“FUTURE READY YOUTH BUSINESS LEADERS: GENDER BASED COMPETENCIES FOR THE X.0 WAVE GENERATION”

Research Paper

Hamid Mattiello, SSBM Geneva, Switzerland, hamid.mattiello@ssbm.ch

“Abstract”

The accelerating convergence of digital transformation, sustainability, and technological innovation requires a new generation of youth business leaders equipped with ethical, culturally aware, paradigm-shifting, and gender-sensitive competencies. This study applies the X.0 wave theory as a comprehensive framework to understand societal, technological, and economic evolution and how successive business and societal revolutions reshape leadership requirements (Mattiello, 2024; Doost Mohammadian, 2022; Mattiello, Wittberg and Castro, 2022, November). It examines gender-based competencies essential for developing future-ready leaders capable of navigating digital, green, and human-centered economic transitions (Schwab, 2016; Schwab and Davis, 2018; OECD, 2025; Durani, 2025; Mansour et al., 2024). The framework identifies key competencies, including digital fluency, gender competence, entrepreneurial and strategic skills, and sustainable ethical leadership, using cross-cultural surveys, case studies, and simulation-based assessments (Mattiello, Mattiello and Wittberg, 2025, April; Mattiello and Mattiello, 2025b; Brooks, Tse, Wright and Burdett, 2024; Mattiello, Wittberg, Castro and Langari, 2022, March). These competencies, combined with ethical governance and inclusive leadership, enable youth to respond effectively to Industry 5.0 and emerging Society 6.0 challenges (Mattiello and Domann, 2024; Henderikx and Stoffers, 2023; Held, Heubeck and Meckl, 2025; Mladenova, Vladimirov and Harizanova, 2025). Findings show that integrating ethics, digital skills, and gender-sensitive practices enhances leadership effectiveness, resilience, and inclusivity, offering actionable guidance to cultivate future-ready leaders who drive sustainable and advanced business ecosystems (Mattiello, Alijani, Rahimi Moghaddam and Ameri, 2024; Doost Mohammadian and Rezaie, 2020; Rüdiger, Köchli, Hunter and Mvunelo, 2025; UN Youth Office, 2025; Avice Huet, 2023).

Keywords: Gender competencies, digital fluency, ethical leadership; entrepreneurial and strategic skills, future-ready leadership, interdisciplinary education, sustainability, X.0 wave theory.

1 Introduction

Digital transformation, sustainability, and technological innovation are rapidly reshaping global business ecosystems, creating an urgent need for youth leaders who are ethical, inclusive, and technologically adaptive (Held, Heubeck and Meckl, 2025; Mladenova, Vladimirov and Harizanova, 2025; Mattiello and Domann, 2024; Al-Swidi et al., 2024). Traditional leadership models often fail to address the intersection of ethics, inclusivity, and innovation, leaving young leaders underprepared for the complexities of Industry 5.0 and the emerging Society 6.0 (Schwab, 2016; Schwab and Davis, 2018; Toffler, 1991; Doost Mohammadian and Rezaie, 2020).

The X.0 wave theory (Mattiello, 2024; Mattiello and Wittberg, 2024; Mattiello, Wittberg, Castro and Langari, 2022, March; Mattiello, Brüggemann, Castro and Bakhtiari, 2022, March) offers a holistic framework integrating technological, cultural, and socio-economic perspectives to explain how leadership expectations evolve through successive revolutions, from the third wave (Toffler, 1980) to today’s hybrid Society 6.0 stage. The theory positions leadership development along hierarchical competencies: foundational digital fluency (D), intermediate strategic and entrepreneurial skills (S),

advanced ethical and gender competence (EG), and top-tier visionary integration (V) (Doost Mohammadian, 2022; Mattiello and Domann, 2024; Mattiello, Castro, Merk and Shahhoseini, 2020; Mattiello, Wittberg, Castro and Bolandian, 2020).

Emerging studies highlight that cultivating digital leadership, dynamic capabilities, and inclusive organizational cultures significantly enhances youth readiness for digital transformation (Held, Heubeck and Meckl, 2025; Henderikx and Stoffers, 2023; Živković, 2022; Schiuma, Santarsiero, Carlucci and Jarrar, 2024). Moreover, ethical governance, sustainability, and gender equity are increasingly recognized as core enablers of innovation and resilience (Pierli, Murmura and Palazzi, 2022; Mansour et al., 2024; Saenz, Wu, Uddaraju, Nafei and Liu, 2025; Arcuri, Di Tommaso and Pisani, 2024; OECD, 2025; Dhatt et al., 2018; LSFI and University of Luxembourg, 2023).

In this context, future-ready leadership requires integration of interdisciplinary competencies, bridging ethics, digital strategy, sustainability, and gender awareness guided by frameworks like the 7PS Model and SME 5.0 concept (Doost Mohammadian and Rezaie, 2020; Mattiello and Domann, 2024; Mattiello, Alijani, Rahimi Moghaddam and Ameri, 2024). Applying a mixed-methods design, this research investigates how these competencies enable youth to navigate socio-technical challenges and contribute to sustainable global business ecosystems (Mattiello and Mattiello, 2025; Mattiello, 2024; Rüdiger, Köchli, Hunter and Mvunelo, 2025; UNDP, 2025; Avice Huet, 2023; Youth Business International and Accenture, 2020; Durani, 2025; Jaccheri, Pereira and Fast, 2021; Petrescu and Suciu, 2024).

2 Literature Review and Theoretical Framework

2.1 The X.0 wave/tomorrow age theory

2.1.1 Overview

The X.0 wave theory, also known as the theory of comprehensive, everything, was developed by Prof. Mattiello (2010–present) as a holistic framework for understanding societal, technological, and economic evolution through successive waves shaped by Knowledge, Technology, and Business (KTB) (Mattiello, 2010; Mattiello and Domann, 2024). Each X.0 wave represents a distinct developmental stage, ranging from cognitive and agricultural phases ($X \leq 1.0$) to industrial ($X = 2.0$), post-industrial/information ($X = 3.0$), AI/intelligence-driven ($X = 4.0$), human-centered ($X = 5.0$), and future transhuman or post-human stages ($X \geq 6.0$) (Mattiello et al., 2024; Toffler, 1980, 1991; Schwab, 2016; Christensen, 1997).

Leadership within this framework integrates emotional, ethical, cultural, and performance intelligence, emphasizing agility, foresight, and creative problem solving (Mattiello, 2017; Mattiello and Domann, 2024). Inclusive and gender-sensitive approaches ensure younger generations are prepared to navigate complex social and technological transformations (Mattiello et al., 2024; OECD, 2025; Schwab, 2017). The decade 2020–2030, identified as the first edge of tomorrow, is particularly critical for cultivating competencies in digital fluency, ethical reasoning, and human-centered leadership (Mattiello, 2024; United Nations Youth Office, 2025).

The X.0 wave theory rests on three principles:

- KTB Integration: Harmonizing knowledge, technology, and business for holistic societal and economic advancement (Mattiello, 2010; Doost Mohammadian, 2017a).
- Seven pillars of sustainability (7PS): Strengthening culture, society, society, economy, environment, technology, education, and politics to support sustainable and ethical development (Mattiello, 2017; Mattiello and Domann, 2024; Doost Mohammadian, 2022; Mattiello et al., 2024).
- Future readiness: Cultivating anticipatory skills for global, ethical, and inclusive innovation in dynamic industrial and societal contexts (Mattiello et al., 2024; Schwab, 2017; Avice Huet, 2023).

