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A Review of Higher Education Artificial Intelligence Frameworks to Empower Industrial & Sustainable Competitiveness in the Global South

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Abstract: The Fifth Industrial Revolution is uniquely characterized by a paradigm shift towards Artificial Intelligence (AI) and Machine Learning (ML), rapidly and fundamentally altering the Industry 5.0 skillsets landscape. To combat workforce deficiencies, Higher Education (HEIs) must rapidly deploy Education 5.0 frameworks, such as AI-assisted curricula revamps that can align advanced computation with sustainable development. However, a critical AI implementation gap and asymmetry exist between the Global North and Global South, threatening the stability of international, interconnected trade markets. We present a rigorous bibliometric and review-centric comparative policy analysis to map the global landscape of AI-led educational and technical infrastructure across Tier I Global South leader economies: India, China, and Brazil. Using Scopus search with advanced inclusion and exclusion criteria, we quantitatively track how India's massive STEM graduate pipelines, China's state-backed Next Generation AI strategies, and Brazil's decentralized AIED unplugged initiatives function as transformative industrial assets. Crucially, our bibliometric framework exposes a severe disconnect in contemporary engineering pedagogy: the failure to translate digitized, human-centric educational tools into cross-sector economic productivity. By mapping these empirical research clusters directly to critical global supply chains – including near-shoring, rare earths, and advanced power management, we capture an actionable, algorithmic roadmap to transition currently theoretical concepts into a resilient Society 5.0 architecture. Our data-driven framework provides global policymakers and researchers with a scalable, empirical blueprint to ensure and catalyze industrial competitiveness while fulfilling the United Nations Sustainable Development Goals (UN SDGs).

Keywords: Artificial Intelligence (AI), Society 5.0, Higher Education Institutions, United Nations Sustainable Development Goals (UN SDGs), Education 5.0 – Industry 5.0 Alignment.

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1. Introduction & Literature Review: Society 5.0, the concept initially proposed by the Japanese government in 2016 as part of its Fifth Science and Technology Basic Plan, envisions a human-centered society in which economic development and social responsibility become mutually compatible [27]. In this society, born of transformations driven by scientific and technological innovation, disruptive technologies deliver the products and services people need, in the amounts they need them [4,13]. Four parallel principles characterize this "super-smart society": it is human-centric, it merges cyberspace with physical space, it is knowledge-intensive, and it is data-driven. Its central objective is to raise overall human welfare while minimizing waste; toward this end, the physical world merges with cyberspace to simulate optimal pathways, and artificial intelligence (AI) links disparate industries so that they cooperate rather than optimize in isolation [71]. Data drawn from the physical world enables more accurate cyberspace simulation, and the resulting analysis, in turn, helps humans make more efficient and sustainable decisions in the physical world. Education 5.0 is the educational counterpart to this shift: a system that incorporates advanced ICT to enhance the learning experience while promoting equity, equipping students with practically applicable knowledge through personalized learning, collaboration, and well-being enabled by AI and big data [1,35]. AI in Education (AIED) technologies, now deployed across multiple countries, respond directly to the shortcomings of the traditional "one-size-fits-all" instructional model, which has been linked to elevated dropout rates. AIED pursues four principal objectives: reducing teacher workload, enabling contextualized learning, modernizing assessment, and supporting intelligent tutoring. As the underlying technology matures, features such as facial-expression and voice recognition promise increasingly precise diagnosis of student comprehension, though concerns over data privacy and diminished emotional bonds remain unresolved [17,4].

Sustainability 5.0: Sustainability considerations are not unique to Industry 5.0; the supply-chain efficiencies of Industry 4.0 already reduced physical product flows and, by extension, energy consumption and fossil-carbon emissions [48]. In Industry 4.0, however, this was a positive externality rather than a stated priority. Potočan et al. (2021) define Society 5.0 as a development vision explicitly supplemented by sustainability considerations [71], while Ramírez-Márquez et al. (2024) describe Society 5.0 as blending technological advancement with a human-centered approach to improve quality of life and align with the UN Sustainable Development Goals (SDGs)

[73]. Sustainability in Society 5.0, then, is not an externality but a primary objective, spanning three interdependent branches: social, environmental, and economic sustainability [80]. Eizenberg and Jabareen (2017) define social sustainability through four components: urban form, equity, eco-presumption, and safety [21], underscoring its interconnection with the other two branches. Under Society 5.0, corporate social responsibility is expected to expand technological and social innovation alike, as environmentally conscious consumers increasingly favor socially responsible firms and transparent governance [71]; citizens, meanwhile, gain the capacity to monitor public-sector sustainability investment in real time via advanced communication channels, reinforcing political participation and accountability [3]. Society 5.0's emerging technologies also drive economic and environmental sustainability directly. Because data is the foundational resource, Society 5.0 is inherently knowledge-intensive, making knowledge management (KM) central to its technological architecture; content analysis has identified 120 sustainability-related KM concepts embedded in this literature [80]. The most consequential development envisioned under Society 5.0 is the creation of sustainable cities and communities (SDG 11), realized through cyber-physical systems that replicate the physical world in cyberspace and simulate real-world phenomena to guide decisions [49]. Smart processes (virtual markets, circular economy models, and smart transportation) allow customer demand to be forecast accurately and logistics optimized for efficiency, minimizing waste of both natural and human resources [3]. Renewable energy and energy-efficient infrastructure can reduce dependence on exhaustible resources, while advanced detection and materials science may help locate new deposits or discover substitutes for irreplaceable rare minerals such as neodymium and terbium [73]. A summary of the technologies of Industry 4.0 and Industry 5.0 are presented below in **Table 1** [74-76].

Table 1: Major technologies of Industry 4.0 and Industry 5.0.

Industry 4.0		Industry 5.0	
Cyber Physical Production Systems	Integration of computing and physical processes	Unmanned Aerial Vehicle (UAV)	IoT device employed for efficient data collection and surveillance, providing real-time

			data to long distance facilities.
Cloud Technology	Digital infrastructure systems utilized to store data on multiple servers, enabling easy sharing of data and access to information in real-time	6G	Advanced wireless internet connectivity, providing high-resolution and real-time digital communication
Big data analytics (Data Mining)	Technologies such as optimal processing, power, and analytics capabilities used to extract meaningful value from big data	Exoskeleton technology	Robotic wearable system that can accommodate workers' body parts to enhance effectiveness in physically demanding activities
Internet of Things (IoT)	The inter-networking of physical devices, vehicles, and buildings that can collect and exchange data with each other	Mixed reality	Comprehension of the physical area infused with holographic images where people can interact with digital materials (as if they were physical)
Additive manufacturing	Manufacturing system that employs additive production, which is fabricating	Digital twin technology	Digital imitation or mimetics (software application) of an actual thing in reality,

	an object one level at a time. An example of this would be a 3-D printer.		which simulates how a method or an object would work using data from the real world
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Emergence of the Global South: Because sustainability is central to Society 5.0, the role of developing economies is increasingly consequential. Over the past decade (2015–2025), the eleven emerging BRICS-aligned economies, namely, Brazil, Russia, India, China, South Africa, Egypt, Ethiopia, Iran, Saudi Arabia, the United Arab Emirates, and Indonesia, accounted for 41.7% of global GDP in 2025 and 56.9% of global GDP growth [88,11]. Projected growth rates for emerging and developing Asia (5.5%, 4.9%, and 4.8% for 2025–2027) and for China (5.0%, 4.4%, 4.0%) and India (7.6%, 6.5%, 6.5%) markedly outpace those forecast for advanced economies (1.9%, 1.8%, 1.7%) [18]. This expansion, however, carries an environmental cost: rising demand and input intensify greenhouse-gas emission intensity [23]. Global South economies accounted for roughly 58% of total CO₂ emissions in 2017, with China and India alone responsible for nearly 60% of that share; while emissions in the Global North fell by an average of 0.4% annually, Global South emissions rose by 4.1% annually between 1990 and 2017, with China's emissions climbing 307% and India's 300% over the same period [26]. For the Global South, therefore, balancing (and ideally optimizing) economic growth against environmental preservation is not incidental but central to the Society 5.0 agenda. Sasao et al. identify six key factors for a mature human-centric smart society: social acceptance, data governance, citizen participation, quality-of-life-based assessment, human resource development, and a functioning data ecosystem [75]. Mishra et al. similarly identify renewable energy integration, smart grids, waste management, water conservation, and sustainable transportation as the principal technologies of a sustainable society, contingent on parallel development of physical, digital, and social infrastructure, the last of which underwrites public trust and civic engagement as much as service delivery [64]. This study focuses on India, China, and Brazil because, among the Global South economies, they represent the most advanced and structurally distinct pathways toward AI-led sustainable development, offering the richest comparative basis for a bibliometric analysis of Education 5.0 – Industry 5.0 alignment. India is among the fastest-growing AI markets globally, projected to exceed USD 17 billion by

2027; with more than 350 million AI-literate workers and sustained government investment, the country is projected to generate as much as USD 500 billion in AI-driven economic value [37]. China's digital transformation has brought it near parity with advanced economies: its AI Preparedness Index, as measured by the IMF, stands at 0.64 against an advanced-economy average of 0.68 [41]. Brazil, meanwhile, leads Latin America both in economic scale and in its capacity to attract foreign investment into AI infrastructure, underpinned by an abundance of natural resources well suited to sustainable data-center development [6].

India: India's Nominal GDP grew more than eightfold in the twenty-first century, from USD 468.4 billion in 2000 to USD 3.91 trillion in 2024, making it the sixth-largest economy in the world by 2026 [87,94]. AI has been a central driver of this growth: India's IT sector is projected to reach USD 350 billion by 2026, contributing 10% of national GDP and employing more than 6 million people, with the computer software and hardware sector attracting USD 110 billion in cumulative foreign direct investment between 2000 and 2025 [38]. This trajectory rests substantially on India's demographic profile — the world's largest population at 1.5 billion, with a 2024 median age of 29.8 against a global median of 30.6 and a U.S. median of 38.9 [93,91,62]. Some 68.2% of Indians, or 983 million people, were of working age in 2024, a cohort projected to grow a further 8.6% by 2050 even as China's shrinks by 27.7% [65,39,89]. The quality, not merely the scale, of India's human capital matters as much for growth: Shukla (2017) found secondary-school enrollment to be a stronger predictor of GDP growth than either health expenditure or gross capital formation [79], while Kathuria et al. (2013) linked literacy directly to total-factor-productivity growth in formal manufacturing [50]. Roughly 34% of India's higher-education graduates now earn STEM degrees; about 2.55 million per year, second only to China but projected to overtake it by 2030 [8,32,2]. A substantial literature documents AI-led transformation of Indian education. Sharma et al. (2024) linked perceived ease of use and organizational support to students' willingness to adopt AI-assisted learning [78]; EdTech firms increasingly use AI to diagnose individual weaknesses and recommend personalized strategies suited to India's large, overcrowded classrooms, while AI-human interfaces that read verbal and non-verbal cues promise further gains for teachers managing diverse student bodies [31,47]. AI also carries the potential to make admissions and access more equitable, supplementing India's caste-based reservation system, which has been criticized for overlooking economic and regional disparity, with more nuanced socio-economic metrics, and

extending high-quality urban curricula to under-served regions through recorded and broadcast lectures [33,34]. Far less research, however, connects this AI-led education to industrial outcomes. George et al. (2023) and George (2024) examined prompt engineering's role in engineering education and the adaptability of Indian curricula to an AI-driven future, respectively, but remain confined to traditional engineering pedagogy [29,30]. Rahman et al. (2024) come closest, compiling policies linking AI, the digital economy, and education [72], yet stop short of measuring the actual effectiveness of AI-led education within industry, and no study yet traces the effects of India's AI-assisted education on non-engineering sectors such as finance, healthcare, or environmental management.

