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Generative AI in Youth Research Training: Evidence from a Sustainable Entrepreneurship Training Program in Morocco

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Abstract

The rapid expansion of Generative Artificial Intelligence is transforming research and entrepreneurship education, yet its role in Global South contexts remains underexplored. This study investigates the integration of Generative AI within a youth research training program in Morocco through a qualitative study involving 30 participants. The Problem AI Interaction Reflection (PAIR) framework was used to examine how Generative AI functioned as a heuristic co-pilot in translating sustainable development challenges into digitally viable entrepreneurial concepts.

The findings indicate that Generative AI reduces structural research barriers, accelerates access to specialized knowledge, and supports iterative problem refinement, particularly for participants from non-specialized backgrounds. However, its pedagogical value depended on structured reflection and sustained human mentorship. While AI enhanced synthesis and confidence, ethical judgment, cultural grounding, and contextual interpretation remained human-led processes.

The study contributes empirical insight into how Generative AI can operate as a capability scaffold when embedded within human-centered design, highlighting implications for inclusive digital entrepreneurship education in the Global South.

Keywords: Generative AI, Youth Researchers, Participatory Action Research, Research Capacity Building, Educational Technology, Global South Contexts

Introduction

The emergence of Generative Artificial Intelligence represents a significant shift in the relationship between technology, education, and knowledge production. Unlike earlier educational AI systems that primarily focused on prediction, classification, or learning analytics, contemporary large language models actively participate in structuring, and refining knowledge. This transformation is reshaping how learners engage with research processes, problem-solving, and idea development, while also raising critical questions regarding cognitive engagement, and the evolving role of educators in AI-supported learning environments.

Existing literature increasingly recognizes the potential of AI tools to enhance learning outcomes, support research capacity, and stimulate innovation among students. However, this body of work remains largely concentrated in higher education contexts in the Global North, where institutional resources, digital infrastructure, and research training ecosystems are relatively well developed. As a result, there is still limited empirical understanding of how Generative AI is integrated into research training in contexts characterized by institutional constraints, unequal access to expertise, and ongoing digital transformation.

This gap is particularly evident in the field of sustainable digital entrepreneurship, where the use of AI in training young researchers and aspiring entrepreneurs remains underexplored. In many Global South settings, including Morocco, Generative AI may play a dual role, not only as a tool for efficiency and content generation, but also as a mediating mechanism that can expand access to research skills and entrepreneurial knowledge. However, current studies do not sufficiently examine how these tools influence skill development, knowledge production, and contextual decision-making while preserving cultural and ethical relevance.

Against this background, this study investigates the following research question: **How does Generative AI contribute to the development of research skills and entrepreneurial self-efficacy among youth in the field of sustainable digital entrepreneurship in Morocco?**

To address this question, the study adopts a qualitative case study design based on a youth research and sustainable entrepreneurship training program involving 30 participants in Morocco. It examines the pedagogical use of the PAIR framework (Problem, AI, Interaction, Reflection) as a structured approach for integrating Generative AI into research learning processes.

Specifically, the study aims to:

- **Analyze AI-enhanced knowledge synthesis processes:** by examining how participants use large language models to translate broad Sustainable Development Goals (SDGs) into context-specific, actionable research and project ideas, particularly in situations where data or methodological guidance is limited.
- **Evaluate algorithmic scaffolding in skill development:** by exploring how iterative interaction with AI systems through prompt engineering supports the development of critical thinking, research structuring skills, and reduced cognitive overload for novice researchers.

- **Investigate human–AI mediation dynamics:** by assessing how mentorship and human guidance shape, validate, and contextualize AI-generated outputs to ensure ethical alignment and cultural relevance within the Moroccan entrepreneurial context.
- **Assess entrepreneurial self-efficacy development:** by determining whether access to AI-supported knowledge systems contributes to increased confidence and intention among participants to engage in sustainable digital entrepreneurship initiatives.

1. Literature Review

1.1 Generative AI in Education

For much of its development, artificial intelligence in education was used primarily as a technical support tool. Its role remained largely instrumental, assisting educators and institutions in identifying patterns rather than producing knowledge. The emergence of Generative Artificial Intelligence, has altered this trajectory by introducing a qualitatively different mode of operation. This model is described as a constructive dimension of machine learning (Alali & Wardat, 2024). Unlike earlier systems, Large Language Models are capable of producing original text and multimodal outputs. These outputs increasingly resemble forms of human expression. They challenge long-standing assumptions about the boundaries between human cognition and machine-generated content.

