between phases of theoretical conceptualization and reflective adjustment to ensure both internal coherence and contextual relevance of the model.

3.4.2. Mechanisms for Contextualization to Moroccan Specificities:

Contextualization to Moroccan specificities has been achieved through four complementary mechanisms: cultural and linguistic integration (taking into account multilingualism and cultural particularities), institutional alignment (coherence with national policies), adaptation to resource constraints, and harmonious articulation between pedagogical tradition and technological innovation. These mechanisms ensure that the developed conceptual framework responds to the specific needs of the Moroccan higher education system while building on international scientific advances.

3.4.3. Empirical Validation Perspective:

The detailed validation and operationalization of this conceptual framework will be the subject of a subsequent empirical experimentation phase. This stage will evaluate the model's operational feasibility, stakeholder acceptance, and effectiveness under real-world implementation conditions. The present theoretical research establishes the conceptual

[8] **GDPR** (General Data Protection Regulation): European Regulation No. 2016/679 that came into force on May 25, 2018, which constitutes the international reference framework for personal data protection. This regulation establishes strict principles concerning the collection, processing, storage, and protection of personal data, with specific requirements for informed consent, transparency, and the right to be forgotten. In the context of Artificial Intelligence in education, the GDPR imposes enhanced obligations regarding automated decision-making algorithms and the use of sensitive data. Although Morocco has its own legislation (Law 09-08 on personal data protection), the reference to GDPR is justified by its status as an international standard, the need for compliance within the framework of European academic partnerships, and its influence on best practices in educational data ethics.

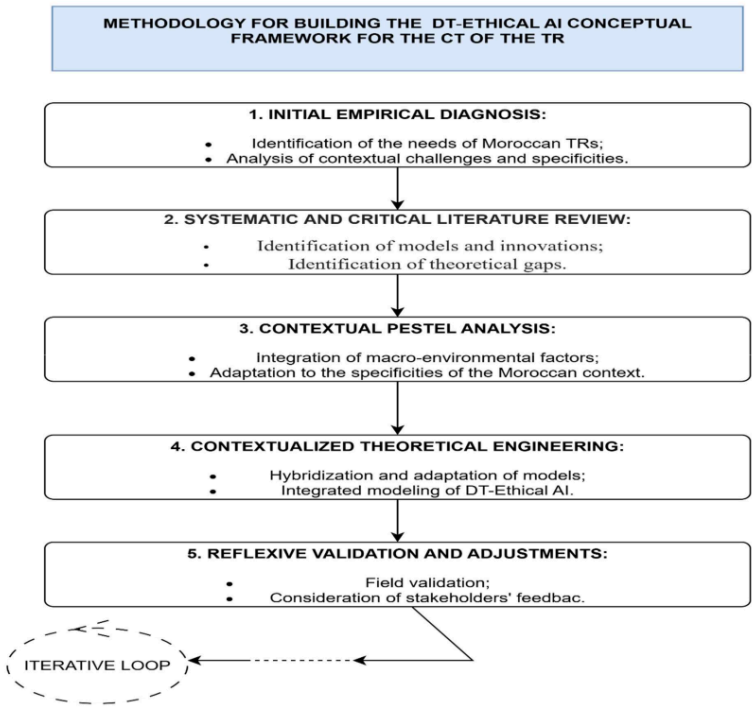
foundations necessary for this future experimentation. The detailed operational procedures for this validation will be presented in a dedicated publication on the empirical phase.

3.5. Methodological Synthesis and Justification of the Approach:

This section provides a synthesis of the methodological framework adopted for constructing our innovative conceptual framework, by explaining the overall logic that articulates the different components of our research approach and by justifying the epistemological and methodological choices made. This synthesis highlights the overall coherence of our approach without delving into the technical details that will be developed in the subsequent empirical phase.

3.5.1. Overall Methodological Framework:

The methodology followed is organized around a logical and integrated progression that can



be outlined as follows:

Figure 4[9] : Methodological framework for developing the DT- Ethical AI conceptual framework for the CT of Moroccan TRs.

This methodological framework is structured around five main interconnected stages:

- the initial empirical diagnosis, enabling the identification of Moroccan needs, challenges, and specificities;
- the systematic and critical literature review, leading to the identification of models, innovations, and gaps;
- the PESTEL contextual analysis, resulting in the integration of macro-environmental factors;
- the contextualized theoretical engineering, aimed at hybridization, adaptation, and integrated DT- Ethical AI modeling;
- and finally, reflective validation and adjustments, involving field-testing and consideration of stakeholder feedback.

