The compounding impact of Artificial Intelligence and Robotics on the future of learning

ROBOTGPTs

Action research findings

A SUSTAINABLE TRAINING INSTITUTION

ITC ILO
International Training Centre
Centre international de formation
Centro Internacional de Formación

Foreword

This report captures the findings of action research on the scope for using Artificial Intelligence (AI) powered robots to **accelerate outreach and impact of capacity building activities aimed at social development**. As the 2023 implementation progress review of the 2030 United Nations (UN) Sustainable Development Strategy Framework has shown, decisive action is needed if the Sustainable Development Goals are still to be achieved – with SDG 8 (Decent Work and employment rich growth) being a particular area of concern. To accelerate positive change, the Pact for the Future endorsed in September 2024 by the UN General Assembly calls for honing five critical skills across the UN system: innovation, data, digital transformation, future foresight and insights from behavioral science (the UN Quintet of Change; for more information go to https://untwo-zero.network/).

The innovation sparks initiative facilitated by the International Training Centre of the International Labour Organization (www.itcilo.org) seeks to promote the Quintet of Change by providing a safe space for experimentation with **innovative capacity development solutions**. As part of this innovation sparks initiative, the ITC-ILO Turin School of Development (https://www.itcilo.org/turin-school-of-development) facilitates **action research** on **the nexus between emerging technologies and social justice through decent work**, looking through a human-centred lens to explore how to **harness these technologies for learning and capacity development**. As the ongoing debate on the impact of Artificial Intelligence on the future of learning shows, decision makers are often unprepared to act fast when technological breakthroughs occur. The action research is meant to address this blind spot, providing a dialogue forum to 'think slow' about emerging technologies today and act fast when a technological breakthrough will be reached in the near future.

The action research linked to the innovation sparks initiative is framed by **a matrix of emerging technologies** (reproduced overleaf) developed by ITCILO based on existing taxonomies but adapted to the context of its own work. The matrix makes a distinction between generic infrastructure domains like energy, and specific application domains like Biotechnology. The action research focuses on **selected application domain**s, assessing **the impact of a given technology for the future of work in general, and the future of learning in particular**.

Since the launch of the innovation sparks initiative in 2204, three action research streams have gotten underway, on (1) neurotechnology, (2) quantum technology **and (3) robotics**. For more information on the research findings regards the impact of neurotechnology and quantum technology on the future of learning go to: https://www.itcilo.org/quantum-technologies-and-future-learning. For the research on robotics, it has been decided to broaden focus away from a single technological domain towards the analysis of the compounding impact of breakthroughs in connected domains, here the scope for deploying robots powered by AI (and supported by sensor technology).

ITCILO puts strong emphasis on the 'action' in its action research activities, with the explicit objective of feeding the findings into product pilots and sandbox experiments. This way, the action research on neurotechnology has since led to a sandbox experiment in the use of neuro-sensors in the training room while the quantum technology action research findings are currently fed into a self-guided distance learning module on *getting quantum ready in the workplace*. As regard the use of RobotGPTs, this report concludes that the technology is not ready for roll-out, but that prototypes could be deployed both in face-to-face training courses on campus and in distance learning activities on the ITCILO Virtual Reality platforms. Refer to the paper for more information.

Emerging technologies in infrastructure domains	
Energy • ***Metrics:*** energy produced per unit cost, distribution distance per unit cost, energy sustainability measures etc. • ***Technology drivers:*** Renewable Energy (Solar, Wind, hydro, incl. space-based solar), energy storage (batteries, supercapacitors), smart grids, hydrogen fuel cells, fusion, carbon capture, circular economy, green algorithms, etc.	**Compute** • ***Metrics:*** FLOPs-equivalent per unit cost, data storage per unit cost, data retrieval speeds etc. • ***Technology drivers:*** digital algorithm progress, transistor miniaturisation (e.g. via nanotechnologies), retrieval algorithms, superconductors, data infrastructure technologies, neuromorphic computers, DNA data storage, **quantum computing hardware** etc.
Materials • ***Metrics:*** number of unique materials/physical functions we can construct, cost for bespoke construction, ability to intervene in existing physical systems etc. • ***Technology drivers:*** atomic/molecular science, protein engineering, smart materials, nanotechnology, 3D & 4D printing/additive manufacturing, advanced composites, metamaterials, biomimetic materials, elastocalorics, **quantum materials**, etc.	**Connectivity** • ***Metrics:*** reliable GB/second per unit cost/energy, population connectivity coverage ratios, number of items connected to the Internet, latency, etc. • ***Technology drivers:*** 6G and successor technologies, fibre optic cables, infrastructure build-out, protocols and standards, high altitude platform stations, LEO satellite constellations, **quantum networking** etc.

Emerging technologies in application domains		
AI & ML • Natural Language Processing • Computer Vision • Predictive Analytics • Robotic Process Automation • Agentic AI • Generative AI / LLMs • AI TRiSM / AI alignment • Explainable AI • **Quantum AI/ML algorithms**	**AR & VR** • Mixed Reality • Extended Reality • Remote Assistance & Collaboration • Training and Simulation • Haptic interfaces • Holography for communication	**Cybersecurity** • Threat Intelligence • Zero Trust Security / ZKPs • Cyber Resilience • Identity and Access Management • Cybersecurity mesh architecture • Disinformation security • Homomorphic encryption • **Quantum cryptography**
Distributed Ledger Technologies • Blockchain • Cryptocurrencies • Smart Contracts • Decentralized Finance • Supply Chain Management	**Sensors & Internet of Things** • Industrial IoT • Smart Homes • Wearables • Connected Vehicles • Environmental/machine sensors • VLEO satellites • Spatial computing • **Quantum metrology**	**Biotechnology** • Bioinformatics • Gene editing, incl. CRISPR • Synthetic biology / bioprinting • Adult stem cells • mRNA therapeutics • luxomics • Personalised 'omics medicine • Cellular programming • **Quantum biotechnology**
Cloud & Edge Computing • Infrastructure as a Service • Platform as a Service • Software as a Service • Serverless Computing • Fog Computing • Edge AI / AI as a service • Real-Time Data Processing • IoT Edge • GitOps / Infrastructure as computing	**Advanced Robotics** • Collaborative Robots • Autonomous Mobile Robots/Vehicles • Drone Technology/Swarm robotics • Robotics Process Automation • Soft robotics • Self-organising, self-healing robotics • Space manufacturing • Reconfigurable/intelligent surfaces	**Simulation** • Digital twins • Predictive Maintenance • Product Lifecycle Management • Smart Cities and Infrastructure • Virtual prototyping • **Quantum simulation**
Neurotechnology • Neuroimaging and Brain Mapping • Brain-Computer Interfaces (BCI) • Neurostimulation/Neuromodulation • Neural Prosthetics • Neural Data Analysis • Neuro-pharmacology/-modulators	**Space & Transport** • Nuclear space propulsion • Hypersonics • Ion propulsion • On-orbit maintenance • Next-gen satellites • Reusable rockets	