This transformation has significant implications for educational practice and theory. Rather than functioning solely as a background analytical tool, Generative AI now actively participates in the production of learning materials. As a result, contemporary scholarship reflects a deeply divided landscape. While some scholars adopt an optimistic stance, viewing Generative AI as a means to enhance instructional scaffolding and expand access to complex knowledge, others express concern about its pedagogical consequences (Baidoo-Anu & Ansah, 2023; Li et al., 2024). Critics argue that an uncritical reliance on Large Languages Models may encourage forms of cognitive offloading, whereby students prioritize efficiency and automation at the expense of sustained analytical engagement (Baidoo-Anu & Ansah, 2023; Ghimire et al., 2024). Beyond questions of learning processes, the integration of Generative AI also raises broader epistemic concerns. Because these systems generate responses based on probabilistic patterns derived from large-scale datasets, they tend to reproduce the biases, dominant languages, and cultural assumptions. Often described as stochastic parrots, such models do not evaluate truth or context but rather recombine existing patterns in statistically plausible ways (Ghimire et al., 2024). Repeated exposure to seemingly authoritative yet unexamined outputs may weaken critical inquiry and reinforce dominant narratives. At the same time, the increasing difficulty of distinguishing between human-authored and machine-generated work complicates conventional understandings of academic integrity, pointing toward what some scholars describe as a post-plagiarism condition in which authorship and originality are no longer easily defined (Li et al., 2024).

The literature reflects a growing divide regarding the pedagogical implications of this transformation. On one hand, several studies emphasize the potential of Generative AI to enhance instructional scaffolding, accessibility, and personalized learning pathways, allowing learners to engage with complex concepts more efficiently (Baidoo-Anu & Ansah, 2023; R. & P. S., 2024). From a constructivist learning perspective, such tools can facilitate active

knowledge construction by enabling learners to iteratively test ideas, receive feedback, and refine their understanding.

On the other hand, a critical body of research raises concerns about cognitive offloading and epistemic dependency. Scholars argue that excessive reliance on AI-generated outputs may reduce deep processing and analytical engagement, encouraging surface-level learning strategies (Ghimire et al., 2024; Jauhiainen & Guerra, 2024; Noroozi et al., 2024). This tension highlights a central contradiction in the literature, while Generative AI can act as a scaffold for higher-order thinking, it can also undermine the very cognitive processes it seeks to support if used uncritically.

Despite these challenges, the literature remains clear that Generative AI cannot replace the relational, and ethical dimensions of teaching. Such tools are most effective when embedded within pedagogical frameworks guided by human judgment and mentorship. Yet an important limitation persists in existing research. Much of the debate surrounding Generative AI in education is situated within Western institutional contexts. Limited attention to how these technologies intersects with youth agency, participatory learning, and locally grounded educational practices in the Global South was perceived. In the Moroccan context in particular, its role in shaping youth engagement and research-oriented learning remains insufficiently theorized.

1.2 Generative AI and Research Skills Development

The integration of Generative AI into research practices has been associated with increased efficiency in early-stage inquiry, particularly in tasks such as literature exploration, synthesis, and preliminary structuring. These tools enable users to move rapidly from broad thematic areas to more focused analytical frameworks, suggesting a shift toward accelerated knowledge acquisition.(Anwar, 2025b)

However, the literature presents diverging interpretations of this phenomenon. Some scholars frame Generative AI as a driver of competency-based learning, emphasizing its role in fostering creativity, lateral thinking, and adaptive problem-solving (Hutson & Ceballos, 2023). From an experiential learning perspective, AI can support iterative cycles of experimentation, reflection, and refinement, thereby enhancing deeper learning processes (Kangwa et al., 2025; Krause et al., 2025).

Conversely, other studies caution that the automation of cognitive tasks may lead to reduced epistemic effort, particularly when learners accept outputs without critical evaluation (Chiu, 2024). This debate reveals a key limitation in the current literature: most studies assess outcomes (efficiency, performance) without sufficiently examining the underlying cognitive mechanisms through which AI influences learning.