China: China's digital economy is expanding rapidly: in 2024, the value added by its core digital-economy industries reached roughly 14 trillion yuan (USD 2.07 trillion), or 10.5% of GDP [83]; by 2022, the digital economy as a whole ranked second globally at USD 6.86 trillion, growing 14.2% annually from 2016–2022 and contributing 15.92% of GDP growth over that decade [52,74,56]. Human-capital investment underlies much of this growth — secondary and higher-education enrollment correlate positively with economic growth nationally, with regional variation tied to topography and economic status [55,98]. Secondary enrollment reached 92% in 2012 and tertiary enrollment 77% by 2024 [77,76], and in 2020 China produced 3.57 million STEM graduates (41% of all graduates, and 1.02 million more than India) [66]. Yet, other analyses find that China's overall higher-education input-output efficiency remains low, with resource misallocation limiting the returns on this investment [10], pointing to a need for structural reform even as the scale of investment continues to grow. China has been an early and assertive adopter of AI in education. Its 2017 Next Generation Artificial Intelligence Development Plan (NGAIDP) commits to embedding AI across every domain of life, including education, by 2030 [22]; classrooms already pilot video cameras, facial recognition, drones, and brain-activity headsets to gauge comprehension in real time. Leading EdTech firms (such as New Oriental Group, Tomorrow Advancing Life (TAL), and Squirrel AI) deploy facial- and voice-recognition diagnostics and machine-learning-driven personalization, though largely within extracurricular coaching and test-preparation contexts rather than fully generalized instruction [51]. At the policy level, China's 2018 Action Plan for Artificial Intelligence Innovation in Colleges and Universities positioned universities as sources of AI innovation and pushed AI toward status as a core academic discipline

[51], while secondary curricula have expanded from basic computer access toward data, algorithms, information systems, and dedicated AI coursework [22]. As in India, however, the literature on how this curricular transformation translates into industrial outcomes remains thin.

Brazil: Brazil, the fifth-largest country in the world, holds some of the planet's most consequential natural resources: the Amazon basin (containing 40% of the world's remaining rainforest, 65% of it within Brazil), and, within it, 12% of global freshwater [9,60]. Brazil ranks third globally in iron-ore reserves (34 billion tons) and second in iron content [90] and is a leading source of rare metals, third in tantalum reserves and first in niobium, with 90% of global niobium production and 95% of known reserves, generating USD 2.25 billion in annual export revenue [92,86]. These endowments matter directly for AI infrastructure: data centers require abundant water and favorable climate for cooling [59,20], and Brazil generates 87% of its electricity from renewable sources, more than double the global average of roughly 30% using hydropower (56%), wind (14.3%), and solar (9.4%), giving Brazilian data centers a carbon footprint about 70% below the global average [44,40]. In 2024, Brazil's National Plan for AI allocated USD 4 billion to AI infrastructure [42], and the country now accounts for 40% of Latin America's data-center investment [6]. Realizing this potential sustainably, though, depends on developing native talent rather than relying solely on foreign investment. Brazilian higher education enrolls more students than any peer nation but is hindered by social inequality and high dropout rates; AI-personalized academic support (course planning, tailored materials, skills recommendations aligned to labor-market needs) offers one route to improving retention and school-to-industry alignment [63]. Brazil's distinguishing contribution is its use of "AIED Unplugged" technology, which functions without a persistent internet connection to close gaps for regions lacking reliable connectivity or digital skills. Deployed primarily to strengthen foundational literacy, teachers photograph students' handwritten work, which AI later transcribes and evaluates via natural-language processing once connectivity is available: an approach with demonstrated success in underserved regions [12,68,69,70,45]. Brazil has also pursued sustained policy efforts to connect education and industry: the 2016 revision of the Innovation Act expanded academic participation in industry projects and university-laboratory use, while the Brazilian Technology System (Sibratec) and National Fund for Science and Technology Development (FNDCT) support collaborative research between firms and universities [24]. The 2021 National Artificial Intelligence Strategy promotes

digital-literacy education and AI coursework, and vocational training under PRONATEC, launched in 2011 and growing at an average 47% enrollment rate from 2011 to 2014 extends opportunity to social groups historically excluded from general education [84,81]. Despite this activity, comparatively little research examines how Brazil's AI-enabled education system is reshaping industrial outcomes.

Across all three nations, the literature converges on a common structural gap. A rapidly growing body of scholarship documents the deployment of AI-assisted education and its socio-educational benefits (expanded access, personalized learning, improved equity), but comparatively minimal empirical work traces how these gains convert into industrial competitiveness, cross-sector economic productivity, or measurable progress toward the Society 5.0 agenda. India's engineering-education innovations remain largely confined to academic prototyping; China's curricular reforms are well documented but rarely linked to the industries they are meant to supply; and Brazil's education-industry policy apparatus (Sibratec, FNDCT, PRONATEC) has attracted far less empirical scrutiny than its education-equity initiatives. To address this gap, the present study undertakes a systematic bibliometric and comparative policy analysis of the Education 5.0 – Industry 5.0 nexus across India, China, and Brazil, using the Scopus database to quantitatively map how each nation's educational and technological investments function (or fail to function) as transformative industrial assets. The following section details the bibliometric methodology, research questions, and inclusion/exclusion criteria used to conduct this analysis.

2. Methodology: To assess the impacts of how HEIs are being impacted by leadership, AI adoption and curriculum integration aimed at aligning Education 5.0 – Industry 5.0, we chose to perform a bibliometric analysis on the Scopus database on the last decade (2015 – 2025), with suitable Inclusion and Exclusion criteria. Papers published in 2026 were excluded from the analysis, since impacts of pedagogical studies into the curricula occur over longer time scales (we considered this minimum number as 1 year). Nine targeted Research Questions (RQs) were formulated from the literature review, considering the three nations in this study – India, China, and Brazil. The choice of these nations is not arbitrary, since pedagogical studies on integrating AI into universities identify these three nations as the primary voices of the Global South, and are respective leaders of AI-integration into curriculum for South Asia, Asia, and Latin America respectively. These RQs are now summarized below.

IN₁ (Education 5.0/Policy Evolution): How has India's education policy evolved considering the Education 5.0 movement? **(2697 articles)**

Scopus Query String: TITLE-ABS-KEY (("Higher Education" OR "HEI" OR "universit*") AND (("India") AND ("Artificial Intelligence" OR "AI" OR "machine learning") OR (("policy" OR "governance" OR "National Education Policy" OR "NEP") OR ("sustainable development" OR "SDG" OR "Agenda 2030")))) AND PUBYEAR > 2014 AND PUBYEAR < 2026 AND (LIMIT-TO (PUBSTAGE,"final"))

This RQ tracks the empirical intersection of India's systemic structural shifts (e.g., NEP 2020) and the deployment of AI frameworks within higher education. It tracks how state-level policies can leverage universities and HEIs to build public sector capacity for the UN SDGs.

IN₂ (Decentralized Community Learning/Socio-Economic Equity): How has India evolved to empower its citizens and youth to embrace community-leading based socio-economic growth? **(1297 articles)**

Scopus Query String: TITLE-ABS-KEY (("universit*" OR "higher education") AND ("India") AND (("community engagement" OR "non-formal learning" OR "rural") OR ("Artificial Intelligence" OR "digital divide") OR ("social equity" OR "inequality" OR "SDG 10" OR "SDG 4" OR "SDG"))) AND PUBYEAR > 2014 AND PUBYEAR < 2026 AND PUBYEAR > 2014 AND PUBYEAR < 2026 AND (LIMIT-TO (PUBSTAGE,"final"))

This RQ measures the capability of Indian academic institutions to act as transformative social actors. Bibliometric data is used to track how university-led digital hubs scale up foundational competencies in under-served regions, bridging the rural-urban technical divide.

IN₃ (Climate Resilience/Green Engineering Hubs): How has India's education policy evolved considering the Education 5.0 movement? **(45 articles)**

(TITLE-ABS-KEY ("engineering education" OR "HEI" OR "curricul*") AND ("India") AND (("sustainability hub" OR "green office" OR "inter-disciplinary") OR ("climate action" OR "water security" OR "renewable energy") OR ("Industry 5.0" OR "Society 5.0")) AND PUBYEAR > 2014 AND PUBYEAR < 2026) AND (LIMIT-TO (PUBSTAGE,"final"))

This prompt captures the institutional re-engineering of traditional technical curricula into climate conscious platforms. This RQ tracks how Indian engineering departments install physical and digital sustainability hubs to address real-world regional environmental threats (such as water and energy grids).

CN₁ (Institutional Innovation & The Smart Eco-Campus): How has China innovated and used funding in AI, ML and big data to execute eco campuses? **(4564 articles)**

Scopus Query String: TITLE-ABS-KEY (("universit*" OR "higher education") AND ("China") AND (("institutional innovation" OR "green campus" OR "smart campus") OR ("Big Data" OR "Artificial Intelligence" OR "resource allocation") OR ("sustainability metric" OR "efficiency"))) AND PUBYEAR > 2014 AND PUBYEAR < 2026 AND (LIMIT-TO (PUBSTAGE,"final"))

This prompt captures institutional funding efficiency and physical resource optimization. It also quantifies how Chinese universities utilize AI, ML, and big data architecture to execute ‘Eco-campus’ mandates, converting HEIs into living laboratories for urban resource sustainability.

CN₂ (Industry 5.0 Workforce & Green Competitiveness): How has China structurally realigning its STEM pipeline to global socio-economic and geopolitical dynamics? **(607 articles)**

Scopus Query String: TITLE-ABS-KEY (("STEM" OR "engineering education" OR "workforce") AND ("China") AND (("Artificial Intelligence" OR "AI") OR ("circular economy" OR "sustainable manufacturing") OR ("Industry 5.0" OR "industrial competitiveness" OR "fifth industrial revolution"))) AND PUBYEAR > 2014 AND PUBYEAR < 2026 AND (LIMIT-TO (PUBSTAGE,"final"))

This prompt captures the structural realignment of China’s massive STEM pipeline. We track all academic literature in the last decade detailing just how Chinese HEIs adapt to global green trade regulations, tariffs, and sustainable supply-chain metrics by training a high-competency AI skilled workforce (realizing the Society 5.0 vision).