Source: ITCILO

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Executive summary

Robotics and artificial intelligence (AI) are rapidly converging and playing an increasingly important role in the world of work. Humanoid robots integrated with large language models (LLMs) such as GPT-4 have captured public attention and raised expectations about collaborative machines that can understand natural language, plan, and act. In March 2025, Google DeepMind unveiled Gemini Robotics, an AI model that couples vision, language, and action (VLA) processing. Based on the Gemini 2.0 LLM, the model allows robots of various sizes and functions to translate visual inputs into behavior and manipulate objects with new dexterity. Other research groups have concurrently developed PaLM-E and RT-2 models that combine multimodal sensing, language understanding, and action generation. Industry contenders including Tesla, Figure, Sanctuary AI and 1X are pushing to commercialize general-purpose humanoid robots with LLM-driven interfaces.

This report reviews the technological landscape of advanced robotics and RobotGPTs, assesses potential uses in adult training, surveys international governance frameworks and ethical guidelines, and offers recommendations for ITCILO's capacity-development programs. A combination of qualitative review and literature-based evidence is used as few field evaluations exist for LLM-driven robots, which are only beginning to leave the laboratory. The research has found RobotGPTs to be an intriguing yet immature class of technologies. By combining large-language-model cognition with advanced robotics, they offer natural language interfaces, planning and reasoning, and embodied interaction. Prototypes such as Gemini Robotics, Helix, Phoenix and Optimus demonstrate rapid advances in dexterity and collaboration. However, costs remain prohibitive, and most models are still in early stages of development. Safety, reliability and ethical concerns further limit their readiness for widespread deployment. Given these constraints, it is unlikely that RobotGPTs will make economic sense for broad adoption by the first horizon of 2030. Yet the long-term potential is significant: as AI and robotics continue to converge, costs will fall and capabilities will grow, creating opportunities to enhance adult learning through demonstration, simulation, translation and facilitation.

Going forward, the following recommendations are submitted for further consideration:

Strategic Positioning

1. **Focus on complementarity.** RobotGPTs should complement, not replace, human trainers. Use cases could include demonstration of complex research tasks, translation, and real-time feedback. Prioritize applications that address accessibility and inclusion, such as language interpretation or regulatory clarification.
2. **Human-oriented by design.** Commit to human-centred design that involves diverse stakeholders in co-creation, mapping social contexts, measuring impacts, and managing risks.
3. **Promote interoperable ecosystems.** Encouraging the use of open-source software and standard interfaces can avoid vendor lock-in.

Capacity development initiative proposals

1. **Launch RobotGPT foresight labs:** Partner with universities and technology hubs to create immersive foresight studios combining VR, digital twins, and LLM-enabled robots. These labs would let stakeholders "time-travel" into possible futures and design policies that anticipate technological breakthroughs before they hit the mainstream.
2. **AI-powered peer mentoring:** Pair learners with "robot mentors" programmed using open LLMs and local labour laws. These robots would facilitate peer learning, moderate group simulations, and help participants practice complex negotiation or safety scenarios.

3. **Campus pilot of a test humanoid RobotGPT:** ITCILO could pilot a humanoid RobotGPT on campus as a live prototype to assist with training activities, particularly in language support, research assistance and teamwork facilitation. The robot would integrate a multilingual large language model with vision and sensor data—like systems like PaLM-E, enabling it to translate between languages, answer participant queries by retrieving and summarizing relevant materials, and moderate group exercises. By evaluating how learners and trainers interact with the prototype in real training scenarios, ITCILO can generate evidence-based insights on the potential and limitations of RobotGPTs.

1. Introduction

1.1 Purpose and scope of this action research

This report serves as an action research study on the impact of AI-powered robots on the future of learning and decent work, and this brief presents four deliverables: a taxonomy of emerging technologies and the sub-domain of advanced robotics; an evaluation of collaborative robot applications using large language models; a cursory evaluation grid covering integration, cost, flexibility, collaboration potential, learning impact, maturity, ethical issues, environmental footprint and equity; and recommendations for capacity development. The focus of the research is on the near future up to 2030, which can be considered the first horizon for significant experimentation and pilot deployment. While current prototypes remain immature, their trajectory suggests notable progress in sociability, flexibility, and integration potential by 2030, even if widespread adoption and cost reductions may not arrive until later horizons. The geographical focus is global.

1.2 Definitions and conceptual framing

The term **RobotGPTs** refers to robotic systems whose high-level intelligence is driven by large language models (LLMs). These systems combine multiple layers:

Layer	Function	Example
Hardware	Physical components, such as actuators, cameras, sensors, wheels, grippers, etc.	Universal UR10e, humanoid robots
Middleware	Software that facilitates data management and communication between different components; connects sensors to control algorithms	ROS (Robot Operating System), NVIDIA Isaac, MoveIt (motion planning)
Cognition/ Reasoning	The 'brain'; the LLM or AI engine that generates plans, dialogues and reasoning	Deepmind RT-2, Google PaLM-E, OpenAI APIs
Interface	The layer with which humans interact, through screens, visuals, voice, text, gestures, etc.	Voice command, touchscreens, chatbot user interfaces

Collaborative robots: Cobots are robots designed to work alongside humans. Cobots are typically predictable, sociable, adaptable, safe and intuitive. They are already selectively used in manufacturing, warehousing, healthcare, hospitality and research. RobotGPTs extend cobots by adding conversational intelligence and high-level planning. Cobots are furthermore typically action-specific; designed to perform a certain set of functions only, and therefore generally not humanoid.

