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Configuring Sustainable AI-Assisted Citizenship: An fsQCA Study of the CAITIZEN Model

Configurando la ciudadanía sostenible asistida por IA: Un estudio fsQCA del modelo CAITIZEN

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ABSTRACT

Context. Artificial intelligence increasingly mediates learning, decision-making, creativity, and citizenship formation in higher education, requiring critical, ethical, fair, collaborative, and reflective capabilities for sustainable development and responsible human–AI interaction.

Problem. Previous CAITIZEN studies established its qualitative architecture and PLS-SEM relationships, but net effects do not reveal sufficient configurations or asymmetry. Which configurations of critical AI literacy (CAIL), ethical responsibility (EARB), fairness and data justice (AFDJ), human–AI collaboration (HAIC), and metacognitive prompting (MTPP) are sufficient for high versus low CAITIZEN?

Purpose. This study compares these configurations through a multidisciplinary sustainable-innovation perspective informed by the OECD Oslo Manual, primarily aligned with SDG 4 and complementarily with SDG 9.

Methodology. An fsQCA study used data collected from July to December 2025 in Jalisco, Mexico, from 511 higher-education students. Five ten-item conditions and the ten-item CAITIZEN outcome were calibrated using P5, 5.00, and P95. Necessity, sufficiency, coverage, consistency, core/peripheral roles, asymmetry, and robustness were assessed.

Theoretical and Practical Findings. No condition was necessary. Five configurations were sufficient for high CAITIZEN (coverage=.866; consistency=.917), while low CAITIZEN followed a distinct configuration (coverage=.600; consistency=.924). *Scientia* extends CAITIZEN toward a configurational theory of sustainable AI-assisted citizenship; *Praxis* provides alternative capability architectures for responsible AI education and sustainable innovation primarily aligned with SDG 4 and complementarily with SDG 9.

Originality. CAITIZEN integrates a multidisciplinary sustainable-innovation perspective with configurational analysis, revealing multiple pathways through combinations of human and technological capabilities.

Conclusions and Limitations. CAITIZEN is configurational, conjunctural, equifinal, and asymmetric. Its cross-sectional, non-probabilistic sample limits generalization and temporal inference, requiring replication to assess stability.

RESUMEN

Contexto. La inteligencia artificial media crecientemente el aprendizaje, la toma de decisiones, la creatividad y la formación ciudadana en la educación superior, requiriendo capacidades críticas, éticas, equitativas, colaborativas y reflexivas para el desarrollo sostenible y la interacción humano–IA responsable.

Problema. Estudios previos de CAITIZEN establecieron su arquitectura cualitativa y relaciones PLS-SEM, pero los efectos netos no revelan configuraciones suficientes ni asimetría. ¿Qué configuraciones de alfabetización crítica en IA (CAIL), responsabilidad ética (EARB), equidad y justicia de datos (AFDJ), colaboración humano–IA (HAIC) y prompting metacognitivo (MTPP) son suficientes para CAITIZEN alto versus bajo?

Propósito. Este estudio compara dichas configuraciones desde una perspectiva multidisciplinaria de innovación sostenible informada por el Manual de Oslo de la OCDE, alineado principalmente al ODS 4 y complementariamente al ODS 9.

Metodología. Un estudio fsQCA utilizó datos recopilados de julio a diciembre de 2025 en Jalisco, México, de 511 estudiantes de educación superior. Cinco condiciones de diez ítems y CAITIZEN como resultado de diez ítems fueron calibrados mediante P5, 5.00 y P95. Se evaluaron necesidad, suficiencia, cobertura, consistencia, condiciones centrales/periféricas, asimetría y robustez.

Hallazgos teóricos y prácticos. Ninguna condición fue necesaria. Cinco configuraciones fueron suficientes para CAITIZEN alto (cobertura=.866; consistencia=.917), mientras CAITIZEN bajo siguió una configuración distinta (cobertura=.600; consistencia=.924). *Scientia* extiende CAITIZEN hacia una teoría configuracional de ciudadanía sostenible asistida por IA; *Praxis* aporta arquitecturas alternativas de capacidades para educación responsable en IA e innovación sostenible alineada principalmente con el ODS 4 y complementariamente con el ODS 9.

Originalidad. CAITIZEN integra una forma multidisciplinaria de innovación sostenible y análisis configuracional mediante combinaciones de capacidades humanas y tecnológicas.

Conclusiones y limitaciones. CAITIZEN es configuracional, conjuntural, equifinal y asimétrico. Su diseño transversal y muestra no probabilística limitan la generalización; se requiere replicación para evaluar su estabilidad.

1. INTRODUCTION

Artificial intelligence (AI) increasingly shapes learning, decision-making, creativity, and citizenship in higher education. Its responsible adoption requires more than technical proficiency; it demands critical, ethical, fair, collaborative, and reflective capabilities enabling individuals to understand, evaluate, and interact responsibly with AI while supporting sustainable development across diverse educational, social, and technological contexts in increasingly interconnected higher education environments (Ng et al., 2021).

Within this context, CAITIZEN conceptualizes sustainable AI-assisted citizenship through Critical AI Literacy (CAIL), Ethical Awareness and Responsibility (EARB), Awareness of Fairness and Data Justice (AFDJ), Human–AI Creative Collaboration (HAIC), and Metacognitive Transparency in Prompting Practices (MTPP). Previous research established CAITIZEN’s qualitative architecture, providing the conceptual basis for examining these interconnected capabilities as an integrated framework for responsible AI-assisted citizenship development across diverse higher education contexts (Mejía-Trejo, 2025).

A methodological and theoretical gap nevertheless remains. Although subsequent PLS-SEM analysis established structural relationships among CAITIZEN capabilities, net effects cannot determine whether different combinations are sufficient for the same outcome or whether high and low CAITIZEN follow asymmetric patterns. Configurational analysis examines conjunction, equifinality, and causal asymmetry, revealing how multiple combinations of interdependent conditions can produce similar or contrasting outcomes (Pappas & Woodside, 2021).

Accordingly, this study applies fuzzy-set Qualitative Comparative Analysis (fsQCA) to identify alternative configurations sufficient for high and low CAITIZEN. This multidisciplinary approach integrates AI, education, ethics, data justice, human–AI collaboration, and metacognition within a sustainable-innovation perspective informed by the OECD/Eurostat (2018) Oslo Manual. The study examines configurations of human capabilities as enabling conditions for responsible AI-assisted citizenship in higher education. These configurations may inform the development of AI-enabled educational and social innovation; however, the study does not evaluate an implemented innovation and therefore does not classify the analyzed outcome as a product or business process innovation under the OECD/Eurostat Oslo Manual framework.

From a sustainable-development perspective, the study primarily aligns with SDG 4 (Quality Education) and complementarily with SDG 9 (Industry, Innovation and Infrastructure) through its focus on responsible AI capabilities in higher education and innovation-oriented capacity development (United Nations, 2015).

The study asks: Which configurations of CAIL, EARB, AFDJ, HAIC, and MTPP are sufficient for high CAITIZEN, and how do they differ for low CAITIZEN? It extends previous structural evidence toward a configurational explanation of sustainable AI-assisted citizenship and alternative capability architectures (Mejía-Trejo, 2026).

2. CONTEXT

Sustainable AI-assisted citizenship develops within an educational environment increasingly transformed by artificial intelligence (AI), digitalization, and human–technology interaction. These transformations create opportunities for learning, creativity, and participation while raising ethical, equity, and governance challenges. Accordingly, the CAITIZEN context is examined at global, international, and national/local levels (Miao & Holmes, 2023).

2.1. Global

Globally, AI is reshaping the capabilities required for education, employment, innovation, and participation. The *Future of Jobs Report 2025* identifies AI and big data among the fastest-growing skills while emphasizing analytical and creative thinking, technological literacy, resilience, and lifelong learning. Thus, AI proficiency increasingly combines technological knowledge with human capabilities for interpreting, evaluating, and responsibly using emerging technologies across increasingly complex educational, professional, and social environments worldwide (World Economic Forum [WEF], 2025).

Generative AI also raises challenges involving privacy, equity, human agency, transparency, and reliability. UNESCO advocates a human-centered approach that preserves human responsibility while developing competencies for understanding and using AI. Responsible AI education therefore requires critical and ethical capabilities alongside technological knowledge, consistent with sustainable AI-assisted citizenship (Miao & Holmes, 2023).

2.2.International

Internationally, digital transformation is reshaping educational systems while remaining heterogeneous. Digital technologies can support teaching, personalization, inclusion, assessment, and educational management but also introduce challenges concerning privacy, algorithmic bias, equity, interoperability, and governance. Digital transformation consequently involves not only technology adoption but changes in educational processes, institutional capabilities, and human–technology relationships, requiring educational institutions to develop strategies that integrate technological innovation with responsible, inclusive, and sustainable learning practices across diverse contexts (OECD, 2023).

Generative AI intensifies these challenges by requiring educational systems to balance opportunities for learning, creativity, and innovation against risks involving dependence, biased outputs, privacy, security, and reduced human agency. This environment highlights the relevance of integrating critical AI literacy, ethical responsibility, data justice, human–AI collaboration, and reflective prompting rather than approaching responsible AI use solely as technological competence, particularly as students increasingly incorporate generative AI into academic activities, decision-making, knowledge creation, and collaborative learning **processes** (Miao & Holmes, 2023). Within higher education, AI, data science, and natural language processing applications further illustrate how these technologies can support educational processes while raising challenges related to their responsible and sustainable implementation (Barenca-Sotelo et al., 2026).

2.3.National and Local

In Mexico, AI-assisted education develops within widespread digital connectivity. ENDUTIH 2024 reported that 83.1% of people aged six years and older used the Internet and 73.6% of households had Internet access. However, connectivity does not necessarily imply critical, ethical, fair, collaborative, and reflective capabilities for interacting responsibly with emerging technologies, making capability development an increasingly relevant educational challenge for responsible AI use (INEGI, 2025).

Jalisco represents a relevant setting because 260,303 students were enrolled in higher education in 2024. This substantial educational population establishes an environment potentially exposed to AI-supported learning and digital interaction, making the development of capabilities for responsible and sustainable human–AI interaction increasingly relevant within contemporary higher education environments increasingly shaped by emerging technologies and evolving digital learning practices (ASEJ, 2025).