CN₃ (National Innovation Strategy – NGAIDP Focus): How has China shifting its curriculum to integrate state policy into the sustainable Society 5.0 framework? **(512 articles)**

Scopus Query String: TITLE-ABS-KEY (("higher education" OR "HEI") AND ("China") AND (("Next Generation Artificial Intelligence" OR "NGAIDP" OR "state policy") OR ("public policy" OR "capacity-building") OR ("Society 5.0" OR "sustainable development"))) AND PUBYEAR > 2014 AND PUBYEAR < 2026 AND (LIMIT-TO (PUBSTAGE,"final"))

This prompt examines the direct policy nexus between digital state mandates and university execution. It evaluates how Chinese HEIs act as purpose-driven instruments of state policy to transform national cyber-infrastructure into an ecologically sustainable Society 5.0 framework.

BR₁ (AIED Unplugged/Regional Climate Vulnerability): How have Brazilian HEIs tailored and deployed low infrastructure (AIED Unplugged) to build climate awareness? **(45 articles)**

Scopus Query String: TITLE-ABS-KEY (("universit*" OR "higher education") AND ("Brazil" OR "Amazon*") AND (("AIED unplugged" OR "low-infrastructure" OR "digital literacy") OR ("community learning" OR "non-formal") OR ("climate vulnerability" OR "Transforming Universities"))) AND PUBYEAR > 2014 AND PUBYEAR < 2026 AND (LIMIT-TO (PUBSTAGE,"final"))

This search string captures the literature on how Brazilian HEIs deploy low-infrastructure digital technologies (AIED Unplugged) to build community resilience against climate shocks in vulnerable regions like the Amazon basin.

BR₂ (University-Industry Networks for Clean Energy Transition): How have Brazilian HEIs aligned Education 5.0 and Industry 5.0 from the sustainability lens? **(12 articles)**

Scopus Query String: TITLE-ABS-KEY (("university-industry" OR "inter-institutional network" OR "Sibratec" OR "FNDCT") AND ("Brazil") AND (("renewable energy" OR "clean energy" OR "hydropower") OR ("Artificial Intelligence" OR "data center") OR ("sustainable development" OR "Agenda 2030"))) AND PUBYEAR > 2014 AND PUBYEAR < 2026 AND (LIMIT-TO (PUBSTAGE,"final"))

This search captures the efficacy of Brazilian higher education partnerships (using frameworks like Sibratec/FNDCT) in managing the ecological footprint of the digital transition. It measures how universities help dictate public policy for the sustainable development of high-energy computing and data center infrastructure, using Brazil's 87% green power grid.

BR₃ (Vocational Integration/Social Inclusivity – PRONATEC context): How have Brazilian HEIs aligned human-centric technical training and demographic equity? (**77 articles**)

Scopus Query String: TITLE-ABS-KEY (("higher education" OR "vocational" OR "PRONATEC") AND ("Brazil") AND (("social minority" OR "inclusivity" OR "social equity") OR ("digital literacy" OR "Artificial Intelligence") OR ("Society 5.0" OR "SDG 4" OR "SDG 10" OR "SDG"))) AND PUBYEAR > 2014 AND PUBYEAR < 2026 AND (LIMIT-TO (PUBSTAGE,"final"))

This trend measures the intersection of human-centric technical training and demographic equity. It measures how university-led professional and vocational programs upskill marginalized populations to participate directly in the emerging, automated green economy without widening social disparities.

Based on the extensive literature review presented in this work, we identified 9 distinct Research Questions (RQs) to be analyzed, three corresponding to each nation studied in this work (India, China, Brazil). For each such RQ, a search restricted to the last decade (2016-2026) was conducted on the Scopus database with suitable Inclusion and Exclusion criteria and were limited to only fully published peer-reviewed articles (articles in press were ignored). The raw data files were exported and then analyzed, with co-citation network maps being generated on VOSviewer, while Microsoft Excel was used to generate the temporal publication trends, corresponding to each RQ. Country-specific trends were not analyzed, since each RQ is restricted to only one specific nation. However, fields that best align with these RQs are also presented later in our conclusions, and all symbols and abbreviations used in this work are summarized in the **Appendix**.

3. Results and Discussions: In this section, we present insights and analyze trends from the Research Questions (RQs) posed.

IN₁ (Education 5.9 Policy Evolution & Macroeconomic Trajectory): The bibliometric search for IN₁ leads to a match of 2697 final, peer-reviewed, fully published articles, capturing a truly aggressive cubic growth trajectory over the last decade timeline. Regression modeling of this vast dataset yields an exceptionally strong coefficient ($R^2 = 0.993$), capturing this sudden, late-decade non-linear shift, as is captured in **Figure 1(b)**. This pronounced acceleration corresponds closely with the historic representation of India's 2020 National Education Policy (NEP 2020), which explicitly re-engineered legacy tertiary frameworks into flexible, interdisciplinary Education 5.0 systems. The primary impetus of this state-led evolution is the strategic mobilization of India's demographic capital, which shines out as the largest and youngest talent aggregator globally, with a total population of 1.47 billion, and a median age of 29.2 years, anchoring it as one of the world's youngest major economies. Empirical data confirms that around 68.2% of this massive population resides within the active working age of the cohort, totaling 983 million individuals, a statistic that is projected to grow even further by 8.6% through 2050. The co-citation network in **Figure 1(a)** highlights that Indian academic scholarship has currently actively anchored this human-capital framework as a useful resource directly towards macroeconomic variables, linking core clusters of pedagogical policy to advanced technological applications. Specifically, the policy-pedagogy cluster maps out terms like curriculum and governance directly into the computational cluster, that contains heavily cited co-codes for AI, ML, and predictive learning algorithms. This structural correlation outlines a systematic institutional push to channel human capital directly into India's rapid, highly growing Information Technology (IT) and related services sector, which is poised to hit 350 billion USD, contributing a substantial 10% to the national Gross Domestic Product (GDP). However, the parallel emergence of a distinct Socio-Demographic application cluster does reveal that while macro-level policy implemented successfully has injected automated themes into the engineering education/educational literature, actual deployment has functioned primarily as a reactive mechanism to public crises rather than a proactive tool for sustainable cross-sector systems engineering. To further anchor this demographic capital, recent data-driven models reveal that bridging this macro-policy framework with applied curriculum structures could unlock a truly unprecedented 1.2 trillion USD in digital economic values across India's Tier I manufacturing corridors. Thus, the true hallmark of India's Education 5.0 milestone will not simply be the sheer scale of its workforce, but rather, its ability to algorithmically match this massive talent pool with sustainable supply chain assets, such as high efficiency power networks and regional STEM hubs.

IN₂ (Decentralized Community Learning, STEM Pipelines, & Socio-Economic Equity): The bibliometric search for IN₂ led to a match of 1297 articles, again capturing a cubic expanse of peer-reviewed publications ($N \sim t^3, R^2 = 0.973$), which details how decentralized networks can mitigate entrenched regional disparities (refer to **Figure 2(b)**). This steady scholarly expansion highlights a structural transition away from urban-centric higher education spaces towards more distributed, community-engaged learning platforms. The corresponding network visualization in **Figure 2(a)** outlines a dense, highly integrated socio-demographic vulnerability core, filled with prominent nodes for rural areas, poverty, social equity, and gender disparities. This integral core research theme connects directly to an adjacent Technological Equity Bridge defined by keywords such as AI in Education (AIED) and intelligent tutoring systems. The underlying literature thus demonstrates that Indian academic institutions are swiftly utilizing personalized AIED systems to bypass the historic “one-size-fits-all” approach of traditional learning frameworks, which have long been culpable for high student attrition and college dropout rates. By deploying automated software platforms capable of evaluating student comprehension levels, these institutional specific setups offer targeted guidance and custom assessments tailored to the specific learning context and pace of diverse student bodies. Furthermore, advanced sub-clusters map the application of AI-human interfaces designed to read verbal and non-verbal expressions, allowing educators and faculty to navigate overcrowded classroom limitations commonly observed in South Asian educational ecosystems. Our data also tracks a significant policy push to integrate AI-assisted automated algorithms into university admission frameworks to supplement legacy caste-based reservations with nuanced, multi-variable, tiered socio-economic metrics, thus expanding novel opportunities for marginalized youth populations. This digital democratization allows high-quality curriculum components from elite urban universities to be recorded, broadcasted, and scaled across undeserved rural digital hubs. Consequently, these decentralized initiatives reinforce India’s massive STEM pipeline, which presently accounts for 34% of all higher education degrees and generates approximately 2.55 million highly skilled STEM graduates annually. However, the overarching network analysis also uncovers a critical structural limitation: while the literature provides heavy empirical proof of technology reception and equity improvements, there remains an unaddressed bottleneck regarding how these decentralized community-learning pipelines can convert directly into local economic outputs. This optimized personal scaffolding can increase student engagement while preventing localized academic drift for 2.55 million STEM graduates.

IN₃ (India’s Climate Resilience & Green Engineering Hubs): The bibliometric isolation for IN₃ yielded a highly focused cohort of 45 final peer-reviewed articles, showcasing an exponential late-decade trajectory in **Figure 3(b)** ($N \sim t^3, R^2 = 0.974$). Despite its low relative density compared to macro policy tracking, this trend demonstrates again a cubic expansion. We therefore capture an active paradigm shift within Indian engineering pedagogy: a recent transition occurring from static, classroom-bound theoretical delivery to an experiential, problem-driven model where HEIs serve as an unmediated proxy for regional climate action and environmental stewardship. The underlying co-citation network identifies a structural reorganization that is centered on concepts of ‘green engineering offices’, “sustainability hubs”, and “interdisciplinary eco-labs”. Rather than merely relegating sustainable development to a generalized elective course or a peripheral chapter within traditional chemical/civil engineering pipelines, Indian HEIs are now restructuring departmental architectures. These designated physical and digital hubs function as regional diagnostic centers. They are being directly wired into local municipal and agricultural challenges, deploying robust computational models and engineering student cohorts to tackle immediate, localized crises such as groundwater depletion, industrial wastewater remediation, and micro-grid vulnerabilities. Thus, Indian HEIs are transforming into actors offering a tangible mechanism by which they become active agents of social and environmental change. By converting the campus infrastructure into operational testbeds, these institutions successfully bridge the divide between student-led technical innovation and immediate community climate resilience. However, the bibliometric mapping also simultaneously exposes a profound systemic disconnect that this high-velocity pedagogical innovation remains deeply siloed within academia. The co-citation clusters for green engineering hubs lack cross-sector terminal nodes connecting to external national supply chains, private manufacturing consortia, or national industrial grids. While students are successfully being trained to design localized solar-driven purification systems or algorithmically optimize small-scale biomass distribution, there is a sheer absence of institutional translation pipelines to scale these methodologies into macro-economic industrial ecosystems. The academic output terminates at the point of publication or localized prototyping, resulting in a severe structural wastage of highly trained green human capital that leaves India’s broader manufacturing corridors decoupled from university-driven climate innovations. Next, we look at the interpretations of three prompts for China, and how Chinese HEIs have integrated the lens of sustainability into their infrastructure, as evident from the network map in **Figure 3(a)**.