The integration of AI tools provides a framework for personalized pedagogy. They facilitate adaptive learning and interactive problem-solving, offering instantaneous feedback that supports independent skill acquisition (Ray, 2023). The emergence of Generative AI is catalyzing a fundamental paradigm shift within the educational landscape. It moves away from conventional, knowledge-retention models toward competency-centric frameworks. This evolution prioritizes the cultivation of higher-order cognitive skills, specifically lateral

thinking, and adaptive problem-solving. It helps to equip learners to navigate an increasingly automated professional environment. (Hutson & Ceballos, 2023)

To maintain the integrity of cognitive development, AI-integrated pedagogical frameworks must prioritize instructional scaffolding over automated content delivery. Generative AI should not replace primary sources. Instead, it should serve as a step-by-step support tool that prompts students to think critically and work through problems on their own. By positioning these tools as 'co-pilots' in the research process, educators can ensure that learners remain cognitively invested, without bypassing the essential analytical labor required for academic mastery (Anwar, 2025b; Chiu, 2024; Hutson & Ceballos, 2023). The practical value of Generative AI depends heavily on the specific task and the researcher's oversight (Anwar, 2025b).

Nevertheless, empirical evidence remains limited regarding how these mechanisms operate in real training environments, particularly among learners with heterogeneous backgrounds and limited prior exposure to research methodologies.

1.3 The Landscape of Generative AI in Entrepreneurship Education

The emergence of generative artificial intelligence represents a transformative shift in both the practice of entrepreneurship and its educational delivery. As Industry 4.0 restructures market opportunities, there is an increasing demand for future entrepreneurs to possess advanced digital and technological competencies to remain competitive. While many traditional programs have historically focused on general entrepreneurial principles, recent scholarship emphasizes the need to move toward a more technical and integrated curriculum to prepare students for a landscape where an estimated 70% of new businesses will involve digital platforms (Bell & Bell, 2023b; Cooper, 2023; Tatpuje et al., 2022; Wahl & Münch, 2022).

Within the literature, Generative AI is conceptualized in three distinct yet overlapping roles. First, as a knowledge provider, it challenges the traditional authority of educators by offering instant access to information, raising concerns about the relevance of conventional teaching methods (Baidoo-Anu & Ansah, 2023; Mittal et al., 2024; Wang et al., 2024). Second, as a learning tool, it enables students to simulate entrepreneurial processes, such as business planning and market analysis, thereby supporting experiential learning (Giannakos et al., 2024; Kloos et al., 2024; Su & Yang, 2023) Third, as a cognitive scaffold, it assists learners in structuring complex tasks while maintaining their active involvement in decision-making.

Despite these opportunities, a central debate persists regarding whether Generative AI promotes surface-level productivity or deep entrepreneurial learning. Some studies argue that students may use AI to generate outputs without engaging in the underlying reasoning processes, leading to superficial learning (Cotton et al., 2024). In contrast, others suggest that when embedded within experiential and constructivist pedagogies, AI can enhance critical thinking by requiring learners to interpret, adapt, and contextualize generated content (Întorsureanu et al., 2025).

In the domain of education for entrepreneurship, Generative AI is beginning to function less as a novelty and more as a working instrument through which students test and refine emerging competencies.

The shift becomes even more pronounced within education through entrepreneurship. In education, Generative AI operates as a provisional scaffold rather than a substitute for initiative. Students may rely on it to draft landing pages, or structure early-stage pitches; yet the

pedagogical emphasis remains on reflection, and confrontation with real-world feedback. The entrepreneurial process itself, negotiating ambiguity, responding to customers, revising assumptions, ultimately tests the limits of AI-generated outputs. In this sense, learning emerges not from the production of polished artifacts, but from the critical interrogation and adaptation of what the technology proposes. (Bell & Bell, 2023b; Bozward & Rogers-Draycott, 2020; Gijbels et al., 2005; Morselli & Gorenc, 2022)

A central debate in current research concerns whether AI use promotes superficial task completion or supports deeper forms of inquiry. The answer appears to depend less on the tool itself than on the pedagogical frame in which it is used. When Generative AI is integrated within constructivist approaches that emphasize reflection and critique, students are required to question, verify, and contextualize what the system produces.

Assessments that involve live problem-solving, industry-linked challenges, or the management of real contextual constraints make it more difficult to outsource thinking to AI. Such approaches aim to ensure that technological fluency develops alongside independent judgment and reflective capacity. Generative AI itself cannot supply these dimensions.(Bender & Koller, 2020; Coulson & Harvey, 2013; Liang et al., 2023; Rudolph et al., 2023)

1.4 Synthesis and Identification of the Research Gap

Overall, the literature demonstrates that Generative AI holds significant potential to transform learning processes, research practices, and entrepreneurship education. However, it remains characterized by three key limitations.