Overall, these contextual levels converge on a common challenge: expanding AI access creates educational and innovation opportunities while requiring multidimensional human capabilities for responsible use. This environment supports examining CAITIZEN configurationally as a framework for sustainable AI-assisted citizenship and responsible educational innovation across diverse technological and learning environments worldwide (Mejía-Trejo, 2025).

3. LITERATURE REVIEW

Artificial intelligence (AI) in higher education has evolved from a predominantly technological issue toward a multidimensional educational phenomenon involving critical understanding, ethical judgment, fairness, human agency, creativity, and reflective interaction. Responsible AI adoption consequently requires more than access, technical proficiency, or frequency of use; it involves human capabilities that enable students to evaluate AI, preserve agency, recognize its social implications, and participate responsibly in increasingly AI-mediated educational environments (Bond et al., 2024).

Recent research on AI literacy reinforces this multidimensional perspective. The literature identifies competencies associated with recognizing AI, understanding how it operates, using and applying it, evaluating its outputs, creating with it, and navigating its ethical implications. These dimensions show that AI literacy combines technological, cognitive, evaluative, creative, and normative capabilities. Such conceptual expansion is particularly relevant to sustainable AI-assisted citizenship because it suggests that responsible interaction with AI depends on differentiated but potentially interconnected capabilities (Almatrafi et al., 2024). See **Table 1**.

Table 1. Conceptual Definition of the Conditions in the CAITIZEN Configurational Model

Condition	Conceptual meaning	Role in sustainable AI-assisted citizenship	Supporting literature
CAIL — Critical Artificial Intelligence Literacy	Capability to understand AI and critically examine its functioning, outputs, limitations, and implications.	Supports informed judgment by enabling users to evaluate AI-generated information, question outputs, recognize limitations, and determine appropriate reliance on AI.	Laupichler et al. (2023)
EARB — Ethical Awareness and Responsibility	Capability to recognize ethical implications and maintain human responsibility for AI-assisted activities.	Integrates privacy, transparency, accountability, autonomy, fairness, safety, and human agency into responsible AI-supported decisions and actions.	Yan et al. (2024)
AFDJ — Awareness of Fairness and Data Justice	Capability to recognize bias, unequal representation, opacity, and potentially discriminatory consequences in AI and data-driven systems.	Enables critical assessment of how AI systems distribute opportunities, risks, visibility, and consequences across individuals and social groups.	Archambault et al. (2024)
HAIC — Human–AI Creative Collaboration	Capability to collaborate with AI while preserving human agency, intentionality, judgment, and creative control.	Enables users to evaluate, modify, accept, or reject AI contributions while maintaining meaningful human participation in problem solving and knowledge creation.	Atchley et al. (2024)
MTPP — Metacognitive Transparency in Prompting Practices	Reflective and self-regulatory capability for planning, monitoring, evaluating, and revising interactions with generative AI.	Frames prompting as an iterative metacognitive process involving objectives, instructions, evaluation of responses, strategy revision, and appropriate reliance on AI.	Tankelevitch et al. (2024)

Source: Mejía-Trejo (2026)

Taken together, these capabilities suggest that responsible AI-assisted citizenship cannot be adequately represented by a homogeneous technological competency. Contemporary measurement research demonstrates considerable heterogeneity among AI-literacy scales and the dimensions they incorporate, reinforcing the multidimensional nature of AI-related competence. This heterogeneity supports examining whether critical literacy, ethical responsibility, fairness, collaboration, and metacognitive transparency can complement one another in different ways rather than assuming that every capability contributes independently and with equivalent importance (Lintner, 2024).

This multidimensional perspective also connects CAITIZEN with innovation for sustainable development. The Oslo Manual provides a framework for understanding innovation in terms of implemented new or improved arrangements that generate value. The present study does not

evaluate such implementation; rather, it examines human capabilities that may support responsible AI-enabled educational and social innovation. From this perspective, responsible AI-assisted citizenship can support educational and social innovation by strengthening the capabilities through which individuals interact critically, ethically, fairly, collaboratively, and reflectively with emerging technologies (OECD/Eurostat, 2018).

From a sustainable-development perspective, these capabilities align primarily with SDG 4 (Quality Education) and complementarily with SDG 9 (Industry, Innovation and Infrastructure), linking responsible AI capability development in higher education with education and innovation-oriented sustainable development (United Nations, 2015). A theoretical gap nevertheless remains concerning how these capabilities operate jointly. Conventional symmetric approaches are appropriate for estimating relationships and net effects among variables but do not by themselves determine whether alternative combinations of conditions can be sufficient for the same outcome. Configurational reasoning instead recognizes conjunctural causation, equifinality, and causal asymmetry, permitting multiple pathways toward an outcome and acknowledging that configurations associated with its absence need not constitute simple inversions of those associated with its presence (Douglas et al., 2020).

3.1. Design of the Measurement Instrument and Analytical Antecedent

The measurement instrument used in the present study was organized around six differentiated domains: CAIL, EARB, AFDJ, HAIC, MTPP, and CAITIZEN, each operationalized through ten items, for a total of 60 items measured on a seven-point Likert-type scale. The complete item wording, item-to-construct assignment, response scale, and coding are reported in Appendix A. The instrument corresponds to the CAITIZEN measurement framework previously documented by Mejía-Trejo (2026). Maintaining these capabilities as conceptually distinguishable constructs is consistent with contemporary AI-literacy assessment, which shows that AI competence cannot be inferred solely from technological use or self-perceived familiarity. Differentiated measurement is especially relevant for configurational analysis because the substantive identity of each condition must be preserved before determining how conditions combine in alternative sufficient configurations, while avoiding conceptual overlap that could obscure the distinct contribution and

configurational role of each capability within the analytical framework. This differentiation also enables the subsequent analysis to identify whether specific capabilities operate jointly, become dispensable, or assume different roles across alternative configurations associated with the same outcome. Preserving these conceptual boundaries is therefore essential for interpreting causal complexity without reducing the five conditions to interchangeable dimensions of a broader competence. It also provides a theoretically coherent basis for examining conjunction, equifinality, and asymmetry, allowing the configurational analysis to reveal how distinct capability profiles may support comparable levels of sustainable AI-assisted citizenship across heterogeneous educational contexts (Hornberger et al., 2023).

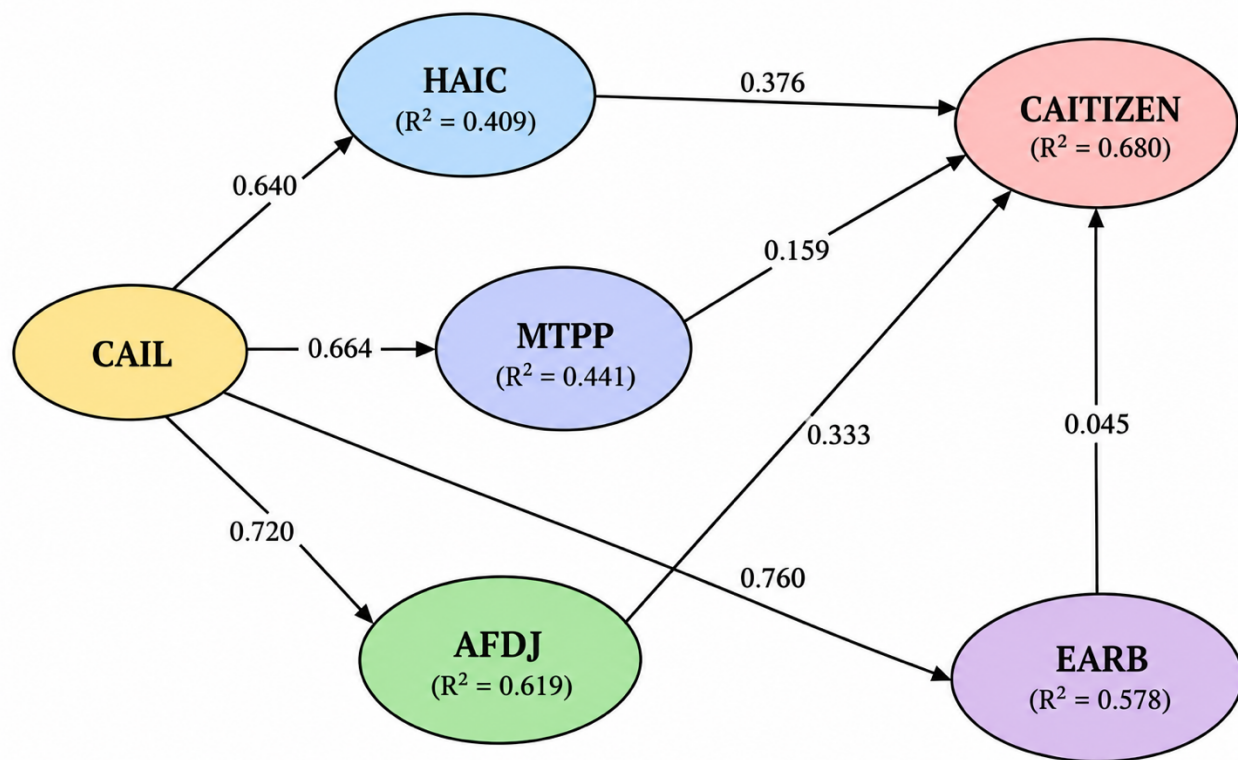
The measurement instrument used in the present study corresponds to the original 60-item CAITIZEN instrument previously documented by Mejía-Trejo (2026). It comprises six domains—CAIL, EARB, AFDJ, HAIC, MTPP, and CAITIZEN—with ten items assigned to each construct. The complete item wording, item-to-construct assignment, response scale, and coding are reproduced in Appendix A to ensure measurement traceability and reproducibility. The conceptual foundations and associated references were previously documented by Mejía-Trejo (2026).