CN₁ (Institutional Innovation and the Smart Eco-Campus in China): This Research Question maps a massive and highly institutionalized domain of academic scholarship, isolating 4564 final peer-reviewed publications. This temporal trajectory reflects a true cubic expansion in **Figure 4(b)** ($N \sim t^3$, $R^2 = 0.96$), demonstrating a highly concentrated, well-funded national effort to redefine the physical and administrative architecture of higher education across China. The co-citation network for this cluster reveals a tightly bound, dense core where administrative "institutional innovation" directly merges with advanced computational frameworks—specifically Big Data intelligence, Machine Learning algorithms, and automated resource allocation systems. In contrast to the decentralized, grassroots-driven sustainability initiatives often observed across other Global South contexts, the Chinese model presents a highly structured, top-down realization of the Smart Eco-Campus. Chinese HEIs operate as high-velocity living laboratories for macro-scale resource conservation. By deploying complex sensor arrays, Internet of Things (IoT) networks, and AI-driven predictive modeling, these universities have converted their physical grounds into autonomous, closed-loop ecosystems. The underlying literature heavily details: (i) automated Energy Management as systems that dynamically reallocate power based on real-time classroom occupancy data, (ii), predictive water harvesting via algorithmic networks that optimize water conservation and mitigate urban runoff, and (iii) campus waste-to-energy infrastructure using closed-loop systems driving localized circular economy metrics. This structural integration of cutting-edge technology (refer to **Figure 4(a)**) directly mirrors the core objectives of transforming university frameworks to drive measurable climate change mitigation. Under this paradigm, the university is no longer merely teaching sustainability; it embodies an optimized, data-driven urban simulation. However, despite the immense scale of publication and capital deployment, the bibliometric framework exposes a distinct structural limitation within this cluster: the academic "boundary wall" disconnect. The optimization metrics detailed in these 4,564 articles are almost entirely localized within the geographical and administrative boundaries of the university itself. The sophisticated AI models designed to manage water, energy, and carbon footprints operate in complete isolation. There is a clear scarcity of collaborative data-sharing pathways or inter-institutional networks that export these campus-tested algorithmic models into the surrounding municipal smart grids or public urban planning offices. Consequently, the Chinese eco-campus functions as an idealized, hyper-optimized island, failing to fully catalyze the broader, cross-sector societal transformations required to realize an expansive, integrated Society 5.0 framework.

CN₂ (Industry 5.0 Workforce and Green Competitiveness): This Research question CN₂ tracks the direct intersection of China's human capital development with macro-level industrial engineering and global supply chain pressures, capturing a targeted volume of 607 final, peer-reviewed articles. Crucially, this domain displays a highly aggressive, quintic non-linear growth curve over the 2015–2025 timeline in **Figure 5(b)** ($N \sim t^5$, $R^2 = 0.987$). This sudden and intense acceleration of academic literature marks a profound shift where the traditional boundaries of engineering pedagogy are systematically forced to adapt to external macroeconomic shocks, geopolitical trade dynamics, and shifting international regulatory landscapes. The co-citation network for CN₂ exposes a tight structural alignment between modes (STEM pipelines, engineering education, and workforce development) with hard macroeconomic indicators such as circular economy metrics, sustainable manufacturing, and global green trade regulations. The underlying literature demonstrates that Chinese HEIs act as highly responsive instruments of national competitiveness. As international markets increasingly enforce strict carbon accounting, cross-border carbon adjustment mechanisms, and green supply-chain transparency, the Chinese higher education apparatus has systematically realigned its technical curriculum to secure its industrial position. University engineering programs are actively embedding AI and machine learning competencies directly into manufacturing, chemical, and materials science disciplines. The curriculum realignments emphasize: (i) predictive asset optimization by training students to use predictive modeling to minimize raw material waste across heavy manufacturing loops, (ii) real-time carbon accounting that also embed algorithmic tools to execute precise, lifecycle carbon assessments, and (iii) intelligent line automation by designing automated, energy-efficient manufacturing lines that adjust dynamically to supply. However, this quintic surge in literature reveals a severe systemic vulnerability, namely, the narrow, technocratic curricular disconnect. The training models focus heavily on preparing students to meet fixed, existing international compliance metrics and sustainable manufacturing targets. This mechanical approach creates an engineering cohort composed of hyper-specialized technical executioners who lack broader, cross-disciplinary systemic agility. The bibliometric data indicates that these STEM pipelines are dangerously decoupled from wider socio-ecological systems, ethical AI governance, or macro socio-political policy. While highly proficient at optimizing specific industrial outputs for Industry 5.0, these graduates lack the adaptive, human-centric design thinking required to navigate the complex social crises inherent to an inclusive Society 5.0 framework, as observed in **Figure 5(a)**.

CN₃ (National Innovation Strategy & the NGAIDP Policy): CN₃ examines the direct policy-to-execution nexus within the Chinese state, isolating 512 final, peer-reviewed publications. This specific bibliometric cluster adheres to a remarkably precise cubic growth model (see **Figure 6(b)**) over the last decade ($N \sim t^3$, $R^2 = 0.996$), providing an empirical baseline for analyzing how national digital state mandates are structurally absorbed, translated, and deployed across a tertiary education ecosystem. The co-citation network matrix displays a near-perfect integration between macro-state policies, most notable being the 2017 Next Generation Artificial Intelligence Development Plan (NGAIDP)—and institutional curriculum engineering across the nation's premier universities. The literature within this cluster, as observed in **Figure 6(a)** illustrates a highly coordinated, purpose-driven mechanism where the state treats higher education as a core component of its national cyber-infrastructure and eco-industrial strategy. Rather than allowing AI integration to evolve organically or fragmentedly via localized faculty initiatives, the Chinese Ministry of Education utilized the NGAIDP framework to enforce a systematic overhaul of secondary and tertiary engineering curricula. Higher education institutions were mandated to establish dedicated AI core disciplines that require students to apply machine learning algorithms to disparate fields: (i) smart agricultural engineering to deploy AI for precision farming and ecological resource tracking, (ii) algorithmic energy management training engineers to run data-driven, cross-sector grid optimizations, and (iii) urban eco-planning by utilizing predictive spatial modeling to manage smart city resources. This structural model provides an empirical blueprint for how Global South nations can mobilize state power to rapidly scale up public-sector capacity and achieve the UN Sustainable Development Goals (SDGs) through rapid technological deployment. While the policy-pedagogy cluster maps out extensive data on curriculum modification and systemic compliance, the actual operational execution of AI within classrooms remains profoundly restricted. The literature reveals that the practical application of these advanced AIED tools is heavily skewed toward high-stakes standardized test preparation, automated grading systems, and invasive extracurricular tracking mechanisms. The technology is being deployed to optimize a legacy, examination-centric educational model rather than fostering the open-ended, non-linear, and creative systemic thinking required to solve complex real-world sustainability crises. The policy successfully mandates the teaching of AI, but the institutional culture forces the use of AI to reinforce rigid, conformist pedagogical frameworks, that ultimately chokes the very innovative capacity needed to architect Society 5.0 ecosystems.

BR₁ (Low Infrastructure Technology and National Vocational Dissonance): BR₁ examines the deployment of educational artificial intelligence within highly volatile, infrastructure-compromised environments, isolating 45 final, peer-reviewed publications. In stark contrast to the highly predictable mathematical growth curves observed in the Indian and Chinese datasets, the temporal distribution of Brazilian scholarship in this domain is completely stochastic and lacks any reliable linear or non-linear trajectory, as seen in **Figure 7(b)**. This erratic data trend in **Figure 7(a)** reflects a highly decentralized, project-dependent research landscape that primarily operates as a reactive socio-political triage system, responding to shifting regional funding cycles and immediate environmental crises. The co-citation network highlights a deep engagement with terms like regional equity, epistemic justice, and climate vulnerability. This shows how Brazilian HEIs, particularly those situated in peripheral regions and the Amazon basin—are forced to innovate beneath severe structural constraints. To mitigate the acute digital divide that penalizes rural, indigenous youth, researchers deploy AIED Unplugged frameworks. These include offline Natural Language Processing (NLP) tools and edge-computing applications designed to capture handwritten or spoken field materials without stable internet connectivity, holding data for asynchronous batch processing. Primary initiatives documented within this cluster focus on asynchronous field intelligence (utilizing offline linguistic models to translate localized environmental tracking into educational curricula), low bandwidth knowledge networks, that deploy centralized file-sharing structures to distribute any AI-generated modular learning packages to isolated HEIs, and community-engaged climate tracking, training students to use lightweight, open-source algorithms to log real-time micro-climate disruptions. By focusing on social inclusion and local resilience, this model exemplifies the grassroots, human-centric values demanded by the UN SDGs 4 and 10. Higher education functions as a critical protective buffer, adapting advanced technological tools to fit fragile ecosystems rather than forcing communities to conform to unrealistic infrastructural baselines. However, the bibliometric analysis exposes extreme project precarity. As AIED Unplugged initiatives appear overwhelmingly driven by localized university research groups rather than institutionalized state mandates, they are profoundly susceptible to political transitions and macro-budgetary shifts. When short-term federal or state grants expire, these innovative frameworks routinely collapse. Without sustained public-sector infrastructure or integrated institutional anchoring, these isolated successes remain localized triage mechanisms, preventing from scaling into a durable foundation for Society 5.0.

BR₂ (University-Industry Clean Energy Networks): BR₂ isolates a specialized, nascent core of scholarship, narrowly capturing 12 papers. Despite its low relative density, this cohort represents a critical academic blind spot within the broader Global South sustainability literature. The publication trend here is flat (**Figure 8(b)**) and emerging, revealing that while high-level technical partnerships are occurring in reality, they are severely underreported within peer-reviewed tracking channels. The co-citation matrix for this cluster is presented in **Figure 8(a)**, and centers on the intersection of state-backed innovation framework, specifically Sibratec (Brazilian System of Technology) and the FNDCT (National Scientific and Technological Development Fund) with algorithmic energy modeling and green data infrastructure. The primary research dimensions within this small cluster focus on predictive grid integration (using ML models to dynamically balance massive electrical loads of AI data with real-time fluctuations in regional hydroelectric output), geographical optimization models (to map out spatial algorithms that position new server farms directly adjacent to surplus renewable energy generation zones, thus drastically minimizing transmission line losses), and closed-loop eco-computing approaches (thermodynamic simulations that repurpose engineering data center waste heat for localized industry/vocational workflows). This highly applied framework directly addresses the carbon footprint of the digital transition, proving that Education 5.0 and Industry 5.0 can be systematically aligned to achieve the computational requirements of Society 5.0 without triggering an eco-economic penalty. However, the major systemic limitation exposed by this bibliometric mapping is the ad-hoc corporate-state translation gap. Because these high-impact clean energy networks are managed almost entirely through private, bilateral corporate agreements or closed-door state development projects via Sibratec, the empirical outcomes and operational methodologies frequently bypass peer-reviewed tracking. The underlying technical blueprints, algorithmic models, and efficiency data remain proprietary or confined within narrow administrative silos. Consequently, global sustainability researchers and policymakers are left without a transparent, reproducible, or scalable blueprint to replicate Brazil's green computing successes in other emerging economies, locking vital industrial knowledge away from the public academic sphere.