First, existing studies focus on potential benefits and risks without systematically examining the mechanisms through which Generative AI influences learning outcomes. Second, empirical research is predominantly situated in formal, Western educational settings, overlooking the dynamics of non-formal, participatory, and youth-centered training environments. Third, there is limited integration between technological discussions and established learning theories, resulting in a fragmented understanding of how AI-mediated learning unfolds in practice.

In response to these gaps, this study adopts a theoretically grounded approach that draws on constructivist learning theory, experiential learning (Kolb, 1984), and technology-mediated scaffolding to analyze how Generative AI shapes research skill development and entrepreneurial engagement. Rather than focusing solely on outputs, the study examines the processes and mechanisms through which AI influences learning, including cognitive offloading, metacognitive activation, and iterative feedback loops.

Empirically, the study contributes to the literature by investigating the integration of Generative AI within a youth-led research and sustainable entrepreneurship training program in Morocco, a context that remains underrepresented in current scholarship. By doing so, it shifts the focus from institutional concerns about AI misuse to its potential as a tool for capability development, inclusion, and agency in resource-constrained environments.

2. Methodology

2.1 Research Design: A Qualitative Case Study

This study adopts a qualitative case study research design to explore the multifaceted integration of Generative Artificial Intelligence within a non-formal educational framework. The case study approach was chosen deliberately because it allowed us to closely examine the

real-time interactions between youth researchers and AI tools within the training program. Rather than treating AI use as a broad trend, this design made it possible to focus on how these interactions unfolded in practice, in a specific context and over a limited period of time. The qualitative lens of this study allows for the investigation of the "how" and "why" behind student engagement with these tools.

The research is epistemologically grounded in a constructivist perspective, which views knowledge as being actively constructed through experience and reflection. This is particularly relevant when examining the use of Generative AI as a heuristic co-pilot, where the learning outcome is a product of the iterative dialogue between the participant's local knowledge and the machine's computational synthesis.

2.2 Context of the Study: Training Program

The empirical setting is a youth training program on sustainable entrepreneurship and research methods, implemented in Morocco. The program aimed to support participants in identifying local challenges linked to the Sustainable Development Goals (SDGs) and transforming them into structured project ideas using Generative AI tools. Participants were trained to use widely accessible Generative AI tools which are ChatGPT and Gemini.

The training was conducted over **[10 weeks /10 sessions - from February 2025 to Mai 2025]**, combining workshops, guided practice sessions, and mentoring activities. Each session included:

- Introduction of a thematic SDG-related problem,
- Guided use of AI tools for idea development and research support,
- Group discussions and peer feedback,
- Reflective exercises on AI use and decision-making.

The training was facilitated by researchers and mentors with expertise in digital entrepreneurship and research methodologies.

2.3 Research Design: A Qualitative Case Study

The study cohort consisted of 30 youth participants purposefully selected to ensure broad representation across different educational backgrounds and genders. Participants ranged from secondary school students to university graduates, all of whom were engaged in identifying and solving challenges aligned with the Sustainable Development Goals (SDGs).

Table 1: Participant characteristics

Category	Description
Total sample size	30 participants
Age range	18–30 years
Educational background	Secondary education students, undergraduate students, and recent graduates
Selection criteria (Entrepreneurial interest)	Interest in entrepreneurship or innovation
Selection criteria (Motivation)	Motivation to participate in research and SDG-related activities
Selection criteria (Digital skills)	Basic digital literacy

Source: *Authors' own elaboration*

To capture a comprehensive perspective across varied socio-economic landscapes, the sampling was distributed equally across three distinct locations:

- **Fes (n=10):** Representing a mid-sized academic and cultural hub.
- **Rabat (n=10):** Selected to provide insights from participants in the administrative and institutional capital.
- **Oujda (n=10):** Included to offer a perspective from the eastern region, highlighting the program's reach into geographically dispersed communities.