The immediate empirical antecedent is the previous CAITIZEN PLS-SEM study. The literature and conceptual foundations underlying CAITIZEN were established in the previous CAITIZEN studies, which provide the documented basis for the five capability conditions examined here. The present study constitutes the configurational continuation of the CAITIZEN research trajectory. Two previous studies provide its direct conceptual and empirical antecedents: the first established the multidimensional CAITIZEN architecture, while the second examined the relationships among its capabilities using PLS-SEM. The present study extends this cumulative evidence through fsQCA to determine whether alternative capability configurations are sufficient for high and low CAITIZEN. Its final structural model established significant relationships from CAIL to EARB, AFDJ, HAIC, and MTPP and significant direct relationships from AFDJ, HAIC, and MTPP to CAITIZEN, whereas the direct EARB–CAITIZEN relationship was not statistically significant.

The **Figure 1** presents this final expost PLS-SEM model as the empirical point of departure for the present research. The previous analysis established the net-effect structural relationships among CAITIZEN capabilities but did not determine whether alternative combinations of these

capabilities are sufficient for high CAITIZEN or whether low CAITIZEN follows a different configurational structure, requiring examination of how these differentiated capabilities operate jointly across alternative pathways and potentially distinct patterns associated with the outcome, thereby extending net-effect analysis toward configurational understanding (Mejía-Trejo, 2026).

Figure 1. Final ex-post PLS-SEM structural model of CAITIZEN



Note. The figure presents the final structural relationships established in the previous PLS-SEM analysis and serves as the empirical antecedent for the configurational analysis developed in the present study. Adapted from Mejía-Trejo (2026).

Source: Mejía-Trejo (2026)

3.2. Configurational Conceptual Model

The present conceptual model changes the analytical perspective from net effects to configurations. CAIL, EARB, AFDJ, HAIC, and MTPP are conceptualized as interdependent conditions, whereas CAITIZEN constitutes the outcome. Unlike an additive model, the configurational perspective does not assume that every capability must be present, that all conditions independently contribute to the outcome, or that their relevance remains constant across

cases. Instead, a condition may become relevant when combined with particular capabilities while becoming peripheral or dispensable within another sufficient pathway (Pappas & Woodside, 2021).

This change in analytical perspective is theoretically important because limited net explanatory power does not necessarily imply configurational irrelevance. A capability that exhibits a weak or nonsignificant independent relationship with an outcome may nevertheless participate meaningfully when combined with other conditions. Consequently, configurational analysis complements rather than contradicts symmetric structural modeling: PLS-SEM explains net relationships among constructs, whereas fsQCA examines whether combinations of conditions constitute sufficient pathways toward the outcome (Fiss, 2011).

Accordingly, **P1—Conjunctural sufficiency** proposes that high CAITIZEN can be associated with combinations of CAIL, EARB, AFDJ, HAIC, and MTPP without requiring any single capability to be independently sufficient. Sustainable AI-assisted citizenship is therefore expected to depend on capability architectures rather than on one universally dominant condition. The relevance of a particular capability consequently depends partly on the other conditions with which it is combined (Misangyi et al., 2017).

P2—Equifinality proposes that more than one configuration can be sufficient for high CAITIZEN. Different combinations of critical literacy, ethical responsibility, fairness and data justice, human–AI collaboration, and metacognitive prompting may therefore be compatible with the same outcome. Equifinality provides a theoretical basis for expecting alternative capability architectures rather than a unique optimal profile of sustainable AI-assisted citizenship (Greckhamer et al., 2018).

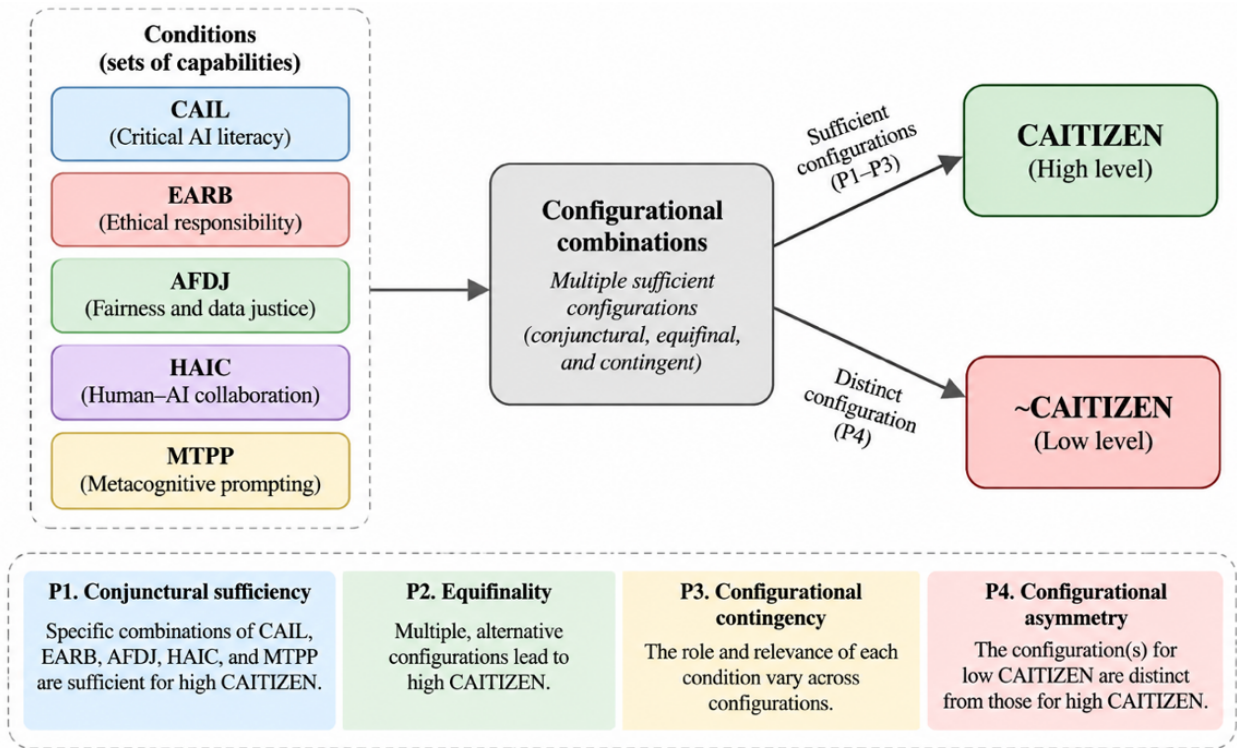
P3—Configurational contingency proposes that the relevance of each capability depends on the broader configuration in which it occurs. CAIL, EARB, AFDJ, HAIC, or MTPP may consequently assume different substantive roles across alternative pathways instead of maintaining a fixed level of importance throughout the model. This proposition avoids establishing an a priori universal hierarchy among the five conditions and allows the empirical analysis to determine their configurational relevance (Park et al., 2020).

Finally, **P4—Configurational asymmetry** proposes that configurations sufficient for low CAITIZEN are not necessarily simple inversions of those sufficient for high CAITIZEN. The

presence and absence of the outcome consequently constitute distinct configurational questions. This principle is important because the capability combinations supporting responsible and sustainable AI-assisted citizenship may differ qualitatively from the combinations associated with its absence, making separate analyses of CAITIZEN and $\sim$ CAITIZEN theoretically necessary (Thiem, 2022).

The resulting conceptual model treats CAIL, EARB, AFDJ, HAIC, and MTPP as a configurational capability space from which sufficient pathways toward CAITIZEN and $\sim$ CAITIZEN may emerge. Rather than predetermining configurations, these are established through necessity analysis, truth-table construction, Boolean minimization, sufficiency assessment, asymmetry analysis, and robustness testing, allowing capability combinations to be identified and interpreted across diverse patterns of cases, preserving the distinction between the ex-ante theoretical model and subsequent empirical fsQCA solutions (Ragin, 2008). Taken together, these propositions establish a coherent configurational rationale for examining sustainable AI-assisted citizenship as an outcome emerging from interdependent capability patterns. The model therefore emphasizes how capabilities operate jointly rather than in isolation, while preserving the possibility that different combinations may generate comparable outcomes. This perspective provides the theoretical basis for the subsequent fsQCA analysis and for interpreting alternative pathways to CAITIZEN and $\sim$ CAITIZEN, while maintaining consistency between the proposed configurational logic, the analytical procedures employed, and the interpretation of sufficient capability combinations across cases, without imposing a universal hierarchy among capabilities or assuming that identical combinations operate equivalently across heterogeneous educational contexts. This flexibility further recognizes contextual diversity while preserving theoretical coherence across alternative configurational explanations of sustainable AI-assisted citizenship. This adaptability strengthens the model's applicability across varied educational settings while preserving theoretical coherence, accommodating contextual diversity, and supporting context-sensitive interpretations of alternative configurational pathways through which interdependent capabilities may shape sustainable AI-assisted citizenship outcomes

Figure 2. Configurational conceptual model of CAITIZEN for fsQCA



Note: CAIL = Critical AI literacy; EARB = Ethical responsibility; AFDJ = Fairness and data justice; HAIC = Human-AI collaboration; MTPP = Metacognitive prompting. CAITIZEN and ~CAITIZEN are analyzed separately following the configurational asymmetry principle.

Source: Authors' elaboration.

4. METHODOLOGY

This study employed fuzzy-set Qualitative Comparative Analysis (fsQCA) to examine how Critical Artificial Intelligence Literacy (CAIL), Ethical Awareness and Responsibility (EARB), Awareness of Fairness and Data Justice (AFDJ), Human-AI Creative Collaboration (HAIC), and Metacognitive Transparency in Prompting Practices (MTPP) combine as conditions associated with high and low CAITIZEN. This approach is appropriate for examining causal complexity because it focuses on necessity and sufficiency, allows multiple configurations to be associated with the same outcome, and treats the configurations associated with the presence and absence of an outcome as potentially asymmetric rather than assuming linear, additive, or symmetric relationships among conditions.