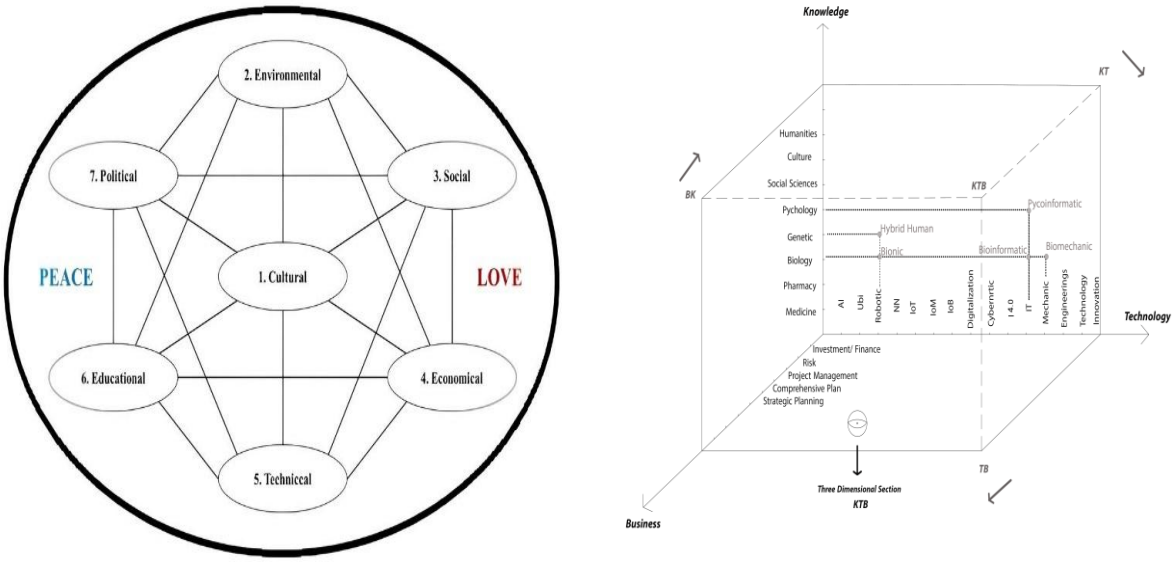

Figure1 Left: Seven pillars of sustainability (7PS) model with priority and connections. Right: Knowledge, technology, business (KTB) model (Source: Mattiello, 2010–17)

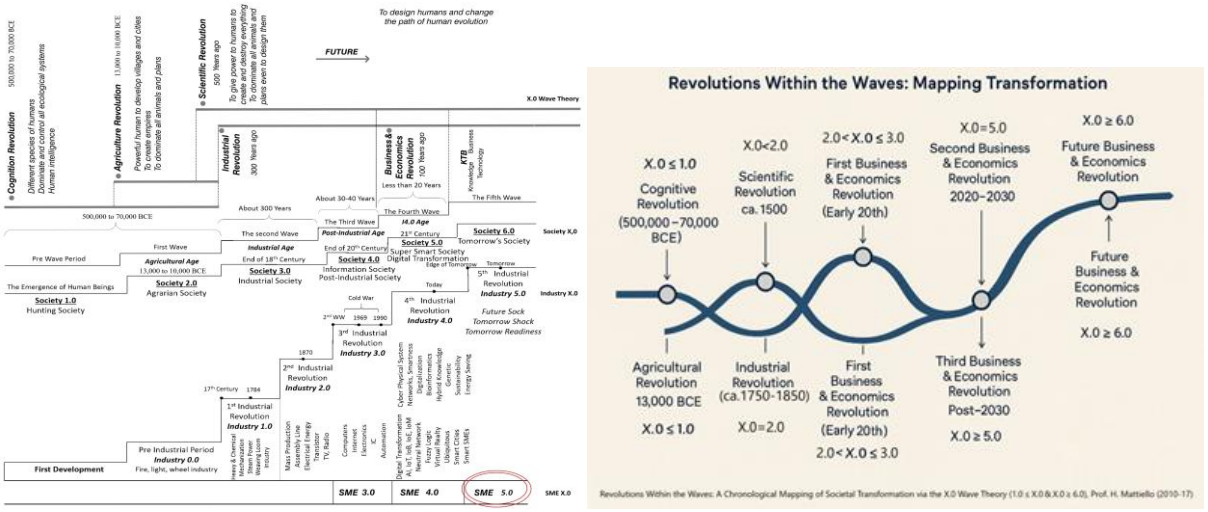

Figure2 The X.0 wave/age (1.0 ≤ X.0 & X.0 ≥ 6.0) theory, revolutions, ages, society, industries, technologies, and SMEs (Source: Mattiello, 2010–17)

2.1.2 Leadership and competency development across X.0 waves

Leadership competencies evolve across business economics (BE) revolutions, reflecting societal, technological, and ethical shifts (Mattiello, 2017; Mattiello et al., 2024; Schwab and Davis, 2018):

- 1st BE revolution ($2 < X \leq 3$): Strategic decision-making, equity awareness, and systems thinking in industrial/post-industrial contexts (Mattiello, 2017; Porter, 1985).
- 2nd BE revolution ($3 < X \leq 4$): Interdisciplinary collaboration, digital and biotechnology fluency, and gender-balanced decision-making (Mattiello and Domann, 2024; Henderikx and Stoffers, 2023; Živković, 2022).
- 3rd BE revolution ($4 < X \leq 5$): Human-centric leadership emphasizing empathy, creativity, sustainability, and adaptive innovation (Mattiello et al., 2024; Doost Mohammadian, 2022; Schwab, 2017).

- 4th (Future) BE revolution (X ≥ 6): Global systems thinking, social innovation, and transhuman integration (Mattiello, 2017; Mattiello, 2018; Doost Mohammadian, 2023a).

Leadership education under the X.0 wave framework emphasizes (Mattiello et al., 2024; Mattiello and Wittberg, 2024):

1. Forecasting: Strategic foresight and inclusive intelligence (Schwab, 2016; Rüdiger et al., 2025).
2. Crisis prevention: Ethical reasoning and gender-sensitive decision-making (OECD, 2025; UNDP, 2025).
3. Adaptive innovation: Creativity, empathy, collaboration, and sustainability orientation (Mattiello, 2024; Mansour et al., 2024).

By integrating interdisciplinary education, AI simulations, mentorship, and gender-sensitive practices, youth leaders are equipped to act ethically, innovate effectively, and foster inclusive, resilient, and sustainable outcomes (Mattiello, 2019; Schwab, 2017; Mattiello and Domann, 2024; Brooks et al., 2024).

#	X.0 wave	Time period	Revolutions	Characteristics / gender & youth leadership	Society & industries	Business paradigms
1	X ≤ 1	500,000–70,000 BCE	Cognition & agriculture	Abstract thinking, communication, emotional intelligence, collaborative reasoning	Early villages, cities civilizations,	N/A
2	2≤X<3	17th–19th c.	Scientific & industrial	Mechanization, mass production, leadership adaptability, systems thinking	Factories, urban growth	SME 1.0
	X.= 2.1	1760–1840	1st Industrial revolution	Steam, mechanization, textile & iron; strategic decision-making, equity awareness	Urbanization, economic growth	SME 2.0
	X= 2.2	Late 19th c.	2nd Industrial revolution	Electricity, steel, chemical industry, assembly line; leadership adaptability	Urban industry mass production	SME 2.0
5	X= 3	20th c. (1969–70)	Post-industrial / information	Digital literacy, collaboration across disciplines, gender inclusion	Knowledge economy, IT	SME 3.0
6	X= 4	Emerging (1970s–now)	AI & biotechnology	AI, biotech, Industry 4.0, ethical reasoning	Work & social transformation	SME 4.0
7	4≤X<5	2020–2030 (first edge)	Industry 5.0 & Society 6.0	Human-centric design, empathy, gender sensitivity, adaptive foresight	Sustainability, social justice	SME X.0
8	X ≥ 6	Hypothetical future	Transhuman / post-human	Systems thinking, social innovation, gender equity, transhuman integration	Society X.0, global networks	Future SME

Table 1 Evolution of leadership, society, and SMEs through X.0 waves (Source: Mattiello, 2010–17)

2.2 Digital transformation, data-driven leadership, gender competencies, industry 4.0 readiness, and seven pillars of sustainability (7PS)

Digital transformation, combining AI, automation, and analytics, is reshaping modern business ecosystems (Brynjolfsson and McAfee, 2014; Mladenova et al., 2025; Held et al., 2025; Al-Swidi et al., 2024). Within the X.0 wave framework, youth leaders must develop digital fluency (D) to harness data

for human-centered and sustainable innovation, balancing technical proficiency with ethical judgment (Mattiello, 2017; Mattiello and Domann, 2024; Schiuma et al., 2024).