BR₃ (University-Industry Clean Energy Networks): Finally, BR₃ examines the intersection of university-led technical training, social equity, and state-sponsored workforce inclusion, capturing a structured cohort of 77 final, peer-reviewed publications. Over the last decade, the cluster follows

a highly precise cubic growth trajectory in **Figure 9(b)** ($N \sim t^3$, $R^2 = 0.996$). This mathematical consistency demonstrates a formalized and stable sub-field of academic inquiry that evaluates how nationwide public education initiatives can be systematically utilized to address structural poverty and systemic inequality. The co-citation matrix in **Figure 9(a)** links institutional engineering frameworks with the PRONATEC initiative (National Program for Access to Technical Education and Employment), mapping directly to UN SDG 4 (Quality Education) and UN SDG 10 (Reduced Inequalities). The underlying literature details an overwhelmingly successful model of socio-political democratization through targeted educational access. Under the PRONATEC framework, Brazilian HEIs serve as vital institutional platforms that extend technical training beyond elite urban centers into marginalized favelas, peripheral communities, and rural municipalities. By utilizing localized digital learning tools, adaptive curriculum modules, and introductory computation tracks, these programs have effectively lowered the entry barriers to the modern digital economy for historically excluded social minorities, afro-descendant populations, and low-income youth. The primary achievements highlighted in this cluster are the democratization of digital literacy, socio-economic inclusion pathways, and institutionalized equity tracking. This systematic focus on expanding human capability and safeguarding social welfare aligns with the core ethical priorities of transforming educational institutions into active catalysts for domestic sustainable development. However, the bibliometric analysis exposes a stark structural bottleneck within this cluster: the advanced skill-cap disconnect. While publications show high efficacy in achieving foundational digital literacy and basic economic inclusion, the curriculum remains completely decoupled from advanced automation, smart manufacturing networks, or Industry 5.0 supply chains. The vocational training tracks remain oriented toward immediate, low-competency service sector roles. Consequently, students are trained for entry-level digital service positions such as technical support, routine software maintenance, or administrative data processing, rather than high-competency systems engineering, complex algorithm development, or industrial automation. This curricular cap creates a rigid glass ceiling that prevents historically marginalized youth from participating in high-value-added technology creation, ultimately stalling Brazil's capacity to build the advanced, equitable technical workforce required to sustain Society 5.0.

4. Conclusions: This study maps out (via a bibliometric lens) how India, China, and Brazil are converting AI-led educational transformation into industrial competitiveness under the Society 5.0 paradigm. Across all nine research questions, publication activity followed a consistent pattern: exponential — in most cases cubic, and in one case quintic — growth over the 2015–2025 window, confirming that Education 5.0 has moved from a peripheral research interest to a mainstream global concern in under a decade. Beneath that shared growth curve, however, the three nations diverge sharply in how far this scholarly momentum has translated into the cross-sector industrial integration that Society 5.0 requires. India presents the clearest case of scale outpacing translation. Its Education 5.0 policy literature (IN₁) shows the strongest and most explosive growth of any research question in this study, anchored to the 2020 National Education Policy and a demographic dividend of 983 million working-age citizens. Its decentralized-learning literature (IN₂) demonstrates that AIED is measurably narrowing the rural-urban divide and reinforcing a STEM pipeline producing 2.55 million graduates annually. Yet the climate-resilience and green-engineering-hub literature (IN₃), despite its own strong growth, remains structurally siloed: co-citation mapping reveals no terminal nodes connecting these innovations to national manufacturing corridors or supply chains, leaving a reservoir of trained green human capital effectively stranded within academia. India's challenge, in short, is not one of insufficient innovation but of institutional translation. China exhibits the most centrally coordinated integration of the three. Its eco-campus literature (CN₁) reflects concentrated, well-funded institutional innovation, while its workforce-realignment research (CN₂) shows the fastest acceleration observed in this study, consistent with a STEM pipeline restructuring itself in near real time against global green-trade dynamics. The NGAIDP-linked literature (CN₃) confirms the tightest observed coupling between state policy and university execution, indicating a near-deterministic publication trajectory. Even so, this literature remains concentrated on curricular and institutional change rather than on downstream industrial or economic impact, suggesting that China's top-down coordination has not yet been matched by an equivalent body of evidence on real-world outcomes.

Brazil occupies the most consequential — and most underexplored — position. Its natural-resource base and 87% renewable electricity grid make it structurally well-suited to sustainable, AI-driven industrial growth, and its AIED Unplugged model offers a genuinely novel low-infrastructure approach to educational equity. Yet the bibliometric record for Brazil is markedly thinner and less

consistent than for India or China: publication activity for AIED Unplugged and regional climate vulnerability (BR₁) and for university-industry clean-energy networks (BR₂) appears essentially random rather than trending, indicating these remain nascent, under-institutionalized research areas. Only the vocational-integration and PRONATEC-linked literature (BR₃) shows sustained, statistically robust growth, suggesting that human-centric technical training, rather than high-technology R&D partnerships, is the more mature strand of Brazil's Education 5.0 – Industry 5.0. Read together, these nine trajectories point to a single overarching conclusion: the Global South's Education 5.0 movement has substantially outpaced its Industry 5.0 integration. Each nation has built, to varying degrees, the human-capital and policy infrastructure that Society 5.0 requires, but none has yet produced a robust empirical literature connecting that infrastructure to measurable industrial or economic transformation. This gap carries direct implications for global supply chains in near-shoring, rare-earth and critical-mineral processing, and power-intensive AI infrastructure, where India, China, and Brazil each hold a distinct comparative advantage that remains only partially leveraged. Closing it will likely require deliberate institutional bridges: translational funding mechanisms that carry India's green-engineering-hub prototypes into manufacturing corridors, applied-outcomes research that follows China's curricular reforms into industrial productivity metrics, and expanded university-industry partnerships that scale Brazil's clean-energy and AI-infrastructure advantages beyond isolated pilot projects.

This study is not without limitations. Restricting the bibliometric search to Scopus-indexed, peer-reviewed literature excludes grey literature, government reports, and non-English regional scholarship that may capture translational activity not yet reflected in the academic record; the exclusion of 2026 publications, while methodologically necessary given publication lag, means the very latest policy responses are not represented. Future work should extend this framework with primary case studies — tracing specific green-engineering-hub graduates, NGAIDP-linked curricula, or PRONATEC cohorts directly into labor-market and industrial outcomes — to test whether the structural gap identified here begins to close as these Education 5.0 initiatives mature. Doing so would move the field from documenting *what* the Global South is building toward demonstrating *whether* it is working, which is the essential (and naturally) progressive step toward the algorithmic, industrially competitive Society 5.0 this study sets out to map.

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Appendix: List of abbreviations and acronyms used in this work.

Abbreviation/Acronym	Description
AI	Artificial Intelligence
AIED	Artificial Intelligence in Education
R^2	Regression Coefficient
RQ	Research Question
UN SDG	United Nations Sustainable Development Goals
STEM	Science, Technology, Engineering & Mathematics
GDP	Gross Domestic Product

The following figures accompany the discussions in the actual manuscript, and are suitably referenced in the main document.

(a)

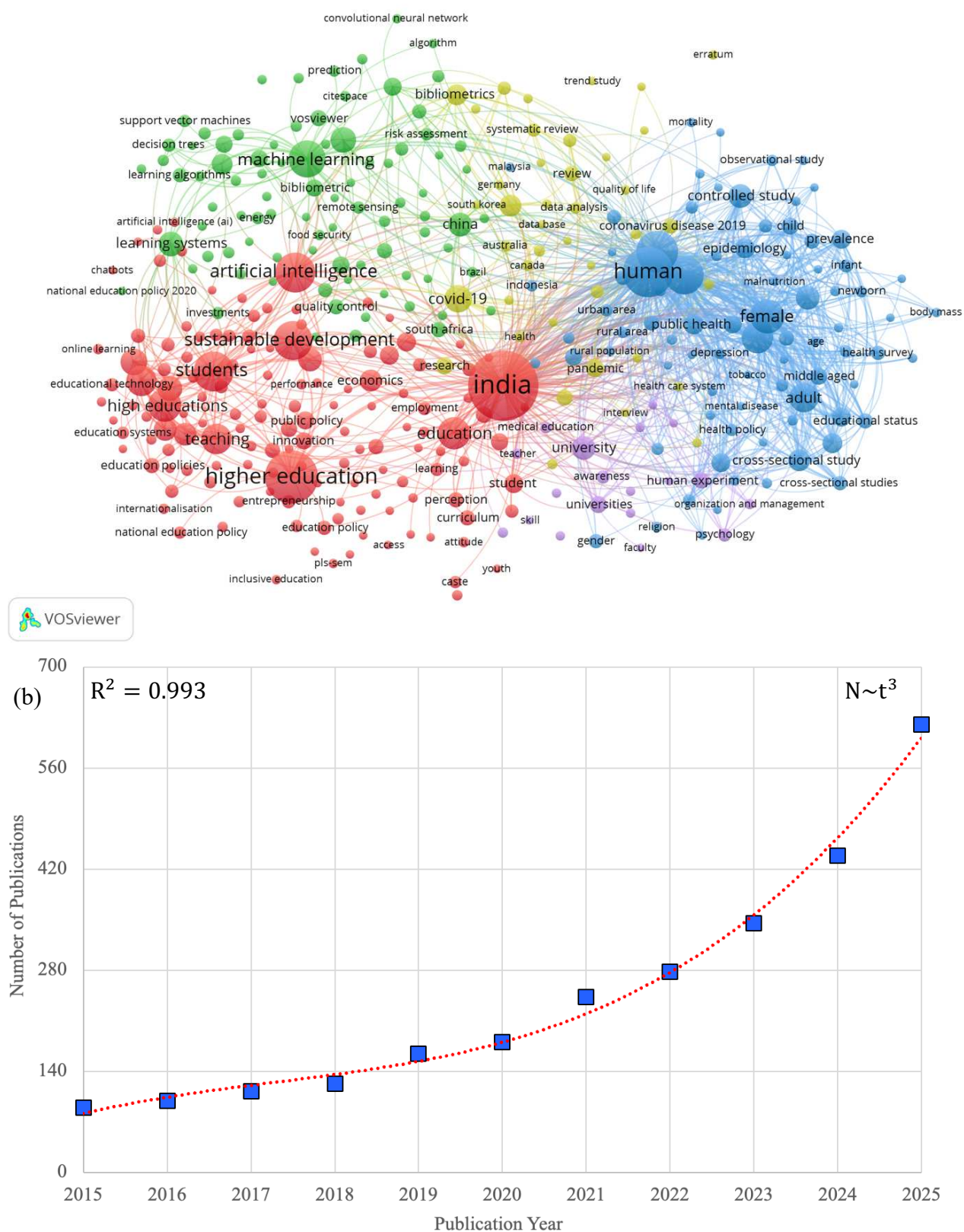


Figure 1: Co-citation network map (a) and temporal publication trends (b) for IN_1 .