4.1. Sample, Measurement, and Calibration

The study used a non-probabilistic purposive sampling procedure. Participants were undergraduate and graduate students enrolled at the University of Guadalajara, Jalisco, Mexico, who had previous experience using artificial intelligence tools. Data were collected through an online questionnaire administered via Google Forms between July and December 2025 and distributed through academic networks, institutional mailing lists, classroom groups, and online learning communities. Participation was voluntary, anonymous, and without compensation. The final analytical sample consisted of 511 undergraduate and graduate students enrolled at the University of Guadalajara, Jalisco, Mexico, who had previous experience using artificial intelligence tools. These 511 responses constituted the dataset used for the fsQCA analysis (Mejía-Trejo, 2026). The analytical model comprised five conditions—CAIL, EARB, AFDJ, HAIC, and MTPP—and CAITIZEN as the outcome. Each construct was operationalized using the ten corresponding items of the original 60-item CAITIZEN instrument documented by Mejía-Trejo (2026) and reproduced in Appendix A. Responses were measured on a seven-point Likert-type scale ranging from 1 = Strongly disagree to 7 = Strongly agree, and the fsQCA construct scores were calculated as the arithmetic mean of the ten originally administered items assigned to each construct. The resulting dataset therefore preserved the multidimensional capability structure established theoretically while enabling each construct to be transformed into fuzzy-set membership scores.

Direct calibration was performed using three anchors representing full non-membership, the crossover point, and full membership. The 5th percentile (P5) was used as the empirical anchor for full non-membership, 5.00 as the theoretical crossover point, and the 95th percentile (P95) as the empirical anchor for full membership. The resulting thresholds were 3.20/5.00/6.60 for CAIL, 3.25/5.00/6.70 for EARB, 3.60/5.00/6.85 for AFDJ, 3.50/5.00/7.00 for HAIC, 3.20/5.00/6.85 for MTPP, and 3.55/5.00/6.90 for CAITIZEN. This procedure transformed the original construct scores into degrees of membership ranging from 0 to 1, thereby enabling systematic comparison of cases according to their relative membership in each configurational condition and outcome while ensuring consistent calibration across all conditions and the outcome.

4.2. Configurational Analytical Procedure

The configurational analysis was conducted using fsQCA 4.1 software. The analytical procedure followed six sequential stages, consistent with established methodological procedures for fuzzy-set configurational analysis (Mejía-Trejo, 2023). First, the six constructs were calibrated into fuzzy sets. Second, necessity analysis examined the presence and absence of each condition for both CAITIZEN and $\sim$ CAITIZEN, using .90 as the reference consistency level for identifying potentially necessary conditions. Third, a truth table was constructed for the five causal conditions, producing 32 logically possible configurations. Fourth, configurations were evaluated using a frequency threshold of five cases, raw consistency $\geq .90$, and PRI consistency $\geq .75$ before Boolean minimization. Fifth, intermediate and parsimonious solutions were compared to identify configurational patterns and interpret core and peripheral conditions. Finally, CAITIZEN and $\sim$ CAITIZEN were analyzed separately, and robustness was assessed through alternative analytical specifications.

The analytical outputs supporting the intermediate solution, the analysis of $\sim$ CAITIZEN, and the two robustness analyses are reproduced in Appendix 2 (Figures A2.1–A2.4), providing direct traceability between the software outputs and the results reported below

5. RESULTS

This section presents the fsQCA results sequentially across five analytical stages, providing a systematic and comprehensive assessment of necessity, sufficiency, configurational patterns, asymmetry, and robustness across the proposed CAITIZEN capability conditions within the overall analytical framework and the study's configurational perspective on sustainable AI-assisted citizenship development. **Table 2** reports the necessary-condition analysis for high and low CAITIZEN; **Tables 3 and 4** compare the complex, parsimonious, and intermediate solutions and detail the sufficient configurations for high CAITIZEN; **Table 5** identifies the core and peripheral conditions across configurations; **Table 6** presents the configuration associated with low CAITIZEN and examines configurational asymmetry; and **Table 7** reports the robustness assessment of the high-CAITIZEN intermediate solution. Together, these results evaluate the **conjunctural, equifinal, contingent, and asymmetric structure of CAITIZEN**.

5.1. Analysis of Necessary Conditions

No individual condition, either in its presence or absence, reached the .90 consistency benchmark for necessity for high or low CAITIZEN. For high CAITIZEN, HAIC showed the highest necessity consistency (.889), followed by AFDJ (.852), MTPP (.823), EARB (.819), and CAIL (.784). Nevertheless, none exceeded the predefined necessity criterion. For low CAITIZEN, none of the corresponding absences reached the .90 threshold either. These findings indicate that no single CAITIZEN capability constitutes a necessary condition, supporting a configurational rather than single-condition explanation. See **Table 2**.

Table 2. Necessary-Condition Analysis for High and Low CAITIZEN

Outcome	Condition	Consistency	Coverage	Interpretation
CAITIZEN	CAIL	.784	.877	Not necessary
CAITIZEN	EARB	.819	.878	Not necessary
CAITIZEN	AFDJ	.852	.902	Not necessary
CAITIZEN	HAIC	.889	.889	Highest, but < .90
CAITIZEN	MTPP	.823	.894	Not necessary
~CAITIZEN	~CAIL	.803	.674	Not necessary
~CAITIZEN	~EARB	.795	.710	Not necessary
~CAITIZEN	~AFDJ	.835	.758	Not necessary
~CAITIZEN	~HAIC	.800	.800	Not necessary
~CAITIZEN	~MTPP	.825	.722	Not necessary

Note. A consistency threshold of .90 was used to identify potentially necessary conditions. No presence condition reaches this benchmark for high CAITIZEN, and no corresponding absence reaches it for low CAITIZEN. HAIC is the closest condition for high CAITIZEN (.889), but it cannot be classified as necessary.

Source: Authors' analysis using fsQCA, version 4.1 (Ragin & Davey, 2023).

5.2. Sufficient Configurations for High CAITIZEN

The sufficiency analysis proceeded by comparing the complex, parsimonious, and intermediate solutions, as reported in **Table 3**. The intermediate solution was retained as the principal basis for substantive interpretation because it balances empirical minimization with theoretically plausible directional expectations. It contains five terms, with solution coverage = .866 and solution consistency = .917. The complex solution also contains five terms (coverage = .839; consistency = .922), whereas the parsimonious solution contains three terms (coverage = .915; consistency = .857). The higher coverage of the parsimonious solution does not make it inherently superior because it relies on stronger simplifying assumptions.

Table 3. Comparison of Complex, Parsimonious, and Intermediate Solutions for High CAITIZEN

Solution	Number of terms	Solution coverage	Solution consistency	Role in interpretation
Complex	5	.839	.922	Conservative solution; no simplifying remainders
Parsimonious	3	.915	.857	Maximum logical simplification; supports identification of core conditions
Intermediate	5	.866	.917	Main substantive solution using theoretically plausible directional expectations

Note. The intermediate solution is emphasized because it balances empirical minimization with theoretically justified directional expectations. The three solutions should not be interpreted as a ranking from better to worse.

Source: Authors' analysis using fsQCA, version 4.1 (Ragin & Davey, 2023).

The five intermediate sufficient configurations are detailed in Table 4. They are C1: HAIC × AFDJ; C2: MTPP × HAIC × EARB; C3: MTPP × HAIC × CAIL; C4: HAIC × EARB × CAIL; and C5: MTPP × AFDJ × EARB × CAIL.

Table 4. Intermediate Sufficient Configurations for High CAITIZEN

Configuration	Sufficient pathway	Raw coverage	Unique coverage	Consistency	Interpretive justification
C1	HAIC × AFDJ	.794	.059	.940	Collaboration and fairness/data justice operate jointly
C2	MTPP × HAIC × EARB	.700	.010	.951	Reflective prompting, collaboration, and ethical responsibility operate jointly
C3	MTPP × HAIC × CAIL	.676	.009	.948	Metacognitive prompting and collaboration combine with critical AI literacy
C4	HAIC × EARB × CAIL	.685	.010	.943	Collaboration combines with ethical responsibility and critical AI literacy
C5	MTPP × AFDJ × EARB × CAIL	.643	.024	.959	Four capabilities jointly form a sufficient architecture without HAIC
Intermediate solution	Five alternative pathways	.866	—	.917	Overall configurational solution

Note. Raw coverage represents fuzzy-set empirical coverage and should not be interpreted as the percentage of the 511 cases belonging exclusively to each configuration. Configurations may overlap. C1 has the largest raw and unique coverage, whereas C5 has the highest consistency; these metrics do not establish a hierarchy among the five sufficient pathways.

Source: Authors' analysis using fsQCA, version 4.1 (Ragin & Davey, 2023).

Their consistency ranges from .940 to .959, while raw coverage ranges from .643 to .794. C1 exhibits the largest raw and unique coverage, whereas C5 presents the highest consistency. These differences describe the empirical properties of the pathways and should not be interpreted as a

ranking of superior configurations, because the configurations overlap. The original fsQCA output confirms these five terms and the overall intermediate solution coverage of .865837 and consistency of .917476 (see Appendix 2, Figure A2.1). Taken together, **Tables 3 and 4** provide empirical support for **P1—Conjunctural sufficiency** and **P2—Equifinality**. High CAITIZEN is associated with combinations rather than a single individually necessary condition, and five distinct sufficient configurations are associated with the same outcome. Furthermore, no condition is present in all five configurations, demonstrating that sustainable AI-assisted citizenship can be associated with alternative capability architectures.

5.3. Core and Peripheral Conditions

Comparison of the intermediate and parsimonious solutions allows conditions to be distinguished according to their core and peripheral roles within each configuration, as summarized in **Table 5**. AFDJ is core in C1; MTPP and EARB are core in C2; CAIL is core in C3 and C4; and MTPP, AFDJ, EARB, and CAIL are core in C5. MTPP is peripheral in C3, while EARB is peripheral in C4. HAIC occurs in four of the five configurations but remains peripheral in C1–C4 and is not specified in C5.

Table 5. Core and Peripheral Conditions in the Intermediate Solution

Condition	C1	C2	C3	C4	C5	Configurational reading
MTPP	—	●	•	—	●	Core in C2 and C5; peripheral in C3
HAIC	•	•	•	•	—	Peripheral in C1–C4
AFDJ	●	—	—	—	●	Core in C1 and C5
EARB	—	●	—	•	●	Core in C2 and C5; peripheral in C4
CAIL	—	—	●	●	●	Core in C3, C4, and C5

Note. ● = core presence; • = peripheral presence; — = condition not specified (“don’t care”). The dash does not indicate absence of the condition. Classification is performed configuration by configuration: conditions belonging to parsimonious terms contained in an intermediate configuration are classified as core; the remaining conditions specified in that intermediate configuration are classified as peripheral.

