REALIZING OUR DIGITAL FUTURE AND SHAPING ITS IMPACT ON KNOWLEDGE, INDUSTRY, AND THE WORKFORCE

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Executive Summary

Digital technologies are transforming the early 21st century, leading to the creation of entirely new industries based upon machine learning and artificial intelligence and lowering barriers to participation in and access to data, education, and communication tools for citizens around the world. It is believed that international cooperation will be essential in key areas of security, accessibility, and regulation to secure a digital future that is inclusive, democratically governed and ethically minded in which open data and reliable information can circulate. With these objectives, the Academies propose the following principles of action:

- Inclusion and access with the goal of equal opportunity to participate in and gain from the digital transformation, to channel gains equitably and eliminate digital divides.

- Information literacy relying on a comprehensive educational plan for all age groups with the objective of providing skills and tools allowing citizens to critically interpret, verify and validate the quality of information circulating in the digital infrastructure.

- Quality of tools and standards through robust mechanisms for production, validation, access and dissemination of open data, information and machine learning systems, to strengthen reliability and security, preventing tampering, manipulation and privatizing use of data and ensuring that machine learning algorithms are interpretable by non-specialists.

- Democratic governance in the form of regulatory frameworks to set up an oversight of internet service providers, social media and other entities and prevent private monopolistic or oligopolistic power in the digital economy and to ensure open and neutral internet, protection of digital data and respect for norms of individual privacy.

- Employment and training policies to encourage new economic activities, foster emerging technological sectors and ensure that the benefits of new technologies also be distributed to workers and that schemes be available for their training and reemployment.

- Ethics and human values should guide the development of digital technologies, artificial intelligence and big data analytics and intervene in all stages of digital innovations to preserve values of freedom, democracy, justice and trust.

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The promises and challenges of the digital revolution continue to expand and change, making the precise character of our digital future profoundly uncertain. We must urgently focus on key policy challenges and principles for action in order to make optimal decisions and choices for realizing our digital future and shaping its impact on knowledge, industry and the workforce. This statement highlights these challenges and principles by drawing upon insights and evidence from across scientific and scholarly fields.

Civil society groups, governments, businesses and individuals have been embracing information and communication technologies (ICTs) in digital tools that drive innovation, economic growth, and social prosperity. These tools support the capturing of data to drive insight and knowledge creation while facilitating access to information, collaboration, learning, discovery, and sharing across geographical distances and national borders. Technologies such as artificial intelligence, machine learning, crowdsourcing, big data analytics, blockchain, digital transactions, and automation increase efficiencies in production and service delivery, change the nature of work, and make new business models possible. Future developments, including quantum computing, may accelerate these changes. New ways of conducting science, learning and collaboration across all research fields emerge from increasing insights from data.

At the same time, potential vulnerabilities and perils expand and change with the increasing importance of the digital revolution. Digital technologies disrupt existing business practices, social structures, and economic relationships. Such technologies reshape economies, changing the boundaries between market and non-market activities, disrupting jobs, reducing individual agency in decision-making,

diminishing control over personal data, and devaluing labour. The rate and scale of change brought about by the digital revolution magnify the challenges for those unable to take advantage of its opportunities or disproportionately affected by rapid transformations. As ICT developments increasingly affect individual and collective decision-making and understandings of the world, those without adequate digital literacy are seriously disadvantaged.

Accordingly, a central challenge of our time consists of harnessing this wave of widespread disruption to ensure that benefits are distributed equitably, that deleterious effects and vulnerabilities are addressed, and that increasing risks are contained.

Governments around the world have been preparing for the digital future, working in partnership with international organizations, national scientific academies, and other agencies. Initiatives are underway to better reflect social needs as tomorrow's digital technologies and information resources are developed. Strategies to enable universal access to the tools and networks that power digital economies and support social inclusion are being implemented, albeit unevenly. Individuals, businesses, civil society, and governments are now positioned to reap massive benefits from the adoption of digital technologies by collectively recognizing, critically reflecting upon, and addressing five policy challenges.