(a)

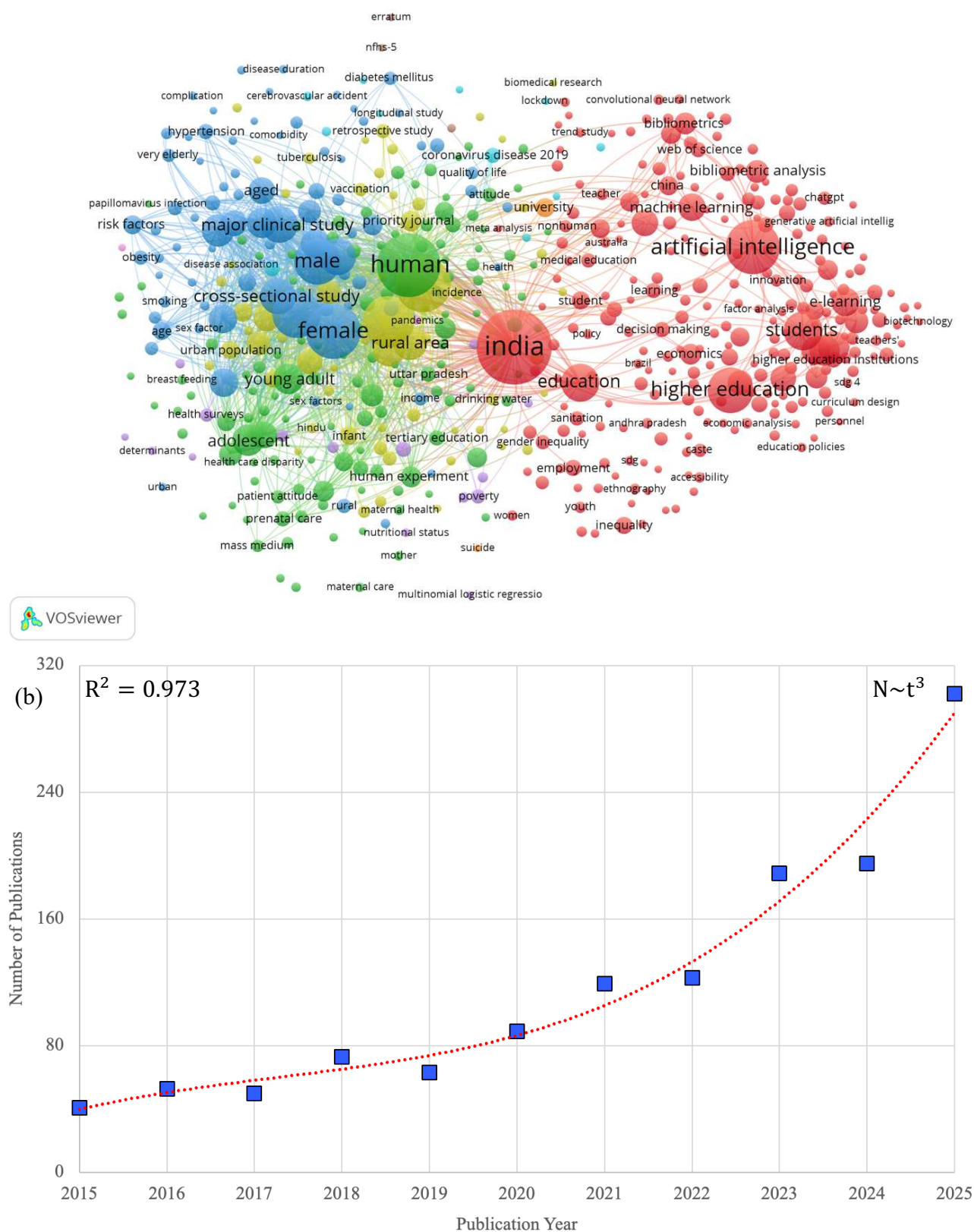


Figure 2: Co-citation network map (a) and temporal publication trends (b) for IN₂.

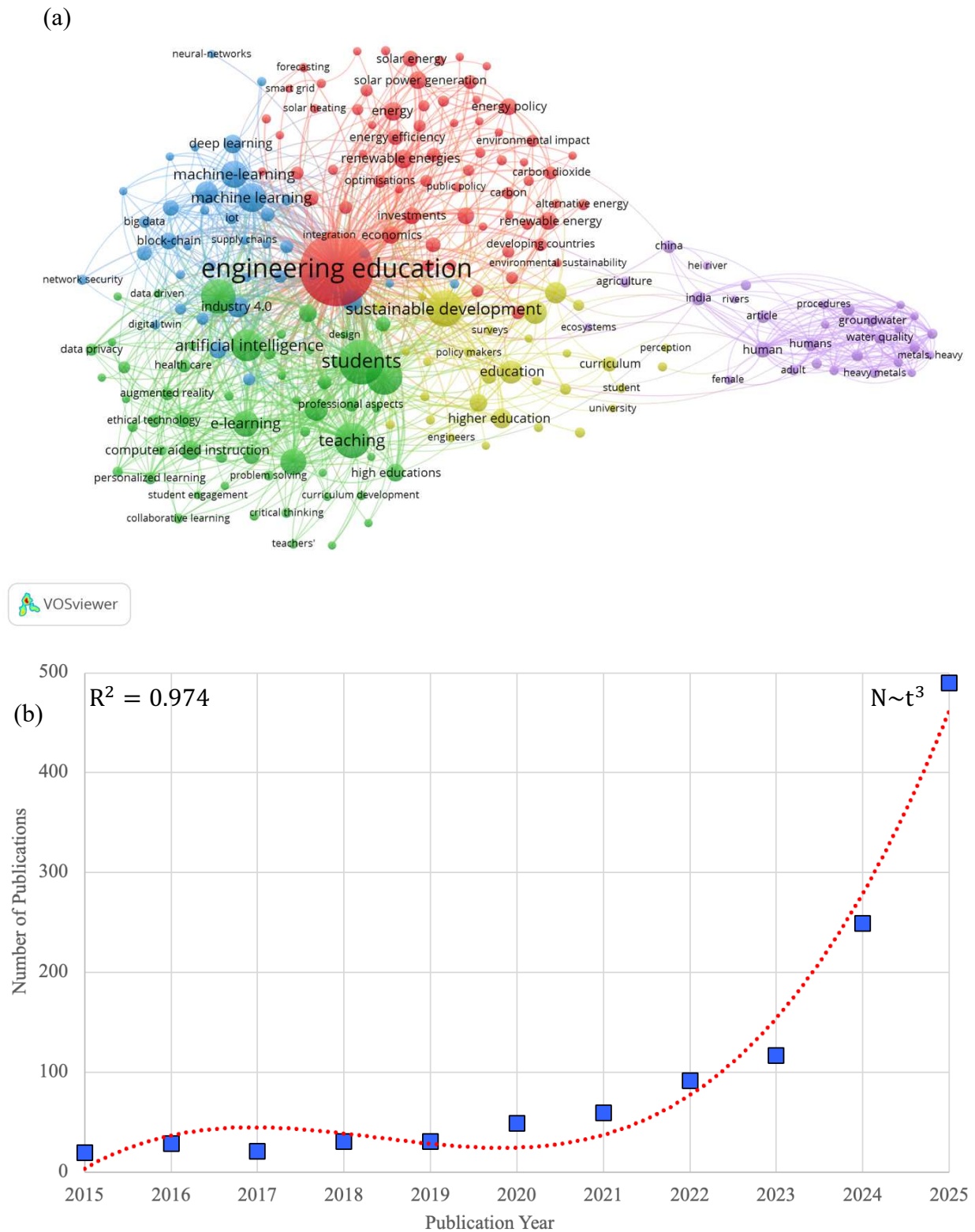


Figure 3: Co-citation network map (a) and temporal publication trends (b) for IN₃.

(a)

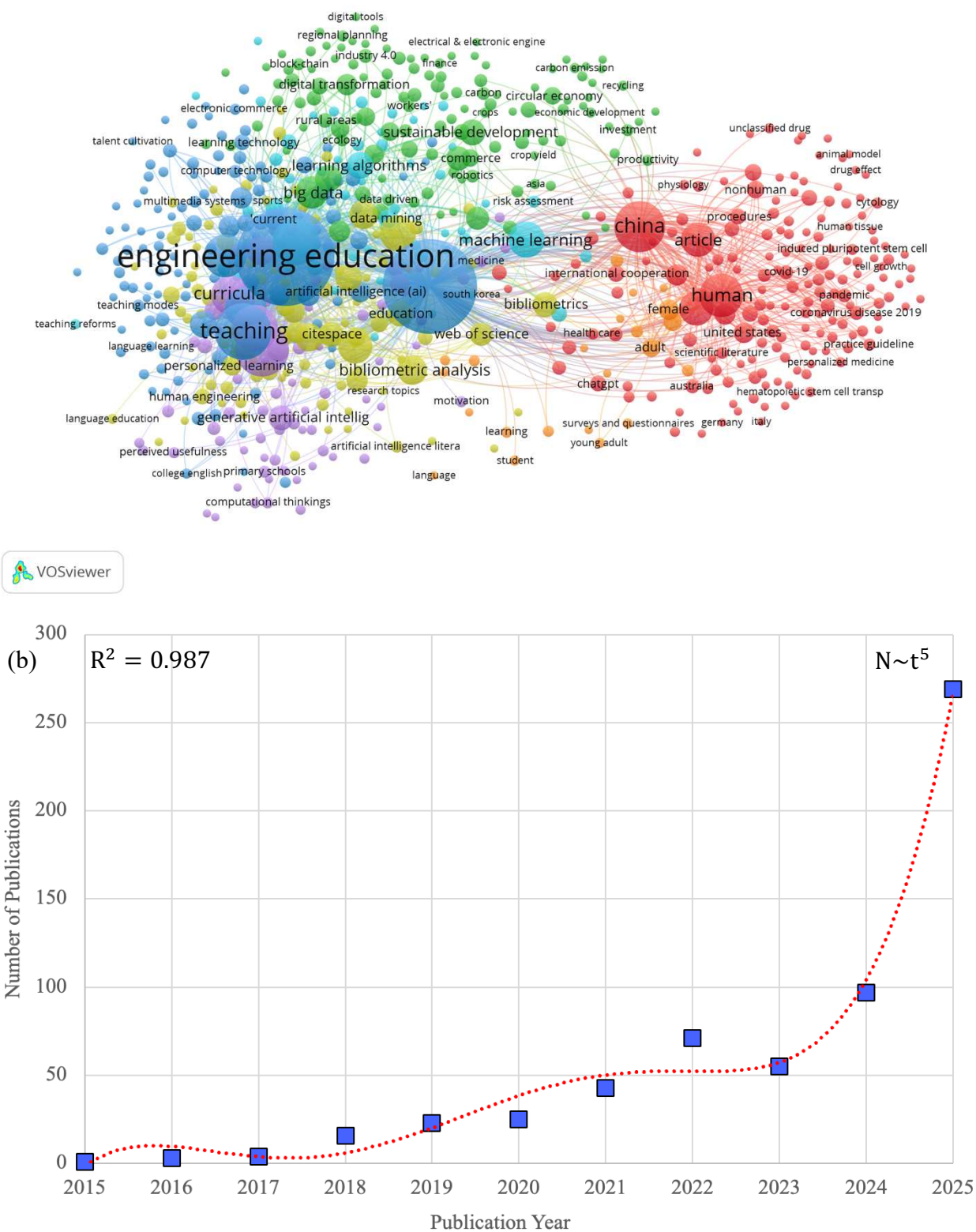


Figure 5: Co-citation network map (a) and temporal publication trends (b) for CN_2 .

