

Key Recommendations for the Convergence of Computational and Citizen Science Research

A CCC Grand Challenges for the Convergence of Computational and Citizen Science Research Brief



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The Computing Community Consortium (CCC), a community-driven initiative supported by the National Science Foundation (NSF), brings together experts across academia, industry, policy, and more to envision and bring forth the future of computing. The recommendations below are the outcome of a CCC visioning workshop examining the enormous potential of citizen scientists — everyday folks assisting with the scientific research process — when paired with computational technology and infrastructure to support them.

The Grand Challenges for the Convergence of Computational and Citizen Science Research workshop was conducted on April 8-9, 2025, in Washington, D.C. and was informed by several precursor input-gathering sessions. These events brought together experts across relevant disciplines to develop a research agenda that brings to fruition a vision on how humans and machines may team up to solve some of the world's most pressing scientific problems.

Clear leadership across federal, state, and tribal governments with targeted investments are essential for the United States and its communities — from rural to urban — to fully capitalize on opportunities for this large-scale convergence and address the challenges facing it. Below is a set of key recommendations and actions grouped into three thematic categories.

National Infrastructure for Convergence

This theme focuses on the sustained platforms, governance systems, and physical/cyber architecture required to support scalable, trustworthy, and nationwide convergence efforts.

- 1. Encourage and incentivize cross-agency collaboration for convergence projects:** Break down silos by integrating citizen science and crowdsourcing with government agency AI, cloud, and technology strategies, and by requiring agencies to co-develop participatory AI projects, maximizing efficiency and impact.
- 2. Create permanent federal funding streams for convergence infrastructure:** Citizen science projects often struggle in the absence of sustainable funding, for example impeding the ability for long-term monitoring projects to support national needs. In addition, funding is scarce for maintenance and evolution of the more centralized platforms that support a multitude of projects. Treat the platforms as national infrastructure (akin to supercomputers) with stable funding for cyber, data, and

socio-technical systems; further dedicated funding is needed to ensure individual projects complete analysis, dissemination and evaluation of impacts.

- 3. Build interoperable and AI-ready data infrastructure for participatory sciences:** Create national frameworks and tooling for FAIR (Findable, Accessible, Interoperable, and Reusable) data exchange across citizen science platforms. Emphasize secure APIs, metadata standards, and plug-and-play model training tools for shared use. (Supported by finding 5)
- 4. Develop scalable provenance frameworks for participatory AI systems:** Fund research on lightweight, privacy-aware provenance capture that spans human actions, AI model evolution, and distributed execution, enabling reproducibility, auditing, and long-term reuse at the national scale.
- 5. Invest in privacy-preserving and sovereignty-respecting data frameworks:** Implement and evaluate mechanisms to advance federated learning, decentralized data commons, community data trusts, and open standards for interoperability that are core to the design of participatory infrastructure. Formalize the necessary governance and legal structures for secure data use to ensure security, privacy, and local control of sensitive contributions.
- 6. Establish national guidance for explainable, transparent, and trustworthy AI in citizen science:** Develop research-backed guidelines for interpretable outputs, community consent, and auditability. Require citizen-facing transparency for federally supported participatory AI systems. (Supported by finding 2, 4, 6)
- 7. Develop next-generation participatory AI governance:** Co-create frameworks that give participatory science communities real agency over AI deployment decisions, data use, and model evolution — especially for federally funded platforms. This includes mechanisms for consent, auditability, and public oversight.
- 8. Launch a National Citizen Science & AI Convergence Hub:** Establish a central, virtual hub (funded by the NSF and other agencies) to share tools, standards, best practices, case studies, and training materials, thus reducing duplication and accelerating adoption. Resources could include guidelines for data sharing, model explainability, and responsible use of AI.

Core Research for Convergence

This theme covers the foundational scientific and socio-technical investigations required to advance the field, focusing on developing new models, metrics, and frameworks for human-AI interaction, trust, and accountability.