Adult learning and experiential training: The focus is on training, upskilling and reskilling for evolving labour markets. Experiential learning relies on simulation, practice and reflection. AI-powered robots have the potential to simulate tasks, provide feedback, and mediate group work. Co-present robots can enhance engagement through embodied, multimodal interaction and natural conversation.

2. Taxonomy of emerging technologies and advanced robotics

2.1 Emerging digital technologies for future learning

According to the taxonomy for emerging technologies developed in the context of earlier ITCILO research, artificial intelligence, machine learning, extended reality (XR), adaptive learning platforms, blockchain for credentialing, Internet of Things (IoT) and advanced robotics are among the technologies shaping the future of work and learning. These technologies interact in complex ways: AI drives adaptive algorithms, XR provides immersive simulations, IoT collects data and advanced robotics add embodied interaction. The convergence of generative AI with robotics has accelerated due to breakthroughs in LLMs and generative vision models.

Within this taxonomy, RobotGPTs straddle at least two quadrants. On one hand, they clearly fall under *Advanced Robotics*, alongside collaborative robots, autonomous vehicles, and soft robotics. On the other hand, their defining feature - the integration of large language models for planning, reasoning, and interaction - places them firmly in the *AI & ML* quadrant. In practice, RobotGPTs are not confined to either box: they represent a convergence technology, combining robotic embodiment with generative cognition and interfaces. This interdisciplinary positioning underscores a potential limitation of the current taxonomy. While the grid rightly captures the breadth of technological domains, it risks treating them as siloed. A revision to the taxonomy might include a cross-cutting category for "AI-augmented physical systems," or visual overlays to illustrate technologies that sit at the nexus of multiple fields. The sector-specific developments taking place within this category include:

Figure 1: Taking a closer look at the domain of robotics

Figure 1 is drawn from a research report by Hetmanczyk (2024) published in the *MDPI Applied Sciences* journal on key development trends in the robotization of production processes.[1]

[1] Hetmanczyk MP. "A Method to Evaluate the Maturity Level of Robotization of Production Processes in the Context of Digital Transformation—Polish Case Study". *Applied Sciences*. 2024; 14(13):5401. https://doi.org/10.3390/app14135401

2.2 Leading RobotGPT models

RobotGPTs are embodied systems that couple LLM-driven cognition with diverse hardware platforms. To ground the discussion, the table below summarizes several leading commercial prototypes and research models, indicating their approximate maturity levels and notable features. Assessment of maturity is qualitative based on publicly available information:

Figure 2: List of leading RobotGPT models

Company / Lab	Model	Maturity (2025)	Notes
Tesla (US)	Optimus	*Low-medium* ● Early prototypes shown	Strong branding, limited evidence of autonomy
Sanctuary AI (Canada)	Phoenix (Gen 7)	*Medium-high* ● Pilot deployments (retail, logistics)	Leading in rapid task learning
Figure AI (US)	Figure 01 / Helix	*Medium* ● VC-backed, rapid prototyping	Partnership with OpenAI for cognition
1X Technologies (Norway)	Neo	*Medium* ● Small pilots	Incremental integration strategy
Agility Robotics (US)	Digit	*Medium* ● Amazon warehouse pilots	Strong in mobility, less in cognition
Apptronik (US)	Apollo	*Low-medium* ● Announced 2023, pilots pending	NASA / DARPA heritage
Gemini Robotics (Google DeepMind, US)	Gemini Robotics-ER	*Low (research stage)* ● Announced March 2025	Research stage, but cutting-edge
Fourier Intelligence (Canada)	GR-1	*Medium* ● Claimed mass production	Positioned for elder care and rehab
Ubtech Robotics (China)	Walker X	*Low-medium* ● CES demos, limited pilots	Strong social-educational focus
Xiaomi (China)	CyberOne	*Low* R&D showcase	Branding more than deployment
Tencent Robotics X (China)	Max	*Low* Lab prototype	Limited public data
Toyota (Japan)	T-HR3	*Low* Research / prototype	Could become GPT-augmented

SoftBank Robotics (Japan)	Pepper, Nao	*High (for social/educational niche, legacy technology)* Widely deployed (legacy)	Precursors to RobotGPTs; *Pepper* model discontinued
Hyundai / Boston Dynamics (Korea / US)	Atlas / Stretch (future GPT-augmented)	*Low-medium (mechanically advanced, not yet GPT-integrated)* Currently mechanical demos	Positioned for GPT integration

Figure 3: Select LLM-powered humanoid robot examples

Sources (left to right): Tesla Optimus (American Satellite[2]); Nao (SoftBank Robotics[3]), Phoenix (Sanctuary AI[4]).

[2] *Tesla Optimus Humanoid Robot*. (2025). Americansatellite.us. https://www.americansatellite.us/Tesla-Optimus.htm
[3] Robotics, S. (2023). *NAO: Personal Robot Teaching Assistant | SoftBank Robotics America*. Us.softbankrobotics.com. https://us.softbankrobotics.com/nao
[4] Sanctuary AI. (2023, May 16) https://www.sanctuary.ai/blog/sanctuary-ai-unveils-phoenix-a-humanoid-general-purpose-robot-designed-for-work

2.3 RobotGPTs as convergence technology

Advanced robotics can be categorized by mobility, morphology, and autonomy:

10. **Industrial robots**. Fixed robots used in manufacturing or warehousing for repetitive tasks. Collaborative robots (cobots) add sensors and software to safely interact with humans. **ISO 10218-2:2025** outlines safety requirements for such installations.
11. **Service and social robots.** Mobile robots used in healthcare, hospitality and domestic contexts. Examples include **Pepper** and **Nao** (developed by SoftBank Robotics), interactive humanoids used for reception and language teaching.
12. **Humanoid general-purpose robots.** Robots designed to imitate human form and dexterity. Tesla's **Optimus**, Sanctuary AI's **Phoenix**, Figure's **Figure 01**, and **1X's Neo** represent this emerging category. They use LLM-based cognition to perform natural language tasks and physical manipulation.
13. **Embodied AI agents.** Agents that combine LLms with multimodal perception (vision, audio, tactile) and reinforcement learning. Models like **PaLM-E** and **RT-2** fit here. These agents generalize across tasks and environments.

