ARTIFICIAL INTELLIGENCE AS A STRATEGIC PILLAR OF THE NATIONAL TECHNOLOGY INITIATIVE BY THE TURKISH TECHNOLOGY TEAM (T3) FOUNDATION: THE T3AI, TEKNOFEST, AND T3 GEMSTONE PROJECTS

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Abstract

Artificial intelligence (AI) has emerged as a strategic epistemic infrastructure that reshapes how societies produce knowledge, exercise authority, and sustain cultural continuity. As control over AI systems increasingly translates into control over language, cognition, and decision-making, nations face growing risks of technological dependency, linguistic marginalization, and loss of cognitive sovereignty. This chapter examines AI as a core pillar of Türkiye's National Technology Initiative, focusing on how sovereignty, language, and integrated ecosystem design can be operationalized beyond policy declarations. Centering on the institutional role of the Turkish Technology Team (T3) Foundation, the study presents an ecosystem-level model that integrates software, hardware, education, and public participation. The chapter highlights three flagship initiatives. First, T3AI is analyzed as a Turkish-centered large language model initiative that addresses linguistic bias, data sovereignty, and benchmarking asymmetries through monolingual model design, localized evaluation frameworks such as the T3AI framework (T3AI'LE), and participatory corpus construction. Second, TEKNOFEST is examined as a beyond-the-nationwide applied AI laboratory that transforms education into practice by mobilizing millions of participants in challenge-based competitions, thereby cultivating human capital, ethical awareness, and systems thinking at scale. Third, T3 Gemstone is presented as a strategic step toward hardware sovereignty, enabling edge AI deployment through indigenous accelerator design and reducing dependence on foreign cloud and chip infrastructures. Together, these initiatives form a vertically and horizontally integrated AI ecosystem that links language preservation, talent formation, secure deployment, and technological resilience. The chapter argues that this model offers a viable pathway for achieving AI sovereignty while remaining compatible with global collaboration, providing a transferable framework for nations seeking to reclaim epistemic agency in the age of AI.

Keywords

Turkish Technology Team Foundation, Artificial Intelligence, TEKNOFEST, T3AI, National Technology Initiative

Introduction

Artificial Intelligence as Epistemic Infrastructure

Artificial intelligence (AI) has evolved from being a computational support technology to becoming the very foundation of the epistemic infrastructure that influences the way societies generate, verify, and share knowledge. Large language models, recommenders, and self-directed decision-making systems are becoming mediators between people, institutions, and information environments. As stated by Alvarado (2023), AI can be considered a paradigmatic epistemic technology due to the fact that these systems are designed to manipulate epistemic content, such as data and models, using operations such as analysis and prediction. AI systems are not just computational instruments, as Crawford (2021) states, but are actually socio-technical constructs that codify the politics and power relations of economy and culture. These systems are not just benign mediators but are instead proactive actors in creating meanings that alter the info-sphere and, by extent, the human reality itself (Popow, 2026).

Recent research has pointed out that control over AI infrastructure means control over knowledge mediation, agenda-setting, and cognitive framing on a large scale (Birhane et al., 2023). In this regard, AI has become pivotal with regard to issues of sovereignty, cultural continuity, and long-term national resilience. This shift in course confronts traditional assumptions about authority and agency, as machine-learning models are now assuming roles of arbitrators of truth in a post-digital knowledge society (Fuchs, 2021). The automation of cognition further threatens to displace human interpretive agency and deprive us of experiential knowledge and context-sensitive inquiry (Stiegler, 2010).

Global AI Concentration and Structural Dependency

The global AI ecosystem is highly concentrated, dominated by a few US and Chinese firms controlling foundational models, datasets, cloud infrastructure, and accelerators. These actors define both technical standards and epistemological assumptions (Crawford, 2021; Birhane et al., 2023). Mayer and Lu (2025) describe this as a bipolar order between two “technopoles,” creating double dependency on US software and Chinese hardware. Such concentration produces algorithmic dependency: states lacking domestic AI capacity rely on foreign systems for governance, education, healthcare, and security. Scholars frame this as technological dependency extending into cognitive sovereignty (Floridi et al., 2018; Cath et al., 2018). van der Vlist et al. (2024) call this consolidation “Big AI” where dominance by major cloud providers creates lock-in effects that constrain national policy autonomy.

AI Colonialism and Linguistic Marginalization

AI colonialism describes how data extraction and algorithmic governance reproduce historical patterns of domination (Birhane et al., 2023). While much training data originates in the Global South, value creation remains concentrated in northern tech hubs. Arora et al. (2023) term this "data colonialism" highlighting unequal value exchange and invisible labor. This process decontextualizes local knowledge and erases spatial and cultural specificity (Baresi, 2025). Language intensifies this imbalance. English dominates datasets and benchmarks, marginalizing morphologically rich languages like Turkish. The result is semantic flattening and epistemic loss. Ofosu-Asare (2025) calls this "cognitive imperialism" where non-Western epistemologies are sidelined. English-centric datasets reinforce Eurocentric worldviews and obscure relational or spiritual knowledge forms (Popow, 2026).