2.4 The Algorithmic Scaffolding Framework (PAIR)

To ensure that Generative AI served as a "heuristic co-pilot" rather than merely as a tool for content generation, the training followed the **Problem, AI, Interaction, Reflection (PAIR)** framework. This model prioritizes instructional scaffolding to prevent "cognitive offloading" while fostering higher-order critical thinking. (Acar, 2023; Anwar, 2025a; Bell & Bell, 2023a)

- **Problem Formulation:** Participants identified local social or environmental challenges aligned with the Sustainable Development Goals (SDGs).
- **AI Interaction:** Participants identified applicable legal or business frameworks relevant to their identified problem by using Large Language Models such as ChatGPT or Gemini.
- **Human-AI Interaction:** This involved iterative prompt engineering, where youth refined their queries to receive constructive, specialized feedback rather than generic outputs.
- **Critical Reflection:** Participants critically evaluated the AI-generated outputs; this reflective process aligns with established models such as Gibbs' (GIBBS, 1988) and Rolfe (Rolfe et al., 2001) frameworks, particularly in their emphasis on analysis and action-oriented revision.

2.5 Data Collection: Semi-Structured Interviews

The study relied on primary data collected through semi-structured interviews conducted between May 2025 and July 2025. This period was chosen to capture the immediate reflections of participants following their engagement with the training program.

To ensure depth and consistency, each interview lasted between 40 and 60 minutes, allowing for a comprehensive exploration of the participants' experiences. The interviews were designed to understand the shift from broad thematic exploration to focused doctrinal and entrepreneurial analysis through three primary analytical axes:

- **Patterns of Engagement:** Investigating how youth utilized Generative AI as a "preliminary search catalyst" and "co-pilot" to optimize time and efficiency in the research process.
- **Barriers to Adoption:** Examining the practical and personal obstacles that limited AI use, including instances of inaccurate or fabricated outputs, uncertainty about reliability, and concerns related to academic integrity.
- **Shifts in Perception:** Exploring how participation in the training reshaped students' understanding of AI, particularly in relation to the continuing importance of human guidance and mentorship.

2.6 Data Saturation and Rigor

Data collection in this study followed the principle of **thematic saturation**, which refers to the point at which additional data no longer generate new themes, concepts, or meaningful variations in the analysis. In practical terms, interviews were conducted iteratively and analyzed in parallel with data collection to monitor emerging patterns.

By approximately the **29th interview**, the analysis indicated that key themes related to Generative AI use in research training, such as patterns of AI engagement, perceived limitations, human–AI collaboration dynamics, and shifts in entrepreneurial confidence, were consistently repeating across participants. At this stage, no substantially new conceptual categories were emerging, suggesting that the dataset had achieved sufficient depth and breadth to represent the diversity of participant experiences across the three cities (Fès, Rabat, and Oujda). This supported the decision to conclude data collection.

To strengthen the **credibility, and confirmability** of the findings, several strategies of methodological rigor were implemented:

Triangulation of data sources: The study relied on multiple qualitative data sources, including semi-structured interviews, direct observations during training sessions, and documentary materials produced by participants (such as AI-generated drafts, refined outputs, and final project proposals). This triangulation allowed for cross-verification of findings and reduced reliance on a single data source, thereby increasing the robustness of the interpretation.

Peer debriefing during analysis: Throughout the coding and thematic development process, preliminary findings and interpretations were regularly discussed with peers and research colleagues. This process helped challenge assumptions, refine thematic categories, and reduce potential researcher bias in interpreting participant narratives.

Audit trail documentation: A systematic audit trail was maintained throughout the research process. This included detailed records of coding decisions, theme development, data reduction steps, and analytical memos. This documentation ensures transparency in how raw qualitative data were transformed into final analytical themes, allowing for potential external review of the research process.

Contextual validation through cross-city comparison: To enhance the contextual validity of the findings, patterns were systematically compared across the three geographical sites (Fès, Rabat, and Oujda). This cross-case comparison allowed the study to identify both shared patterns and context-specific variations in how participants engaged with Generative AI. It also helped ensure that the findings were not limited to a single institutional or regional context but reflected broader tendencies within the Moroccan youth sample.

2.7 Data Analysis

Data were analyzed using hybrid thematic analysis, combining inductive and deductive approaches.

- A deductive coding phase was first conducted using the PAIR framework as an initial analytical structure.
- An inductive phase followed, allowing new themes to emerge directly from the data.

Emerging themes included :

- Levels of AI trust and skepticism

- Cognitive dependency vs. critical use
- Cultural and contextual adaptation of AI outputs
- Role of mentorship in validating AI-generated content
- Development of entrepreneurial self-efficacy

All interviews were transcribed, coded, and systematically compared across participants and locations.