Here, LLMs are not a separate technology but the cognitive core that makes robotics generative and adaptive. LLMs are advanced neural networks trained on massive textual data sets to predict the next word and generate fitting prose. Their training equips them with a form of semantic knowledge and the ability to reason in language, and when integrated with robotics they can interpret natural-language instructions and formulate high-level plans. However, LLMs on their own do not have a built-in understanding of the physical world: they have no visual of objects or a sensation of their weight, and they have not experienced spatial constraints. In purely text-based form, an LLM cannot know what commands as basic as "grasp the bottle" mean in terms of joint trajectories or tactile feedback. Attempts to connect a chatbot to a robot can yield plausible but ungrounded commands, resulting in unrealistic or unsafe plans. To make language models useful for embodied agents, they must be coupled with sensory data, control policies, and planning frameworks. The following approaches illustrate different attempts to ground language in perception and action:

- **SayCan[5].** This 2022 approach utilizes an LLM (originally PaLM) to generate high-level skills while a value function estimates their feasibility. Combining both yields sequences that are both useful and possible, reducing errors compared to earlier models.
- **PaLM-E[6]**. Announced by Google in 2023, PaLM-E feeds raw robot sensor data into a PaLM-like language model, enabling the model to perform both language and vision tasks and transfer knowledge across modalities.

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[5] "Do As I Can, Not As I Say: Grounding Language in Robotic Affordances". Michael Ahn et al. (2022). *ArXiv:2204.01691 [Cs]*. https://arxiv.org/abs/2204.01691

[6] *PaLM-E: An embodied multimodal language model*. (n.d.). Research.google. https://research.google/blog/palm-e-an-embodied-multimodal-language-model/

- **RT-2 (Robotics Transformer 2)[7].** Google DeepMind's 2023/2024 model finetunes a pre-trained vision-language model with robot data by representing actions as textual tokens. It can interpret unseen commands, reason about objects and reuse knowledge to select improvised tools.
- **Gemini Robotics and Gemini Robotics-ER[8]**. Announced in March 2025, these models integrate vision, language, and action to enable robots to handle objects and perform delicate manipulations like fold origami. The embodied reasoning (ER) variant provides spatial understanding and planning.
- **RoboGPT and RoboPlanner[9]**. The 2024 RoboGPT framework divides tasks into sub-goals using a planning module trained on 67K planning examples, a skills module, and a re-planning module that shows improved performance on long-horizon tasks.
- **ELLMER (Embodied LLM with Multimodal Example Retrieval)[10].** A 2025 study uses GPT-4 with a retrieval-augmented generator to generate action plans conditioned on vision and force feedback. The system enabled a robot to make coffee and decorate plates in unpredictable conditions.

2.4 Investment landscape and drivers

Large technology companies and well-funded start-ups are investing significantly in general-purpose humanoid robots. **Figure AI**'s Helix model uses a unified neural network for all behaviors and demonstrated two robots collaborating on tasks with natural language prompts[11]. **Tesla** claims its Optimus will perform repetitive or unsafe tasks and uses LLM-powered interfaces to converse with users[12]. **Sanctuary AI** announced its seventh-generation Phoenix robot with improved hydraulics, better vision and tactile sensing, and the ability to learn new tasks within 24 hours[13]. These investments are motivated by labour shortages, demographics, supply-resilience and the potential for robots to operate around the clock. However, obstacles persist in high costs, mobility limitations, battery constraints, regulatory uncertainty, and public acceptance.

An August 2025 report[14] published in *Nature's* Scientific Reports Journal analyzed the patent landscape regarding collaborative robot technology. It is important to note that this encompasses all 'cobot' technology, not exclusively LLM-driven robots. However, the general trends in the broader field provide insights into the research trends and investment surrounding AI-powered and collaborative robotics.

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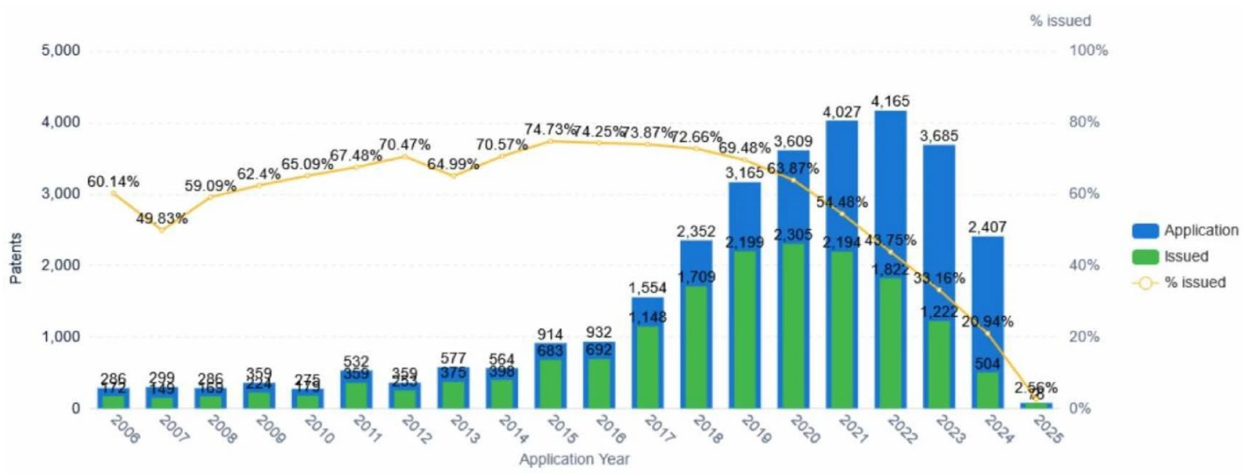
[7] *RT-2: Vision-Language-Action Models*. Anthony Brohan et al. (2023). Robotics-Transformer2.Github.io. https://robotics-transformer2.github.io/
[8] Gemini Robotics Team et al. (2025). *Gemini Robotics: Bringing AI into the Physical World*. ArXiv.org. https://arxiv.org/abs/2503.20020
[9] Yaran Chen et al. (2023). *RoboGPT: an intelligent agent of making embodied long-term decisions for daily instruction tasks*. ArXiv.org. https://arxiv.org/abs/2311.15649
[10] Ruaridh Mon-Williams et al. (2025). Embodied large language models enable robots to complete complex tasks in unpredictable environments. *Nature machine intelligence*, *7*(4), 592–601. https://doi.org/10.1038/s42256-025-01005-x
[11] Oitzman, M. (2025, February 22). *Figure humanoid robots use Helix VLA model to demonstrate household chores*. The Robot Report. https://www.therobotreport.com/figure-humanoid-robots-demonstrate-helix-model-household-chores/
[12] Klingler, N. (2024, May 29). *Tesla Bot Optimus – a General-purpose Humanoid Robot*. Viso.ai. https://viso.ai/edge-ai/tesla-bot-optimus/
[13] McFadden, C. (2024, April 26). *Sanctuary AI unveils its lighter, faster, and smarter Phoenix AI robot*. Interesting Engineering. https://interestingengineering.com/innovation/sanctuary-ai-unveils-7th-generation-phoenix
[14] Di Zhang and Liuhua Liu. "Analysis of collaborative robot technology patent map and research on development trends." *Sci Rep* 15, 30083 (2025). https://doi.org/10.1038/s41598-025-14074-0