Structural Challenges of Turkish in NLP Systems

Turkish poses structural challenges for NLP due to its agglutinative morphology, heavy inflection, and flexible word order. Tohma and Kutlu (2020) note that theoretically unlimited suffixation complicates morphological analysis and semantic interpretation compared to Indo-European languages. While linguistically rich, this structure challenges transformer models lacking sufficient Turkish corpora. Even Turkish-specific models such as BERTurk show weaknesses in contextual reasoning. Adalı (2024) emphasizes difficulties in accurate stemming for webpage indexing, despite Turkish's transparent grammar. Tunalı (2022) finds transformer-based models outperform classical methods in text classification but require large, high-quality monolingual datasets. Data scarcity and limited cultural grounding remain central obstacles.

Benchmarking Bias and Evaluation Asymmetries

AI development is shaped by benchmark datasets, most of which reflect English and Western contexts, reinforcing linguistic hierarchies (Raji et al., 2020). Large QA datasets like SQuAD are influential (Rajpurkar et al., 2016), yet translated Turkish versions often contain inconsistencies that degrade performance (Gemirter & Goularas, 2021). This creates a "legitimacy gap" for AI in non-Western contexts (Roberts, 2024). Scholars advocate localized, culturally grounded benchmarks to reflect societal communication patterns (Blodgett et al., 2020). Without them, multilingual competence claims remain overstated. Participatory benchmarking frameworks can integrate diverse epistemologies and prevent misrepresentation of indigenous realities (Ofosu-Asare, 2025). Western accuracy metrics often overlook culturally embedded semantics (Ishkhanyan, 2025).

Hardware Sovereignty and the Limits of Cloud Dependence

Beyond software, hardware sovereignty is critical for national AI capacity. Dependence on foreign GPUs and accelerators exposes states to supply-chain and security risks. van der Vlist et al. (2024) describe "Cloud AI wars" where firms like Amazon and Google develop proprietary chips, reinforcing infrastructural power (Mayer & Lu, 2025). Edge AI, which processes data locally, reduces latency, privacy, and security risks. Rabiee and Hoagg (2023) show that robotic control benefits from local processing due to actuator constraints. Excessive reliance on foreign cloud providers may undermine national security and economic autonomy, necessitating domestically governed digital infrastructures (Misra et al., 2025).

From Policy to Infrastructure: The Missing Link

Many national AI strategies acknowledge sovereignty concerns but focus on policy declarations and funding rather than infrastructural implementation (Floridi et al., 2018; Cath et al., 2018). Mügge (2024) critiques the "global race" framing, arguing it prioritizes geopolitical competition over societal empowerment. Bridging rhetoric and practice requires empirical models of integrated AI ecosystems. Misra et al. (2025) argue that digital sovereignty in Industry 5.0 demands governed digital resources and autonomous architectures. Dynamic frameworks such as "Digital Federalism" can reconcile state authority with transnational cooperation through multi-tiered sovereignty (Ishkhanyan, 2025).

This chapter adopts a systems-oriented framework that conceptualizes AI sovereignty across five interdependent layers:

1. Language and cultural representation: Ensuring linguistic integrity and avoiding semantic flattening in AI models.
2. Data governance and benchmarking: Establishing data sovereignty and localized evaluation metrics.
3. Hardware and computational infrastructure: Developing domestic accelerators and edge AI architectures to reduce cloud dependence.
4. Education and human capital formation: Building a continuous pipeline of skilled labor through hands-on innovative training.
5. Deployment, security, and institutional control: Ensuring on-premise control and safety-critical oversight of algorithmic systems.

1. Positioning Türkiye's National Technology Initiative

Türkiye's National Technology Initiative ranks technological self-sufficiency as a national strategic priority, stressing domestic manufacturing, open innovation, and people's participation. In this regard, artificial intelligence is seen as an economic growth driver and a channel for strategic independence and cultural expression.

Guarascio et al. (2025) advocate that European countries need a "new industrial policy" to be able to manage the dependency on the few suppliers and improve the productive capabilities in the key areas. Technology policy of Turkish Goverment supports this trend, and the AI is considered a "silver bullet" to end the global technological dependency cycle (Bulut et al., 2025; Guarascio et al., 2025).

The T3 Foundation is the main non-profit actor that is responsible for conveying the vision into tangible operational infrastructures, which includes the connection of education, hardware development, software engineering, and public engagement. This institutional function is very similar to what Ishkhanyan (2025) calls Digital Federalism, where there is a centralized vision for standard-setting and a decentralized, participatory innovation process. By positioning AI as a critical infrastructure for national resilience, the initiative confronts the "sovereignty-internationalism paradox" by developing local capacity and at the same time collaborating with international ethical norms (Ishkhanyan, 2025).