Ethical and gender-sensitive leadership, corresponding to ethical and sustainable (E) and gender competence (G), ensures that strategic decisions promote societal well-being, inclusiveness, and long-term sustainability (Mattiello et al., 2024; Schwab, 2017; OECD, 2025). Competencies such as empathy, equity awareness, and collaborative problem-solving enhance creativity, adaptability, and organizational performance (Mattiello and Mattiello, 2025b; Mattiello et al., 2025a; Doost Mohammadian and Ghasabzadeh Langari, 2023).

The 7PS, including culture, environment, society, economy, technology, education, and politics, provide an ethical and strategic foundation. Integrating digital fluency, ethical reasoning, and gender awareness with 7PS enables leaders to anticipate trends, prevent crises, and foster inclusive, human-centered, and resilient business ecosystems (Mattiello et al., 2024; Mattiello and Domann, 2024; Doost Mohammadian, 2022).

Future-ready youth leaders must "go digital without losing humanity," balancing technology with empathy (Mattiello, 2024; Schwab, 2017; United Nations Youth Office, 2025). The key drivers shaping this landscape include:

2.2.1 Tools and technology: Smarter, data-driven operations through IoT, AI, automation, and analytics.

2.2.2 People and competencies: Leaders equipped to analyze data, control systems, and ensure operational standards.

2.2.3 HR and innovation: Experts capable of designing, implementing, and applying innovative solutions across organizations.

The shift from traditional to data and business economies via the internet of business (IoB) highlights readiness gaps in technology adoption, digital skills, and organizational maturity, underscoring the urgency of developing youth leaders aligned with the X.0 wave competencies (Mattiello, 2017; Brynjolfsson and McAfee, 2014; Schwab, 2017; Doost Mohammadian and Rezaie, 2020; Henderikx and Stoffers, 2023; Mattiello et al., 2022a–2022d).

2.3 Digital transformation and youth leadership

Digital transformation is reshaping the skills and competencies required of future business leaders (Mladenova et al., 2025; Held et al., 2025; Al-Swidi et al., 2024). For youth leaders, digital fluency is not only technical proficiency but also includes understanding digital strategy, data-driven decision-making, and technological innovation to enable organizational sustainability (Schiuma et al., 2024; Henderikx and Stoffers, 2023; Živković, 2022). Dynamic capabilities, such as adaptability, innovative thinking, and digital leadership are essential for SMEs and youth-led ventures navigating rapidly evolving markets (Doost Mohammadian, 2022; Doost Mohammadian and Rezaie, 2020).

Scholars argue that successful digital leadership requires integrating technological knowledge with ethical reasoning, cultural awareness, and strategic foresight, enabling leaders to manage transformation while sustaining organizational performance (Porter, 1985; Drucker, 2007; Christensen, 1997; Schwab, 2016; Schwab and Davis, 2018). The X.0 wave Theory provides a framework to examine these competencies hierarchically, combining digital fluency, strategic thinking, ethical leadership, and visionary integration (Mattiello, 2024; Mattiello and Domann, 2024; Doost Mohammadian, 2022).

2.4 Sustainability and ethical leadership

Sustainability and ethical leadership are increasingly recognized as integral to the development of youth business leaders (Doost Mohammadian, 2023; Mattiello et al., 2024). Integrating green innovation into organizational strategy supports long-term performance and aligns with the Sustainable Development Goals (SDGs) (Al-Swidi et al., 2024; Mansour et al., 2024; Pierli et al., 2022). Ethical governance ensures that youth leaders promote accountability, transparency, and inclusive practices across digital

and physical ecosystems (Mattiello and Domann, 2024; Doost Mohammadian and Ghasabzadeh Langari, 2023).

Blue-green smart cities and sustainable urban mobility concepts highlight how ethical leadership extends beyond corporate environments to societal transformation (Doost Mohammadian, 2023a; 2023b; 2023c; 2023d). In this context, youth leaders equipped with sustainability competencies can foster innovation, mitigate risks, and drive inclusive economic growth (Mattiello, 2024; Mattiello et al., 2024).

2.5 Gender competence and inclusive leadership

Gender-sensitive competencies are critical for future-ready leadership (OECD, 2025; Mattiello and Mattiello, 2025b). Studies demonstrate that female leadership positively impacts innovation, environmental performance, and corporate governance (Arcuri et al., 2024; Mansour et al., 2024; Saenz et al., 2025; Pierli et al., 2022). Incorporating gender competence ensures inclusive decision-making, equity in human capital, and enhanced organizational resilience (Dhatt et al., 2018; Luxembourg Sustainable Finance Initiative, 2023; Brooks et al., 2024).

Empowering youth, particularly girls, with leadership and sustainability skills strengthens the pipeline of future business leaders capable of driving equitable economic transformation (UNDP, 2025; United Nations Youth Office, 2025; Avice Huet, 2023; Durani, 2025; Youth Business International and Accenture, 2020). Integrating gender awareness with digital literacy and ethical leadership produces leaders who can navigate complex socio-technical challenges while promoting social justice (Jaccheri et al., 2021; Petrescu and Suciu, 2024).

2.6 Entrepreneurial and strategic skills

Entrepreneurial and strategic skills complement digital fluency and ethical awareness in developing youth leadership (Toffler, 1970; 1980; 1991; Christensen, 1997; Porter, 1985). Strategic thinking, problem-solving, and opportunity recognition allow youth leaders to respond proactively to technological disruptions and societal shifts (Drucker, 2007; Doost Mohammadian, 2017a, 2017b). Hybrid SMEs and SME 5.0 frameworks demonstrate how combining entrepreneurial agility with structured models such as the 7PS framework enhances competitiveness and sustainability (Doost Mohammadian and Rezaie, 2020; Mattiello and Domann, 2024).

Simulation-based assessments and mixed-methods approaches validate the development of these skills, showing that integrating experiential learning, MOOCs, and future-ready educational programs supports the holistic growth of youth leaders (Mattiello, Wittberg and Castro, 2022a, 2022b, 2022c; Mattiello et al., 2022d; Mattiello et al., 2020a, 2020b; Mattiello and Rezaie, 2020; Mattiello, 2020).

2.7 Integrating Competencies via the X.0 wave theory

The X.0 wave Theory synthesizes these domains, digital fluency, sustainability, gender competence, and entrepreneurial strategy, into a coherent model for youth leadership development (Mattiello, 2024; Mattiello and Domann, 2024). By applying hierarchical competency development (D-S-EG-V), the theory provides actionable pathways for cultivating leaders capable of navigating Industry 5.0, Society 6.0, and beyond (Doost Mohammadian, 2022; Mattiello et al., 2024; Rüdiger et al., 2025).