Figure 4: “Global annual patent applications for collaborative robot technology (2006–2025)”
(credit: Zhang & Liu 2025)



Over the last decade, there has been a general increase in patents regarding collaborative robot technology. From 2023 to 2025 the number of patent applications waned; however the report suggests this may in part be due to a natural slowdown as the field matures regarding core innovations; a strategic interest by companies to focus on product quality and commercialization rather than patent quantity; and increasingly exacting legal and examination standards.

Figures 5 & 6: “Statistics of patent types in collaborative robotics” and “Distribution of patent quantities by country and region worldwide” (credit: Zhang & Liu 2025)

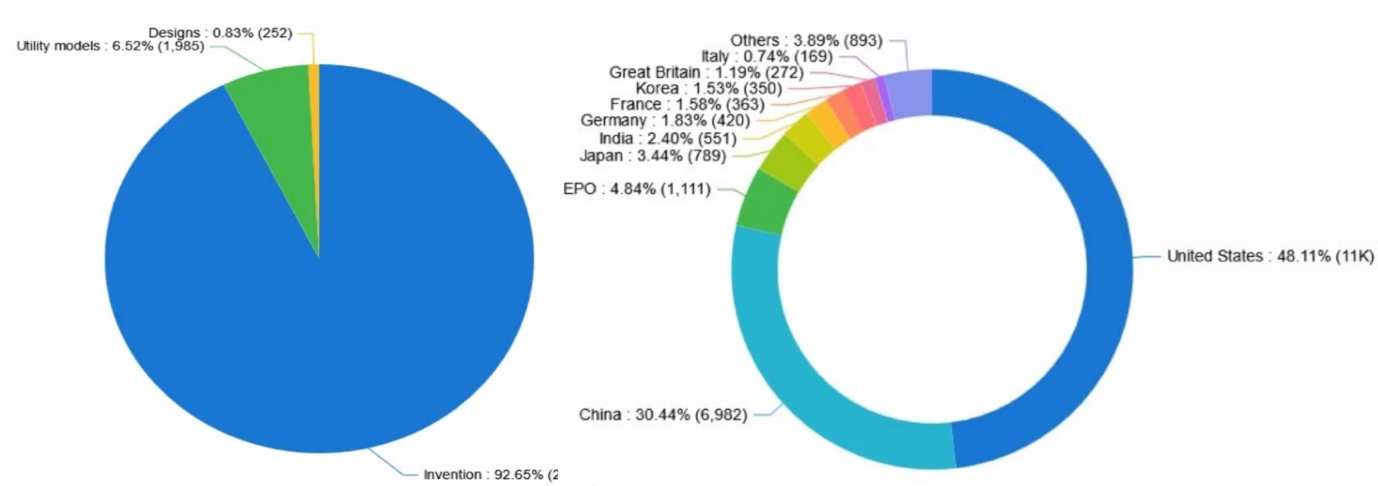


Figure 5 shows that the vast majority of patents in collaborative robot technology account for invention, followed by utility models and design patents (regarding ornamental or user-interface aspects of cobots).

Invention and utility model patents comprise the key algorithmic, functional, and control systems of collaborative robots. This indicates that the market is still dominantly in the stage of technological innovation, even if the *number* of global patent applications has decreased. Figure 6 indicates that the United States and China lead significantly in collaborative robotics patent filings, followed by the European Patent Office (EPO).

3. RobotGPT applications and use cases

3.1 Manufacturing and industrial automation

Industrial cobots integrated with LLMS can interpret natural language instructions and adjust processes in real time. A case study of Tesla's Optimus indicates that using the robot could reduce up to 75% of manual assembly time while automating only 60% of tasks due to interdependencies[15]. LLM integration allows workers to communicate tasks verbally rather than through programming. Safety features remain crucial; standards like ISO 10218-2 require both risk assessment and protective measures. Potential applications include:

- **Assembly assistants**. Robots assemble parts while explaining steps to trainees. LLMs can answer questions about procedures and highlight safety precautions.
- **Quality inspection**. Vision-language models can detect defects and provide natural-language reports. For example, RT-2 generalizes to unseen objects and can reason about objects' purpose.
- **Training for safety protocols**. Robots can simulate hazardous scenarios (e.g., chemical spills) and coach learners through proper responses. Embodied AI can adapt to trainees' pace and language.

3.2 Warehousing and logistics

LLM-powered robots could navigate warehouses, select items, and communicate with workers. Collaborative tasks require understanding complex instructions and adapting to dynamic environments. In training contexts, robots could simulate picking tasks and provide feedback on ergonomic practices. Environmental sensors integrated with IoT can monitor conditions like temperature and generate alerts.