- 1. Encourage and incentivize cross-disciplinary and cross-sectoral collaboration for convergence projects:** Break down silos by investing in strategies that incentivize collaboration and knowledge sharing between computational and citizen science researchers for development of infrastructure and systems of use for both communities, including the use of competition platforms such as Kaggle. Encourage collaboration between academic researchers, federal agencies, industry (especially cloud and AI providers), and local communities to co-design participatory AI platforms. (Supported by finding 7).
- 2. Develop Human-AI teaming frameworks for public participation:** Prototype and study new models for complementary collaboration between AI and citizen scientists, particularly incorporating large language models. Specifically investigate novel systems where complementary roles are driven both by multi-agent decisions and community needs. Explore how these systems balance efficiency with human contextual insight in problems such as task assignment, anomaly detection, and data collection or labeling of large datasets.
- 3. Develop explainable AI for non-expert users:** Research novel user interface and data visualization techniques to make AI decision-making transparent and interpretable to the general public, as well as developers or researchers, enabling the general public to gain fluency with AI concepts and better understand how AI is used. Determine to what extent these techniques build trust and enable broader public engagement with AI-driven platforms.
- 4. Design real-time feedback systems for citizen science:** Research systems that enable adaptive, multilingual, and just-in-time digital feedback loops that guide users during data collection and analysis. This includes experimentation with LLMs, AR/VR, edge computing, and mobile-first design. Study these systems for improvement in data quality, user engagement, and learning outcomes.
- 5. Institutionalize evaluation and trust metrics:** Fund research on trust diagnostics, engagement dynamics, and societal benefit indicators to guide iterative improvement and accountability.
- 6. Advance participatory AI governance models:** Research mechanisms to ensure communities have real governance over how AI is deployed and data are used, including mechanisms for consent, opt-out, accountability, and oversight. Incentivize co-development of toolkits that help projects explain AI behavior to users, including uncertainty visualization, explainable model outputs, and citizen-led model critique workflows. Offer funding (e.g., challenge grants) for co-designed AI tools that are built with community organizations, encouraging broad public participation in scientific research.

- 7. Pilot Human-AI teaming systems across multiple scales and domains:** Fund research as well as deployment testbeds at local and global scales in domains where humans and AI collaborate in real time, including disaster response, health, and environmental monitoring, building scalable models for multi-agent systems.

Training and Capacity Building

This theme focuses on developing the human capital — the skills, knowledge, and organizational structures — needed to create, manage, and participate in convergence projects across all sectors.

- 1. Cross-disciplinary training programs:** Develop new academic and practitioner training pathways that combine AI, civic science, cybersecurity, human-centered design, and policy — fostering a new generation of convergence-ready scientists, engineers, and public leaders. (Supported by finding 7 and national mandates)
- 2. Leverage citizen science for workforce development:** Integrate computational citizen science into K–12 and continuing education curricula to build STEM, ML/AI skills and civic literacy, aligned with workforce needs in AI and data science.
- 3. Embed real-time feedback systems via AI across citizen science platforms:** Deploy systems incorporating AI that train and guide users, effectively building user capacity and skills while also improving data quality. Leverage LLMs, AR/VR, and mobile-first design for multilingual, adaptive guidance that sustains participation and boosts data quality. (Supported by finding 3)
- 4. Broaden participation:** Using AI, bring citizen science into familiar digital and physical environments (apps, games, AR) to expand participation.

We also recommend measures to incentivize continued dialogue to capture the momentum from this visioning workshop and build capacity for convergence. This can be accomplished through:

- 1. Annual Convergence Research Summits:** Bring together citizen science leaders, computational researchers, public agency representatives, and community advocates to review progress, share outcomes, and set updated priorities.
- 2. Dynamic Report Updates:** Publish living documents or digital supplements to this report every 12–18 months, incorporating new research findings, policy shifts, technology developments, and community input.
- 3. Online Community of Practice and Knowledge Exchange:** Launch a moderated, cross-sector forum where teams can share use cases, code, infrastructure solutions, and insights in real-time. This will reduce duplication and accelerate innovation.

- 4. Evaluation and Metrics Working Group:** Convene a working group to define success metrics for convergence efforts — tracking not only scientific output, but also public trust, equity in participation, and societal benefit.

By strategically converging citizen science and computation, America can usher in a new era of scientific innovation, technological leadership, and public engagement. These coordinated efforts promise not only to sustain, but also significantly amplify the United States' global leadership in science and technology, improve public-sector efficiency, and meaningfully engage millions of citizens in the essential scientific questions of our time, while upskilling them on the use of AI. In the face of global competition, U.S. leadership in these technologies and outcomes is not guaranteed. The time to act decisively, through informed policy and targeted investment, is now.

Read the Full Report

For a fuller picture of the impact of large-scale convergence and a more detailed roadmap for making it happen, we encourage all members of the computing community to read the [*Grand Challenges for the Convergence of Computational and Citizen Science Research*](#) report.

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