Future-ready youth leaders are thus equipped to balance technological innovation with ethical, sustainable, and inclusive decision-making (Schiuma et al., 2024; Henderikx and Stoffers, 2023; OECD, 2025; UNDP, 2025). Cross-cultural considerations, intergenerational collaboration, and exposure to international best practices further enhance leadership effectiveness (United Nations Youth Office, 2025; Avice Huet, 2023; Durani, 2025).

3 Methodology

A mixed-methods approach was employed to examine how gender-based competencies shape future-ready youth leaders in digital, green, and human-centered economies, guided by the X.0 wave framework (X ≥ 4) (Mattiello, 2018; Mattiello, 2019; Mattiello, 2020; Mattiello et al., 2024). This approach enabled triangulation of quantitative and qualitative data, assessing competency development and leadership outcomes across diverse cultural contexts (Creswell and Creswell, 2018; Mattiello and Domann, 2024; Schwab, 2017; Doost Mohammadian, 2022).

3.1 Research design

The study followed a six-stage, mixed-methods design to assess gender-sensitive, digital, and sustainable competencies in youth business leaders:

3.1.1 Gap analysis: Identify skill deficits in youth programs and SMEs.

3.1.2 Case studies: Assess opportunities and barriers in X.0 initiatives.

3.1.3 Validation: Confirm key competencies via expert panel review.

3.1.4 DEMATEL: Map cause-effect relationships among competencies and governance structures.

3.1.5 ISM (Interpretive structural modelling): Structure competencies from foundational to advanced.

3.1.6 Simulation: Test program effectiveness via scenario-based interventions using AI tools and X.0-enhanced scenarios.

This design ensured alignment with X.0 principles while enabling culturally adapted, gender-sensitive evaluation of leadership development (Yin, 2018; Mattiello, 2017; Mattiello and Domann, 2024 Mattiello, 2021; Brynjolfsson and McAfee, 2014; Mattiello et al., 2024; Gaspersz and Rahayu, 2018).

3.2 Cross-cultural case study selection

To explore variations in gender-inclusive youth leadership, a comparative study was conducted across Western (Global North) and non-Western (Global South) contexts. Focus areas included Industry 5.0 adoption, interdisciplinary education, entrepreneurial innovation, and culturally aligned gender competencies within the X.0 wave framework (Mattiello et al., 2024; Schwab, 2017; Mattiello and Domann, 2024; Doost Mohammadian, 2022).

#	Region	Countries (n)	Focus areas	n	Gender	Education
1	**Western cultures**	CH, DE, FR, IT, ES, NL, BE, AT, DK, US, CA, NZ (12)	Industry 5.0 adoption, gender-inclusive organizational culture, SME leadership practices	54	27 M, 26 F	66% UG, 34%Grad
2	**Non-western cultures**	IN, CN, BR, ZA, AE, MX (6)	Interdisciplinary education, entrepreneurial innovation, culturally aligned gender competencies in leadership development	36	17 M, 19 F	66% UG, 34%Grad
3	**Total sample**	18 countries	Cross-cultural youth leadership, X.0 competency analysis	90	47 M, 42 F	66% UG, 34% Grad

Table 2 Cross-cultural case study selection and sample distribution (Source: Mattiello, 2024)

3.3 Conceptual framework

The youth X.0 leadership integration model hierarchically maps competencies from foundational to integrative, future-ready capabilities using DEMATEL and ISM methods (Mattiello, 2021; Mattiello et al., 2024; Mattiello and Domann, 2024; Gaspersz and Rahayu, 2018).

3.3.1 Level 1 / foundational: Digital fluency (D) and entrepreneurial strategic skills (S)

3.3.2 Level 2 / intermediate: Ethical and sustainable leadership (E)

3.3.3 Level 3 / advanced/strategic: Gender competence (G)

3.3.4 Level 4 / top performer: Integrated X.0 leadership with visionary foresight (V)

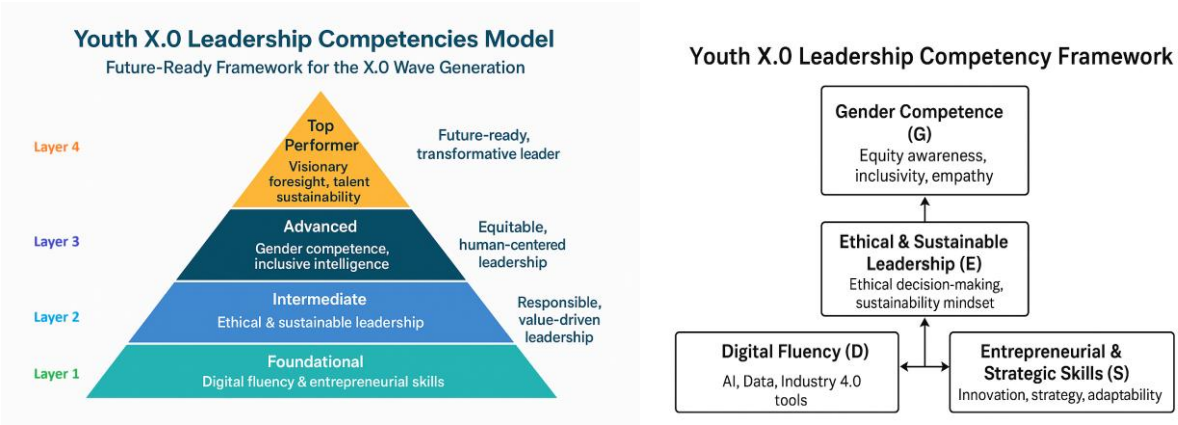

Figure3 Youth X.0 leadership competency development model: hierarchical mapping (Source: Mattiello, 2010–24)

		Indicators & outcomes	Assessment	Role in development
1	**D**	AI tools, IoT, data analytics → technologically competent leader	Surveys, digital projects, simulations	Cause: Builds technical foundation; enables strategic application (Mattiello et al., 2024; Mattiello and Domann, 2024; Brynjolfsson and McAfee, 2014)
	S	Innovation, adaptability, startup execution → sustainable talent & foresight	Case studies, SME reports	Cause: Builds technical foundation; enables strategic application (Mattiello et al., 2024; Mattiello and Domann, 2024; Brynjolfsson and McAfee, 2014)
2	**E**	Ethical decision-making, sustainability mindset → responsible, value-driven leadership	Interviews, self-assessment, scenario analysis	Cause: Ensures ethical grounding (Mattiello, 2017; Schwab, 2017; Mattiello and Domann, 2024)
3	**G**	Empathy, bias recognition → human-centered, high-performing teams	Simulations, expert review	Effect: Drives inclusive, high-performing teams (Mattiello et al., 2024; Doost Mohammadian, 2022)
4	**V**	Digital, ethical, and gender foresight → future-ready, transformative leaders	SME evaluation, AI-enhanced simulations	Effect: Integrates all competencies for Industry 5.0 and Society 6.0 (Mattiello, 2017; Mattiello et al., 2024; Schwab, 2017)

Table 3 Youth X.0 leadership competency framework (Source: Mattiello, 2017–2024)

3.4 Data collection

3.4.1 Quantitative approach

Surveys captured perceptions, competencies, and learning approaches:

Instrument	Items	Focus / example	Sample
YL-AIEEQ	25	Measures ethical AI integration, gender equity, and personalized leadership	90 youth leaders (Western n=54, Non-western n=36; 47 M, 42 F; 66% UG, 34% Grad; STEM, humanities, social sciences) (Mattiello et al., 2024; Doost Mohammadian, 2022)
R-SPQ-2F	20	Evaluates deep vs. surface learning approaches for leadership skill acquisition	90 youth leaders (as above) (Biggs et al., 2001; Mattiello, 2017)

