

Exploring the Intersection of Intelligent Play: A Multidimensional Sustainability Study of Generative AI-Enabled Toys

Wenqiang Lu^{1,*}

College of Engineering, Clark University, 01610, USA

* Corresponding author: Wengqiang Lu

15957796381@163.com

Abstract: The rapid integration of Generative Artificial Intelligence within the ludic domain has catalyzed a fundamental paradigm shift in contemporary toy functionalities, transitioning them from passive artifacts into autonomous, adaptive companions. This technological application facilitates unprecedented opportunities for personalized edutainment and emotional scaffolding; however, it simultaneously necessitates a rigorous re-evaluation of sustainability through a more granular lens. The present study interrogates the nexus between technological novelty and sustainability imperatives by examining three commercially available AI toys alongside a speculative conceptual model. Our findings suggest that achieving a truly sustainable AIToy ecosystem requires a departure from traditional linear production models. Instead, the industry must pivot toward a circular, human-centric design philosophy that harmonizes cognitive enrichment with environmental and ethical stewardship.

Keywords: *Generative AI; Cognitive Externalization; Sustainability; Human-Toy Interaction; Ethical Design*

1. Introduction

The landscape of contemporary play is currently undergoing a radical transformation, driven by the convergence of advanced robotics and large-scale generative models. Within this context, AI-powered toys, or AIToys, have emerged as sophisticated agents of interaction that transcend the rudimentary functionalities of their "smart" predecessors.^[1] This transformation is further supported by recent advances in large language model reasoning, multi-turn instruction handling, and dialogue generation, which enable child-facing systems to move beyond fixed-response interaction toward more context-sensitive conversational engagement.^[2] These artifacts are defined by their capacity for machine learning, natural language processing, and affective computing, enabling a level of reciprocity that was previously confined to the realm of science fiction.^[3] As these objects become increasingly embedded in the domestic lives of children, they function as more than mere instruments of leisure; they act as conduits for cognitive externalization, where internal mental processes are augmented and mirrored by the toy's adaptive responses.^[4] In this sense, the long-term acceptance of AIToys may also depend on whether their interaction design can align with user preferences while reducing repeated frustration, discomfort, or other negative user experiences during sustained use. However, the rapid proliferation of these complex systems occurs within a broader global crisis of environmental degradation and ethical uncertainty.^[9] Traditional toy manufacturing has long been criticized^[10] for its reliance on non-biodegradable polymers and short-lived product cycles, a trajectory that remains problematic in the transition to digitalized play. Previous investigations into green design, such as the work of Liu^[30] and Wang^[31] have articulated the necessity of finding equilibrium between industrial output and ecological preservation, yet these frameworks often struggle to accommodate the unique challenges posed by the integration of electronic components and AI modules. The inherent difficulty in disassembling multi-material electronic toys often leads to their exclusion from conventional recycling streams, thereby exacerbating the issue of persistent waste. Moreover, the ethical dimensions of AIToys introduce a layer of complexity that extends beyond material safety. The capacity for these toys to gather sensitive vocal and emotional data, as highlighted in recent discussions by Pavliv^[7] raises profound questions regarding surveillance and the long-term psychological impact on child development. Recent research on AI governance further suggests that static rule-based controls may not be sufficient when new or unforeseen harmful interaction patterns emerge, which is especially concerning in child-oriented intelligent systems.^[6] While proponents argue that AI-enhanced companions support

empathy and social learning, there is a legitimate concern that prolonged engagement might induce a form of social dependency or distort a child's understanding of interpersonal boundaries.^[29]

This study seeks to address these multifaceted tensions by evaluating how sustainability principles, ecological, ethical, and economic are articulated and implemented within the emerging AIToy market. From an economic standpoint, this is also important because the market viability of intelligent toys increasingly depends on data-driven growth evaluation, budget allocation under uncertainty, and the ability to assess adoption strategies across heterogeneous consumer segments.^[11] By moving beyond a singular focus on technological capability, we explore the systemic implications of design choices, such as the modular "Magicbox" approach of FOLOTOY or the non-invasive storytelling of POE BEAR. Our research trajectory was not a linear progression; it involved significant deliberation on how to balance the enthusiasm of marketer promises with the empirical realities of manufacturing constraints. We acknowledge that the data presented reflects a specific temporal snapshot of the 2025 market, and as such, certain conclusions regarding the long-term efficacy of bio-based plastics or circular economy models must be viewed with a degree of academic caution. Ultimately, this inquiry aims to bridge the gap between innovation and responsibility, proposing that the future of intelligent play must be as sustainable as it is transformative.

