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Autonomous and intelligent systems (A/IS) offer unique and impactful opportunities as well as risks both to people living in high-income countries (HIC) and in low-and middle-income countries (LMIC). The scaling and use of A/IS represent a genuine opportunity across the globe to provide individuals and communities—be they rural, semi-urban, or urban—with the means to satisfy their needs and develop their full potential, with greater autonomy and choice. A/IS will potentially disrupt economic, social, and political relationships and interactions at many levels. Those disruptions could provide an historical opportunity to reset those relationships in order to distribute power and wealth more equitably and thus promote social justice.[1] They could also leverage quality and better standards of life and protect people's dignity, while maintaining cultural diversity and protecting the environment.

One possible vehicle that can be used to agree on priorities and prioritize resources and actions is the United Nations Agenda for Sustainable Development, which was adopted by the UN General Assembly in 2015; 193 nations voted in favor of the Agenda, which also includes 17 Sustainable Development Goals (SDGs) for the world to achieve by 2030. The Agenda challenges all member states to make concerted efforts toward the above mentioned goals, and thus toward a sustainable, prosperous, and resilient future for people and the planet. These universally applicable goals should be reached by 2030.[2]

The value of A/IS is significantly associated with the generation of various types of superior and unique insights, many of which could help achieve positive socioeconomic outcomes for both HIC and LMIC societies, in keeping with the SDGs. The ethical imperative driving this chapter is that A/IS must be harnessed to benefit humanity, promote equality, and realize the world community's vision of a sustainable future and the SDGs:

…….of universal respect for human rights and human dignity, the rule of law, justice, equality and nondiscrimination; of respect for race, ethnicity and cultural diversity; and of equal opportunity permitting the full realization of human potential and contributing to shared prosperity. A world which invests in its children and in which every child grows up free from violence and exploitation. A world in which every woman and girl enjoys full gender equality and all legal, social and economic barriers to their empowerment have been removed. A just, equitable, tolerant, open and socially inclusive world in which the needs of the most vulnerable are met.[3]

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We recognize that how A/IS are deployed globally will be a determining factor in whether, in fact, "no-one gets left behind", whether human rights and dignity of all people are respected, whether children are protected, and whether the gap between rich and poor, within and between nations, narrows or widens. A/IS can advance the Sustainable Development Agenda's transformative vision, but at the same time, A/IS can undermine it if risks reviewed in this chapter are not managed properly.

For example, A/IS create the risk of accelerating inequality within and among nations, if their development and marketing are controlled by a few select companies, primarily in HIC. The benefits would largely accrue to the highly educated and wealthier segment of the population, while displacing the less educated workforce, both by automation and by the absence of educational or retraining systems capable of imparting skills and knowledge needed to work productively alongside A/IS. These risks, although differentiated by IT infrastructure, educational attainment, economic, and cultural contexts, exist in HIC and LMIC alike. The inequality in accessing and using the internet, both within and among countries, raises questions on how to spread A/IS benefits across humanity. Ensuring A/IS "for the common good" is an ethical imperative and at the core of *Ethically Aligned Design, First Edition*; the key elements of this "common good" are that it is human-centered, accountable, and ensure outcomes that are fair and inclusive.

This chapter explores the imperative for A/IS to serve humanity by improving the quality and standard of life for all people everywhere. It makes recommendations for advancing equal access to this transformative technology, so that it drives the well-being of all people, rather than further concentrating wealth, resources, and decision-making power in the hands of a few countries, companies, or citizens. The recommendations further reflect policies and collaborative public, private, and people programs which, if implemented, will respect the ethical imperative embedded in the Sustainable Development Agenda's transformative vision. The respect of human rights and dignity, and the advancement of "common good" with equal benefit to both HIC and LMIC, are central to every recommendation within this chapter.

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Section 1—A/IS in Service to Sustainable Development for All

A/IS have the potential to contribute to the resolution of some of the world's most pressing problems, including: violation of fundamental rights, poverty, exploitation, climate change, lack of high-quality services to excluded populations, increased violence, and the achievement of the SDGs.

Issue: Current roadmaps for development and deployment of A/IS are not aligned with or guided by their impact in the most important challenges of humanity, defined in the seventeen United Nations Sustainable Development Goals (SDGs), which collectively aspire to create a more equal world of prosperity, peace, planet protection, and human dignity for all people.[4]

Background

SDGs promoting prosperity, peace, planet protection, human dignity, and respect for human rights of all, apply to HIC and LMIC alike. Yet ensuring that the benefits of A/IS will accrue to humanity as a whole, leaving "no one behind", requires an ethical commitment to global citizenship and well-being, and a conscious effort to counter the nature of the tech economy, with its tendency to concentrate wealth within high income populations. Implementation of the SDGs should benefit excluded sectors of society in every country, regardless of A/IS infrastructure.