Table 4 Quantitative instruments, measures, and sample for youth X.0 leadership study (Source: Mattiello, 2017–2024)

3.4.2 Qualitative approach

Interviews, focus groups, and program simulations provided in-depth insights (Creswell and Creswell, 2018; Mattiello, 2017; Yin, 2018):

Method	Participants	Focus / purpose
Expert interviews	Educators, SME managers, mentors	Validate X.0 competencies, identify skill gaps (Mattiello et al., 2024; Mattiello and Domann, 2024)
Student Surveys	Youth leaders	Assess competencies, leadership readiness, gender equity (Mattiello, 2017; Doost Mohammadian, 2022)
Program Simulations	Youth leadership initiatives	Test program effectiveness via AI- and X.0-enhanced scenarios (Mattiello et al., 2024; Brynjolfsson and McAfee, 2014)

Table 5 Data collection methods for youth X.0 leadership study (Source: Mattiello, 2017–2024)

3.4.3 Quantifying youth leadership impact metrics

Program effectiveness was quantified using:

- Youth leadership impact score ($YLimpact_i$)(*Source: Mattiello et al., 2024):*

$$YLimpact_i = \alpha D_i + \beta G_i + \gamma E_i + \delta S_i, \qquad (\alpha + \beta + \gamma + \delta = 1)$$

Where D_i, G_i, E_i, and S_i are individual scores for digital fluency, gender competence, ethical and sustainable leadership, and strategic/entrepreneurial skills; $\alpha, \beta, \gamma, \delta$ are their weighting coefficients (Mattiello et al., 2024; Mattiello and Domann, 2024).

- The youth X.0 leadership performance index ($YLXPI$)(*Source: Mattiello et al., 2024):*

$$YLXPI = \sum_{\{i=1\}}^{\{n\}} YLimpact_i$$

#	Formula	Definition	Components
1	$YLimpact_i$	Individual leadership capability	D_i, G_i, E_i, and S_i (weighted)
2	$YLXPI$	Program-level leadership outcome	Sum of $YLimpact_i$ scores

Table 6 Impact assessment of youth X.0 leadership: scores and aggregates (Source: Mattiello et al., 2024; Brynjolfsson and McAfee, 2014)

This quantitative framework enabled cross-cultural and gender-sensitive evaluation of youth leadership programs (Mattiello and Domann, 2024; Schwab, 2017; Brynjolfsson and McAfee, 2014; Doost Mohammadian, 2022).

3.5 Expected outcomes

3.5.1 Enhanced gender-sensitive and human-centered leadership competencies.

3.5.2 Improved digital fluency, ethical reasoning, and AI awareness.

3.5.3 Strengthened interdisciplinary, entrepreneurial, and strategic capacity.

3.5.4 Measurable impact on SME and organizational performance.

3.5.5 Validated Youth X.0 Leadership Integration Model with hierarchical competency mapping.

4 Results and Insights

4.1 Core competencies

Analysis identified six gender-sensitive competencies as critical for future-ready youth leaders: empathic intelligence, ethical agility, collaborative adaptability, strategic foresight, sustainability orientation, and digital fluency (Mattiello, 2018; Mattiello, 2019; Mattiello, 2020; Mattiello, 2023; Mattiello et al., 2024; Schwab, 2016, 2017; Doost Mohammadian, 2017, 2022, 2023; Schiuma et al., 2024; Živković, 2022; Henderikx and Stoffers, 2023; Mladenova et al., 2025). These competencies align with X.0 wave principles, the 7PS model of sustainability, and contemporary perspectives on leadership in digital, green, and human-centered economies (Mattiello and Domann, 2024; OECD, 2025; Al-Swidi et al., 2024; Held et al., 2025; Arcuri et al., 2024).

4.2 Competency gaps

Analysis revealed prominent gaps across gender and cultural lines (Biggs et al., 2001; Mattiello et al., 2024; Mattiello and Domann, 2024; Toffler, 1970, 1980; Porter, 1985; Christensen, 1997; Schwab and Davis, 2018; Mansour et al., 2024; Pierli et al., 2022; Dhatt et al., 2018; Schwab, 2017; Durani, 2025; UNDP, 2025; Luxembourg Sustainable Finance Initiative, 2023):

4.2.1 Males: Weaker in gender competence and ethical reasoning, reflecting vulnerability in X.0-aligned leadership skill development.

4.2.2 Non-western participants: Lower digital fluency, highlighting regional disparities in Industry 5.0 and Society 6.0 readiness.

4.2.3 Females: Excelled in empathy, collaboration, and ethical agility, confirming that deep, reflective learning enhances X.0 competencies.

4.2.4 Overall: Digital, ethical, and gender-sensitive leadership gaps were prominent, emphasizing the need for integrated, experiential programs.

4.3 Quantitative findings

4.3.1 Learning approaches and leadership competencies

- Deep, reflective learning positively correlates with leadership competencies, supporting X.0-aligned development in digital fluency, ethical reasoning, and gender-sensitive leadership

(Biggs et al., 2001; Mattiello, 2017; Mattiello et al., 2024; Brooks et al., 2024; Jaccheri et al., 2021).

- Surface learning negatively correlates with competencies, particularly among males, indicating shallow learning impedes ethical and gender-sensitive leadership development (Mattiello, 2017; Mattiello and Domann, 2024; Petrescu and Suciu, 2024).
- Deep strategy was more influential than motivation alone in driving leadership outcomes (Mattiello et al., 2024; Mattiello, 2025).

The results of the correlation matrix							
Variables	1	2	3	4	5	6	7
Academic performance	1						
Deep motivation	0.19	1					
Deep strategy	0.22*	0.62*	1				
Surface motivation	-0.30*	-0.29*	0.34*	1			
Surface strategy	-0.37*	-0.32*	-0.40*	0.61*	1		
In-depth approach	0.22*	0.89*	0.90*	-0.36*	0.39*	1	
Surface approach	-0.37*	-0.35*	-0.41*	0.88*	0.91*	-0.42*	1

Table 7 Correlation matrix of leadership competencies and learning approaches

Note: Significant* at $p < 0.05$ or $p < 0.01$; Deep motivation not significant ($p = 0.19$) (Mattiello et al., 2024).

4.3.2 Gender-based differences in leadership outcomes

- Female participants: Benefit more from deep, reflective learning, showing stronger gains in X.0 competencies (Mattiello, 2017; Mattiello et al., 2024).
- Male participants: Negatively affected by surface learning, highlighting vulnerability in developing leadership skills (Biggs et al., 2001; Mattiello and Wittberg, 2024; Mattiello and Mattiello and Wittberg, 2025; Mattiello 2025).

Regression analysis confirmed that gender-sensitive interventions significantly impact leadership development (Mattiello et al., 2024).

Criterion variable	Predictive variable	f	p	r	R^2	β	t	p
Leadership development in future-	Female	6.62	0.002	0.36	0.13	0.056	0.492	0.624
ready gender-based youth	Male					-0.331	-2.90	0.005

Table 8 Regression of learning approaches on gender-based leadership outcomes (Source: Mattiello et al., 2024; OECD, 2025; Mattiello and Mattiello and Wittberg, 2025; Mattiello 2025)

4.3.3 Simulation and YLXPI outcomes

Simulation-based assessments confirmed that X.0-aligned programs enhance leadership effectiveness:

- Integrating digital, ethical, and gender-sensitive curricula improved YLXPI scores (Western: 0.82, non-Western: 0.76) (Mattiello, 2017; Mattiello et al., 2024; Mattiello and Domann, 2024; Brynjolfsson and McAfee, 2014; Mladenova et al., 2025; Held et al., 2025).
- Mentorship, project-based learning, and AI simulations increased scores by 8–12%, emphasizing the importance of experiential and tech-driven interventions (Schiuma et al., 2024; Henderikx and Stoffers, 2023).