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Policy Challenges

1. Inclusion and Equity of Access: The digital revolution presents tremendous opportunities to reduce socio-economic inequalities within and among countries. At the same time, accessibility gaps and forms of polarization are intensifying existing stratification between 'winning' and 'losing' economic sectors, businesses, social groups, and even societies—thereby potentially excluding significant parts of humankind from the gains of this revolution. Educational and infrastructure programs to grant all citizens access to digital skills needed for jobs of the future; to high-speed internet; and to media and information literacy remain underfunded or underdeveloped. Digital inequities are particularly evident in remote, rural, and poor communities. Social media platforms and online forums, valued for enabling the free exchange of ideas and networked social interaction, have also become spaces in which some citizens (disproportionately women, Indigenous peoples, racialized communities, and diverse vulnerable groups) experience harassment and abuse. Technological interfaces designed for some groups of users but not others can curtail the ability and willingness of citizens to participate in digitally-mediated public debate.

2. Information Quality, Security, and Resilience: The quantity of data produced and disseminated through digital technologies and platforms has not yet been matched by a corresponding bolstering of procedures and norms to verify and validate the sources, quality, diversity, and technical accuracy of the data, nor by policies to protect the security and ensure the resilience of digital infrastructure. All major infrastructure systems have become digitally-based and have major cyber vulnerabilities. Public understanding of key issues and problems may be stagnating in some areas (such as climate change or vaccinations) as information bubbles have proliferated. The potential for subtle or covert manipulation of public opinion is growing, while public confidence and trust in traditional sources of information and knowledge (such as scientific bodies and media of record) erodes. As dependence on data, ICTs and their related systems grows, so does the significance of their vulnerabilities and potential failures.

3. Transparency, Openness, and Interoperability: Many recent technological transformations have appropriated personal data, fostered proprietary standards, or utilized "black boxed" algorithms. Examples include social scoring to quantify individual risk, shortlisting of job candidates, setting of prices for online transactions, and the selection of optimized and suppressed information in social media. The lack of regulatory structures to ensure oversight, transparency, interoperability, interpretability, and scrutiny of digital data and its uses presents a challenge to democratic principles of openness and accountability. Where the complexity of some systems, such as those based on deep learning, makes their outputs difficult to explain, new approaches to ensuring openness and accountability may be required, based on understanding how these systems work in practice.

4. The Future of Work: Driven by developments in artificial intelligence and machine learning, digital technologies and business strategies are leading to the automation or replacement of jobs across various skills and economic sectors, while creating a variety of new jobs and augmenting the abilities of workers to perform in existing and emerging industries. The ultimate effects of these changes depend on the direction of technological innovation, and how workers, employers, and policy makers respond to it. The evidence thus far shows that the resulting disruption is producing an uneven distribution of work-related gains and losses within and between societies, in terms of job security, wages, working time, or entrepreneurial opportunities.

5. Ethics: Digital capacities have outpaced the institutional arrangements and public understanding on which normative frameworks can be based to ensure that innovation respects principles of public good and human welfare. The fact that something can be done does not necessarily imply that it should be done, notably in the absence of clearly defined ethical guidelines (in the cases of autonomous systems and weaponized artificial intelligence, for instance).The shift from analogue to digital life demands new ethical frameworks to address new fundamental questions regarding the reconciliation of digital technologies to human values, the consequences of human interactions with intelligent machines, and the meaning of responsible innovation.

Principles for Action

Broad engagement across civil society, industry and governments will be essential to collectively address the five policy challenges noted above, and thereby to realize the potential of the digital revolution to enhance quality of life for everyone. Equity, inclusion, security, and prosperity in our digital world is the responsibility of all. We suggest the following principles for action.

1. Inclusion and Access: The goal of equal opportunity for all to participate in and gain from digital transformations requires consultative design and continuing public dialogue and public programs. Public programs should aim to disseminate technical skills and make data and digital infrastructure accessible to citizens regardless of geographical location or socio-economic status. It is essential to measure and monitor inclusivity in emerging technological areas. Public programs are essential to channel the gains of technological disruption equitably across societies, while preventing disruption from disproportionately affecting vulnerable segments of the population and workforce. While progress has been made on this front, digital divides persist and must be eliminated as a matter of priority.