1.1. T3AI as a National Large Language Model Initiative

Rationale for a Turkish-Centered LLM has commenced when the shift to large language models (LLMs) has been so immense that they virtually turned into the main infrastructure for access to information, support in making decisions, or content generation. Unfortunately, most of the existing LLMs have been constructed from datasets where English and other high-resource languages account for the vast majority, and this has led to systematic underperformance in languages with complex morphology and culturally embedded semantics (Blodgett et al., 2020). Turkish suffers from these limitations through errors such as suffix interpretation, tense and aspect and mood constructions, named entity recognition, and culturally specific references. Research by Gemirter and Goularas (2021) has proved that even BERT-based multilingual models like mBERT are not good with Turkish and hence a specialized monolingual Turkish language model is necessary for getting satisfactory results.

T3AI is one of the projects that have been introduced to overcome these disadvantages by adopting a Turkish-first model development paradigm. Instead of treating Turkish as an auxiliary language within a multilingual framework, T3AI views it as the primary linguistic and epistemic reference point. This method is in perfect line with the recent literature calling for language-centered AI design and underscoring the necessity of considering linguistic structure and cultural context in deciding model architecture and data curation strategies (Joshi et al., 2020). By doing monolingual development, the model is able to steer clear of any information loss that comes with machine-translating training data from English (Tunalı, 2022).

In terms of data sovereignty and corpus construction, a major point in T3AI is that it wants to keep the ownership of data at the front line. The training corpora will consist of materials coming from nationally curated sources such as academic publications, public sector documents, historical archives, and culturally validated resources.

1.1.1. Benchmarking and Evaluation

Looking into the problem of benchmark bias, the benchmark datasets play a decisive role in shaping AI research trajectories. Yet, as multiple studies demonstrate, widely used NLP benchmarks systematically privilege English-language tasks and Western cultural contexts, thereby reinforcing existing hierarchies in AI development (Raji et al., 2020; Blodgett et al., 2020). Turkish-adapted models often appear performant on global leaderboards while failing in real-world Turkish applications due to "evaluation asymmetries." Furthermore, the use of biased datasets can limit access to investment or public services by mischaracterizing entire populations (Arora et al., 2023).

This bias has direct consequences for Turkish NLP. Gemirter and Goularas (2021) observe that simple evaluation metrics like "Exact Match" (EM) can be misleading in agglutinative languages where multiple correct variations of a word's syntax exist. Therefore, relying on Western notions of "good" language output is inappropriate for Turkish, which requires more nuanced linguistic priorities (Ofosu-Asare, 2025).

As for the design and function of T3AI, a project-specific model was developed to address this evaluation gap. This specific model systematically assesses LLMs across dimensions such as:

- Morphological accuracy
- Contextual coherence
- Cultural and historical knowledge of Türkiye
- Domain-specific reasoning in Turkish

Empirical evaluations conducted within the T3AI framework demonstrate that even state-of-the-art open-source LLMs exhibit substantial deficiencies in these areas, corroborating findings in recent Turkish NLP research. By institutionalizing localized benchmarking, the model operationalizes recommendations from AI evaluation scholarship advocating for context-aware performance metrics (Raji et al., 2020). Such metrics ensure that the AI systems are "culturally attuned" and respectful of the specific narratives of the community (Ofosu-Asare, 2025).

1.1.2. The Rationale for a Turkish-Centered LLM Paradigm

The global transition to LLMs represents more than a mere technological advancement; it signifies the emergence of a new primary infrastructure for information access and autonomous content generation. In this digital era, language models function as the cognitive gateways through which societies interact with the vast repositories of human knowledge. However, a critical examination reveals a profound linguistic and epistemic imbalance. The vast majority of existing LLMs are constructed from datasets where English and a handful of other high-resource languages account for the overwhelming majority of training tokens.

This concentration of linguistic power leads to systematic underperformance in languages with complex morphology, such as Turkish. As an agglutinative language, Turkish utilizes a highly productive system of affixation where a single root can support a long chain of suffixes to convey tense, aspect, mood, and case. Western-centric models often fragment Turkish words into semantically meaningless sub-units during tokenization, disrupting the model's ability to learn underlying grammatical rules.

The T3AI project addresses these disadvantages by adopting a Turkish-first model development paradigm. By establishing Turkish as the primary linguistic and epistemic reference point, the initiative avoids the "semantic thinning" that occurs when training data is machine-translated from English. This is compared in Table 1. This approach aligns with modern literature advocating for language-centered AI design, ensuring that specific linguistic structures and cultural contexts are fundamental to the model architecture.

1.1.3. Linguistic Architecture and the Agglutinative Challenge

Turkish linguistic structure presents unique challenges for standard transformer-based architectures. A single word like *çalıstırılamayabilenlerdensiniz* (translation: You are among those who may not be able to work.) demonstrates the density of information packed into Turkish morphemes. The T3AI initiative prioritizes advanced tokenization techniques tailored to these morphological complexities.