(a)

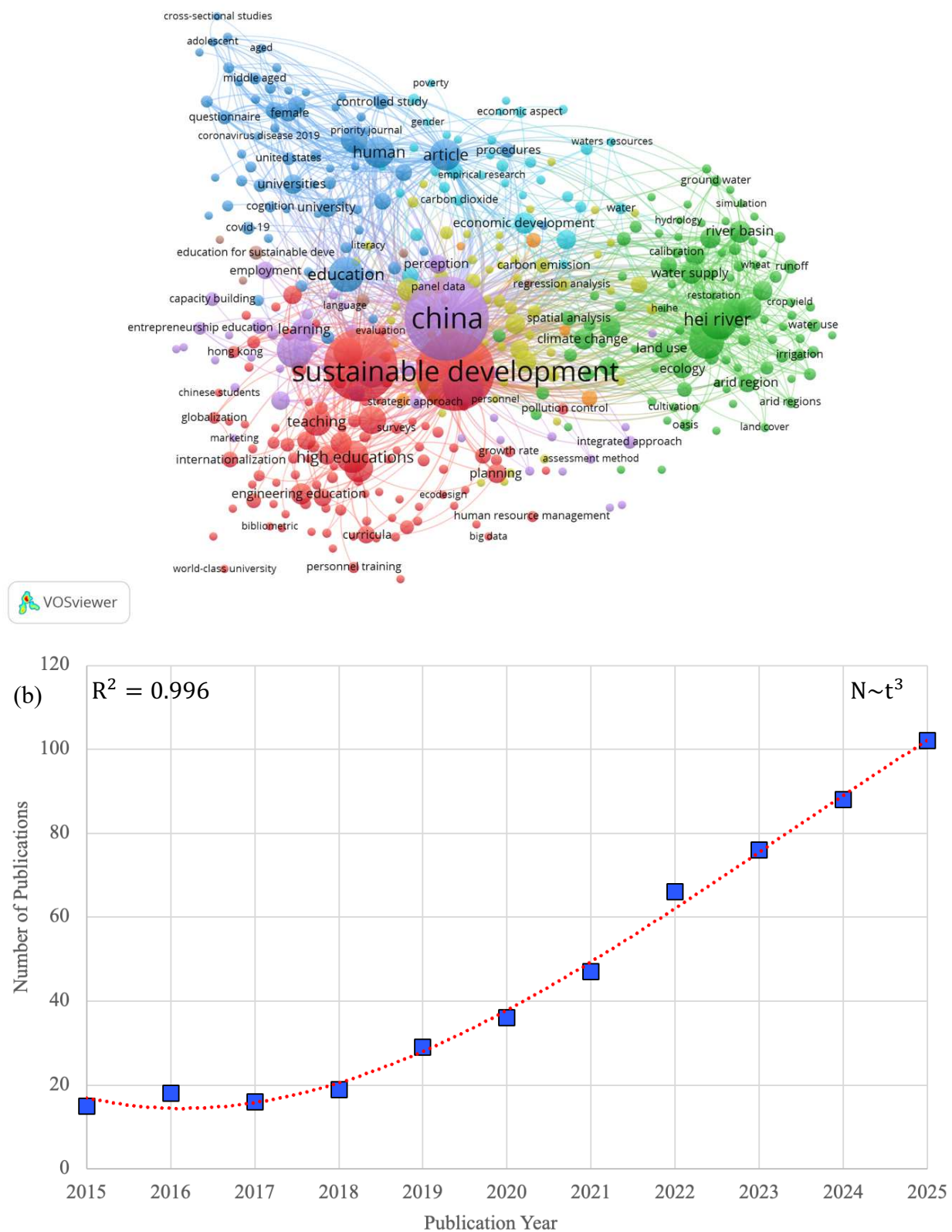


Figure 6: Co-citation network map (a) and temporal publication trends (b) for CN₃.

(a)

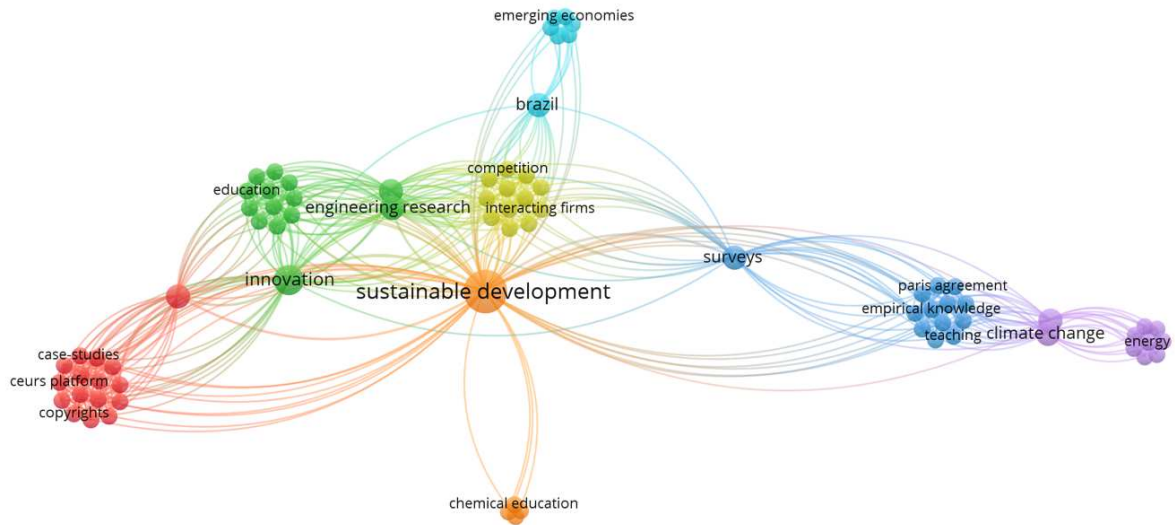
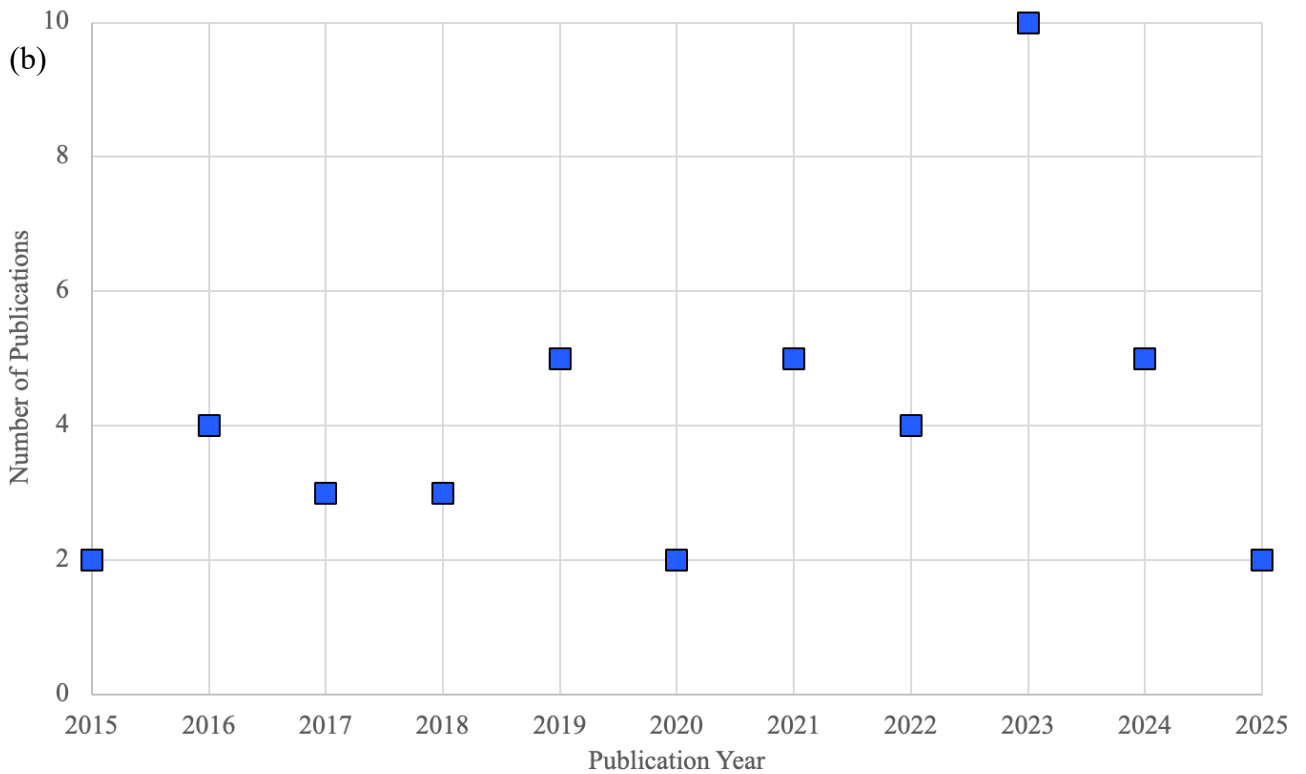
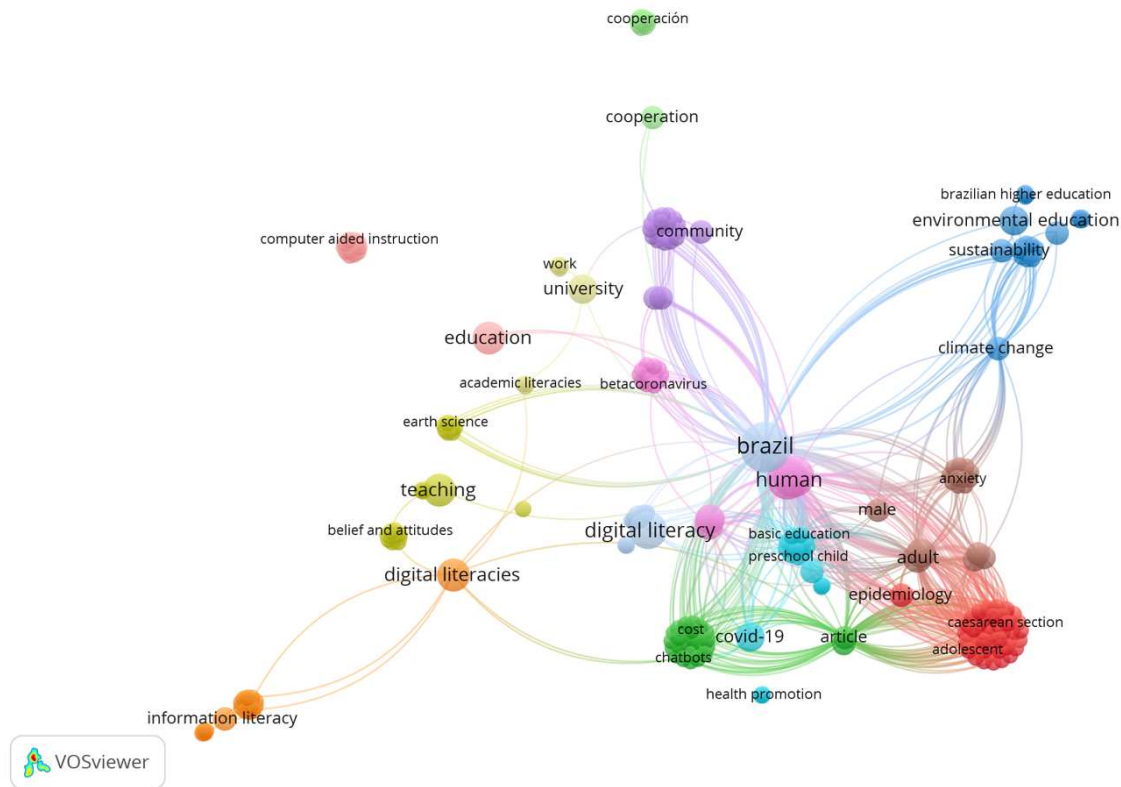


Figure 7: Co-citation network map (a) for BR₁. Publication trends (b) appear to be random.