- Gender-balanced teams consistently outperformed single-gender teams, demonstrating inclusivity's strategic value (Mattiello, 2017; Arcuri et al., 2024; Mansour et al., 2024; Saenz et al., 2025).

Program feature / context	YLXPI score / outcome	Key insight
Digital, ethical, and gender-sensitive curricula	Western: 0.82 non-Western: 0.76 (0–1 scale)	X.0-aligned curricula significantly enhance leadership effectiveness
Mentorship, project-based learning, AI-enhanced simulations	8–12% increase in YLXPI	Experiential and tech-driven interventions yield measurable impact
Gender-balanced teams	Higher simulated leadership performance	Inclusivity drives superior team and organizational outcomes

Table 9 Simulation outcomes of youth X.0 leadership programs using YLXPI (Source: Mattiello and Mattiello and Wittberg, 2025; Mattiello 2025)

4.3.4 Cross-cultural and gender-specific analysis

- Western participants: Stronger digital and ethical integration (Mattiello, 2017; Schwab, 2017; Mattiello et al., 2024; Mladenova et al., 2025).
- Non-western participants: Higher entrepreneurial agility but lower gender competence (Mattiello et al., 2024; Doost Mohammadian, 2022, 2023; Al-Swidi et al., 2024).
- Females: Excel in empathy, collaboration, and ethical reasoning (Biggs et al., 2001; Mattiello et al., 2024; UNDP, 2025; Durani, 2025).
- Males: More variability in digital and entrepreneurial skills, highlighting the importance of culturally and gender-adapted interventions (Mattiello, 2017; Mattiello and Domann, 2024).

Implication: Leadership programs must adapt to cultural and gender contexts for equitable competency development (Schwab, 2017; Mattiello et al., 2024; Saenz et al., 2025).

4.4 Qualitative Findings

4.4.1 Insights from expert interviews and focus groups highlighted

- Leadership gaps and competency validation: Persistent gaps in ethical reasoning, gender-sensitive leadership, and digital fluency (Mattiello and Domann, 2024; Mattiello et al., 2024; Doost Mohammadian, 2022).
- Contextual barriers: Cultural norms, limited access to interdisciplinary programs, and lack of mentorship constrained competency development (Mattiello, 2017; Schwab and Davis, 2018; Rüdiger et al., 2025).
- Skill transfer: Hands-on, experiential projects and AI-enhanced simulations improved practical application of strategic and entrepreneurial skills (Brynjolfsson and McAfee, 2014; Mattiello et al., 2024; Schiuma et al., 2024).

4.4.2 Youth perspectives

- Integrated curricula combining digital, ethical, and gender-sensitive components fostered confidence, teamwork, and innovation (Mattiello, 2017; Mattiello et al., 2024; Brooks et al., 2024).
- Deep, reflective learning approaches were perceived as more engaging and impactful than surface learning (Biggs et al., 2001; Mattiello, 2017; Jaccheri et al., 2021).
- Female participants reported enhanced empathy and collaboration; male participants acknowledged the value of gender-sensitive practices (Mattiello et al., 2024; UNDP, 2025; LSFI, 2023).

4.4.3 Thematic patterns

- Experiential learning drives competency: Project-based and AI-enhanced simulations produced higher perceived skill acquisition (Brynjolfsson and McAfee, 2014; Henderikx and Stoffers, 2023; Schiuma et al., 2024).
- Mentorship amplifies outcomes: Guidance from mentors and SME managers translates theoretical knowledge into actionable leadership capabilities (Mattiello and Domann, 2024; Mladenova et al., 2025; Held et al., 2025).
- Cultural context matters: Leadership development is strongly influenced by cultural norms, highlighting the need for cross-cultural adaptation (Schwab, 2016; Mattiello, 2017; Durani, 2025; Saenz et al., 2025).

4.4.4 Cross-cultural and gender-specific analysis

- Western youth: Confident in applying digital tools and ethical frameworks (Mattiello, 2017; Schwab and Davis, 2018; Mattiello et al., 2024; Mattiello and Mattiello and Wittberg, 2025; Mattiello 2025).
- Non-western youth: Highlight challenges in gender-inclusive leadership (Mattiello et al., 2024; Doost Mohammadian, 2022, 2023; Al-Swidi et al., 2024).
- Females: Emphasize collaboration and ethical reasoning as strengths (Mattiello et al., 2024; UNDP, 2025; Brooks et al., 2024).
- Males: Note difficulties in integrating gender-sensitive strategies (Biggs et al., 2001; Mattiello and Domann, 2024; Petrescu and Suciu, 2024).

Implication: Qualitative insights confirm that X.0-aligned programs require deep, experiential, and culturally-sensitive learning approaches to develop well-rounded, future-ready youth leaders, complementing quantitative YLXPI measures and supporting the hierarchical competency framework (Mattiello, 2017; Mattiello et al., 2024; Schwab, 2017; Doost Mohammadian, 2022, 2023).

5 Discussion

This study demonstrates that gender-sensitive, interdisciplinary, and ethically aligned leadership education is essential for preparing youth to navigate the X.0 wave, where human empathy, digital intelligence, and socio-technical awareness converge in Industry 5.0 and Society 6.0 (Mattiello, 2017; Mattiello et al., 2024). Using the X.0 framework, findings reveal that leadership development must move beyond equity rhetoric to strategic implementation, embedding deep learning, gender awareness, ethical fluency, and technological literacy as core competencies (Biggs et al., 2001; Schwab, 2017; Doost Mohammadian, 2023a–d; Mattiello and Domann, 2024).

5.1 Integration of X.0 competencies

YLXPI simulations and AI-enhanced scenario assessments confirmed that programs integrating mentorship, digital ethics, AI-driven learning, smart city literacy, and inclusivity achieve measurable leadership gains (Mattiello, 2017; Mattiello et al., 2024; Doost Mohammadian, 2023a–d; Doost Mohammadian and Rezaie, 2020a–b; Doost Mohammadian and Ghasabzadeh Langari, 2023a–b). Key observations include:

5.1.1 Western participants achieved slightly higher YLXPI scores (0.82) than non-Western participants (0.76), reflecting stronger integration of digital, ethical, and smart-system competencies.

5.1.2 Gender-balanced teams consistently outperformed single-gender groups, highlighting the organizational value of inclusive leadership and cross-functional collaboration.

These findings emphasize that X.0-aligned programs must embed smart urban, mobility, and IoT awareness, preparing youth to manage socio-technological systems, hybrid SMEs, and sustainable ecosystems (Doost Mohammadian, 2023a–d; Mattiello et al., 2022a–f; Mattiello et al., 2020a–c).

5.2 Key insights (what we learned)

5.2.1 Deep learning and gender:

- Female youth benefit more from deep, reflective learning, enhancing foresight, ethical agility, and leadership competency (Biggs et al., 2001; Mattiello et al., 2024).
- Male youth often require targeted interventions to overcome surface learning limitations, particularly in integrating digital fluency, IoT literacy, and smart system thinking (Mattiello, 2017; Doost Mohammadian, 2022a–b; Mattiello et al., 2020a–b).

5.2.2 Gender-sensitive pedagogy:

- Embedding empathy, collaboration, and ethical reasoning strengthens leadership impact and organizational performance while linking strategic education to SME growth, hybrid industries, and sustainable urban systems (Mattiello et al., 2024; Doost Mohammadian and Rezaie, 2020a–b; Mattiello and Domann, 2024).