Before specialized models (see Table 1) like T3AI, Turkish NLP relied on multilingual models. However, empirical studies consistently show that these lack the depth required for high-stakes applications.

Table 1

AI LLM Models' Comparison

Model Type	Linguistic Approach	Common Failures in Turkish
English-Centric (GPT-4)	Zero-shot / Few-shot transfer	Suffix hallucinations; cultural blindness.
Multilingual (mBERT)	Auxiliary language support	Inaccurate aspect/mood; poor local NER.
Monolingual (T3AI)	Turkish-first reference	Optimized for agglutination and cultural semantics.

By treating Turkish as the primary reference point, the model architecture is optimized to handle long-range dependencies inherent in Turkish suffix chains, which are often misinterpreted by models expecting the rigid word-order patterns of English.

1.1.4. Data Sovereignty and the "AILE" Model

A cornerstone of the T3AI initiative is data sovereignty. In an era where data is a strategic resource, maintaining ownership over training corpora is essential for national security and cultural integrity. The training materials for T3AI are drawn from nationally curated sources, ensuring the model is grounded in verified, culturally relevant information.

The T3AI'LE project (meaning "family" in Turkish) reflects a commitment to democratizing AI development.[1] The model was developed with the active contribution of 1,792 volunteers from 67 different provinces. This collaborative effort involved:

- Data Validation: Volunteers refined Turkish-specific datasets to ensure grammatical accuracy.
- Instruction Tuning: Community members provided diverse prompts to help the model learn natural Turkish registers.
- Ethical Oversight: The open-source nature allows for "ethical AI" development that reflects social values rather than "black box" opaque sourcing.

1.1.5. Historical Continuity: The Ottoman Archive Project

T3AI extends its linguistic scope into the historical depths of the Turkish language. Türkiye possesses approximately 100 million pages of documents from the Ottoman era, written in a blend of Turkish, Arabic, and Persian. T3AI serves as a catalyst for "AI-Assisted Ottoman-Turkish End-to-End Translation."

[1] https://www.t3ai.org/

- Handwritten Text Recognition (HTR): Utilizing models like Transkribus to transcribe manuscripts.
- Linguistic Normalization: Correcting archaic texts for modern computational use.
- Stylistic Classification: Using Convolutional Neural Networks (CNNs) to classify architectural styles based on textual descriptions.

This integration ensures that T3AI is not only a tool for the future but a bridge to the past, capable of understanding administrative records and centuries-old heritage.

1.1.6. Secure Deployment and Digital Sovereignty

T3AI addresses risks related to data privacy and surveillance through on-premise architectures. Relying on foreign cloud providers creates a "legitimacy gap," subjecting public data to foreign corporate oversight.

Institutional Trust: T3AI models can be housed within state frameworks, providing legitimate control over sensitive data.

Compliance: Development aligns with Türkiye's Law on the Protection of Personal Data (GDPR), emphasizing "Privacy by Design".

Technological Autonomy: Reducing dependence on foreign suppliers whose laws may contradict local governance.

As we approach 2026, the T3AI initiative is expanding into vertical integration (finance, law, healthcare) and support for Turkic dialects to facilitate regional information flow. By nurturing the complexity of the Turkish language and securing its digital borders, T3AI ensures that Türkiye can speak with its own voice in the age of AI.

1.1.7. Secure Deployment and Institutional Trust

On-Premise Architectures and Data Protection A notable factor of T3AI is its sustained support to on-premise deployment. The T3AI models, unlike the cloud-reliant AI services, can be housed in the institutional frames which guarantee that the delicate data is kept within the national borders. Roberts (2024) suggests that a normative angle towards digital sovereignty is that "legitimate control" is required and when countries rely upon foreign "Big Tech" providers for cloud services that are essential for state functioning then the control is reduced. On-premise deployment eliminates the issue of "legitimacy gap" by allowing the public to indirectly consent to foreign corporate oversight (Roberts, 2024).

This particular design choice is in line with the governance-oriented AI literature which is paying attention to the risk of cross-border data flows, such as the problems with compliance with regulations, the exposure to surveillance and the loss of trust

(Cath et al., 2018). Misra et al. (2025) mention that the technological autonomy is the result of a significant reduction in dependence upon the foreign suppliers whose national laws might be contradictory to the local governance. Nations that grant processing of data in their own territory can shield personal privacy and intellectual property from the meddling of foreign forces (Misra et al., 2025).

Implications for Public Sector AI Adoption Trust is still the main obstacle to the introduction of AI technology in the public sector. According to the research, the lack of transparency, the non-existence of accountability, and the security of the data are the main factors that will negatively impact the institutional preparedness to adopt AI systems (Floridi et al., 2018). For instance, in educational technology, the appropriateness of a management system is often determined through its conformity to national standards, which ensures that data is treated ethically (Bulut et al., 2025; Bulut et al., 2026; Wicaksono et al., 2025). Through the T3AI technology, a secure and localized deployment is not only enabled but also greatly reduced.