2. GREEN TOY DESIGN: THEORETICAL FOUNDATIONS AND MATERIAL COMPLEXITIES

The discourse surrounding green design in the toy industry has historically fluctuated between disparate terminologies such as ecological design and environmental design, though both converge on the fundamental ambition of mitigating the adversarial relationship between industrial proliferation and the natural equilibrium. Traditionally, the industry's ecological impact is characterized by a pervasive reliance on plastic—accounting for approximately 90% of global production—which, when coupled with the ephemeral nature of childhood interest, results in an average product lifespan of merely six months. While Albastroiu Nastase et al. (2021) utilize a business model lens to emphasize the transition toward a circular economy within the Romanian context, their findings underscore a broader structural tension: the conflict between the toy's physical durability and the rapid obsolescence of its perceived play value.

This leads us to consider the heightened complexity introduced by AIToys, where the integration of electronic modules and sensors complicates the already arduous task of disassembly. Kang and Zhu (2015) conducted a rigorous bioaccessibility analysis of lead content in low-cost plastic toys, revealing significant risks associated with base materials; however, their study focused primarily on passive objects, leaving a critical research gap regarding how active electronic components in AIToys might alter the chemical stability and recyclability of the surrounding plastic matrix. Modern green toy design must therefore evolve into a holistic framework that addresses not only material safety and the utilization of biodegradable polymers as suggested by Yadou et al. (2025), but also the energy efficiency of the underlying AI algorithms and hardware.

The industry's current response, exemplified by the strategic pivot of major entities like LEGO and Mattel toward bio-based plastics, represents a necessary yet perhaps insufficient step toward genuine sustainability. While these initiatives align with United Nations Sustainable Development Goals such as SDG 12, the reliance on modular design and 3D printing—technologies praised for their capacity to reduce waste and facilitate repair—remains contingent upon consumer willingness to engage in maintenance rather than replacement. This interplay between material innovation and user behavior suggests that green design in the era of Generative AI cannot be viewed solely as a technical challenge; it is possible that the most significant environmental gains will emerge from the extension of a toy's "social lifespan" through its adaptive, companion-like qualities, though further empirical research is needed to determine if this digital longevity truly offsets the ecological cost of its physical hardware.

2.1 Toy Design With Ecological Consideration

The ecological footprint of play artifacts is increasingly defined by the precarious intersection of material permanence and digital obsolescence. Traditional toy production remains tethered to a high-volume, plastic-centric model, where approximately 90% of products are derived from non-recyclable polymers. When these physical substrates are augmented with AI-driven electronics, the

resultant hybridity creates a significant barrier to end-of-life processing; the integration of sensors and AI modules complicates disassembly, leading many recycling centers to reject such items. Sustainable design in this context must prioritize a holistic lifecycle approach, encompassing the use of bio-based or recycled plastics as seen in the recent transitions by LEGO and Mattel. However, the ecological impact of AIToys extends beyond their physical casing to include the energy demands of continuous interactivity and data processing. There is a possibility that hardware optimization and the adoption of modular structures—such as the "Magicbox" kit utilized by FOLOTOY to retrofit existing plush toys—could mitigate electronic waste by decoupling the digital "brain" from the physical body. Despite these innovations, it remains to be seen whether the energy consumption inherent in large-scale generative models can be sufficiently balanced against the potential reduction in material turnover.