5.2.3 Cross-cultural adaptation:

- Digital, ethical, and gender-sensitive competencies require context-specific tailoring, including IoT, AI, mobility, and clean energy literacy, to optimize leadership outcomes across diverse SME and urban contexts (Schwab, 2017; Mattiello and Domann, 2024; Doost Mohammadian, 2023a–d; Doost Mohammadian and Ghasabzadeh Langari, 2023a–b).

5.2.4 X.0 wave alignment:

- Structured integration of digital fluency, ethics, gender competence, and smart city literacy prepares youth for complex socio-technological transitions, including hybrid SMEs, clean urban mobility systems, and blue-green smart city frameworks (Mattiello, 2017; Doost Mohammadian, 2023a–d; Mattiello et al., 2022a–f).

5.2.5 Integrated leadership development:

- Cohesive curricula combining digital, ethical, sustainability, and strategic training with SME, IoT, and urban-mobility knowledge boost innovation, readiness, and global competitiveness (Mattiello et al., 2024; Doost Mohammadian, 2022a–b; Mattiello and Rezaie, 2020a–b).

5.3 Leadership challenges and strategic solutions

These challenges are reframed as "today's challenges and tomorrow's crises for future leaders," emphasizing the competencies youth must master in hybrid, digital, and sustainable systems (Mattiello, 2017; Mattiello et al., 2024; Doost Mohammadian, 2023a–d):

5.3.1 Be gender-sensitive, inclusive, and equity-driven.

5.3.2 Lead ethically, responsibly, and sustainably.

5.3.3 Remain adaptive, human-centered, digitally fluent, and IoT-literate.

5.3.4 Navigate social, environmental, technological, and SME/urban complexities with foresight.

Integrating these principles into curricula ensures that leadership development is not only reactive or responsive but truly anticipatory, preparing youth to navigate present complexities and proactively address future crises and opportunities (Mattiello, 2017; Mattiello et al., 2024; Doost Mohammadian, 2023a–d; Mattiello et al., 2022a–f).

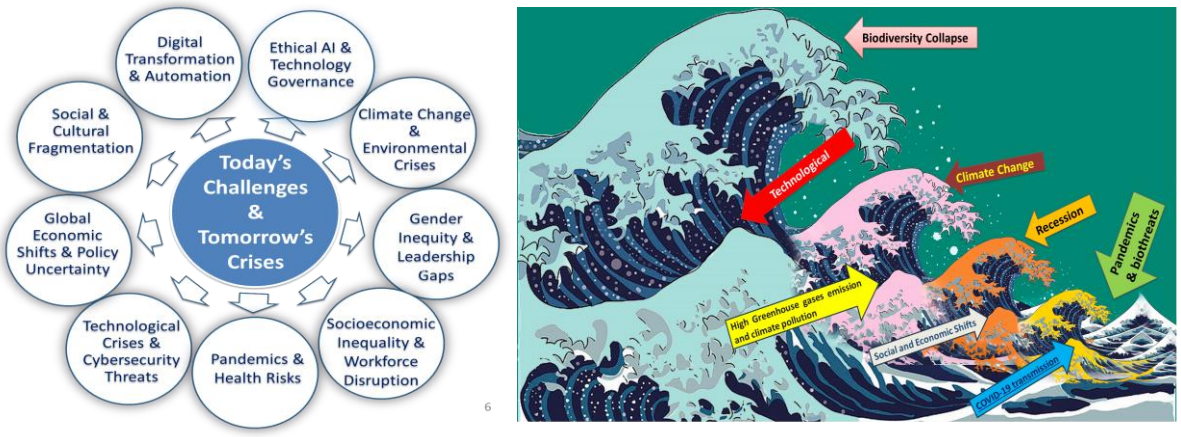

Figure4 Future leaders' challenges and crises (Source: Mattiello, 2010–present)

Table 10 summarizes the key challenges identified in developing youth X.0 leadership competencies and proposes strategic solutions to address them:

#	Challenges	Solutions
1	Surface learning & gender bias: shallow learning limits ethical agility and foresight, particularly among male youth	Promote deep learning to strengthen adaptive, ethical leadership (Biggs et al., 2001; Mattiello, 2017)
2	Cross-cultural variability: leadership readiness differs across gender norms and educational systems	Apply gender-sensitive pedagogy tailored to cultural and gender contexts (Schwab, 2017; Mattiello and Domann, 2024)
3	Weak digital–ethical integration: digital fluency and ethics often develop separately	Design cross-disciplinary curricula integrating AI, ethics, sustainability, and strategy (Brynjolfsson and McAfee, 2014; Mattiello et al., 2024)
4	Interdisciplinary gaps: STEM, business, and sustainability remain siloed	Encourage contextual adaptation to align education with local realities while maintaining X.0 relevance (Mattiello, 2017)
5	Limited gender competency focus: traditional curricula overlook inclusivity	Use simulation-based training to build ethical, collaborative, gender-aware leadership capacity (Mattiello et al., 2024)

Table 10 Challenges and strategic solutions for developing X.0 wave youth leadership (Source: Mattiello, 2010–present)

5.4 Strategic actions for future X.0 youth leaders

5.4.1 Educational and HR priorities include:

- Training smart tech specialists and fostering digital, IoT, and smart city literacy (Mattiello, 2017).
- Preparing youth for post-pandemic, hybrid workforces and sustainable SME ecosystems (Mattiello, 2017; Doost Mohammadian, 2022a–b).
- Strengthening talent development and succession planning (Mattiello, 2020; Mattiello et al., 2024; Mattiello, 2025).
- Integrating gender sensitivity, ethical governance, adaptability, human-centered approaches, and digital fluency (Mattiello et al., 2024).

5.4.2 Operationalization:

- Core gender-based competencies are structured into fundamental and advanced skill sets, aligned with X.0 wave stages, 7PS pillars, and SME/urban-mobility/IoT systems knowledge (Mattiello, 2010; Mattiello et al., 2024; Doost Mohammadian, 2023a–d).

#	Level	Competencies	Leadership impact
1	Fundamental	Digital fluency; ethical & sustainable leadership/ethical agility; entrepreneurial & strategic skills (EQ, PQ, CI); empathic intelligence	Navigate digital, ethical, and socio-technical complexity (Mattiello, 2019; Mattiello, 2020; Mattiello, 2021; Doost Mohammadian, 2023a–d)
2	Advanced	Gender competence/collaborative adaptability; strategic Foresight; sustainability orientation; entrepreneurial mindset	Drive inclusive, resilient, and sustainable strategy (Mattiello et al., 2024; Doost Mohammadian and Ghasabzadeh Langari, 2023a–b)

Table 11 Core gender-based competencies for future youth X.0 leaders (Source: Mattiello, 2017-2024)

5.4.3 Call to action

1. Integrate gender and ethics into leadership education (Mattiello, 2019; Mattiello, 2020; Mattiello, 2021; Doost Mohammadian, 2023a–d).
2. Promote deep, interdisciplinary learning experiences (Biggs et al., 2001).
3. Apply X.0 wave principles globally to bridge cultural divides (Mattiello, 2017-2025; Doost Mohammadian, 2017-2024; Schwab, 2017).
4. Prepare youth to anticipate and respond to socio-environmental and technological crises, ensuring they become resilient, visionary, and ethically responsible leaders (Mattiello et al., 2024).