"The Road to Dignity by 2030" document of the UN Secretary General reports on resources and methods for implementing the 2030 Agenda for Sustainable Development and emphasizes the importance of science, technology, and innovation for a sustainable future.[5] The UN Secretary General posits that:

"A sustainable future will require that we act now to phase out unsustainable technologies and to invest in innovation and in the development of clean and sound technologies for sustainable development. We must ensure that they are fairly priced, broadly disseminated and fairly absorbed, including to and by developing countries." (para. 120)

A/IS are among the technologies that can play an important role in the solution of the deep social problems plaguing our global civilization, contributing to the transformation of society away from an unsustainable, unequal socioeconomic system, towards one that realizes the vision of universal human dignity, peace, and prosperity.

However, with all the potential benefits of A/IS, there are also risks. For example, given A/IS technology's immense power needs, without

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new sources of sustainable energy harnessed to power A/IS in the future, there is a risk that it will increase fossil fuel use and have a negative impact on the environment and the climate.

While 45% of the world's population is not connected to the internet, they are not necessarily excluded from A/IS' potential benefits: in LMIC mobile networks can provide data for A/IS applications. However, only those connected are likely to benefit from the income-producing potential of internet technologies. In 2017, internet penetration in HIC left behind certain portions of the population often in rural or remote areas; 12% of U.S. residents and 20% of residents across Europe were unable to access the internet. In Asia with its concentration of LMIC, 52% of the population, on average, had no access, a statistic skewed by the large population of China, where internet penetration reached 45% of the population. In numerous other countries in the region, 99% of residents had no access. This nearly total exclusion also exists in several countries in Africa, where the overall internet penetration is only 35%: 2 of every 3 residents in Africa have no access.[6] Those with no internet access also do not generate data needed to "train" A/IS, and are thereby excluded from benefits of the technology, the development of which risks systematic discriminatory bias, particularly against people from minority populations, and those living in rural areas, or in low-income countries. As a comparison, one study estimated that "in the US, just one home automation product can generate a data point every six seconds."[7] In Mozambique, where about 90% of the population lack internet access, "the average household generates zero digital data

points."[8] With mobile phones generating much of the data needed for developing A/IS applications in LMIC, unequal phone ownership may build in bias. For example, there is a risk of discrimination against women, who across LMIC are 14% less likely than men to own a mobile phone, and in South Asia where 38% are less likely to own a mobile phone.[9]

Recommendations

The current range of A/IS applications in sectors crucial to the SDGs, and to excluded populations everywhere, should be studied, with the strengths, weaknesses, and potential of the most significant recent applications analyzed, and the best ones developed at scale. Specific objectives to consider include:

- Identifying and experimenting with A/IS technologies relevant to the SDGs, such as: big data for development relevant to, for example, agriculture and medical tele-diagnosis; geographic information systems needed in public service planning, disaster prevention, emergency planning, and disease monitoring; control systems used in, for example, naturalizing intelligent cities through energy and traffic control and management of urban agriculture; applications that promote human empathy focused on diminishing violence and exclusion and increasing well-being.

- Promoting the potential role of A/IS in sustainable development by collaboration between national and international government agencies and nongovernmental organizations (NGOs) in technology sectors.

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- Analyzing the cost of and proposing strategies for publicly providing internet access for all, as a means of diminishing the gap in A/IS' potential benefit to humanity, particularly between urban and rural populations in HIC and LMIC alike.

- Investing in the documentation and dissemination of innovative applications of A/IS that advance the resolution of identified societal issues and the SDGs.

- Researching sustainable energy to power A/IS computational capacity.

- Investing in the development of transparent monitoring frameworks to track the concrete results of donations by international organizations, corporations, independent agencies, and the State, to ensure efficiency and accountability in applied A/IS.

- Developing national legal, policy, and fiscal measures to encourage competition in the A/IS domestic markets and the flourishing of scalable A/IS applications.

- Integrating the SDGs into the core of private sector business strategies and adding SDG indicators to companies' key performance indicators, going beyond corporate social responsibility (CSR).

- Applying the well-being indicators[10] to evaluate A/IS' impact from multiple perspectives in HIC and LMIC alike.

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Issue: A/IS are often viewed only as having impact in market contexts, yet these technologies also have an impact on social relations and culture.