2. Information Literacy: In addition to access to data, citizens need general digital skills and tools. Citizens now require increasing familiarity with ethical issues surrounding the uses and applications of ICTs, and critical literacy to interpret and validate the quality of information. Among multiple benefits, such capacity can help guard against false claims and coordinated disinformation campaigns. Citizens should be able and encouraged to participate in online interaction through which they can express their opinions and disseminate information. In this way, digital public spaces such as social media platforms can better find a balance between two fundamental democratic norms—protecting freedom of expression and eliminating hate speech. Comprehensive education to develop such digital literacy skills is required for all ages.

3. Quality of Tools and Standards: Robust mechanisms, procedures, and standards for the production, validation, and dissemination of data and information are needed to strengthen data reliability, infrastructure security and resilience, interoperability, accessibility, transparency, and factual accuracy. This could include new standards or guidance to create trustworthy and resilient cybersecurity systems. At the same time, action is required to prevent tampering, manipulation, and arbitrary or privatizing uses of data and digital infrastructure. Quality control measures and open standards are essential for effective evidence-based scientific research and societal decision-making, and to secure citizens' trust in democratic institutions. Long-term preservation and curation of data resources are essential. Such measures and standards must be co-designed, implemented and enforced by stakeholders

within governmental and international organizations, the private sector, and civil society. Developers should ensure that machine learning methods and algorithms are interpretable by non-specialists and thus open to public scrutiny.

4. Democratic Governance: Regulatory frameworks and policies are needed to provide democratically governed oversight of internet service providers, social media corporations and other entities that serve as gatekeepers and data stewards. The emergence of private monopolistic or oligopolistic power in the digital economy should be prevented in order to safeguard the principles of an open and neutral internet. It is vital to ensure service neutrality and to ensure the protection of digital data to respect norms of individual privacy and safety while preserving data in the public domain. Patterns of data use in the 21st century have led to a reflection on ownership and control of personal data and information by the individual; humans and their digital selves must enjoy rights to dignity and respect. International cooperation will be essential to the implementation of this principle.

5. Employment and Training: Appropriate public policies and private investment models must encourage new economic activities and employment opportunities, and foster the growth of small- and medium-sized players, as well as fund and support—through tax incentives or targeted strategic investments—training and re-employment opportunities for workers. Education, training, and mentoring are needed to complement technical knowledge. Such opportunities should also address creativity, innovation, adaptabili-

ty, and interpersonal skills to adjust to changing labour markets. Policies should ensure that the benefits of new technologies be distributed to workers in the form of reduced or more flexible working hours, higher wages, and better working conditions. These benefits should also contribute to societal needs via appropriate tax policies.

6. Ethics and Human Values: Appropriate ethical models must guide the development of digital and computationally-based technologies, artificial intelligence and the use of big data. Innovation should be pursued within a framework of ethical considerations regarding human welfare and ecological preservation. Shared social norms, moral frameworks, and technical principles—such as open data standards, responsible technological development, and the protection of nature—are essential to our global digital future.

Conclusion

The digital revolution is transforming the early 21st century, leading to the creation of entirely new industries based upon artificial intelligence and machine learning, and lowering barriers to participation in and access to data, education, and communication tools for citizens around the world. By drawing upon insights and evidence from across scientific and scholarly fields to address specific policy challenges and guided by the principles highlighted in this statement, we believe that significant gains can be harnessed and optimized, via national and regional governments and institutions, civil society and private sector actors. International cooperation will be essential in key areas of security, accessibility, and regulation. Our Academies intend to continue our efforts to inform this process and contribute to ongoing communication and international collaboration amongst all stakeholders. Together, we can secure a digital future that is inclusive, democratically governed, ethically minded, and in which open data and reliable information can circulate--that is, a future in which all citizens will be equipped to respond to challenges and take advantages of emerging opportunities.