3. Results

3.1 From Traditional Barriers to AI-Enhanced Synthesis

The initial research phase of the training program highlighted a significant shift in how participants identified and deconstructed local challenges aligned with the Sustainable Development Goals (SDGs). The participants focused on pressing regional issues, such as waste management, water scarcity and the promotion of digital inclusion for marginalized youth. However, prior to the integration of Generative AI, their research practices were constrained by limited access to structured and actionable information. These youth researchers faced substantial baseline research constraints, primarily relying on traditional search engines that often-yielded generic results. As one participant from Oujda noted: *"Before, I spent days looking for specific regulations and market data and only found old PDFs that were hard to understand"*. In many cases, the information was difficult to retrieve or interpret. It was often embedded in dense institutional language, which made navigation and practical application challenging.

Baseline observations and early interviews indicate that participants relied predominantly on conventional search engines, which often produced fragmented, outdated, or overly technical content. Approximately 24 out of 30 participants reported spending several days gathering basic regulatory or market data, frequently encountering difficulties in interpreting institutional documents. As one participant from Oujda explained: *"Before, I spent days looking for specific regulations and market data and only found old PDFs that were hard to understand."*

Following the introduction of Large Language Models, a significant shift occurred in both the **efficiency** and **structure** of the research process. Participants reported a reduction in initial research time from several days to a few hours, enabling them to rapidly move from broad thematic exploration to structured project design. For instance, **21 participants** explicitly noted that AI tools helped them generate preliminary project frameworks, including problem definition, value proposition, and stakeholder mapping. A participant from Fez stated: *"The AI didn't just give me an answer; it gave me a structure to follow. It turns my messy ideas into a real project plan in minutes."*

Beyond efficiency gains, the results suggest a qualitative transformation in problem framing. Before training, most project ideas were loosely connected to SDG themes; after AI integration, **over two-thirds of participants (n=20)** demonstrated the ability to articulate **context-specific and operationalized solutions**, linking global sustainability targets to local regulatory constraints, market conditions, and community needs.

This shift can be explained through a **cognitive offloading mechanism**, whereby AI reduces the burden of information retrieval and initial structuring, allowing participants to reallocate cognitive resources toward higher-order tasks such as contextualization and innovation. In this

sense, Generative AI functioned not merely as an information tool, but as a **catalyst for accelerated synthesis**, enabling participants to bridge the gap between abstract sustainability goals and actionable entrepreneurial models.

3.2 Algorithmic Scaffolding and Durable Skill Acquisition

The findings suggest that the Interaction phase of the PAIR framework played an important role in shaping students' engagement. At the outset, most participants formulated broad and undifferentiated prompts (e.g., "write a business plan"). However, by the mid-point of the training, 28 out of 30 participants demonstrated the ability to decompose complex problems into smaller analytical components, such as market entry strategies, regulatory compliance, and financial feasibility. As one participant from Rabat noted: *"At first, I just asked it to write a business plan, but the result was too general. I had to break my project into specific parts… and ask the AI to analyze each piece one by one."* This process required them to unpack entrepreneurial and legal issues step by step rather than accept the first output generated by the Many participants started to refine their problem articulation and analytical reasoning to obtain meaningful outputs.

This shift in research methodology was underpinned by high levels of cognitive engagement. 93% of participants (n=28) reported that interacting with Generative AI required them to think more critically about question formulation and information validity. Rather than passively consuming outputs, they developed evaluative strategies to assess relevance and reliability, often triangulating AI-generated content with external sources. Participants noted that prompt engineering required them to pause and reflect on their understanding, fostering deeper inquiry and the exploration of diverse perspectives that they might have previously overlooked. This process enhanced their durable skills, particularly critical thinking and problem-solving. They learned to filter AI-generated content and verify its reliability against primary sources.

From a theoretical perspective, these findings highlight the role of Generative AI as an algorithmic scaffold that supports learning by structuring complexity while preserving learner agency. By providing immediate yet revisable outputs, AI encourages experimentation, hypothesis testing, and reflective iteration, key processes associated with durable skill acquisition.

The framework was instrumental in bridging the technical divide for participants with non-specialized backgrounds. For those lacking formal legal or management training, the AI provided an essential foundational project structure that reduced their intrinsic cognitive load. This made complex, and real-world project learning accessible to a wider range of students. It helped them to participate in advanced entrepreneurship discussions on equal footing with their specialized peers. A student with a non-business background observed: *"The AI helped me understand the language of business. It gave me a map of the project that I didn't have before, so I could focus on the creative social part of my idea"*.