Source: Authors’ analysis using fsQCA, version 4.1 (Ragin & Davey, 2023).

The pattern reported in **Table 5** supports **P3—Configurational contingency**, because the role of each capability depends on the configuration in which it occurs. Particularly noteworthy is EARB: although its direct relationship with CAITIZEN was not statistically significant in the previous PLS-SEM model, EARB is a core condition in two sufficient configurations (C2 and C5) and a peripheral condition in C4. Thus, limited net explanatory power does not imply

configurational irrelevance. Similarly, HAIC recurs across four pathways but is neither individually necessary nor core in those configurations, demonstrating that recurrence across configurations should not be confused with necessity or core status.

5.4. Configuration for Low CAITIZEN and Asymmetry

The separate analysis of the negated outcome produced a markedly different configurational pattern. As is shown in **Table 6**, one restrictive **complex-solution configuration** was identified for low CAITIZEN:

$$\sim\text{MTPP} \times \sim\text{HAIC} \times \sim\text{AFDJ} \times \sim\text{EARB} \times \sim\text{CAIL} \rightarrow \sim\text{CAITIZEN}$$

This configuration reached raw coverage = .600, unique coverage = .600, and consistency = .924. The original fsQCA output reports the more precise values of .600427 for raw and unique coverage and .924165 for consistency (see Appendix 2, Figure A2.2).

Table 6. Causal Asymmetry: Configuration for Low CAITIZEN

Outcome	Complex-solution configuration	Raw coverage	Unique coverage	Consistency
$\sim\text{CAITIZEN}$	$\sim\text{MTPP} \times \sim\text{HAIC} \times \sim\text{AFDJ} \times \sim\text{EARB} \times \sim\text{CAIL}$	.600	.600	.924

Note. The configuration indicates the **joint absence of all five capabilities**. It does not imply that the absence of any single capability is individually necessary for low CAITIZEN.

Source: Authors' analysis using fsQCA, version 4.1 (Ragin & Davey, 2023).

The result in **Table 6** provides empirical support for **P4—Configurational asymmetry**. Whereas high CAITIZEN exhibits five alternative sufficient pathways, low CAITIZEN is associated with **one restrictive joint-absence configuration**. Consequently, the configurational structure of $\sim\text{CAITIZEN}$ is not simply the inverse of each high-CAITIZEN pathway. Explaining the presence of sustainable AI-assisted citizenship is therefore not equivalent to reversing the explanation of its absence.

5.5. Robustness

Finally, the stability of the high-CAITIZEN intermediate solution was examined under alternative analytical specifications to determine whether the identified configurational structure remained stable across reasonable variations in analytical thresholds and retained its substantive interpretability under more demanding decision rules and alternative empirical specifications. Two

complementary robustness analyses were conducted to assess the stability of the high-CAITIZEN intermediate solution under alternative analytical specifications. Robustness A assessed sensitivity to the frequency threshold by reducing the cutoff from ≥ 5 to ≥ 4 while maintaining raw consistency $\geq .90$ and $PRI \geq .75$. The same five intermediate pathways were retained, with solution coverage = .866 and solution consistency = .917 (see Appendix 2, Figure A2.3). Robustness B assessed sensitivity to the consistency threshold by maintaining the frequency cutoff at ≥ 5 and increasing raw consistency from $\geq .90$ to $\geq .95$, while maintaining $PRI \geq .75$. The same five intermediate pathways were retained, with solution coverage = .866 and solution consistency = .917 (see Appendix 2, Figure A2.4). Together, these analyses indicate that the substantive configurational solution remained stable under both the alternative frequency threshold and the more stringent raw-consistency criterion.

Table 7. Robustness of the High-CAITIZEN Intermediate Solution

Specification	Frequency threshold	Raw consistency rule	Retained intermediate pathways	Coverage	Consistency
Main model	≥ 5	$\geq .90 + PRI \geq .75$	Same five pathways	.866	.917
Robustness A	≥ 4	$\geq .90 + PRI \geq .75$	Same five pathways	.866	.917
Robustness B	≥ 5	$\geq .95 + PRI \geq .75$	Same five pathways	.866	.917

Note. Robustness refers here to **stability under alternative analytical specifications**. It should not be interpreted as evidence of external validity or causal identification.

Source: Authors' analysis using fsQCA, version 4.1 (Ragin & Davey, 2023).

Overall, **Tables 2–7** provide a coherent empirical sequence: **Table 2** establishes that no individual condition is necessary; **Tables 3 and 4** demonstrate conjunctural sufficiency and equifinality; **Table 5** reveals configurational contingency through changing core and peripheral roles; **Table 6** establishes asymmetry between high and low CAITIZEN; and **Table 7** assesses the stability of the principal intermediate solution. Collectively, the results indicate that CAITIZEN is configurational, conjunctural, equifinal, contingent, and asymmetric, providing the empirical basis for evaluating **P1–P4**.

6. DISCUSSION

This section critically interprets the configurational findings in relation to the CAITIZEN theoretical framework, previous net-effect evidence, and the multidisciplinary context of

innovation for sustainable development. It further examines how the identified capability architectures extend existing knowledge and contribute to understanding responsible human–AI interaction in higher education. Particular attention is given to how configurational relationships complement previous structural evidence, reveal alternative pathways toward the outcome, and provide a multidisciplinary basis for interpreting sustainable AI-assisted citizenship across diverse educational and technological contexts. The discussion is organized into two complementary dimensions. *Scientia* examines how the findings extend the understanding of sustainable AI-assisted citizenship through conjunction, equifinality, contingency, and asymmetry. *Praxis* considers how these findings inform strategies and capability-development interventions in AI-mediated higher education. In both dimensions, the results are interpreted in relation to critical AI literacy, ethical responsibility, fairness and data justice, human–AI collaboration, and metacognitive prompting rather than as technological competencies.

6.1. Theoretical Implications (*Scientia*)

The first theoretical contribution is that CAITIZEN is interpreted as a configurational capability architecture rather than an additive accumulation of independently indispensable capabilities. None of the five conditions reaches the .90 necessity threshold, while five distinct configurations are sufficient for high CAITIZEN. This finding supports the configurational premise that an outcome may emerge through conjunctions of conditions and multiple sufficient pathways rather than through a single universally necessary factor (Ragin, 2008). It also extends the multidimensional conception of AI literacy, which integrates technological, cognitive, evaluative, creative, and ethical competencies, by showing that these dimensions may acquire meaning through their combinations rather than only through their independent contributions (Almatrafi et al., 2024). The empirical evidence therefore supports P1—Conjunctural sufficiency and P2—Equifinality.

A second contribution emerges from the five alternative high-CAITIZEN architectures. HAIC × AFDJ associates collaborative human–AI interaction with fairness and data justice; MTPP × HAIC × EARB integrates reflective prompting, collaboration, and ethical responsibility; MTPP × HAIC × CAIL combines metacognition, collaboration, and critical AI literacy; HAIC × EARB

× CAIL connects collaboration, ethics, and critical understanding; and MTPP × AFDJ × EARB × CAIL forms a sufficient pathway without HAIC. These configurations are consistent with research that conceptualizes responsible AI engagement through differentiated capabilities involving critical understanding, ethical responsibility, fairness, human agency, collaboration, and reflective interaction (Laupichler et al., 2023). However, the present findings add a configurational relationship: these capabilities need not operate with identical relevance or appear simultaneously for high CAITIZEN to emerge.

The third theoretical contribution concerns configurational contingency and the complementarity between PLS-SEM and fsQCA. The previous CAITIZEN PLS-SEM model identifies significant direct relationships from AFDJ, HAIC, and MTPP to CAITIZEN, whereas the direct EARB–CAITIZEN relationship is not statistically significant (Mejía-Trejo, 2026). In the present configurational analysis, however, EARB is a core condition in C2 and C5 and a peripheral condition in C4. Conversely, HAIC appears in four of the five pathways but remains peripheral in those configurations and is irrelevant in C5. This comparison indicates **that** limited net explanatory power does not necessarily imply configurational irrelevance, while recurrence across configurations does not necessarily imply core status or necessity. The finding supports P3—Configurational contingency and reinforces the theoretical complementarity between symmetric and asymmetric approaches: PLS-SEM explains net structural relationships, whereas fsQCA identifies sufficient capability combinations (Fiss, 2011).

A fourth contribution derives from configurational asymmetry. High CAITIZEN is associated with five alternative pathways, whereas low CAITIZEN is associated with the joint absence of MTPP, HAIC, AFDJ, EARB, and CAIL. This result supports P4 because the configuration associated with ~CAITIZEN is not a simple inversion of each configuration associated with CAITIZEN. The finding is consistent with configurational theory, which treats the presence and absence of an outcome as analytically distinct phenomena (Thiem, 2022). Consequently, the development of sustainable AI-assisted citizenship and its absence are interpreted as structurally asymmetric configurational phenomena, rather than opposite points on a single additive continuum.

From a multidisciplinary perspective, these findings would extend CAITIZEN across the intersection of AI literacy, ethics, data justice, human–AI collaboration, metacognition, education, and innovation studies. The contribution does not imply the formation of a new scientific discipline; rather, it strengthens an interdisciplinary research space in which sustainable AI-assisted citizenship is examined as a system of complementary human and technological capabilities. This interpretation is informed by the Oslo Manual’s innovation framework (OECD/Eurostat, 2018); however, the present study does not evaluate an implemented innovation. Instead, its findings identify configurations of human capabilities with potential implications for responsible AI-enabled educational and social innovation. From an educational perspective, responsible AI development additionally requires a human-centered orientation that preserves human agency and responsibility (Miao & Holmes, 2023). It also aligns with evidence-based social innovation approaches linking citizen participation with sustainable development (Hernández-Rodríguez & Mora-Pérez, 2026).

The configurational perspective would therefore contribute to innovation for sustainable development primarily through SDG 4—Quality Education and complementarily through SDG 9—Industry, Innovation and Infrastructure, by providing a theoretical basis for developing responsible AI capabilities rather than treating technological adoption itself as the desired educational outcome (United Nations, 2015).