2.2 Toy Design With an Ethical Approach

As toys evolve from inert objects into interactive companions capable of simulating empathy and trust, the ethical dimension of their design becomes a central pillar of responsible innovation. Unlike their predecessors, AIToys employ affective computing to recognize and respond to emotional cues, creating a relational dimension that blurs the ontological boundaries between human and machine. This capacity for emotional responsiveness necessitates a rigorous scrutiny of data governance; many AIToys collect sensitive vocal and affective data, which, without transparent parental controls and anonymized processing, poses a latent threat to children's privacy. Beyond conventional privacy disclosure, responsible governance may also require adaptive oversight mechanisms capable of identifying emerging harms that are not fully captured by predefined safety rules.^[14]

Furthermore, the potential for algorithmic systems to shape behavior or induce emotional dependency introduces an unprecedented risk of psychological manipulation. Ethical design must therefore transcend mere compliance with data protection laws to encompass a "privacy-first" and inclusive philosophy. In practice, this also implies the need for more transparent and auditable governance structures, so that child-facing AI systems are not managed solely through opaque vendor-defined safety claims.^[15] Current market examples, such as POE BEAR's avoidance of invasive sensors and FOLOTOY's customizable dashboards, suggest a move toward empowering rather than exploitative interactions. Nevertheless, further research is required to understand the long-term impact of these digital companions on the social development and identity formation of young users.

2.3 Toy Design With an Economic Perspective

The economic sustainability of AIToys challenges the traditional industry reliance on rapid product turnover and short lifecycles. Because these intelligent artifacts require substantial initial investment in research, development, and software integration, their market viability is often predicated on a higher price point justified by extended usability. This logic is consistent with data-driven growth models that emphasize long-term return, monetization efficiency, and budget optimization under uncertain market conditions rather than short-term hardware turnover alone.^[16] This shift leads us toward circular economy models where value is derived from durability, repairability, and continuous software enrichment rather than frequent replacement.^[18] Such a transition may be strengthened by segmented operational strategies that align pricing, service intensity, and content delivery with different user tiers instead of relying on a uniform replacement-driven sales logic.^[17] Subscription-based content, exemplified by the "Miko Max" service, offers a potential pathway for aligning economic growth with product longevity, though it simultaneously raises concerns regarding the accessibility and affordability of intelligent play.^[20] This model is economically attractive because recurring digital services make it easier for firms to estimate content ROI, optimize budget allocation, and sustain user engagement without depending exclusively on repeated hardware purchases.^[19]

Moreover, manufacturing innovations such as 3D printing and modular design enable more material-efficient production and scalable customization. These strategies not only lower the long-term production costs but also support the economic life of the toy by facilitating localized repairs. While the global toy market—valued at tens of billions of dollars across China, the U.S., and Europe—presents vast opportunities for sustainable innovation, the success of these economic models remains contingent upon a significant shift in consumer consciousness toward valuing long-term developmental utility over ephemeral novelty.

3. Methodology

3.1 Research Design and Case Selection

To navigate the multifaceted landscape of AIToy sustainability, this study adopts a qualitative, multi-case analytical framework inspired by the process-oriented methodology of Papadakis.^[13] Such a design is particularly appropriate when the research object involves heterogeneous evidence streams, uneven observability, and partially missing product-level information across technical, ethical, and market dimensions.^[23] Their approach, which prioritizes contextual sensitivity in multidisciplinary evaluations, provides a robust foundation for interpreting how technological promises intersect with material and ethical realities.^[24] We selected four distinct play objects to represent the current spectrum of AI integration: Miko 3, FOLOTOY, POE BEAR, and the speculative AI Barbie.

The selection process was not without its internal debates.^[21] We initially considered a wider array of connected toys; however, to ensure research depth, we narrowed the focus to these four cases based on their prominence in 2025 market discourse and their diverse pedagogical or emotional value propositions. Miko 3 serves as a benchmark for established robotic educational platforms, whereas FOLOTOY and POE BEAR represent emerging trends in retrofitting and non-invasive storytelling. The inclusion of AI Barbie, though currently a speculative concept, is crucial for addressing future-oriented ethical concerns that might otherwise remain obscured in contemporary market analysis.^[22]

Table 1. Overview of Analyzed AIToy Cases and Sustainability Affordances

Case Name	AI Integration Type	Primary Play Value	Key Sustainability / Design Feature	Status
Miko 3	Deep Learning / Touchscreen	STEAM Edutainment	Modular content via subscription (Miko Max)	Commercially Available
FOLOTOY	GPT-4o / Magicbox kit	Multilingual Mentorship	Retrofitting existing plush toys; material extension +1	Commercially Available
POE BEAR	Generative AI / App-based	Storytelling & Creativity	No cameras/mics; privacy-first and screen-free +1	Commercially Available
AI Barbie	Large Language Models (LLM)	Personalized Companionship	Speculative digital-first model; privacy-by-design	Speculative Concept