1.2. TEKNOFEST as an Applied AI Laboratory

Large-scale competitions play a critical role in translating theoretical knowledge into applied competence. Research on innovation ecosystems demonstrates that challenge-based environments accelerate skill acquisition and interdisciplinary collaboration. Within the T3 Foundation ecosystem, TEKNOFEST functions as a nationwide applied AI laboratory. Thousands of teams engage annually in AI-driven challenges across domains such as healthcare, transportation, defense, and natural language processing.

This competitive environment reinforces problem-solving skills, systems thinking, and ethical awareness, competencies emphasized in contemporary AI education research (Holmes et al., 2022). Furthermore, TEKNOFEST serves as a site for "epistemic insurgence," where the next generation of technologists builds alternative futures that affirm knowledge as a collective human endeavor (Popow, 2026). This challenge-based model helps bridge the gap between abstract policy and material systems (Cath et al., 2018).

1.2.1. The Laboratory Framework: National Technology Initiative as Strategic Infrastructure

The foundational philosophy of the TEKNOFEST applied laboratory is rooted in the "National Technology Initiative" (Milli Teknoloji Hamlesi). This strategic framework posits that sustainable growth requires a nation to transition from a consumer of global technologies to a primary producer of original systems.

The scale of this laboratory is unprecedented. Since 2018, TEKNOFEST has recorded nearly 4 million applications, creating a massive pipeline of human capital. For the 2025 iteration, the festival expanded to 63 main categories, reflecting the increasing granularity of applied AI challenges. The financial commitment, exceeding ₺65 million in prize money and ₺85 million in material support[2]-functions as "innovation insurance," lowering the entry barrier for students to experiment with high-compute hardware and complex datasets.

The laboratory operates through a rigorous filtration process designed to mimic the R&D lifecycle of professional AI firms (see Table 2). This structure cultivates "systems thinking" requiring participants to navigate the interplay between hardware constraints and algorithmic efficiency.

Table 2

TEKNOFEST Competition Stages and AI Symbiosis

Stage	**Primary Deliverable**	**Core AI Competency Evaluated**
Preliminary Design Report (PDR)	Technical specification & architecture	Theoretical feasibility & logic
Project Detail Report (PDR)	Dataset analysis & prototype data	Data literacy & technical rigor
Online Simulation	Validation in virtual environments	Edge-case handling & robustness
Final Presentations	Physical/Software demonstrations	Commercial potential & communication

1.2.2. Ethical Awareness and Algorithmic Fairness

A recurring theme in AI research is the risk of "cognitive disengagement" and harmful biases. TEKNOFEST addresses this by requiring participants to justify their data selection. By working with domestic datasets, such as Turkish medical records or linguistic data, teams confront the challenges of "algorithmic fairness." In the AI in Healthcare track, "social benefit" is weighted alongside technical accuracy, framing AI as a sociotechnical artifact rather than just a mathematical optimization task.

Healthcare as a Primary Site of Applied AI: "CoMed" and the Reality of AI "Brittleness"

The AI in Healthcare Competition, coordinated by TÜYZE (Türkiye Health Data Research and Artificial Intelligence Applications Institute), is a critical track where high-dimensional medical data is translated into clinical insights. In 2025, 3,275 teams applied to develop models for the early detection of polyps, strokes, and cardiomegaly.

2 www.teknofest.org

The journey of the "CoMed" (Collaborative Medicine) project highlights the gap between theoretical success and material implementation. The team utilized Computer Vision (CV) to analyze brain MRI and CT scans, aiming to maximize the F1 score which is vital for medical diagnostics.

Despite strong training performance, the team faced failure during final evaluations due to a data-formatting error-rounding float numbers to integers in the final JSON output. This experience reflects the laboratory's role in teaching that technical excellence requires meticulous attention to system integration (Abdibrokhim, 2025).

Aviation and Autonomous Transportation: Advancing Strategic Autonomy

The aviation track is of strategic importance for national independence. AI models here must operate under extreme constraints, handling high-speed data streams and making millisecond decisions.

The transition from general "Transportation" to "Aviation" categories (2021–2025) reflects an increase in technical complexity.

2021-2023: Focus on basic object detection and path planning (e.g., Teams Ayasoft, GAiA-TECH).

2024-2025: Focus on edge computing and real-time mission-critical AI (e.g., Yıldız AI Softwhere).

Quantitative Growth and Structural Expansion

The quantitative data from the 2018–2025 period reveals a steady and strategic expansion of AI within the TEKNOFEST (Table 4) ecosystem. Initially, the focus was limited to a few core competitions, but by 2025, the number of AI-focused events increased more than fivefold (see Table 4). This growth is characterized by a dual approach: "Direct AI Competitions" which focus on building the models themselves, and "AI-Integrated Competitions" where AI serves as the core intelligence for autonomous hardware like UAVs and UGVs.