The fsQCA findings have potential relevance to innovation for sustainable development by identifying alternative configurations of human and technological capabilities associated with CAITIZEN, providing an evidence-based foundation for designing differentiated and responsible AI-enabled educational interventions aligned primarily with SDG 4 and complementarily with SDG 9. These patterns may inform context-sensitive educational strategies while recognizing diverse capability combinations, institutional conditions, and pathways toward responsible citizen engagement. Practical application requires assessing feasibility, contextual suitability, and educational outcomes before claiming sustainable development impacts.

6.2. Practical Implications (*Praxis*)

The principal practical implication is that higher-education institutions would not need to assume a single universal capability profile for developing sustainable AI-assisted citizenship. The five sufficient pathways suggest that educational interventions could be designed around alternative but coherent capability architectures. For example, initiatives could combine human–AI collaboration with fairness and data justice, integrate reflective prompting with ethical responsibility and collaboration, or combine critical AI literacy with ethical responsibility and metacognitive prompting. Such alternatives would allow institutions to adapt educational innovation to different curricular, disciplinary, technological, and student contexts while preserving the multidimensional character of responsible AI education.

This flexibility is particularly relevant within the contextual conditions described for higher education. Digital connectivity and AI access expand opportunities for learning and innovation, but connectivity alone does not ensure critical, ethical, fair, collaborative, or reflective AI use. In Mexico, widespread Internet use coexists with the need to develop capabilities for responsible interaction with emerging technologies (INEGI, 2025).

Jalisco provides a substantial higher-education environment in which these competencies become increasingly relevant, reinforcing the practical importance of capability development in the study context (ASEJ, 2025). Internationally, educational digitalization similarly creates opportunities while intensifying challenges concerning privacy, algorithmic bias, equity, interoperability, and governance (OECD, 2023).

The findings would also have implications for curriculum design, faculty development, AI-literacy programs, assessment, and institutional AI policies. Rather than organizing training exclusively around technical proficiency or prompt production, institutions could incorporate critical evaluation of AI outputs, ethical accountability, recognition of bias and unequal representation, preservation of human creative agency, and reflective monitoring of prompting practices. This approach is consistent with the multidimensional conception of responsible AI competence identified in the literature (Bond et al., 2024). Importantly, the configurations should not be interpreted as a ranking of educational strategies. Instead, they would provide **alternative**

evidence-based profiles that institutions could examine according to their educational context and objectives.

Finally, the low-CAITIZEN configuration has a preventive practical implication. Because low CAITIZEN is associated with the joint absence of all five capabilities, educational assessment would benefit from detecting multidimensional capability deficits rather than treating weakness in one isolated competency as sufficient evidence of low sustainable AI-assisted citizenship. Conversely, the findings do not establish that strengthening one particular capability independently would produce high CAITIZEN. Interventions would therefore be more consistent with the evidence when they promote coherent bundles of critical, ethical, fair, collaborative, and metacognitive capabilities. From a sustainable-development perspective, these educational capabilities may also contribute primarily to SDG 4 (Quality Education) and complementarily to SDG 9 (Industry, Innovation and Infrastructure) by strengthening responsible AI-related capabilities in higher education and innovation-oriented capacity development (United Nations, 2015).

7. CONCLUSION

This section concludes the study by integrating three elements: the response to the research question and propositions, the principal theoretical and practical findings, and the final scope and limitations of the research. The conclusion synthesizes how the configurational evidence extends previous CAITIZEN research from net-effect relationships toward a multidimensional explanation based on conjunction, equifinality, contingency, and asymmetry, while identifying the boundaries within which these findings are interpreted.

7.1. How the Research Question and Propositions Are Addressed

The research question asks which configurations of CAIL, EARB, AFDJ, HAIC, and MTPP are sufficient for high CAITIZEN and how they differ from those associated with low CAITIZEN. The results answer this question by identifying five sufficient configurations for high CAITIZEN and one distinct joint-absence configuration for low CAITIZEN. No individual capability is necessary. Accordingly, the evidence supports **P1—Conjunctural sufficiency, P2—Equifinality, P3—Configurational contingency, and P4—Configurational asymmetry**. The study therefore

establishes that CAITIZEN is better understood configurationally as a set of alternative capability **architectures** rather than as a single universal combination of independently indispensable conditions.

The originality of this contribution resides in extending the previous CAITIZEN research trajectory from its multidimensional conceptual architecture and PLS-SEM net relationships toward a configurational explanation. The previous structural model explains relationships among constructs, whereas the present study demonstrates how these differentiated capabilities combine through alternative sufficient pathways (Mejía-Trejo, 2025, 2026). This extension integrates education, AI literacy, ethics, data justice, human–AI collaboration, metacognition, and sustainable innovation, thereby reinforcing the multidisciplinary orientation of CAITIZEN and its relationship with innovation for sustainable development.

7.2. Research Findings

The principal *Scientia* finding is that sustainable AI-assisted citizenship exhibits configurational complexity. Five different capability combinations are sufficient for high CAITIZEN, no single condition is necessary, and the substantive role of a capability changes across configurations. Particularly, EARB is configurationally important despite its nonsignificant direct relationship in the previous PLS-SEM model, while HAIC is recurrent but peripheral rather than necessary. These findings demonstrate the added theoretical information obtained when net-effect analysis is complemented by configurational analysis (Fiss, 2011; Pappas & Woodside, 2021).

The principal *Praxis* finding is that responsible AI education would benefit from multiple coherent capability-development architectures rather than a uniform intervention model.

The configurations identify empirically sufficient capability profiles in the evaluated sample; their potential use for curriculum, institutional practice, or policy represents a practical implication to be tested rather than an intervention effect established by this study. Institutions could adapt combinations of critical literacy, ethical responsibility, fairness and data justice, human–AI collaboration, and metacognitive prompting to their educational contexts. At the same time, the joint-absence configuration associated with low CAITIZEN indicates the relevance of preventing simultaneous multidimensional capability deficits. These findings would provide a practical

foundation for curriculum development, AI-literacy initiatives, faculty development, and responsible AI policies oriented toward sustainable educational innovation.

These configurational findings provide a knowledge-based contribution with potential relevance to innovation for sustainable development, particularly by informing responsible and differentiated AI-enabled education through context-sensitive pathways that may guide future educational strategies, institutional initiatives, and empirical interventions across diverse higher education settings.

7.3. Final Scope of the Research

The scope of the findings is bounded by the study design. The analysis uses 511 complete cases from higher-education students in Jalisco, Mexico, collected between July and December 2025, and therefore represents this population and period rather than all higher-education contexts. The cross-sectional and non-probabilistic design limits statistical generalization and temporal inference, while fsQCA identifies empirically sufficient set-theoretic configurations but does not by itself establish experimental causality. The robustness results indicate specification stability of the principal intermediate solution under the reported analytical thresholds, but they do not constitute evidence of external validity.

Future research would therefore examine whether the identified configurations remain stable across other universities, regions, disciplines, educational levels, and longitudinal settings. Comparative studies could also integrate PLS-SEM and fsQCA across independent samples to examine whether net relationships and configurational patterns remain complementary under different institutional and technological conditions. In this sense, the present study closes one stage of CAITIZEN development while opening a research agenda in which sustainable AI-assisted citizenship is examined as a multidisciplinary, configurational, and context-sensitive capability architecture for responsible educational innovation and sustainable development.

8. REFERENCES

- Almatrafi, O., Johri, A., & Lee, H. (2024). A systematic review of AI literacy conceptualization, constructs, and implementation and assessment efforts (2019–2023). *Computers and Education Open*, 6, 100173.
<https://doi.org/10.1016/j.caeo.2024.100173>

- Archambault, S. G., Ramachandran, S., Acosta, E., & Fu, S. (2024). Ethical dimensions of algorithmic literacy for college students: Case studies and cross-disciplinary connections. *The Journal of Academic Librarianship*, 50(3), 102865.
<https://doi.org/10.1016/j.acalib.2024.102865>
- Auditoría Superior del Estado de Jalisco [ASEJ]. (2025). *Poder Ejecutivo del Estado de Jalisco 2024: Apartado desempeño*. Auditoría Superior del Estado de Jalisco.
https://www.asej.gob.mx/transparencia_asej/sites/default/files/informes_finales/Poder%20Ejecutivo%20del%20Estado%20de%20Jalisco%202024%20Apartado%20Desempe%C3%B1o.pdf
- Atchley, P., Pannell, H., Wofford, K., Hopkins, M., & Atchley, R. A. (2024). Human and AI collaboration in the higher education environment: Opportunities and concerns. *Cognitive Research: Principles and Implications*, 9, 20.
<https://doi.org/10.1186/s41235-024-00547-9>
- Barenca-Sotelo, C. U., Maciel-Arellano, M. del R., & Larios-Rosillo, V. M. (2026). Toward a sustainable innovation in the faculty evaluation process: A systematic review of AI, data science, and NLP applications in higher education. *Scientia et PRAXIS*, 6(11), 1–24.
<https://doi.org/10.55965/setp.6.11.a1>
- Bond, M., Khosravi, H., De Laat, M., Bergdahl, N., Negrea, V., Oxley, E., Pham, P., Chong, S. W., & Siemens, G. (2024). A meta systematic review of artificial intelligence in higher education: A call for increased ethics, collaboration, and rigour. *International Journal of Educational Technology in Higher Education*, 21, Article 4.
<https://doi.org/10.1186/s41239-023-00436-z>
- Douglas, E. J., Shepherd, D. A., & Prentice, C. (2020). Using fuzzy-set qualitative comparative analysis for a finer-grained understanding of entrepreneurship. *Journal of Business Venturing*, 35(1), 105970.
<https://doi.org/10.1016/j.jbusvent.2019.105970>
- Fiss, P. C. (2011). Building better causal theories: A fuzzy set approach to typologies in organization research. *Academy of Management Journal*, 54(2), 393–420.
<https://doi.org/10.5465/amj.2011.60263120>
- Greckhamer, T., Furnari, S., Fiss, P. C., & Aguilera, R. V. (2018). Studying configurations with qualitative comparative analysis: Best practices in strategy and organization research. *Strategic Organization*, 16(4), 482–495.
<https://doi.org/10.1177/1476127018786487>
- Hernández-Rodríguez, T. M., & Mora-Pérez, C. O. (2026). Gender, culture of peace, and citizen participation as evidence-based social innovation for sustainable governance. *Scientia et PRAXIS*, 6(11), 59–85. <https://doi.org/10.55965/setp.6.11.a3>
- Hornberger, M., Bewersdorff, A., & Nerdel, C. (2023). What do university students know about artificial intelligence? Development and validation of an AI literacy test. *Computers and Education: Artificial Intelligence*, 5, 100165.
<https://doi.org/10.1016/j.caeai.2023.100165>
- Instituto Nacional de Estadística y Geografía [INEGI]. (2025). *Encuesta Nacional sobre Disponibilidad y Uso de Tecnologías de la Información en los Hogares (ENDUTIH) 2024*. INEGI.
https://www.inegi.org.mx/contenidos/saladeprensa/boletines/2025/endutih/ENDUTIH_24.pdf