3.3 Hospitality and retail

Humanoid robots with natural language capabilities could serve as receptionists, concierges or retail assistants. They can greet guests, provide directions, and handle transactions. Because hospitality work is interactive and unpredictable, robots in this sector require a high degree of social intelligence and adaptability. Tests of Phoenix and Figure 01 emphasize improved dexterity and multi-robot collaboration, which could translate to tasks like setting tables or stocking shelves. In training, hotel schools could use robots to simulate guest interactions in multiple languages.

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[15] Klingler, N. (2024, May 29). *Tesla Bot Optimus – a General-purpose Humanoid Robot*. Viso.ai. https://viso.ai/edge-ai/tesla-bot-optimus/

3.4 Research and laboratory work

Robots can act as laboratory assistants, performing repetitive pipetting or sample handling while answering questions about protocols. LLMs can parse scientific texts and summarize procedures. Systems like **ELLMER** illustrate how retrieving examples and combining them with sensor feedback allows robots to handle long-horizon tasks in unpredictable environments. In educational settings, robotics labs can use LLM-powered agents to support students in debugging code or designing experiments.

RobotGPTs also have the potential to elevate training on occupational safety and health. A primary function could be simulations, such as first aid, or situations in high-risk work environments.[16]

3.5 Adult education and training

Potential uses of RobotGPTs in adult learning include:

- **Translation and interpretation**. Robots acting as interpreters during training sessions, providing real-time translation and cultural context. This is particularly relevant for ITCILO's multilingual audience.
- **Contextualized instruction.** LLM integration allows robots to provide detailed explanations, answer questions on the fly, and adapt instructions to learners' prior knowledge. In training, robots could refer to regulations and adjust complexity.
- **Predictive modelling and simulation**. Robots could run safety drills or predictive scenarios in training labs, using LLMs to describe underlying physics or labour-law implications.
- **Facilitating group work**. Robots may mediate group discussions, ask probing questions and ensure inclusive participation.
- **Scalability and remote learning.** Robots could facilitate blended or remote sessions by acting as local proxies for instructors, streaming content and interacting physically with equipment on behalf of remote participants. Combined with XR, robots could create more immersive experiences.
- **Data-driven feedback and kinesthetic learning**. Sensors could record learners' interactions, enabling analysis of performance and personalized feedback. Ethical data governance is required to protect privacy. By physically demonstrating tasks and allowing learners to imitate, robots can enhance muscle memory and motor skill acquisition.

Many of these applications remain speculative as fully autonomous LLM-powered robots are not yet widely deployed. Pilot studies and co-design with learners will be critical in advancing their potential uses.

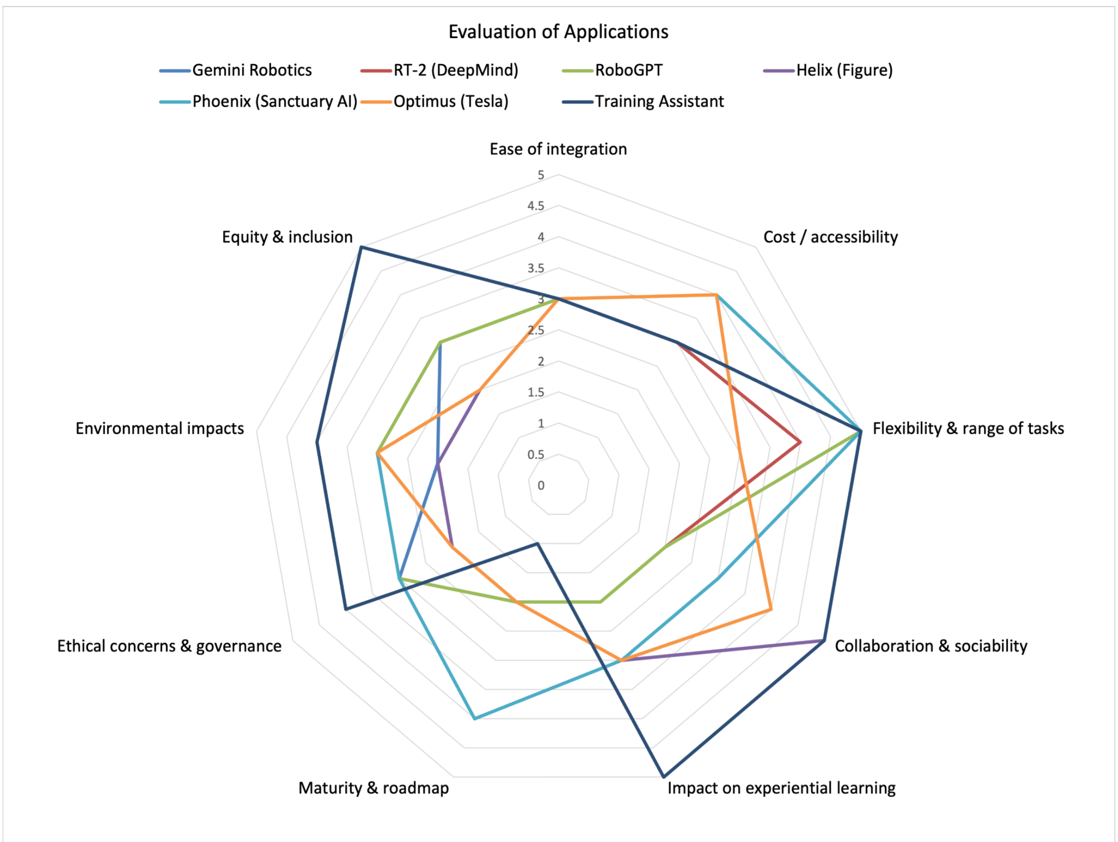
[16] *Revolutionizing health and safety: The role of AI and digitalization at work.* April 23, 2025. ILO. DOI: https://doi.org/10.54394/KNZE0733

4. Evaluation grid of RobotGPT applications

4.1 Outline of the evaluation grid

Chart 1 summarizes the application assessment for select exemplar systems: Gemini Robotics (Google), RT-2 (DeepMind), RoboGPT, Helix (Figure), Phoenix (Sanctuary AI), Optimus (Tesla) and hypothetical **Training Assistant** applications in education and training. The chart visualizes how each system performs across nine evaluation criteria: ease of integration, cost and accessibility, flexibility of tasks, collaboration and sociability, impact on experiential learning, maturity and roadmap, ethical and governance considerations, environmental impacts, and equity and inclusion. The subsequent discussion draws out some of the key patterns and differences revealed by this visual comparison. Because many projects are prototypes, maturity and costs remain uncertain.