3.2 Data Collection and Sources

The data corpus for this research was synthesized from an array of primary and secondary sources to capture the perspectives of both manufacturers and marketers. This multi-source design is necessary because AIToy sustainability claims are typically distributed across heterogeneous modalities, including promotional text, product specifications, user reviews, and interaction-oriented narratives rather than a single standardized disclosure framework.^[25] We systematically harvested promotional narratives from official websites, product listings, and digital brochures, alongside industry reports and press releases. To balance these manufacturer-driven viewpoints, we integrated user-generated feedback from platforms like Amazon and specialized toy review sites, which provided critical insights into the lived experiences of children and parents.

A significant challenge encountered during this phase was the inherent opacity of corporate sustainability disclosures. While companies like Mattel and Hasbro provide general reports on sustainable packaging and bio-based plastics, specific ecological data for individual AI components remained elusive. This led us to adjust our analytical focus toward interpreting communicative strategies and manufacturer claims rather than purely quantitative lifecycle assessments, acknowledging that our findings are to some extent limited by the availability of public information.

3.3 Content Analysis and Coding Framework

We applied an inductive category development framework as outlined by Li to systematically examine the language, values, and implicit assumptions embedded in the marketing materials. This is especially important in AI-related product discourse, where scenario-based reformulation and stylistic reframing can alter user interpretation even when the underlying functional claim

remains similar.^[26] This process involved multiple iterations of coding, where initial descriptive codes were refined into broader thematic dimensions: ecological responsibility, ethical governance, and economic viability.

The coding process revealed a subtle tension between technological exuberance and sustainability imperatives. For instance, when analyzing the "Magicbox" kit by FOLOTOY, the coding shifted from a purely functional description to a broader economic-ecological theme as we recognized its potential for extending the lifespan of existing plush products. Similarly, the analysis of AI Barbie required a divergent approach, focusing on speculative discourse and expert warnings regarding emotional development to construct a proactive ethical critique. By triangulating these diverse data streams, we aimed to uncover how toy companies construct the value proposition of AIToys and how these narratives possibly influence consumer trust and purchasing decisions. In analytical terms, this also means viewing the AIToy market as a dynamic system in which technical affordances, user feedback, and service adaptation co-evolve over time rather than as a static collection of isolated product features.^[27]

4. Findings

4.1 Ecological Synthesis: Between Physical Longevity and Digital Footprints

The analysis of our selected cases reveals a nuanced landscape where ecological considerations are frequently overshadowed by the allure of technological novelty. Miko 3 demonstrates a commitment to durability through a robust physical chassis and a subscription-based content model that purportedly increases academic engagement by up to 55%. This approach potentially extends the toy's functional life by ensuring that the software evolves alongside the child's cognitive development, thereby challenging the six-month average lifespan typical of traditional playthings. From a business sustainability perspective, such software enrichment may also operate as a retention mechanism that substitutes recurring engagement for rapid hardware replacement.^[5] However, the environmental cost of maintaining continuous deep learning algorithms and cloud connectivity remains an obscured variable in manufacturer disclosures.

In contrast, FOLOTOY represents a more radical departure from linear consumption by utilizing a "Magicbox" kit to retrofit existing plush toys. This strategy effectively decouples the digital intelligence from the physical substrate, suggesting a possible path toward material sustainability that emphasizes the reuse of existing resources. Yet, we must reflect on the inherent contradiction in this model: while it rescues old toys from landfills, the hardware itself remains a complex assembly of electronic components that are notoriously difficult to recycle. POE BEAR further complicates this ecological narrative by adopting an offline functionality for story playback, which arguably reduces continuous energy consumption. These diverse strategies lead us to think that ecological sustainability in AIToys is currently fragmented, with a persistent tension between reducing material waste and the escalating energy demands of generative AI.

4.2 Ethical Governance: Empathy, Privacy, and Ontological Blurring

The ethical dimension of our findings centers on the transition of AIToys from passive objects to affective companions that foster empathy and trust. FOLOTOY and POE BEAR implement distinct strategies to safeguard the child's domestic environment; the former utilizes a parental dashboard for content governance, while the latter intentionally omits cameras and microphones to minimize invasive surveillance. Such design choices reflect a growing industry awareness of data protection as a prerequisite for consumer trust.