5.5 Sustainability and innovation goals

#	Goal	Expected impact
1	Ensure sustainable business continuity	Digitally fluent, competent workforce (Mattiello, 2017; Doost Mohammadian, 2022a–b)
2	Modernize educational and business models	Resilient, innovative hybrid SMEs integrating AI, IoT, and mobility systems (Mattiello et al., 2022a–f)
3	Innovate inclusive business ecosystems	Stronger citizen services and sustainable economies through smart cities and Blue-Green frameworks (Doost Mohammadian, 2023a–d; Mattiello and Rezaie, 2020a–b)
4	Implement smart, ethical leadership strategies	Future-ready leaders via inclusive, AI-augmented and IoT-informed training (Brynjolfsson and McAfee, 2014; Mattiello et al., 2024)

Table 12 Sustainability and innovation objectives for future-ready leadership (Source: Mattiello, 2010-2024)

5.6 Implications for practice

Educators and institutions must reconceptualize leadership curricula as dynamic ecosystems integrating ethics, gender equity, digital fluency, IoT literacy, and smart-city/urban-mobility knowledge (Mattiello, 2017; Doost Mohammadian, 2023a–d). Reflection, mentorship, and simulation-based learning should become foundational tools for fostering adaptive, human-centered leaders capable of harmonizing technology with empathy and sustainability (Mattiello et al., 2024).

#	Core area	Key competencies	Leadership impact
1	Core skills	IoT, AI, ML, Automation, digital fluency	Navigate digital & socio-technical complexity (Mattiello, 2017; Doost Mohammadian, 2023a–d)
2	Strategic Foresight	Anticipate tech & business shifts	Guide resilient, adaptive organizations (Mattiello et al., 2024)
3	Ethical & inclusive leadership	Governance, privacy, sustainability	Ensure ethical, responsible decisions
4	HR & talent development	Build & coach future-ready workforce	Strengthen adaptive capacity & collaboration
5	Global competence	Cross-cultural, technological, economic navigation	Lead inclusively in global contexts
6	Human-centered innovation	User-centered, gender-sensitive tech adoption	Drive creative, ethical solutions (Mattiello, 2017; Doost Mohammadian, 2023a–d; Mattiello, et al., 2024)

Table 13 Core competencies for future-ready youth X.0 leaders (Source: Mattiello, 2017-2024)

6 Conclusion and Future Suggestions

Embedding gender-sensitive, ethical, and interdisciplinary competencies within the X.0 wave framework equips youth leaders to drive sustainable innovation, inclusive governance, and resilient, technology-enabled organizations and societies (Mattiello, 2017; Mattiello, Wittberg and Castro, 2022a; Mattiello, Wittberg, Castro and Langari, 2022a; Mattiello, Brüggemann, Castro and Bakhtiari, 2022; Mattiello, Castro, Merk and Shahhoseini, 2020; Mattiello, Wittberg, Castro and Bolandian, 2020; Mattiello and Rezaie, 2020; Mattiello, 2020; Mattiello, 2019; Mattiello, Alijani, Rahimi Moghaddam and Ameri, 2024; Toffler, 1991). Leveraging AI, immersive learning, and cross-cultural adaptation accelerates competency development and ensures readiness for Industry 5.0, Society 6.0, and beyond (Schwab, 2017; Brynjolfsson and McAfee, 2014). Despite robust mixed-method validation, cultural variation and subjective measurement of soft skills remain constraints, highlighting the need for continued empirical refinement (Mattiello, Wittberg and Castro, 2022b; Mattiello, Wittberg, Castro and Langari, 2022b).

6.1. Conclusion

6.1.1 Gender-based competencies as strategic enablers:

- Ethical agility, empathy, and collaborative adaptability enhance leadership effectiveness.
- Gender diversity is central to resilient, inclusive leadership (Mattiello, 2017; Mattiello, Wittberg and Castro, 2022c; Mattiello, Wittberg, Castro and Langari, 2022c; Mattiello, Brüggemann, Castro and Bakhtiari, 2022).

6.1.2 X.0 wave alignment:

Integration of digital, ethical, and interdisciplinary skills provides a structured roadmap to navigate complex socio-technical and ecological challenges (Mattiello, 2017; Mattiello and Rezaie, 2020; Mattiello, 2020; Mattiello, Alijani, Rahimi Moghaddam and Ameri, 2024).

6.1.3 Learning approaches:

- Deep, reflective, and strategy-oriented learning fosters competency acquisition.
- Surface learning, particularly among male youth, limits ethical, digital, and gender-sensitive development.

- Experiential learning, mentorship, and AI-enhanced simulations mitigate these gaps (Biggs et al., 2001; Mattiello, Castro, Merk and Shahhoseini, 2020; Mattiello, Wittberg, Castro and Bolandian, 2020; Mattiello, 2020; Mattiello, 2019).

6.1.4 Interdisciplinary and ethical integration:

Cohesive digital fluency, ethics, sustainability, and gender-aware leadership prepares youth to lead hybrid SMEs and global systems with foresight, problem-solving, and adaptability (Mattiello, Wittberg and Castro, 2022a; Mattiello, Wittberg, Castro and Langari, 2022a; Mattiello, Brüggemann, Castro and Bakhtiari, 2022).

6.1.5 Global and cultural relevance:

X.0 wave-aligned leadership is effective across diverse contexts, supporting a 'think globally, act regionally' approach to inclusive, technologically fluent leadership (Schwab, 2017; Mattiello, 2019).

6.2. Future directions and recommendations

6.2.1 Empirical validation:

Conduct longitudinal, mixed-method, and cross-cultural studies to confirm competency frameworks and sustained program impact (Mattiello, Wittberg and Castro, 2022b; Mattiello, Wittberg, Castro and Langari, 2022b).

6.2.2 AI and immersive learning:

Employ AI, VR, and simulations to accelerate acquisition of digital, ethical, and gender-sensitive competencies (Brynjolfsson and McAfee, 2014; Mattiello, Castro, Merk and Shahhoseini, 2020; Mattiello, Wittberg, Castro and Bolandian, 2020).

6.2.3 Intersectional leadership:

Examine how gender interacts with culture, socioeconomic status, and cognition to inform inclusive leadership development (Mattiello, 2017).

6.2.4 Post-human/transhuman preparedness:

Extend the X.0 wave model toward transhuman and post-human leadership paradigms ($X \geq 6.0$) (Toffler, 1991; Mattiello, 2017).

6.2.5 Policy and Curriculum Integration:

Embed X.0 wave-aligned frameworks in education, SME training, and leadership programs to ensure ethical, sustainable, and inclusive outcomes (Mattiello and Rezaie, 2020; Mattiello, 2020; Mattiello, Alijani, Rahimi Moghaddam and Ameri, 2024).

6.2.6 Assessment standardization:

Develop validated tools for measuring digital fluency, ethical agility, and gender-sensitive leadership impact (Mattiello, Brüggemann, Castro and Bakhtiari, 2022; Mattiello, 2017).

6.2.7 Global–regional balance:

Cultivate a global mindset while respecting local cultural and social contexts to optimize leadership effectiveness (Schwab, 2017; Mattiello, 2019).

6.3. Final summary:

By integrating digital fluency, gender awareness, ethical reasoning, and sustainability competencies into leadership development, youth leaders are empowered to navigate complex, socio-technical, and ecological systems. The X.0 wave framework provides a structured roadmap for cultivating inclusive, visionary, and ethically responsible leaders capable of shaping Industry 5.0, Society 6.0, and future socio-economic ecosystems (Mattiello, 2017; Mattiello, Wittberg and Castro, 2022a; Mattiello, Wittberg, Castro and Langari, 2022a; Mattiello, Brüggemann, Castro and Bakhtiari, 2022; Mattiello, Castro, Merk and Shahhoseini, 2020; Mattiello, Wittberg, Castro and Bolandian, 2020; Mattiello and Rezaie, 2020; Mattiello, 2020; Mattiello, 2019; Mattiello, Alijani, Rahimi Moghaddam and Ameri, 2024; Toffler, 1991).

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