This methodological progression follows a constructivist logic that prioritizes initial empirical grounding, enrichment through existing knowledge, fine contextualization, and participatory construction of the conceptual framework. The iteration loops embody a pragmatic approach aimed at continuous improvement and adaptation to on-the-ground realities.

3.5.2. Strengths and Innovations of the Approach:

The hybrid methodology adopted presents several fundamental strengths that guarantee the scientific robustness and contextual relevance of the developed conceptual framework.

Epistemological coherence: The constructivist-pragmatic stance allows for anchoring theoretical modeling in contextualized reality, avoiding abstraction or decontextualization. This coherence is reflected in the recognition that knowledge is progressively constructed through the interaction between empirical data (initial diagnosis), theoretical knowledge (literature review), contextual constraints (PESTEL analysis), and participatory adjustments (reflective validation).

Scientific rigor: The systematic review guarantees comprehensive identification of models and innovations, while ensuring critical analysis of existing limitations. This exhaustive approach has enabled not only precise identification of existing models and innovations in the field, but also rigorous identification of theoretical gaps that our research aims to fill.

Methodological innovation: Contextualized theoretical engineering allows us to go beyond simple transposition of Western models, by producing an original, adapted, and operationalizable framework for the Moroccan context. This approach natively integrates ethical considerations from the design phase "*ethics by design*", making ethics a structuring principle rather than an external constraint.

Stakeholder consideration: Anchoring the conceptual framework in empirical data from the initial diagnosis, which identified the needs and constraints of Moroccan TRs, guarantees its

[9] Source: authors.

preliminary contextual relevance. This collaborative approach, inherent to DT, establishes as a fundamental principle the continuous involvement of stakeholders, which will be fully activated during the subsequent empirical experimentation phase. This future involvement of faculty is essential to promote appropriation and successful implementation of the proposed innovations.

3.5.3. Acknowledged Limitations and Transition to the Conceptual Framework:

Our methodological approach, while rigorous and innovative, presents certain limitations that we fully acknowledge. The main limitation lies in its essentially theoretical nature at this stage. Although the conceptual framework is built on solid empirical foundations (initial diagnosis) and robust theoretical bases (systematic review), its operational validation remains to be demonstrated. Furthermore, the strong contextualization to the Moroccan higher education system, while being an asset for local relevance, may limit the direct transferability of results to other contexts.

This multi-stage methodology, based on the complementarity of constructivism, systematic review, and contextual engineering, constitutes the robust scientific foundation of the proposed conceptual framework. It prepares the transition toward detailed formalization of this framework, which will be presented in the following section, with a view to guiding the design and experimentation of truly innovative, ethical, and adapted CT programs tailored to the specific needs of Moroccan TRs. This theoretical research establishes the conceptual foundations necessary for an empirical experimentation phase that will validate the effectiveness and relevance of this integrated approach in the specific context of Moroccan higher education.

4. Results: Formalization of the innovative DT–Ethical AI conceptual framework for the continuing training of Moroccan teacher-researchers

Cette section présente les résultats de notre démarche méthodologique sous la forme d'un cadre conceptuel intégré, articulant DT et IA éthique pour la FC des EC au Maroc. Ce cadre répond aux défis identifiés dans notre diagnostic initial (S. CHAOUI K.Derkaoui, 2025) tout en comblant les gaps théoriques révélés par notre revue systématique de la littérature (Section 2.3.3), notamment en matière de personnalisation des parcours, d'équité d'accès et d'intégration éthique des technologies avancées.

55 This section presents the results of our methodological approach in the form of an integrated conceptual framework, articulating DT and ethical AI for the CT) of TRs in Morocco. This framework addresses the challenges identified in our initial assessment (S. CHAOUI K.Derkaoui, 2025) while filling the theoretical gaps revealed by our systematic literature review (Section 2.3.3), particularly regarding personalized learning pathways, equitable access, and ethical integration of advanced technologies.

4.1. Overall architecture of the integrated conceptual framework:

The developed conceptual framework is organized around a systemic and iterative architecture, where DT serves as the overall design methodology and ethical AI acts as a

catalyst and amplifier of human capabilities. This integration is not merely a juxtaposition of tools, but rather a profound synergy that manifests through a structured process and interdependent foundational principles.