However, the speculative case of AI Barbie introduces more profound concerns regarding the potential for emotional manipulation. Experts suggest that the capacity of generative models to recall past interactions and simulate deep companionship may blur the boundaries between real and simulated relationships, potentially inducing a form of dependency that alters social learning. This leads us to consider whether a privacy-first design is sufficient to mitigate the psychological impacts of prolonged engagement with an emotionally intelligent machine. In practice, alignment in child-facing systems also depends on whether the model can reliably follow layered safety instructions and preserve meaningful human override across different interactional contexts.^[28] It is possible that the very features that drive educational value also inadvertently create a "black box" of affective

influence, requiring further research to determine if current ethical safeguards can keep pace with the increasing autonomy of these systems.

4.3 Detailed Case Breakdown

4.3.1 Miko 3: AI-Powered Educational Robot (2021)

Miko 3, developed by RN Chidakashi Technologies, represents a benchmark in the integration of deep learning within the domestic play environment for children aged 5 to 10. Our analysis indicates that its primary value proposition lies in a sophisticated suite of STEAM-focused applications, encompassing coding, math games, and emotional support. From a design perspective, Miko 3 utilizes a touchscreen interface combined with expressive gestures to facilitate personalized learning, yet this complexity introduces a paradox of durability. While the manufacturer emphasizes a child-safe and robust physical design, the inherent fragility of its touchscreen and the rapid depletion of battery life noted by users suggest a potential disconnect between intended longevity and actual hardware resilience.^[12] Economically, Miko 3 pivots toward a service-oriented model via the "Miko Max" subscription, ensuring that the toy's pedagogical utility evolves with the child's developmental milestones, a critical sustainability affordance that may extend the product's functional lifespan.

4.3.2 Folo AI Toy – AI Assistant Toy (2024)

Folo AI Toy exemplifies a significant shift toward "circularity through retrofitting" by employing a "Magicbox" kit that converts traditional plush toys into GPT-4o-powered interactive companions. This design philosophy is particularly noteworthy for its material sustainability; by decoupling the AI "brain" from the physical toy body, Folo AI Toy effectively extends the life of pre-existing play artifacts, thereby reducing the immediate demand for new plastic production. The toy's support for multiple roles—such as storytellers and language mentors—allows for a highly customizable and screen-free pedagogical experience. The ethical architecture is grounded in a robust parent dashboard, allowing for meticulous control over conversation topics, which serves to mitigate concerns regarding algorithmic manipulation. Nevertheless, its reliance on stable internet connectivity and a subscription model presents an economic barrier that might limit its accessibility to broader demographics.

4.3.3 Poe the AI Story Bear: AI Storytelling Companion (2024)

Poe the AI Story Bear introduces a non-invasive interaction model that focuses on generative storytelling, supporting up to 30 languages without the use of cameras or microphones. By utilizing a companion app to generate stories via Microsoft Azure and ChatGPT—which are then transmitted to the plush toy for offline playback—Poe effectively addresses the dual challenges of data privacy and energy efficiency. The offline functionality is a significant design affordance, as it reduces the ecological cost of continuous high-bandwidth data transmission while enhancing portability. From a sustainability perspective, Poe's limited hardware footprint possibly reduces the volume of future electronic waste. Ethically, the toy is praised for fostering imaginative play within a secure digital boundary, though this "restricted" AI interaction model may lead to a lower perceived value compared to more autonomous robots.

5. Conclusion

The integration of Generative Artificial Intelligence into the ludic landscape has fundamentally redefined the ontological status of toys, transitioning them from static artifacts into dynamic agents of cognitive externalization and emotional scaffolding. Throughout this inquiry, we have interrogated the multifaceted dimensions of sustainability within the AIToy ecosystem, revealing a complex tension between the exuberance of technological innovation and the material, ethical, and economic imperatives of our contemporary era. Our analysis of cases such as Miko 3, FOLOTOY, and Poe Bear suggests that while modular software architectures and "circular-by-retrofitting" strategies offer promising pathways for extending product lifespans, the industry remains tethered to a digital-physical paradox where escalating computational energy demands possibly offset the gains made in material conservation. Furthermore, the capacity of these intelligent companions to foster deep affective bonds necessitates a more robust ethical framework that transcends mere data privacy to encompass the long-term psychological well-being and autonomy of the child. Considering these factors, this research leads us to further thinking that achieving genuine

sustainability in intelligent play requires a paradigm shift—a move toward a "symbiotic sustainability" design philosophy where technological affordances are harmonized with ecological limits and ethical stewardship. While certain limitations regarding the transparency of corporate data persist, it is clear that the future of AI Toys must be predicated on a holistic commitment to responsible innovation, ensuring that the enrichment of the child's cognitive world does not come at an unsustainable cost to the physical and social environments they will inherit.