Before the training, participants' research processes were characterized by linear and time-consuming information searches, reliance on fragmented and often outdated sources, and difficulty translating SDG-related challenges into operational project ideas. Empirical evidence from baseline interviews indicates that 24 out of 30 participants required several days to identify relevant regulatory, technical, or market information.

Their outputs at this stage were predominantly descriptive, with weak connections between identified problems and actionable entrepreneurial solutions.

After the integration of Generative AI, a distinct shift was observed:

- Research time for initial project structuring decreased from *several days to a few hours*
- 21 participants were able to generate structured project outlines (problem definition, value proposition, stakeholders)
- 20 participants (≈67%) demonstrated the ability to translate SDGs into context-specific, operational solutions.

This transformation can be explained through a cognitive offloading mechanism combined with AI-mediated knowledge structuring. By externalizing low-level cognitive tasks (search, summarization, initial organization), Generative AI reduces extraneous cognitive load and enables participants to engage in higher-order processes such as problem reframing, and opportunity identification.

Unlike static learning resources, AI provides immediate and revisable outputs. This creates a cycle of:

Hypothesis → Output → Evaluation → Refinement, which is central to deep learning and problem-solving.

3.3 Entrepreneurial Intent and the Human Element

The final block of interviews addressed the long-term impact of the training on the participants' professional identity and their transition from research to practice. This phase of the study revealed a significant correlation between digital proficiency and entrepreneurial self-efficacy, while simultaneously highlighting the critical boundaries of machine intelligence.

Integrating Generative AI into the research workflow significantly boosted participants' confidence in their ability to launch "sustainable digital entrepreneurship" ventures. By democratizing access to specialized knowledge that was previously a barrier to entry, the tools served as institutional catalysts for venture feasibility. Youth researchers reported a shift from technological fear to a sense of intelligent collaboration, where the ability to leverage global tools for local impact reduced the perceived obstacles of early-stage entrepreneurship. Post-training data show that 25 out of 30 participants expressed increased confidence in their ability to develop and implement sustainable digital entrepreneurship projects. This shift was particularly pronounced among participants with no prior entrepreneurial or managerial experience. As one participant from Rabat stated: *"Before this training, the technical and legal side felt like a wall… now I feel like I have the resources I need."* This sense of empowerment was particularly noted among those lacking prior managerial experience, as the AI provided the capability scaffolding necessary to compete in global markets.

This increase in self-efficacy can be attributed to a capability-building mechanism, whereby Generative AI reduces informational and technical barriers, making complex entrepreneurial processes more accessible. By providing on-demand access to legal, financial, and strategic knowledge, AI tools functioned as institutional substitutes, compensating for gaps in formal support structures.

However, the findings also reveal clear limitations of AI systems. Despite the high efficiency and nearly zero marginal cost of AI-generated advice, participants identified the human trainer as an indispensable component of the entrepreneurial ecosystem. Generative AI was perceived as lacking the relational and ethical depth required for true leadership. Participants emphasized that the human mentor provided emotional intelligence, nuanced ethical guidance, and the contextual wisdom necessary to navigate the Moroccan business landscape.

The interaction between AI scaffolding and human mentorship was not sequential but layered. In several training sessions, mentors encouraged participants to question AI-generated recommendations that appeared overly generic or insufficiently adapted to Moroccan realities. Rather than rejecting the outputs outright, trainers asked students to justify why a suggestion was relevant, or to identify where local constraints might alter its feasibility. This mediation prevented uncritical adoption of algorithmic advice. It also reinforced the idea that AI could assist the process, but could not replace contextual judgment. The reflective dialogue between participant, mentor, and tool became central to the development of culturally grounded entrepreneurial ideas.

One student from Oujda reflected: *"The AI can give me a hundred marketing ideas, but it can't look me in the eye and tell me if my project is truly ethical for my neighbors, or give me the courage to keep going when I fail"*. This suggests that although AI can simulate certain aspects of practice, entrepreneurship itself still relies heavily on human judgment, empathy, and intuition.

Before the training, many participants perceived entrepreneurship, particularly in sustainable and digital sectors, as largely inaccessible, a perception driven by limited technical and legal knowledge, the absence of structured guidance, and a high level of perceived risk and uncertainty surrounding venture creation. This initial state was reflected in their hesitation to engage with complex entrepreneurial tasks and their tendency to view regulatory and market requirements as insurmountable barriers. In contrast, the post-training findings reveal a significant shift in perception and capability. A total of 25 out of 30 participants reported increased confidence in their ability to design and potentially implement a sustainable entrepreneurial project. This evolution was accompanied by a clearer understanding of project feasibility, a stronger willingness to engage in entrepreneurial action, and a noticeable reduction in the perceived complexity of technical and regulatory processes.