Table 3

Growth of AI-Focused Competitions and Participation (2018–2025)

Year	AI-Based (Direct)	AI-Integrated (Usage)	Total AI Competitions	Total Application Teams	Finalist Teams
2018	1	1	2	134	18
2019	1	2	3	548	85
2020	1	2	3	458	71
2021	3	3	6	1,562	199
2022	3	3	6	3,900	235
2023	4	3	7	4,845	228
2024	4	3	7	12,929	348
2025	6	5	11	9,163	370

Strategic Developmental Phases

The developmental trajectory of AI at TEKNOFEST is categorized into three distinct eras. The Core Formation Period (2018–2020) served as a foundational stage where participants were introduced to machine learning, image processing, and basic autonomous systems through competitions like Swarm UAVs and Robotaxi. This was followed by the Specialization and Institutionalization Period (2021–2023), which expanded AI into vertical sectors such as healthcare and transportation, while simultaneously fostering a focus on Turkish Natural Language Processing (NLP). The current Strategic Geniuses and Generative AI Period (2024–2025) marks a shift toward cutting-edge global trends, integrating LLMs, multimodal AI, and AI-driven content creation into the national tech ecosystem.

Diversity of Subject Matter

TEKNOFEST has consistently diversified its AI subject matter, ensuring the technology is not siloed but applied across various industrial and social domains. (Table 4) By 2025, the list of topics grew to include highly specialized areas like aviation AI (see Table 5), address analysis, and advanced autonomy for "Star" class combat UAVs.

Table 4

Evolution of AI Subject Diversity (2018–2025)

Year	AI Subject Headlines (Selected List)	Total Subject Areas
2018	Basic Artificial Intelligence	1
2019	Basic AI, Swarm UAV / Autonomous Systems	2
2020	Basic AI, Autonomy (Robotaxi + Swarm UAV), Turkish NLP	3
2021	Health AI, Transportation AI, Turkish NLP, Autonomous Systems, Swarm Simulation	5
2022	Health AI, Transportation AI, Turkish NLP, Autonomous Systems, Swarm/Simulation	5
2023	Health, Transportation, NLP, Autonomy, Combat UAV, Psychology AI	6
2024	Health, Transportation, NLP, Autonomy, Combat UAV, Psychology, Advanced Simulation	7
2025	Health, Transportation, Psychology, NLP, LLM, AI Film, Aviation AI, Advanced Autonomy	10

Real-World Impact and National Contributions

The impact of these competitions is best measured by the success of student-led projects that address real-world challenges. For instance, the B_TEDMAKERS project in 2024 utilized deep learning for chest X-ray analysis to assist physicians in pneumonia detection. In the environmental sector, the Quantum project (2025) developed an early warning system for stubble fires by fusing sensor and image data. Other notable projects include SPORT PAPBiL, which uses machine learning for sports talent discovery, and Next, an AI-based tourist route planner.

These initiatives contribute to the "National Technology Initiative" by building a robust human resource pool and increasing sector-wide AI awareness. Crucially, TEKNOFEST supports Türkiye’s digital independence by encouraging the development of Turkish-specific datasets and models, ensuring that strategic AI systems remain secure and locally grounded. Ultimately, TEKNOFEST has successfully positioned AI as a sustainable technology culture that secures Türkiye's future in a data-driven world

Epistemic Insurgence and the Geopolitics of Technology: Unmapping the Buffer Zone

To understand TEKNOFEST, one must view it through the lens of "epistemic insurgence." This refers to the rejection of "geocultural passivity." For centuries, regions like Anatolia have been viewed as "buffer zones" between the West and the Orient (Geopolitics, 2025). By building autonomous UAVs and sophisticated NLP models, TEKNOFEST participants are "unmapping" this peripheral position. This is an act of geo-cultural emancipation, asserting that the "center lies East" and that the region has the agency to define its own technological future. TEKNOFEST creates a "relational constellation of actors" who identify with the National Technology Initiative, affirming knowledge as a collective human endeavor rather than a foreign import.

1.3. T3 Gemstone and Indigenous AI Hardware Development

Recent geopolitical events have emphasized the need for hardware sovereignty to be a key factor in the AI ecosystems of the future. Mayer and Lu (2025) point out that in the hardware area China is the leader, so it has an enormous "infrastructural power" over the other main economies. Nations have no choice but to invest in local chip design and production to gain and keep technological independence (Guarascio et al., 2025).