- Laupichler, M. C., Aster, A., Haverkamp, N., & Raupach, T. (2023). Development of the “Scale for the assessment of non-experts’ AI literacy” – An exploratory factor analysis. *Computers in Human Behavior Reports*, 12, 100338.
<https://doi.org/10.1016/j.chbr.2023.100338>
- Lintner, T. (2024). A systematic review of AI literacy scales. *npj Science of Learning*, 9, 50.
<https://doi.org/10.1038/s41539-024-00264-4>
- Mejía-Trejo, J. (2023). *Análisis cualitativo comparativo. Tomo II. Difuso (fsQCA): Teoría y práctica*. Academia Mexicana de Investigación y Docencia en Innovación (AMIDI).
<https://doi.org/10.55965/abib.2023.9786075956756>
- Mejía-Trejo, J. (2025). Innovating sustainable artificial intelligence citizenship: A qualitative study of the CAITIZEN model using ATLAS.ti. *Scientia et PRAXIS*, 5(10), 126–154.
<https://doi.org/10.55965/setp.5.10.a5>
- Mejía-Trejo, J. (2026). Extended CAITIZEN: A PLS-SEM study of sustainable AI-assisted citizenship innovation. *Scientia et PRAXIS*, 6(11), 86–118.
<https://doi.org/10.55965/setp.6.11.a4>
- Miao, F., & Holmes, W. (2023). *Guidance for generative AI in education and research*. UNESCO.
<https://unesdoc.unesco.org/ark:/48223/pf0000386693>
- Misangyi, V. F., Greckhamer, T., Furnari, S., Fiss, P. C., Crilly, D., & Aguilera, R. V. (2017). Embracing causal complexity: The emergence of a neo-configurational perspective. *Journal of Management*, 43(1), 255–282.
<https://doi.org/10.1177/0149206316679252>
- Ng, D. T. K., Leung, J. K. L., Chu, S. K. W., & Qiao, M. S. (2021). AI literacy: Definition, teaching, evaluation and ethical issues. *Proceedings of the Association for Information Science and Technology*, 58(1), 504–509.
<https://doi.org/10.1002/pra2.487>
- OECD/Eurostat. (2018). *Oslo manual 2018: Guidelines for collecting, reporting and using data on innovation* (4th ed.). OECD Publishing.
<https://doi.org/10.1787/9789264304604-en>
- OECD. (2023). *OECD digital education outlook 2023: Towards an effective digital education ecosystem*. OECD Publishing.
<https://doi.org/10.1787/c74f03de-en>
- Pappas, I. O., & Woodside, A. G. (2021). Fuzzy-set qualitative comparative analysis (fsQCA): Guidelines for research practice in information systems and marketing. *International Journal of Information Management*, 58, 102310.
<https://doi.org/10.1016/j.ijinfomgt.2021.102310>
- Park, Y. K., Fiss, P. C., & El Sawy, O. A. (2020). Theorizing the multiplicity of digital phenomena: The ecology of configurations, causal recipes, and guidelines for applying QCA. *MIS Quarterly*, 44(4), 1493–1520.
<https://doi.org/10.25300/MISQ/2020/13879>
- Ragin, C. C. (2008). *Redesigning social inquiry: Fuzzy sets and beyond*. University of Chicago Press.
<https://doi.org/10.7208/chicago/9780226702797.001.0001>

- Ragin, C. C., & Davey, S. (2023). *fsQCA* (Versión 4.1) [Software]. University of California, Irvine. <https://sites.socsci.uci.edu/~cragin/fsQCA/software.shtml>
- Tankelevitch, L., Kewenig, V., Simkute, A., Scott, A. E., Sarkar, A., Sellen, A., & Rintel, S. (2024). The metacognitive demands and opportunities of generative AI. In *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems* (Article 680, pp. 1–24). Association for Computing Machinery. <https://doi.org/10.1145/3613904.3642902>
- Thiem, A. (2022). Beyond the facts: Limited empirical diversity and causal inference in qualitative comparative analysis. *Sociological Methods & Research*, 51(2), 527–540. <https://doi.org/10.1177/0049124119882463>
- United Nations. (2015). *Transforming our world: The 2030 Agenda for Sustainable Development*. <https://sdgs.un.org/2030agenda>
- World Economic Forum. (2025). *The future of jobs report 2025*. <https://www.weforum.org/publications/the-future-of-jobs-report-2025/>
- Yan, L., Sha, L., Zhao, L., Li, Y., Martinez-Maldonado, R., Chen, G., Li, X., Jin, Y., & Gašević, D. (2024). Practical and ethical challenges of large language models in education: A systematic scoping review. *British Journal of Educational Technology*, 55(1), 90–112. <https://doi.org/10.1111/bjet.13370>

Appendix A

CAITIZEN Measurement Instrument and Item-to-Construct Assignment

Construct	Code	Item
CAIL. Critical Artificial Intelligence Literacy	CAIL1	I understand how artificial intelligence systems transform data into patterns or predictions.
CAIL. Critical Artificial Intelligence Literacy	CAIL2	I distinguish among the main types of artificial intelligence, such as predictive, generative, and autonomous AI, and their applications.
CAIL. Critical Artificial Intelligence Literacy	CAIL3	I understand how the clarity and precision of a prompt influence AI-generated responses.
CAIL. Critical Artificial Intelligence Literacy	CAIL4	I identify the technical limitations and margins of error of the AI models I use.
CAIL. Critical Artificial Intelligence Literacy	CAIL5	I detect when an AI-generated output contains bias or unsupported inferences.
CAIL. Critical Artificial Intelligence Literacy	CAIL6	I verify AI-generated information by comparing it with reliable academic or human sources.
CAIL. Critical Artificial Intelligence Literacy	CAIL7	I recognize when a decision should be made by a person rather than by an algorithm.
CAIL. Critical Artificial Intelligence Literacy	CAIL8	I analyze the ethical implications of using AI in teaching, research, and institutional management.
CAIL. Critical Artificial Intelligence Literacy	CAIL9	I identify when an AI application may violate privacy, equity, or digital rights.
CAIL. Critical Artificial Intelligence Literacy	CAIL10	I promote the responsible, transparent, and traceable use of AI in my professional or academic environment.
EARB. Ethical Awareness and Responsibility	EARB1	I explicitly declare when and how I use artificial intelligence in my academic work to maintain transparency and personal responsibility.
EARB. Ethical Awareness and Responsibility	EARB2	Before using AI, I analyze possible ethical risks, such as bias, privacy, authorship, or misinformation, and how to prevent them.
EARB. Ethical Awareness and Responsibility	EARB3	I respect privacy and data protection when using AI tools by avoiding the disclosure of sensitive information.
EARB. Ethical Awareness and Responsibility	EARB4	I avoid applying AI in ways that may cause harm, exclusion, or misinformation in my academic environment.
EARB. Ethical Awareness and Responsibility	EARB5	I encourage my peers to use AI ethically, transparently, and responsibly as a practice of academic integrity.
EARB. Ethical Awareness and Responsibility	EARB6	I take responsibility for AI-generated outputs in my academic activities and correct errors derived from their use.
EARB. Ethical Awareness and Responsibility	EARB7	I evaluate the social effects of the AI I use, considering equity, inclusion, and sustainability.
EARB. Ethical Awareness and Responsibility	EARB8	I recognize that academic products must preserve human authorship, using AI only as technical or creative support.
EARB. Ethical Awareness and Responsibility	EARB9	I reject using AI to plagiarize, falsify, or impersonate my own or others' academic work.
EARB. Ethical Awareness and Responsibility	EARB10	I promote transparency and the common good in the use of AI, ensuring that its benefits are shared equitably.
AFDJ. Awareness of Fairness and Data Justice	AFDJ1	I recognize that limited or homogeneous datasets may generate unfair algorithmic decisions.
AFDJ. Awareness of Fairness and Data Justice	AFDJ2	I consider external auditing of algorithms necessary to detect and correct bias.
AFDJ. Awareness of Fairness and Data Justice	AFDJ3	I value AI systems making public the criteria they use to make decisions.
AFDJ. Awareness of Fairness and Data Justice	AFDJ4	I believe that including cultural and gender diversity in development teams improves algorithmic fairness.
AFDJ. Awareness of Fairness and Data Justice	AFDJ5	I identify the importance of continuously supervising AI models to prevent discrimination.
AFDJ. Awareness of Fairness and Data Justice	AFDJ6	I consider it essential for educational institutions to establish policies to evaluate algorithmic justice.
AFDJ. Awareness of Fairness and Data Justice	AFDJ7	I observe that imbalance in data representation can affect a system's accuracy and impartiality.
AFDJ. Awareness of Fairness and Data Justice	AFDJ8	I defend people's right to know the variables that influence an algorithm's decisions.
AFDJ. Awareness of Fairness and Data Justice	AFDJ9	I consider transparency in the origin and processing of data to be key for equity in AI.
AFDJ. Awareness of Fairness and Data Justice	AFDJ10	I support the publication of institutional reports on detected biases and improvements implemented in educational algorithms.
HAIC. Human-AI Creative Collaboration	HAIC1	I use AI as a starting point to generate ideas that I later develop personally.
HAIC. Human-AI Creative Collaboration	HAIC2	I combine my own contributions with AI suggestions to create more innovative outcomes.