Data Availability Statement

Data will be made available on request.

Funding

Conflicts of Interest

The author(s) declare no conflicts of interest.

Ethical Approval and Consent to Participate

Not applicable.

(* Note: If your study involves human participants, animals, or sensitive data and requires ethical approval, please make sure to clearly state the name of the approving ethics committee and provide the corresponding approval number.)

References

- [1] Jourabchi Amirkhizi, P., Pedrammehr, S., Pakzad, S., & Shahhoseini, A. (2025). *Generative artificial intelligence in adaptive social manufacturing: a pathway to achieving industry 5.0 sustainability goals. Processes, 13(4), 1174.*
- [2] Han, C. (2025). *Can Language Models Follow Multiple Turns of Entangled Instructions?. arXiv preprint arXiv:2503.13222.*
- [3] Zhang, Z., Li, S., Zhang, Z., Liu, X., Jiang, H., Tang, X., ... & Jiang, M. (2025). *IHEval: Evaluating language models on following the instruction hierarchy. arXiv preprint arXiv:2502.08745.*
- [4] Lee, J. Y. J., Bonab, H., Zalmout, N., Zeng, M., Lokegaonkar, S., Lockard, C., ... & Wang, H. (2025, August). *DocTalk: Scalable graph-based dialogue synthesis for enhancing LLM conversational capabilities. In Proceedings of the 26th Annual Meeting of the Special Interest Group on Discourse and Dialogue (pp. 658-677).*
- [5] Liu, W. (2025). *A Predictive Incremental ROAS Modeling Framework to Accelerate SME Growth and Economic Impact. Journal of Economic Theory and Business Management, 2(6), 25–30.*
- [6] Ho, M. T., Mantello, P., & Vuong, Q. H. (2024). *Emotional AI in education and toys: Investigating moral risk awareness in the acceptance of AI technologies from a cross-sectional survey of the Japanese population. Heliyon, 10(16).*
- [7] Pavliv, V., Akbari, N., & Wagner, I. (2024, November). *AI-powered smart toys: interactive friends or surveillance devices?. In Proceedings of the 14th International Conference on the Internet of Things (pp. 172-175).*
- [8] Tan, Z., Li, Z., Liu, T., Wang, H., Yun, H., Zeng, M., ... & Jiang, M. (2025). *Aligning large language models with implicit preferences from user-generated content. arXiv preprint arXiv:2506.04463.*
- [9] Yu, C., Li, P., Wu, H., Wen, Y., Deng, B., & Xiong, H. (2024). *USM: Unbiased Survey Modeling for Limiting Negative User Experiences in Recommendation Systems. arXiv preprint arXiv:2412.10674.*
- [10] Yu, C., Wu, H., Ding, J., Deng, B., & Xiong, H. (2025, September). *Unified Survey Modeling to Limit Negative User Experiences in Recommendation Systems. In Proceedings of the Nineteenth ACM Conference on Recommender Systems (pp. 1104-1107).*
- [11] Liu, W. (2025). *Few-Shot and Domain Adaptation Modeling for Evaluating Growth Strategies in Long-Tail Small and Medium-sized Enterprises. Journal of Industrial Engineering and Applied Science, 3(6), 30–35.*
- [12] Venkatesh, V., & Davis, F. D. (2000). *A theoretical extension of the technology acceptance model: Four longitudinal field studies. Management science, 46(2), 186-204.*
- [13] Papadakis, S. (Ed.). (2025). *AI in early education: Integrating artificial intelligence for inclusive and effective learning. John Wiley & Sons.*
- [14] Yu, C., Wang, H., Chen, J., Wang, Z., Deng, B., Hao, Z., ... & Song, Y. (2026). *When Rules Fall Short: Agent-Driven Discovery of Emerging Content Issues in Short Video Platforms. arXiv preprint arXiv:2601.11634.*