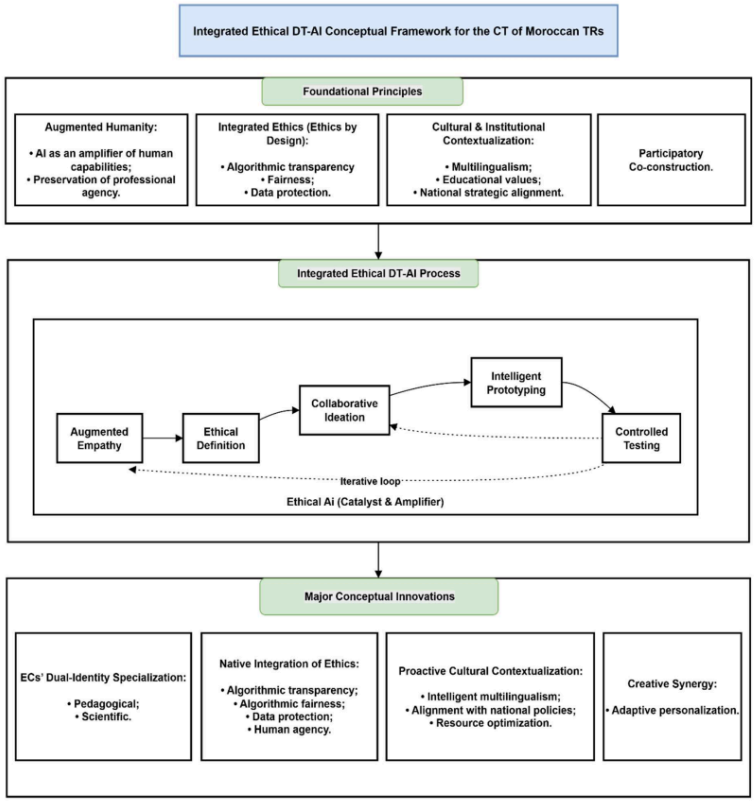


Figure 5[10] : Architecture of the integrated conceptual framework for DT-Ethical AI for the continuing training of Moroccan teachers-researchers.

This architecture is based on four founding principles that constitute its philosophical and ethical foundation:

[10] Source: Authors.

- The **principle of augmented humanity** posits that AI should serve to amplify the human capabilities of TRs rather than replace them, preserving their professional agency and disciplinary expertise. Humans remain at the center of the training process, with AI acting as an intelligent facilitator that enriches the experience without substituting for it.

- The **principle of integrated ethics** "*ethics by design*" transforms ethical considerations from an afterthought into a structuring foundation. Each component of the framework natively integrates mechanisms for ensuring equity, algorithmic transparency, data protection, and inclusion.

- The **principle of cultural and institutional contextualization** recognizes that the effectiveness of a training system depends on its adaptation to the cultural, linguistic, and institutional specificities of the implementation context. In the Moroccan case, this principle translates into the integration of multilingualism, respect for traditional educational values, and alignment with national strategic orientations.

- The **principle of participatory co-construction** prioritizes the active involvement of TRs in the design, adaptation, and evaluation of training systems. This collaborative approach ensures that solutions meet real needs while promoting ownership and acceptance of the proposed innovations.

4.2. Adapted DT- Ethical AI Process:

The conceptual framework operationalizes the integration of DT and ethical AI through five interconnected and iterative phases, each enriched by specific AI applications that respect fundamental ethical principles.

Phase 1: Augmented Empathy combines traditional qualitative DT empathy (in-depth interviews, contextual observations) with ethical data analysis for a deep understanding of the needs of Moroccan TRs. This empathetic synthesis enables the construction of personas that reflect the diversity of profiles while respecting cultural specificities.

Phase 2: Ethically Oriented Definition transforms empathetic insights into clearly defined training challenges, integrating ethical and contextual considerations from the outset. This collaborative reformulation involves TRs in defining the very challenges to be solved, avoiding the pitfall of a top-down approach

Phase 3: Assisted Collaborative Ideation revolutionizes the creative process by combining collective human creativity with the generative capabilities of ethical AI. Algorithmic assistance enriches the human creative process while preserving participants' creative agency and respecting intellectual property.

Phase 4: Intelligent Prototyping materializes the selected ideas in the form of training system prototypes, leveraging advanced technological tools while preserving the human dimension. Each prototype undergoes integrated ethical evaluation to verify its compliance with principles of equity, inclusion, and cultural respect.