Construct	Code	Item
HAIC. Human–AI Creative Collaboration	HAIC3	I analyze how AI responses influence my creative process.
HAIC. Human–AI Creative Collaboration	HAIC4	I learn new ways of solving problems when interacting with AI.
HAIC. Human–AI Creative Collaboration	HAIC5	I consider AI a creative partner that complements my human abilities.
HAIC. Human–AI Creative Collaboration	HAIC6	Collaboration with AI inspires new perspectives or approaches that I would not have had alone.
HAIC. Human–AI Creative Collaboration	HAIC7	I use AI to experiment with different creative styles or solutions.
HAIC. Human–AI Creative Collaboration	HAIC8	I reflect on how my work improves through interaction with AI.
HAIC. Human–AI Creative Collaboration	HAIC9	I adjust AI proposals to align them with my own creative vision or purpose.
HAIC. Human–AI Creative Collaboration	HAIC10	In creative projects, I combine my human decisions with AI's generative capabilities to achieve original outcomes.
MTTP. Metacognitive Transparency in Prompting Practices	MTTP1	I systematically record the prompts I use in order to learn from my own process.
MTTP. Metacognitive Transparency in Prompting Practices	MTTP2	I adjust my prompts when I detect that AI responses do not meet my learning objectives.
MTTP. Metacognitive Transparency in Prompting Practices	MTTP3	I analyze changes in AI responses to understand how my requests affect the results.
MTTP. Metacognitive Transparency in Prompting Practices	MTTP4	I reflect on the clarity and precision of my prompts before submitting them.
MTTP. Metacognitive Transparency in Prompting Practices	MTTP5	I document the reasoning I follow when modifying a prompt or interpreting a response.
MTTP. Metacognitive Transparency in Prompting Practices	MTTP6	I compare different versions of the same prompt to identify which one produces more useful results.
MTTP. Metacognitive Transparency in Prompting Practices	MTTP7	I evaluate whether my prompting strategies contribute to a deeper understanding of the topic.
MTTP. Metacognitive Transparency in Prompting Practices	MTTP8	I plan the structure and purpose of the prompt before beginning my interaction with AI.
MTTP. Metacognitive Transparency in Prompting Practices	MTTP9	I review the coherence between my initial objectives and the results obtained from AI.
MTTP. Metacognitive Transparency in Prompting Practices	MTTP10	At the end of the activity, I reflect on what I learned from the process of interacting with AI.
CAITIZEN. AI-assisted Sustainable Citizenship	CAITIZEN1	I identify myself as part of a society that coexists daily with artificial intelligence.
CAITIZEN. AI-assisted Sustainable Citizenship	CAITIZEN2	I consider it important to understand how AI influences my rights and responsibilities as a citizen.
CAITIZEN. AI-assisted Sustainable Citizenship	CAITIZEN3	I believe that everyone should participate in public decisions related to the use of AI.
CAITIZEN. AI-assisted Sustainable Citizenship	CAITIZEN4	I am interested in AI being used transparently by governments and institutions.
CAITIZEN. AI-assisted Sustainable Citizenship	CAITIZEN5	I think that access to AI knowledge is a form of citizen empowerment.
CAITIZEN. AI-assisted Sustainable Citizenship	CAITIZEN6	I am concerned that AI may reinforce inequalities if inclusive policies are not implemented.
CAITIZEN. AI-assisted Sustainable Citizenship	CAITIZEN7	I trust that informed citizenship can guide the ethical development of AI.
CAITIZEN. AI-assisted Sustainable Citizenship	CAITIZEN8	I am willing to learn continuously in order to adapt to an AI-driven society.
CAITIZEN. AI-assisted Sustainable Citizenship	CAITIZEN9	I believe that being a citizen in the AI era implies actively collaborating in its regulation and oversight.
CAITIZEN. AI-assisted Sustainable Citizenship	CAITIZEN10	I value the importance of combining technological innovation with collective responsibility and social sustainability.

Notes. CAIL = Critical Artificial Intelligence Literacy; EARB = Ethical Awareness and Responsibility; AFDJ = Awareness of Fairness and Data Justice; HAIC = Human–AI Creative Collaboration; MTTP = Metacognitive Transparency in Prompting Practices; CAITIZEN = AI-assisted Sustainable Citizenship.

Scale/coding. All items were measured using a seven-point Likert-type scale: 1 = Strongly Disagree; 2 = Disagree; 3 = Somewhat Disagree; 4 = I do not know; 5 = Somewhat Agree; 6 = Agree; and 7 = Strongly Agree.

Instrument source. The complete measurement instrument, including its conceptual foundations and associated references, was previously documented in Mejía-Trejo (2026). The 60 items reproduced in this appendix correspond to the original instrument administered in the present study.

CAIL2 traceability. CAIL2 is included because it formed part of the original 60-item instrument administered. It was subsequently removed during PLS-SEM measurement-model purification to improve the construct's AVE; therefore, the final PLS-SEM measurement model retained 59 indicators.

Source basis. Extracted from Table 2 of Mejía-Trejo (2026), *Extended CAITIZEN: A PLS-SEM Study of Sustainable AI-Assisted Citizenship Innovation*. The appendix preserves the complete 60-item instrument originally administered.

Appendix 2. fsQCA Analytical Outputs and Robustness Evidence

This appendix presents the original fsQCA 4.1 outputs supporting the intermediate solution for CAITIZEN, the solution for ~CAITIZEN, and the robustness analyses under alternative analytical specifications. These outputs provide direct analytical traceability for the configurational results reported in the study.

Figure A2.1. fsQCA 4.1 intermediate solution for CAITIZEN.

TRUTH TABLE ANALYSIS

File: /Users/juanmejiaatrejo/Desktop/XXXXCATIZEN.fsQCA/CAITIZEN.FSQCA.CALIBRADO.csv
Model: fCAITIZEN = f(fMTPP, fHAIC, fAFDJ, fEARB, fCAIL)
Algorithm: Quine-McCluskey

--- INTERMEDIATE SOLUTION ---

consistency cutoff: 0.953457

Assumptions:

fMTPP (present)
fHAIC (present)
fAFDJ (present)
fEARB (present)
fCAIL (present)

	raw coverage	unique coverage	consistency
fHAIC*fAFDJ	0.793591	0.0588129	0.94048
fMTPP*fHAIC*fEARB	0.699844	0.00995964	0.951037
fMTPP*fHAIC*fCAIL	0.67627	0.00858903	0.947755
fHAIC*fEARB*fCAIL	0.685286	0.0102034	0.942724
fMTPP*fAFDJ*fEARB*fCAIL	0.643012	0.023726	0.958547
solution coverage:	0.865837		
solution consistency:	0.917476		

Source: Authors' analysis using fsQCA 4.1.

Figure A2.2. fsQCA 4.1 solution for the negation of CAITIZEN (~CAITIZEN).

```
*****
*TRUTH TABLE ANALYSIS*
*****

File: /Users/juanmejiaatrejo/Desktop/XXXXCATIZEN.fsQCA/CAITIZEN.FSQCA.CALIBRADO.csv
Model: ~fCAITIZEN = f(fMTPP, fHAIC, fAFDJ, fEARB, fCAIL)
Algorithm: Quine-McCluskey

--- COMPLEX SOLUTION ---
frequency cutoff: 5
consistency cutoff: 0.924165

              raw      unique
              coverage  coverage  consistency
              -----  -
~fMTPP*~fHAIC*~fAFDJ*~fEARB*~fCAIL  0.600427  0.600427  0.924165
solution coverage: 0.600427
solution consistency: 0.924165
```

Source: Authors' analysis using fsQCA 4.1.

Figure A2.3. fsQCA 4.1 robustness analysis with frequency cutoff = 4

```
*****
*TRUTH TABLE ANALYSIS*
*****

File: /Users/juanmejiaatrejo/Desktop/XXXXCATIZEN.fsQCA/CAITIZEN.FSQCA.CALIBRADO.csv
Model: fCAITIZEN = f(fMTPP, fHAIC, fAFDJ, fEARB, fCAIL)
Algorithm: Quine-McCluskey

--- INTERMEDIATE SOLUTION ---
frequency cutoff: 4
consistency cutoff: 0.953457
Assumptions:
fMTPP (present)
fHAIC (present)
fAFDJ (present)
fEARB (present)
fCAIL (present)

              raw      unique
              coverage  coverage  consistency
              -----  -
fHAIC*fAFDJ  0.793591  0.0588126  0.94048
fMTPP*fHAIC*fEARB  0.699844  0.00995946  0.951037
fMTPP*fHAIC*fCAIL  0.676271  0.00858903  0.947755
fHAIC*fEARB*fCAIL  0.685286  0.0102034  0.942724
fMTPP*fAFDJ*fEARB*fCAIL  0.643012  0.0237263  0.958547
solution coverage: 0.865836
solution consistency: 0.917476
```

Source: Authors' analysis using fsQCA 4.1

Figure A2.4. fsQCA 4.1 robustness analysis with raw consistency cutoff = .95.

 TRUTH TABLE ANALYSIS

File: /Users/juanmejiatrejo/Desktop/1.CATIZEN.fsQCA/ANTECEDENTES/
 CAITIZEN.FSQCA.CALIBRADO.csv
 Model: fCAITIZEN = f(fMTPP, fHAIC, fAFDJ, fEARB, fCAIL)
 Algorithm: Quine-McCluskey

--- INTERMEDIATE SOLUTION ---
 frequency cutoff: 5
 consistency cutoff: 0.953457
 Assumptions:
 fMTPP (present)
 fHAIC (present)
 fAFDJ (present)
 fEARB (present)
 fCAIL (present)

	raw coverage	unique coverage	consistency
fHAIC*fAFDJ	0.793591	0.0588126	0.94048
fMTPP*fHAIC*fEARB	0.699844	0.00995946	0.951037
fMTPP*fHAIC*fCAIL	0.676271	0.00858903	0.947755
fHAIC*fEARB*fCAIL	0.685286	0.0102034	0.942724
fMTPP*fAFDJ*fEARB*fCAIL	0.643012	0.0237263	0.958547
solution coverage:	0.865836		
solution consistency:	0.917476		

Note: After applying the .95 raw-consistency threshold, fsQCA reported an effective consistency cutoff of .953457. The intermediate solution retained five configurations, with solution coverage = .865836 and solution consistency = .917476.

Source: Authors' analysis using fsQCA 4.1



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