4. Discussion

Our findings challenge the prevailing dichotomy in current literature between "AI-enhanced productivity" and "cognitive offloading". While scholars like Baidoo-Anu and Ansah (2023) and Ghimire et al. (2024) caution that Generative AI may foster surface-level learning by automating intellectual tasks, our results suggest that the outcome is contingent upon the pedagogical frame. By implementing the PAIR framework, we observed that participants did not passively accept AI outputs. Instead, the "Interaction" and "Reflection" phases forced a high level of metacognitive activation.

Our study confirms that when Generative AI is used as an autonomous content generator, it risks undermining analytical labor; however, we extend this understanding by demonstrating that when embedded in a structured scaffolding model, the same tools act as a catalyst for

"durable skill acquisition" rather than a substitute for it. The shift from broad, simple questions to precise, iterative prompt engineering indicates that Generative AI can actually *increase* cognitive engagement if learners are required to "unpack" business and legal frameworks step-by-step.

For our participants, Generative AI bridged the gap between local SDG challenges and global business knowledge. This confirms the potential of AI to democratize specialized knowledge, but adds a new dimension, in resource-constrained environments, Generative AI functions as an institutional catalyst" that lowers the barrier to entry for youth entrepreneurship. It suggests that in the Global South, the digital divide is being reshaped into a prompting divide, where the ability to utilize Generative AI as a co-pilot becomes a critical new competency for venture feasibility. Theoretically, our study supports the constructivist perspective that knowledge is co-constructed through iterative dialogue. Our findings imply that the most significant pedagogical contribution of Generative AI is not the content it produces, but the reflective dialogue it necessitates.

We propose that the PAIR framework offers a viable model for education through entrepreneurship. Our results highlight that the AI-Human-Mentor triad is a layered, rather than sequential, process. The Human Element, specifically the mentor's ability to provide emotional intelligence and contextual wisdom, remains the essential filter for AI-generated advice. This extends the literature (Bell & Bell, 2023; Morselli & Gorenc, 2022) by proving that entrepreneurship, particularly when centered on sustainable impact, requires a form of contextual judgment that Generative AI cannot replicate.

Conclusion

This study provides empirical evidence on the integration of Generative AI within a non-formal youth training program in Morocco. By tracking 30 participants across three regional hubs, we demonstrate that when integrated through the Problem, AI, Interaction, Reflection (PAIR) framework, Generative AI acts as both a heuristic co-pilot and a critical access mediator for youth researchers.

Theoretically, this study contributes to the literature by proving that the efficacy of AI in research training is contingent upon structured pedagogical scaffolding rather than technological sophistication alone. We extend constructivist learning perspectives by showing that the interaction between human judgment and algorithmic output facilitates metacognitive activation, a transformative process for entrepreneurial self-efficacy. Furthermore, by grounding our analysis in the Moroccan context, we challenge the Western-centric focus of existing scholarship, positing that in developing economies, Generative AI serves as a vital mechanism for democratizing access to specialized knowledge.

Despite these contributions, the study has limitations that necessitate future research. The sample size of 30 participants and the specific focus on a non-formal Moroccan training context limit the broad generalizability of the findings. Additionally, our analysis did not control for potential algorithmic biases inherent in Large Language Models, which may prioritize dominant global narratives over local socio-economic realities. Future inquiries should therefore conduct comparative studies between formal and non-formal settings, employ longitudinal analyses to track long-term venture viability, and extend these investigations to other developing regions to verify the consistency of AI as an access mediator.

For educators and policymakers, these findings underscore three essential priorities. First, institutions should institutionalize algorithmic scaffolding, such as the PAIR framework, to ensure AI is used to enhance cognitive engagement rather than encourage cognitive offloading. Second, programs must foster cultural autonomy by embedding reflective cycles that require students to verify AI outputs against local legal and market constraints. Finally, it is crucial to re-center the human mentor, as their role in providing ethical, emotional, and contextual wisdom remains indispensable. Ultimately, when embedded within rigorous human-led structures, Generative AI serves as a powerful catalyst for inclusive opportunity; when detached from such supports, its contribution to genuine skill acquisition remains highly uncertain.

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