T3 Gemstone mitigates these threats through a locally-controlled AI accelerator platform that combines matrix multiply accelerators (MMA) with digital signal processors (DSP). Because of the energy-efficient performance that is suitable even for physical AI applications, T3 Gemstone is able to provide not just online inference in robotics, autonomous vehicle, and industrial monitoring systems but also making the whole process more efficient and sustainable. This hardware-software co-design opens up "ecopoiesis," a design philosophy that is based on keeping life and ecological integrity (Baresi, 2025).

Edge AI systems have the power to make the system more resilient by diminishing the reliance on cloud infrastructures that are centralized. The research indicates that processing done in the vicinity of users brings about an improvement in latency, privacy, and uptime, particularly in applications where the risk is very high. T3 Gemstone is a perfect example of the application of hardware-software co-design principles as it integrates optimized hardware with real-time GNU/Linux environments which have been advocated in the latest AI systems research. This localized method is an indispensable part of "technological resilience," which means that systems are capable of enduring the effects of failure or outside disturbance (Misra et al., 2025).

1.3.1. Edge AI and Autonomous Systems: The T3 Gemstone Architecture

The T3 Gemstone development boards represent a significant leap in indigenous Turkish hardware design, moving beyond simple microcontrollers into the realm of high-performance Single Board Computers (SBCs). Developed by the Turkish Technology Team (T3) Foundation, these boards are specifically engineered to meet the demanding requirements of TEKNOFEST competitions, particularly in fields like Manned and Unmanned Systems, IoT, and advanced robotics.

The Gemstone O1 is characterized as a "mini pocket computer" that integrates AI hardware accelerators with an optimized Real-Time Debian-based GNU/Linux operating system. It is designed to provide students, researchers, and entrepreneurs with a localized alternative to global high-performance edge computing platforms. (Table 5)

The Gemstone O1 utilizes a sophisticated multi-processor architecture to balance high-level operating system tasks with low-level, real-time hardware control.

The Computing Core

The board's processing power is distributed across three primary units:

CPU (Central Processing Unit): A quad-core 64-bit ARM Cortex-A53 running at 1.4 GHz. This unit is responsible for running high-level operating systems like Linux and managing general system tasks.

MCU (Microcontroller Unit): For tasks requiring deterministic, real-time performance, the board includes two single-core ARM Cortex-R5F units running at 800 MHz.

GPU (Graphics Processing Unit): The integrated GPU supports advanced rendering and parallel data processing through industry-standard APIs, including OpenGL ES, OpenCL, and Vulkan, complementing the SoC's dedicated AI accelerators, which deliver up to 4 TOPS of deep learning performance.

Memory and Storage

At the core of the T3 Gemstone O1 is a single System-on-Chip (SoC) based on the TI AM67A Jacinto 7 architecture. Rather than comprising discrete, independently placed components, the CPU, MCU, GPU, and AI accelerators are integrated on a single silicon die, interconnected through a shared on-chip fabric and memory subsystem. This unified architecture minimizes inter-block latency and enables efficient end-to-end execution of computationally intensive AI and vision workloads within a single chip.

4GB LPDDR4 RAM: Providing the necessary bandwidth for system memory and multitasking.

32GB eMMC: Built-in flash storage that allows the board to operate independently without the need for an external microSD card.

The defining feature of the Gemstone O1 is its ability to process complex AI and computer vision tasks at the edge with high efficiency.

AI Capability and Operational Logic

The fundamental logic of the T3 Gemstone O1 is built around the inferencing of pre-trained models (see Table 5).

Hardware-Accelerated Execution: Various AI models are accelerated using the MMA and 2x C7x DSP modules.

Throughput: The board contains two Deep Learning Accelerators, delivering a combined performance of 4 TOPS (Trillion Operations Per Second).

Integration: The results of these high-speed AI operations are easily accessible by the CPU or MCU for further decision-making in robotic applications.

Table 5

Summary of Technical Specifications

Component	**Specification Details**
CPU	Quad-core 64-bit ARM Cortex-A53 [at] 1.4 GHz
MCU	2 x Single-core ARM Cortex-R5F [at] 800 MHz
AI Accelerator	2 x 2 TOPS (Total 4 TOPS) Deep Learning Accelerator
GPU	50 GFLOPS (OpenGL ES 3.2, OpenCL 1.2 EP, Vulkan 1.2)
RAM	4GB LPDDR4 System Memory
Storage	32GB onboard eMMC Flash
OS	Real-Time Debian-based GNU/Linux
Specialized Hardware	Matrix Multiply Accelerator (MMA) & C7x DSP +1

Applications in Modern Robotics

Because of its unique blend of Linux-level flexibility and real-time MCU control, the Gemstone O1 is ideal for:

Autonomous Navigation: Using the MMA to process LIDAR or camera data for real-time obstacle avoidance.

Complex Computer Vision: Running object detection or facial recognition models at 4 TOPS without draining massive amounts of power.

Industrial IoT: Monitoring high-speed sensor data and making local decisions using machine learning before sending refined data to the cloud.