Phase 5: Ethically Controlled Testing evaluates the effectiveness and acceptability of prototypes under real-world conditions, integrating rigorous ethical control mechanisms. This participatory contextual validation involves all stakeholders in the final evaluation of the systems.

Ce processus itératif permet des ajustements constants en fonction des retours d'expérience, garantissant l'amélioration continue des dispositifs de formation et leur adaptation aux besoins évolutifs des EC.

This iterative process allows for constant adjustments based on feedback, ensuring continuous improvement of training systems and their adaptation to the evolving needs of TRs.

4.3. Major Conceptual Innovations:

The developed conceptual framework is distinguished by four major innovations that directly address the identified theoretical gaps and contextual needs of the Moroccan higher education system.

-Specialization for the Dual Identity of Teacher-Researchers:

Our framework natively integrates the specificity of the dual pedagogical and scientific identity of TRs which is often neglected in generic CT approaches. The AI-enhanced empathy phase enables precise identification of needs related to improving pedagogical skills (didactic innovation, distance learning) as well as those relating to scientific development (research methodologies, publication, valorization). This recognition of the professional duality of TRs allows for the design of training pathways truly adapted to the complexity of their profession and the diversity of their missions.

-Native Integration of Ethics "*Ethics by Design*":

The "Ethics by Design" principle constitutes a fundamental innovation of the framework, transforming ethics from a peripheral consideration into a structuring principle. This approach is embodied through four pillars: algorithmic transparency (explainability of AI decisions), algorithmic fairness (prevention of discriminatory biases), protection of personal data, and preservation of human agency (maintaining TRs' control over their pathways). This native integration addresses growing ethical concerns regarding educational AI, particularly relevant in the context of digital transformation in higher education.

-Proactive Cultural and Institutional Contextualization:

The framework proactively integrates Moroccan specificities through three adaptation mechanisms: intelligent multilingualism (Arabic, French, English), alignment with national educational policies (Strategic Vision 2015-2030, ESRI Pact 2030), and resource optimization in the face of budgetary constraints. This contextualization goes beyond simple adaptation to become a fundamental design factor, ensuring the relevance and acceptability of systems within the specific context of Moroccan higher education

-Creative Synergy and Adaptive Personalization:

The framework capitalizes on the synergy between the human creativity of DT and the analytical capabilities of AI to offer adaptive personalization of training pathways. This approach resolves the tension between algorithmic personalization and equitable access by developing mechanisms that respect diversity while maintaining equity. AI enables "*augmented empathy*" by processing vast datasets to better understand individual needs, and "*augmented ideation*" by proposing varied creative pathways, while ensuring that this personalization does not lead to discrimination or exclusion.

4.4. Added Value Compared to Existing Approaches:

This conceptual framework fills three major gaps identified in the literature: the absence of specialization for the CT of TRs, the superficial integration of ethics in existing approaches, and the lack of consideration for non-Western contexts. By addressing the specific challenges of the Moroccan context revealed by our initial diagnosis—particularly regarding pathway personalization, equitable access, and integration of advanced technologies—it proposes an unprecedented synergistic articulation between DT and ethical AI, surpassing simple juxtaposition approaches to create genuine conceptual hybridization.

5. Discussion: Contributions, Limitations, and Perspectives

This section critically analyzes the proposed conceptual framework, evaluates its theoretical and practical scope, and identifies the inherent limitations of this theoretical research as well as the perspectives it opens for future research and the transformation of CT practices.

5.1. Theoretical Contributions and Practical Implications:

The developed conceptual framework significantly enriches the scientific literature through several major theoretical contributions. The introduction of the concept of "*augmented empathy*" constitutes an original theoretical extension that goes beyond the limitations of traditional DT empathy by ethically integrating AI analytical capabilities. This innovation makes it possible to reconcile the qualitative and subjective understanding of needs with the quantitative analysis of large-scale behavioral patterns.

The articulation between algorithmic personalization and equitable access resolves a major theoretical tension in the field of educational AI. Our framework proposes conceptual mechanisms to ensure that pathway personalization does not lead to discrimination, thus preserving equity while optimizing pedagogical effectiveness.

From a practical standpoint, implementing this conceptual framework could significantly transform CT practices in Moroccan higher education. The approach would enable unprecedented personalization of learning pathways, addressing the major challenge identified in our initial diagnosis. Faculty members could benefit from training that is truly adapted to their discipline, level of experience, and specific professional objectives.