Figure 7 - Multi-criteria evaluation of RobotGPT applications (qualitative estimates)



The radar chart can be thought of as a vector-based grid. Each of the nine evaluation criteria is represented by a spoke radiating outward from the center. The distance along each spoke corresponds to the assessed level of performance: longer vectors denote stronger performance on that criterion, while shorter vectors indicate weaker performance. A qualitative 0–5 scale captures maturity and capability: a score of 0 means the capability is absent, 1–2 indicates low to medium capability, 3 reflects a moderate capability, 4 denotes medium-high capability and 5 signifies a leading capability.

These thresholds provide reference bands rather than strict quantitative cut-offs. Because scores were derived from publicly available information and evaluation rather than systematic measurement, the resulting vectors should be interpreted as directional indicators that support qualitative comparison rather than precise benchmarking. For clarity, the **Training Assistant** in the chart is a hypothetical, low-cost humanoid robot designed specifically for educational settings; it serves as a proxy for future accessible platforms aimed at translation, research assistance and group facilitation.

4.2 Key trends and takeaways

Several common patterns and considerations emerge when comparing the competing systems mal across these evaluation criteria:

- **Flexibility is strong across most systems.** Models like Gemini Robotics and Helix demonstrate generalization to diverse tasks, and emerging research frameworks emphasize long-horizon planning. This suggests that versatility is quickly becoming a baseline expectation for AI-powered robots.
- **Cost and accessibility remain major barriers.** All commercial prototypes are assessed as high-cost and therefore out of reach for most users. Only the hypothetical Training Assistant envisions a more affordable form factor. Adoption is therefore limited to well-resourced institutions, however novel financing models, as well as continuous development of technologies is likely to lower the piercing barriers within the next few years.
- **Sociability and human-interaction vary widely.** Helix, Optimus and the hypothetical Training Assistant are designed with natural language interfaces and human-like interaction in mind. In contrast, RT-2 and RoboGPT focus on navigation and manipulation, offering little in the way of social engagement. This underscores a critical bifurcation between industrial tools and general-purpose service robots.
- **Maturity levels are low.** Most systems are prototypes or early-generation models. Even Sanctuary AI's seventh-generation Phoenix is described as moving toward commercial readiness with only pilot deployments thus far.[17] Few producers have clear roadmaps to widespread deployment by 2030, indicating that the market is still several years from maturity.
- **Ethical and governance issues are pervasive.** Across the board, concerns include potential job displacement, user privacy, and safety in physical interaction. ILO's 2025 research brief *Work Transformed* states that "The potential for discrimination embedded in algorithmic decision-making raises ethical concerns, and over-reliance on automation can lead to skill degradation and new forms of inequality"[18]. Additionally, most systems still lack clear sustainability strategies. The ILO emphasizes that "Trust in AI will not emerge from technology alone—it must be earned through inclusive policymaking, ethical design, and institutional safeguards".[19]

[17] Demaitre, Eugene. "Sanctuary AI Integrates Tactile Sensors into Phoenix General Purpose Robots - the Robot Report." *The Robot Report*, 26 Feb. 2025, www.therobotreport.com/sanctuary-ai-integrates-tactile-sensors-into-phoenix-general-purpose-robots/.
[18] Gomez Tamayo, S., & Petrelli, A. (2025). *Work transformed: the promise and peril of artificial intelligence* (, Ill.). p. 9. ILO. https://doi.org/10.54394/PJST2835
[19] Gomez Tamayo, S., & Petrelli, A. (2025). *Work transformed: the promise and peril of artificial intelligence* (, Ill.). p. 6. ILO. https://doi.org/10.54394/PJST2835

Taken together, these trends generally suggest that while the technology is advancing quickly in terms of task flexibility and human-machine interaction, significant gaps remain in affordability, maturity, governance, and sustainability. Systems such as Helix and Gemini illustrate the cutting edge but also underscore the need for careful evaluation before they become mainstream training tools.

5. Governance frameworks and ethical considerations

5.1 International regulatory landscape

European Union AI Act. In May 2024, the EU adopted **Regulation (EU) 2024/1689**[20]; its first comprehensive AI law. The Act employs a risk-based approach with four categories: unacceptable, high, limited, and minimal risk. It bans AI practices that create unacceptable risk, such as social scoring or emotion recognition in education. High-risk systems (including AI for education and worker management) must implement risk assessment, data quality controls, traceability, documentation, human oversight and robustness. Limited-risk systems, such as chatbots, require transparency. The Act emphasizes human dignity and fundamental rights, providing an important benchmark for robot GPT compliance in the EU.

UNESCO Recommendation on the Ethics of AI[21]**.** Adopted by 193 countries in 2021 and operationalized through the **Global AI Ethics and Governance Observatory** launched in 2024, this framework promotes inclusive, sustainable, and ethical AI. It provides a **Readiness Assessment Methodology (RAM)** for governments to evaluate legal, technical, and institutional preparedness, and key principles include diversity, fairness, transparency, and environmental sustainability. For AI-powered robots, these guidelines call for participatory design and effective grievance mechanisms.

NIST AI Risk Management Framework (RMF)[22]**.** Developed by the U.S. National Institute of Standards and Technology, the RMF structures risk management into four iterative functions: Govern, Map, Measure and Manage. These functions apply to robot GPTs by guiding developers and training providers to anticipate potential harms (e.g., bias, safety issues), measure performance, and continuously update systems. This RMF serves as one of several leading voluntary guides to help institutions manage AI risk.