The T3 Gemstone O1 is a sophisticated platform that democratizes access to high-end AI acceleration. By combining a quad-core ARM processor with dedicated matrix accelerators and a real-time Linux environment, it provides a robust foundation for the next generation of autonomous systems and intelligent devices. As an open source software project, it continues to evolve as a cornerstone of technological education and entrepreneurship.

Local-to-global AI language model and the formation of AI human capital is quite intertwined. AI sovereignty is not viable if the skilled workforce is not continuously and broadly cultivated. AI education, at the same time, has been emphasizing that the very first exposure to computational thinking, and AI concepts is the main condition for entering the innovation capacity that involves the use of these technologies (Holmes et al., 2022). Popow (2026) states that "counter-algorithmic pedagogies" should be established that allow students not only to participate as passive users but also to help design the ethical AI infrastructures. If education does not reach this level, countries might face a "brain drain" problem, as a result of which the best minds will be attracted by the places where the competition in AI is the strongest and thus be out of their own country's reach (Mügge, 2024).

The T3 Gemstone project meets this need by offering the community easy and ready-to-use AI hardware for conducting experiments manually. Furthermore, the platform allows for real-time inference on edge devices by using machine learning frameworks like TensorFlow Lite, thus making the connection between theoretical learning and practical application stronger. This integration follows the principle of "participatory design," where the users and the developers of technology are considered equal partners throughout the process (Ofosu-Asare, 2025).

Experiential learning models claim that the best way to acquire knowledge is for the learners to actively participate in solving real-world problems and using the tools (Kolb, 1984). T3 Gemstone brings this principle to life by integrating AI education into a wider innovation ecosystem comprising workshops, mentorship, and national competitions. This "community-focused" approach guarantees that learning systems arise from local ontological frameworks rather than imposing foreign models onto them (Popow, 2026).

Such integration captivates the process of AI education through discussion and interaction among the teaching staff and students all along the development of the technology, connecting the early-stage techno-educational activities with the established ones in the AI race.

2. Discussion

2.1. Ecosystem-Level Synthesis

When analyzed collectively, T3AI, TEKNOFEST, and T3 Gemstone constitute a vertically and horizontally integrated AI ecosystem. Vertical integration connects education, model development, and deployment, while horizontal integration spans software, hardware, education, and governance. This multidimensional integration produces outcomes that extend beyond technical performance:

- Cultural continuity through Turkish-centered AI models.
- Institutional trust via secure deployment architectures.
- Talent sustainability through early and continuous education.
- Strategic resilience through indigenous hardware.

Such multidimensional integration aligns with contemporary frameworks of technological sovereignty and innovation-driven development (Birhane et al., 2023). By bridging the gap between national authority and transnational collaboration, this ecosystem provides a structured yet flexible model for governing AI (Ishkhanyan, 2025).

2.2. Global Synthesis and Future Directions

The artificial intelligence ecosystem developed under Türkiye's National Technology Initiative represents a profound ontological and epistemological rupture in knowledge governance. As this chapter has demonstrated, AI sovereignty is not a single technological achievement but a systemic condition requiring the coordinated development of language, hardware, data, and human capital. This systemic approach addresses the sovereignty–internationalism paradox by asserting domestic authority while participating in a globally interconnected digital world (Ishkhanyan, 2025). By resisting "Big AI" cloud dependence and prioritizing localized benchmarking, this model preserves cognitive sovereignty and prevents the "epistemicide" of alternative knowledge systems (Baresi, 2025).

Despite its success, the model faces challenges. Research highlights risks such as the erosion of social interaction due to rapid automation (Holmes, 2023).

Human Oversight: TEKNOFEST addresses this by being a onsite festival, fostering "trust and motivation" through one-on-one mentorship.

Digital Divide: The T3 Foundation mitigates this by providing direct hardware grants and decentralizing the festival to cities like Sanlıurfa in 2026 to ensure equitable access.

TEKNOFEST has evolved from a public exhibition into a sophisticated applied AI laboratory. By integrating pedagogical frameworks with the material requirements of healthcare, aviation, and NLP, it has created a site where theoretical knowledge is forged into national strength. As AI continues to unsettle global geopolitics, TEKNOFEST stands as a critical platform for ensuring the future is built not as a set of imported protocols, but as a sovereign human endeavor.

In a global context, the T3 Foundation's model highlights that the future of AI should not be optimized solely for control but consecrated for justice, care, and cultural flourishing. As AI systems continue to map yesterday's empires onto today's algorithms, the need for decolonial, participatory frameworks becomes a political imperative for every nation (Popow, 2026). Without a fundamental rethinking of how authority and legitimacy are encoded into our technologies, AI risks becoming a new architecture of digital colonialism rather than a tool for shared human prosperity (Roberts, 2024). Ultimately, the integrated ecosystem approach offers a roadmap for nations to reclaim their intellectual agency and ensure that the digital transition is inclusive, equitable, and sustainable.

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