Moreover, adopting the DT approach enriched by ethical AI implies a shift from a top-down design logic to a participatory logic where TRs become co-designers of their own pathways. This transformation would foster the emergence of communities of practice and strengthen

the acceptability of technological innovations through a collaborative and transparent approach.

5.2. Limitations and Implementation Challenges:

Despite its significant contributions, the conceptual framework presents several limitations that must be acknowledged. The main limitation lies in its essentially theoretical nature at this stage. Although founded on a rigorous systematic review and empirical diagnosis, the framework has not yet been tested under real conditions, which limits our ability to evaluate its operational feasibility and practical effectiveness.

The intrinsic complexity of articulating DT and ethical AI can create tensions that are difficult to resolve in practice. The balance between human empathy and algorithmic analysis, between collaborative creativity and technological efficiency, requires fine-tuned trade-offs that are not always obvious. Furthermore, the strong contextualization to the Moroccan system, while being an asset for local relevance, may limit the direct transferability of results to other contexts.

From a technological standpoint, developing ethical AI systems sophisticated enough to personalize pathways while respecting principles of equity and transparency represents a considerable challenge. Ensuring the security and confidentiality of personal data also constitutes a critical issue, particularly in a context where data protection regulations are rapidly evolving.

Finally, implementation will require organizational transformations that may encounter institutional resistance. The proposed conceptual framework aims to deepen and accelerate a pedagogical culture already in constant improvement toward a more collaborative and technologically augmented approach. This evolution involves changes in mindsets and practices that take time and require appropriate support to ensure harmonious integration within Moroccan higher education institutions.

5.3. Future Research Perspectives:

The immediate priority for future research consists of empirical validation of the conceptual framework through controlled experiments in real CT contexts. These experiments must test the pedagogical effectiveness of the model, its acceptability by TRs, its operational feasibility, and its ethical compliance.

A progressive experimentation approach, beginning with limited pilots before considering broader deployments, would allow for adjusting the framework based on feedback and minimizing failure risks. This iterative approach naturally aligns with the DT philosophy that favors continuous improvement.

Developing specific tools for each phase of the DT-Ethical AI process also constitutes an important research direction. These developments could include contextual needs analysis platforms, ethical pedagogical scenario generators, and multidimensional evaluation systems integrating ethical and cultural considerations.

Extending the framework's application to other geographical and cultural contexts would also make it possible to test its transferability and identify the specificities that influence its adaptation. This comparative research would enrich our understanding of contextual adaptation mechanisms and inform the development of more universal frameworks while respecting local specificities.

6. Conclusion : -

Needless to say, this research has established the conceptual foundations of an innovative CT framework for TRs in Morocco, by proposing an unprecedented articulation between DT and ethical AI. The developed framework constitutes a structured and contextualized response to the challenges of personalization, equity, and innovation currently facing Moroccan higher education.

Our research establishes an original conceptual framework that surpasses existing approaches by proposing genuine synergistic integration between DT and ethical AI. This integration is not limited to a juxtaposition of tools but develops new theoretical concepts: augmented empathy, assisted collaborative ideation, integrated "*ethics by design*" ethics, and cultural contextualization as a fundamental design variable.

The originality of our contribution lies in three major conceptual innovations: the native integration of ethics as a structuring principle, the recognition of TRs' dual pedagogical and scientific identity, and proactive cultural contextualization adapted to Moroccan specificities. This framework fills a significant theoretical gap by proposing a synergistic articulation between the augmented empathy of DT and the analytical capabilities of ethical AI, resolving the tension between algorithmic personalization and equitable access.

The adoption of this conceptual framework represents more than simply modernizing training tools; it embodies a paradigmatic transformation of CT, shifting from a top-down transmission logic to a collaborative, adaptive, and ethically responsible approach.

The empirical validation of this framework constitutes the next crucial step that will confirm its effectiveness and relevance in the specific context of Moroccan higher education. This experimental phase, which will be the subject of a subsequent publication, will test the model's operational feasibility, its acceptability among stakeholders, and its effectiveness under real implementation conditions

Beyond CT, this conceptual framework could contribute more broadly to the transformation of Moroccan higher education by training faculty members who are better equipped to innovate pedagogically and integrate advanced technologies in an ethical manner. This research thus invites us to rethink CT not as a peripheral activity for skill upgrades but as a strategic lever for qualitative transformation of higher education, directly contributing to national economic and social development objectives by training faculty members who are better prepared for contemporary challenges in education and research.

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