Background

A/IS are expected to have an impact beyond market domains and business models, diffusing throughout the global society. For instance, A/IS have and will impact social relationships in a way similar to how mobile phones changed our daily lives, reflecting directly on our culture, customs, and language. The extent and direction of this impact is not yet clear, but documented experience in HIC and high internet-penetration environments of trolls, "fake news," and cyberbullying on social media offer a cautionary tale.[11] Depression, social isolation, aggression, and the dissemination of violent behavior with damage to human relations, so extreme that, in some cases, it has resulted in suicide, are all correlated with the internet.[12] As an example, the technology for "smart homes" has been used for inflicting domestic violence by remotely locking doors, turning off heat/AC, and otherwise harassing a partner. This problem could be easily extended to include elder and child abuse.[13] Measures need to be developed to prevent A/IS from contributing to the emergence or amplification of social disorders.

Recommendations

To understand the impact of A/IS on society, it is necessary to consider product and process innovation, as well as wider sociocultural and ethical implications, from a global perspective, including the following:

- Exploring the development of algorithms capable of detecting and reporting discrimination, cyberbullying, deceptive content and identities, etc., and of notifying competent authorities; recognizing that the use of such algorithms must address ethical concerns related to algorithm explainability as well as take into account the risk to certain aspects of human rights, notably to privacy and freedom from oppression.

- Developing a globally recognized professional Code of Ethics with and for technology companies.

- Identifying social disorders, such as depression, anxiety, psychological violence, political manipulation, etc., correlated with the use of A/IS-based technologies as a world health problem; monitoring and measuring their impact.

- Elaborating metrics measuring how, where and on whom there is a cultural impact of new A/IS-based technologies.

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Issue: The right to truthful information is key to a democratic society and to achieving sustainable development and a more equal world, but A/IS poses risks to this right that must be managed.

Background

Social media have become the dominant technological infrastructure for the dissemination of information such as news, opinion, advertising, etc., and are currently in the vanguard of the movement toward customized/targeted information based on user profiling that involves significant use of A/IS techniques. Analysis of opinion polls and trends in social networks, blogs, etc., and of the emotional response to news items can be used for the purposes of manipulation, facilitating both the selection of news that guides public opinion in the desired direction and the practice of sensationalism.

The "personalization of the consumer experience", that is, the adaptation of articles to the interests, political vision, cultural level, education, and geographic location of the reader, is a new challenge for the journalism profession that expands the possibilities of manipulation.

The information infrastructure is currently lacking in transparency, such that it is difficult or impossible to know (except perhaps for the infrastructure operator):

- what private information is being collected for user profiling and by whom,

- which groups are targeted and by whom,

- what information has been received by any given targeted group,

- who financed the creation and dissemination of this information,

- the percentage of the information being disseminated by bots, and

- who is financing these bots.

Many actors have found this opaque infrastructure ideal for spreading politically motivated disinformation, which has a negative

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effect on the creation of a more equal world, democracy, and the respect for fundamental rights. This disinformation can have tragic consequences. For instance, human rights groups have unearthed evidence that the military authorities of Myanmar used Facebook for inciting hatred against the Rohingya Muslim minority, hatred which facilitated an ethnic cleansing campaign and the murder of up to 50,000 people.[14] The UN determined that these actions constituted genocide, crimes against humanity, and war crimes.[15]

Recommendations

To protect democracy, respect fundamental rights, and promote sustainable development, governments should implement a legislative agenda which prevents the spread of misinformation and hate speech, by:

- Ensuring more control and transparency in the use of A/IS techniques for user profiling in order to protect privacy and prevent user manipulation.

- Using A/IS techniques to detect untruthful information circulating in the infrastructures, overseen by a democratic body to prevent potential censorship.

- Obliging companies owning A/IS infrastructures to provide more transparency regarding their algorithms, sources of funding, services, and clients.

- Defining a new legal status somewhere between "platforms" and "content providers" for A/IS infrastructures.

- Reformulating the deontological codes of the journalistic profession to take into account the intensive use of A/IS techniques foreseen in the future.

- Promoting the right to information in official documents, and developing A/IS techniques to automate journalistic tasks such as verification of sources and checking the accuracy of the information in official documents, or in the selection, hierarchy, assessment, and development of news, thereby contributing to objectivity and reliability.

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Section 2—Equal Availability

Issue: Vastly different power structures among and within countries create risk that A/IS deployment accelerates, rather than reduces, inequality in the pursuit of a sustainable future. It is unclear how LMIC can best implement A/IS via existing resources and take full advantage of the technology's potential to achieve a sustainable future.

Background

The potential use of A/IS to create sustainable economic growth for LMIC is uniquely powerful. Yet, many of the debates surrounding A/IS take place within HIC, among highly educated and financially secure individuals. It is imperative that all humans, in any condition around the world, are considered in the general development and application of these systems to avoid the risk of bias, excessive inequality, classism, and general rejection of these technologies. With much of the financial and technical resources for A/IS development and deployment residing in HIC, not only are A/IS benefits more difficult to access for LMIC populations, but those A/IS applications that are deployed outside of HIC realities may not be appropriate. This is for reasons of cultural/ethnic bias, language difficulties, or simply an inability to adapt to local internet infrastructure constraints.