(a)



(b)

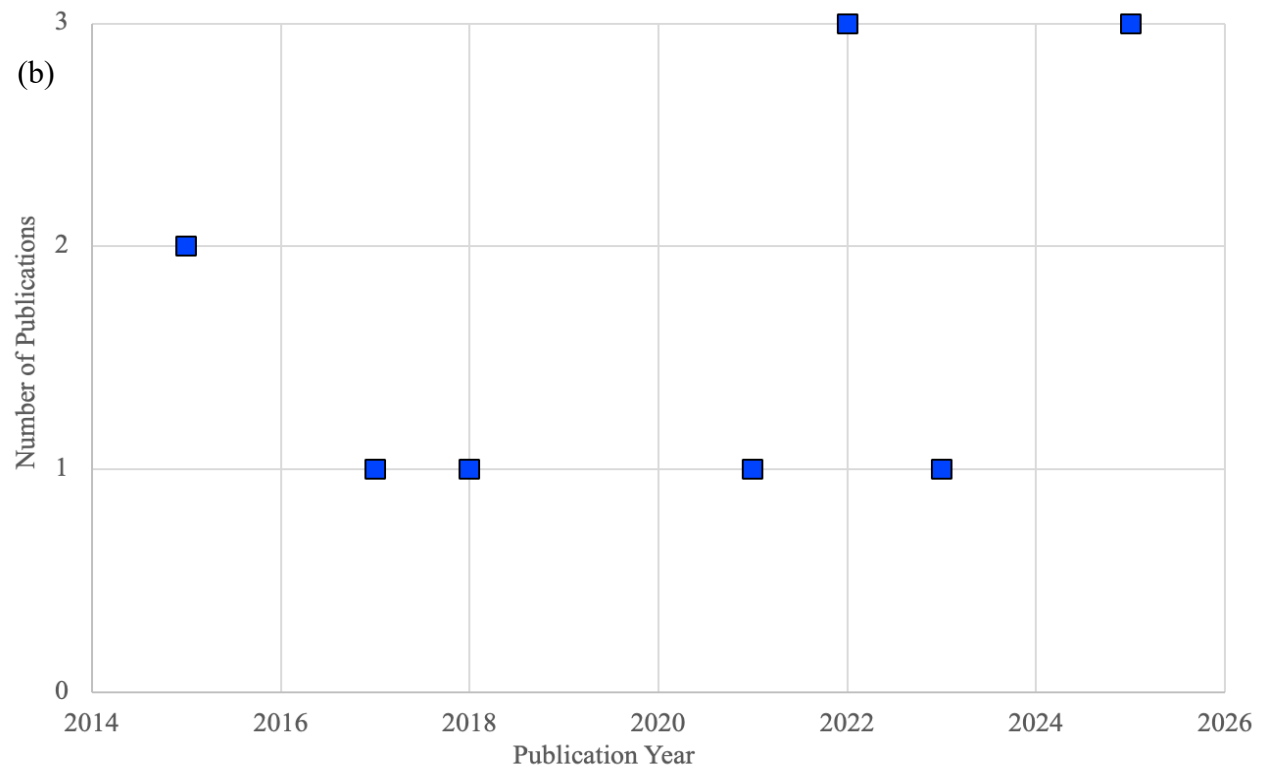


Figure 8: Co-citation network map (a) for BR₂. Publication trends (b) appear to be random.

(a)

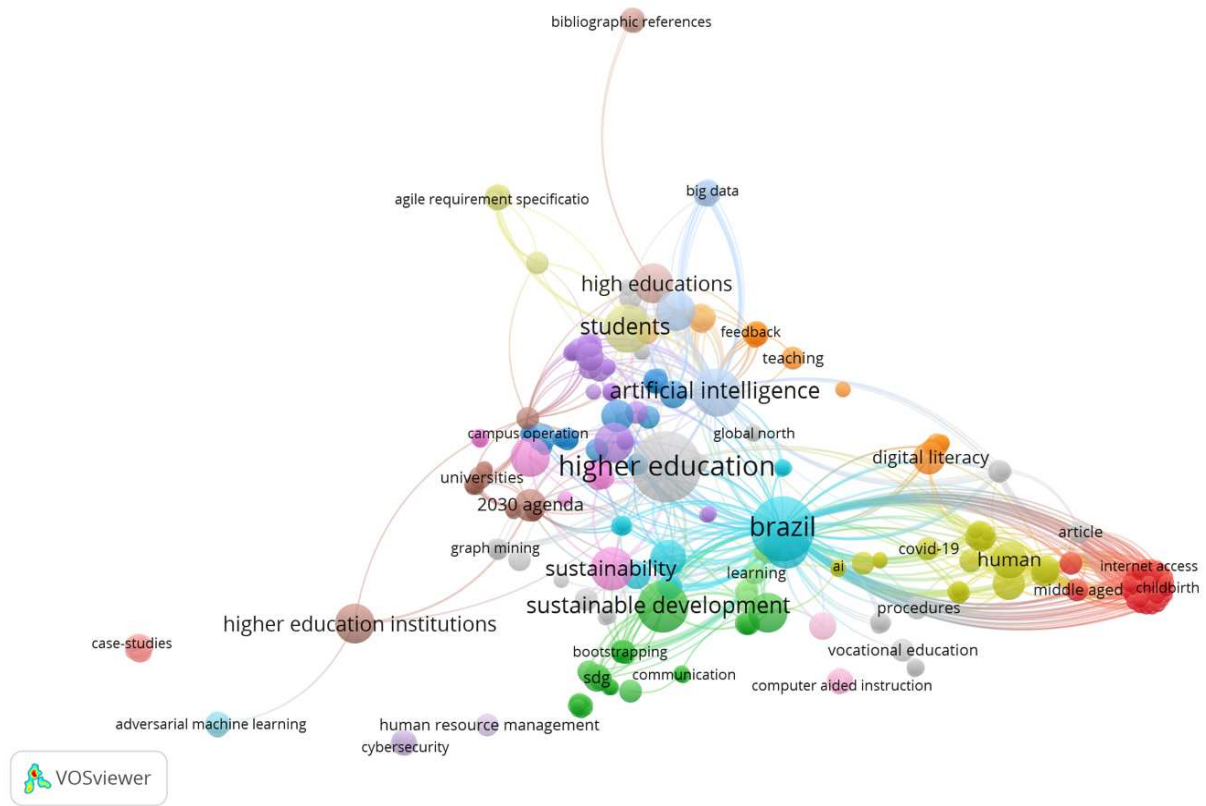
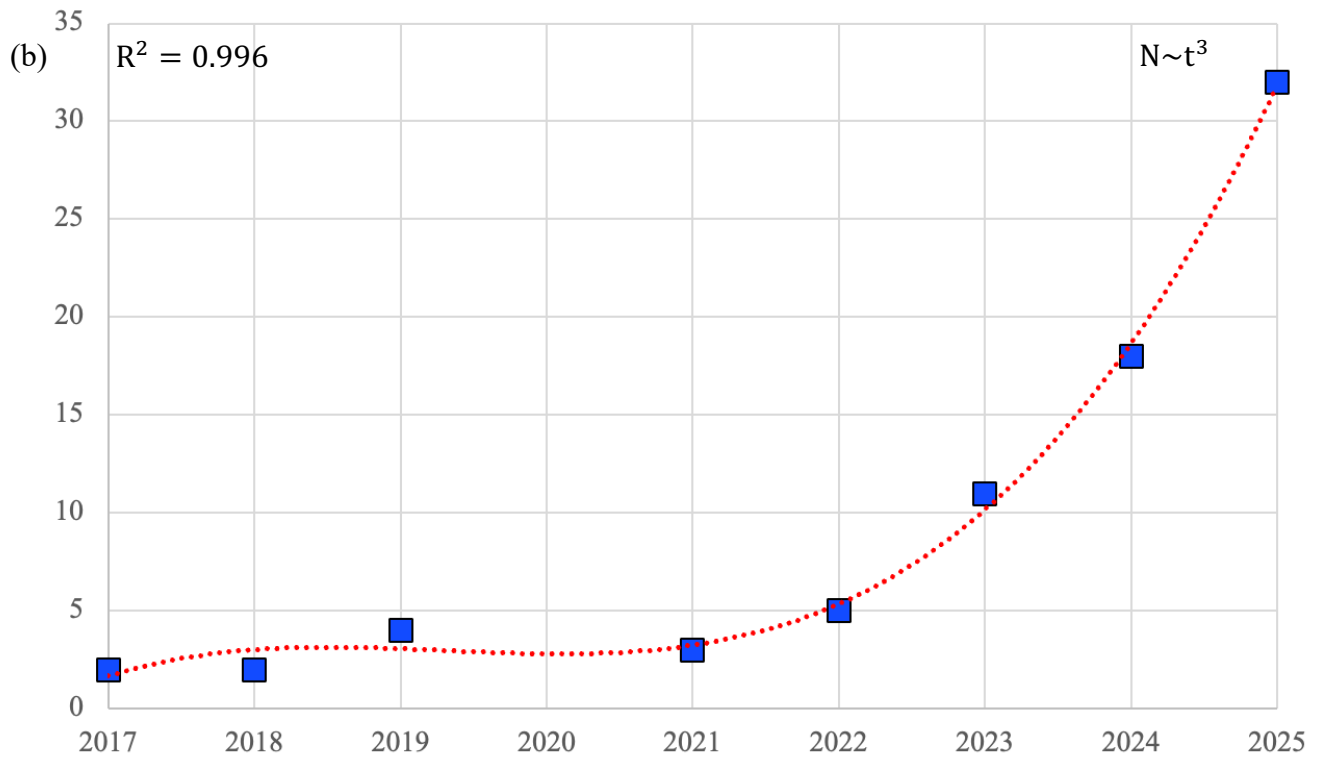


Figure 9: Co-citation network map (a) and temporal publication trends (b) for BR₃.