OECD AI Principles[23]**.** The Organisation for Economic Co-operation and Development adopted non-binding principles promoting human-centric, transparent and accountable AI; they were updated in 2024. The principles emphasize inclusive growth, sustainable development, democratic values and responsible stewardship of trustworthy AI. Although voluntary, they influence national strategies and complement binding regulations like the EU AI Act.

Other frameworks. ISO/IEC standards such as ISO 8373 (terminology), ISO 13482 (personal care robots), ISO 10218 (industrial robots) and ISO 23880 (education robots) define safety and performance

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[20] European Commission. (2025). *AI Act*. European Commission. https://digital-strategy.ec.europa.eu/en/policies/regulatory-framework-ai

[21] "UNESCO Launches Global AI Ethics and Governance Observatory at the 2024 Global Forum on the Ethics of Artificial Intelligence." *Digital Skills and Jobs Platform*, 2024, digital-skills-jobs.europa.eu/en/latest/news/unesco-launches-global-ai-ethics-and-governance-observatory-2024-global-forum-ethics.

[22] "Navigating the NIST AI Risk Management Framework." *Hyperproof*, hyperproof.io/navigating-the-nist-ai-risk-management-framework/.

[23] OECD. "The OECD Artificial Intelligence (AI) Principles." *Oecd.ai*, OECD, 2019, oecd.ai/en/ai-principles.

requirements. The **G7 Code of Conduct for Advanced AI Systems** (2023) recommends transparency, human oversight and security. Many governments are developing national AI strategies, often referencing human rights, equality and sustainable development.

5.2 Ethical concerns and social justice

Decent work and labour displacement. Robots performing manual or cognitive tasks may displace workers, particularly in manufacturing and logistics. However, they can also improve health and safety. The challenge is to manage transitions through upskilling, social protection and labour regulation.[24]

Equity and inclusion. High costs of robot GPTs may exacerbate digital divides between high-income and low-income regions. Systems must support multiple languages, accessible interfaces (for persons with disabilities), and culturally sensitive communication. Gender and racial biases in training data can manifest in robot behavior, requiring rigorous testing and bias mitigation.

Privacy and surveillance. Robots equipped with cameras and microphones can collect sensitive data. Strong data protection measures, informed consent and privacy-by-design are essential.

Safety and autonomy. Physical interaction with robots poses risks of injury. Compliance with safety standards (ISO 10218-2) and real-time monitoring is mandatory. Autonomous robots must handle uncertainty, avoid harmful actions and allow human override.

Environmental impact. Manufacturing and operating robots consume energy and resources. Sanctuary AI's use of miniaturized hydraulics reduces power consumption, but large robots still have significant carbon footprints. Life-cycle assessments (LCA) should inform procurement decisions.[25]

Intellectual property and content provenance. LLM-powered robots generate content based on training data. Protecting intellectual property rights and ensuring accurate attribution is critical in educational contexts.[26]

5.3 Integration into capacity-development frameworks

ITCILO's capacity development framework emphasizes the transfer of knowledge, innovation in learning modalities, and alignment with decent work objectives. Robot GPTs should be integrated within blended learning strategies rather than replacing human trainers. The roles of robots may include demonstration, simulation and facilitation, while human instructors provide contextual interpretation, empathy and social-emotional support. Policies must ensure that robot deployment aligns with ethical guidelines and labour standards.

[24] Gomez Tamayo, S., & Petrelli, A. (2025). *Work transformed: the promise and peril of artificial intelligence* (, Ill.). ILO. https://doi.org/10.54394/PJST2835

[25] *Revolutionizing health and safety: The role of AI and digitalization at work.* April 23, 2025. ILO. DOI: https://doi.org/10.54394/KNZE0733.

[26] *Generative AI: Navigating intellectual property.* (2024). WIPO. DOI: https://doi.org/10.34667/tind.49065.

6. Conclusions and recommendations

6.1 Conclusions

RobotGPTs are an intriguing yet immature class of technologies. By combining large-language-model cognition with advanced robotics, they offer natural language interfaces, planning and reasoning, and embodied interaction. Prototypes such as Gemini Robotics, Helix, Phoenix and Optimus demonstrate rapid advances in dexterity and collaboration. However, costs remain prohibitive, and most models are still in early stages of development. Safety, reliability and ethical concerns further limit their readiness for widespread deployment. Given these constraints, it is unlikely that Robot GPTs will make economic sense for broad adoption by the first horizon of 2030. Yet the long-term potential is significant: as AI and robotics continue to converge, costs will fall and capabilities will grow, creating opportunities to enhance adult learning through demonstration, simulation, translation and facilitation.

6.2 Recommendations

Strategic positioning

1. **Focus on complementarity.** RobotGPTs should complement, not replace, human trainers. Use cases could include demonstration of complex research tasks, translation, and real-time feedback. Prioritize applications that address accessibility and inclusion, such as language interpretation or regulatory clarification.
2. **Human-oriented by design.** Commit to human-centred design that involves diverse stakeholders in co-creation, mapping social contexts, measuring impacts, and managing risks.
3. **Promote interoperable ecosystems.** Encouraging the use of open-source software and standard interfaces can avoid vendor lock-in.

Capacity development initiative proposals

1. **Launch RobotGPT foresight labs:** Partner with universities and technology hubs to create immersive foresight studios combining VR, digital twins, and LLM-enabled robots. These labs would let stakeholders "time-travel" into possible futures and design policies that anticipate technological breakthroughs before they hit the mainstream.
2. **AI-powered peer mentoring:** Pair learners with "robot mentors" programmed using open LLMs and local labour laws. These robots would facilitate peer learning, moderate group simulations, and help participants practice complex negotiation or safety scenarios.
3. **Campus pilot of a test humanoid RobotGPT:** ITCILO could pilot a humanoid RobotGPT on campus as a live prototype to assist with training activities, particularly in language support, research assistance and teamwork facilitation. The robot would integrate a multilingual large language

model with vision and sensor data—similar to systems like PaLM-E, enabling it to translate between languages, answer participant queries by retrieving and summarizing relevant materials, and moderate group exercises. By evaluating how learners and trainers interact with the prototype in real training scenarios, ITCILO can generate evidence-based insights on the potential and limitations of RobotGPTs.

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