- [15] Lin, A. (2025). *Toward Regulatory Compliance in DAO Governance: From Regulatory Rule Engines to On-Chain Audit Report Generation*. *Journal of World Economy*, 4(6), 12-20.
- [16] Liu, W. (2025). *Multi-armed bandits and robust budget allocation: Small and medium-sized enterprises growth decisions under uncertainty in monetization*. *European Journal of AI, Computing & Informatics*, 1(4), 89–97.
- [17] Wu, Y. (2025). *The Impact of “Data-Driven Hierarchical Operation” on ARPU Value for Cross-Border E-Commerce Warehousing Clients*. *Journal of Progress in Engineering and Physical Science*, 4(6), 15-21.
- [18] Wang, C. (2025). *Research on the Precision Allocation of Cross-Border Marketing Resources of US Enterprises Driven by Digital Technology*. *Innovation in Science and Technology*, 4(11), 7-13.
- [19] Wu, Y. (2026). *Research on Dynamic Prediction Model of Brand Marketing Content ROI Based on Machine Learning*. *International Journal of Advance in Applied Science Research*, 5(2), 31-38.
- [20] Wang, C. (2026). *A Study on Data-Driven Budget Optimization for US Enterprises’ Cross-Border Marketing*. *Frontiers in Management Science*, 5(1), 41-46.
- [21] Utami, A., & Crescenzi-Lanna, L. (2025). *Preschool Learning with Artificial Intelligence (PLAI): Exploring Children’s Interaction with AI Toys and Robots*. In *Proceedings of the 24th Interaction Design and Children* (pp. 1222-1224).
- [22] Zhang, Y., & Gao, H. (2025). *AI-Enabled Construction of Chinese Traditional Toy Gene Mapping and Innovative Design Research*. *Journal of Arts and Cultural Studies (ACS)*, 1(2), 01.
- [23] Wang, H., Li, Q., & Liu, Y. (2024). *Multi-response Regression for Block-missing Multi-modal Data without Imputation*. *Statistica Sinica*, 34(2), 527.
- [24] Wang, P., Wang, H., Li, Q., Shen, D., & Liu, Y. (2024). *Joint and individual component regression*. *Journal of Computational and Graphical Statistics*, 33(3), 763-773.
- [25] Lee, J. Y. J., Bonab, H., Zalmout, N., Zeng, M., Lokegaonkar, S., Lockard, C., ... & Wang, H. (2025, August). *DocTalk: Scalable graph-based dialogue synthesis for enhancing LLM conversational capabilities*. In *Proceedings of the 26th Annual Meeting of the Special Interest Group on Discourse and Dialogue* (pp. 658-677).
- [26] Li, K., Chen, X., Song, T., Zhou, C., Liu, Z., Zhang, Z., ... & Shan, Q. (2025). *Solving situation puzzles with large language model and external reformulation*. *arXiv preprint arXiv:2503.18394*.
- [27] Zhu, H., Luo, Y., Liu, Q., Fan, H., Song, T., Yu, C. W., & Du, B. (2019). *Multistep flow prediction on car-sharing systems: A multi-graph convolutional neural network with attention mechanism*. *International Journal of Software Engineering and Knowledge Engineering*, 29(11n12), 1727–1740.
- [28] Zhang, Z., Li, S., Zhang, Z., Liu, X., Jiang, H., Tang, X., ... & Jiang, M. (2025). *IHEval: Evaluating language models on following the instruction hierarchy*. *arXiv preprint arXiv:2502.08745*.
- [29] Lin, A. (2026). *Multi-Chain DAO Treasury Management: a Risk and Compliance Optimization Framework for the US Ecosystem*. *Journal of Intelligence and Engineering Technology*, 1(1), 11-18.
- [30] Liu, Z., Jin, C., Li, S., Li, W., & Wang, J. (2024). *Improvement for modeling the damping of the wake oscillator based on the Van der Pol scheme*. *Physics of Fluids*, 36(7).
- [31] Wang, J., Chang, Y., Cao, S., Dong, Y., Li, S., Jia, L., & Li, W. (2025). *Explanatory framework of typhoon extreme wind speed predictions integrating the effects of climate changes*. *Climate Dynamics*, 63(3), 142.