Furthermore, technological innovation in LMIC comes up against many potential obstacles, which could be considered when undertaking initiatives aimed at enhancing LMIC access:

- Reluctance to provide open source licensing of technological development innovations,

- Lack of the human capital and knowledge required to adapt HIC-developed technologies to resolving problems in the LMIC context, or to develop local technological solutions to these problems,

- Retention of A/IS capacity in LMIC due to globally uncompetitive salaries,

- Lack of infrastructure for deployment, and difficulties in taking technological solutions to where they are needed,

- Lack of organizational and business models for adapting technologies to the specific needs of different regions,

- Lack of active participation of the target population,

- Lack of political will to allow people to have access to technological resources,

- Existence of oligopolies that hinder new technological development,

- Lack of inclusive and high-quality education at all levels, and

- Bureaucratic policies ill-adapted to highly dynamic scenarios.

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For A/IS capacities and benefits to become equally available worldwide, training, education, and opportunities should be provided particularly for LMIC. Currently, access to products that facilitate A/IS research of timely topics is quite limited for researchers in LMIC, due to cost considerations.

If A/IS capacity and governance problems, such as relevant laws, policies, regulations, and anti-corruption safeguards, are addressed, LMIC could have the ability to use A/IS to transform their economies and leapfrog into a new era of inclusive growth. Indeed, A/IS itself can contribute to good governance when applied to the detection of corruption in state and banking institutions, one of the most serious recognized constraints to investment in LMIC. Particular attention, however, must be paid to ensure that the use of A/IS is for the common good—especially in the context of LMIC—and does not reinforce existing socioeconomic inequities through systematic discriminatory bias in both design and application, or undermine fundamental rights through, among other issues, lax data privacy laws and practice.

Recommendations

A/IS benefits should be equally available to populations in HIC and LMIC, in the interest of universal human dignity, peace, prosperity, and planet protection. Specific measures for LMIC should include:

- Deploying A/IS to detect fraud and corruption, to increase the transparency of power structures, to contribute to a favorable investment, governance, and innovation environment.

- Supporting LMIC in the development of their own A/IS strategies, and in the retention or return of their A/IS talent to prevent "brain drain".

- Encouraging global standardization/harmonization and open source A/IS software.

- Promoting distribution of knowledge and wealth generated by the latest A/IS, including through formal public policy and financial mechanisms to advance equity worldwide.

- Developing public datasets to facilitate the access of people from LMIC to data resources to facilitate their applied research, while ensuring the protection of personal data.

- Creating A/IS international research centers in every continent, that promote culturally appropriate research, and allow the remote access of LMIC's communities to high-end technology.[16]

- Facilitating A/IS access in LMIC through online courses in local languages.

- Ensuring that, along with the use of A/IS, discussions related to identity, platforms, and blockchain are conducted, such that core enabling technologies are designed to meet the economic, social, and cultural needs of LMIC.

- Diminishing the barriers and increase LMIC access to technological products, including the formation of collaborative networks between developers in HIC and LMIC, supporting the latter in attending global A/IS conferences.[17]

- Promoting research into A/IS-based technologies, for example, mobile lightweight A/IS applications, that are readily available in LMIC.

- Facilitating A/IS research and development in LMIC through investment incentives, public-

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private partnerships, and/or joint grants, and collaboration between international organizations, government bodies, universities, and research institutes.

- Prioritizing A/IS infrastructure in international development assistance, as necessary to improve the quality and standard of living and advance progress towards the SDGs in LMIC.

- Recognizing data issues that may be particular to LMIC contexts, i.e., insufficient sample size for machine learning which sometimes results in **de facto** discrimination, and inadequate laws for, and the practice of, data protection.

- Supporting research on the adaptation of A/IS methods to scarce data environments and other remedies that facilitate an optimal A/IS enabling environment in LMIC.

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Section 3—A/IS and Employment

Issue: A/IS are changing the nature of work, disrupting employment, while technological change is happening too fast for existing methods of (re)training the workforce.

Background

The current pace of technological development will heavily influence changes in employment structure. In order to properly prepare the workforce for such evolution, actions should be proactive and not only reactive. The wave of automation caused by the A/IS revolution will displace a very large share of jobs across domains and value chains. The U.S. "automated vehicle" case study analyzed in the White House 2016 report *Artificial Intelligence, Automation, and the Economy* is emblematic of what is at stake: "2.2 to 3.1 million existing part- and full-time U.S. jobs are exposed over the next two decades, although the timeline remains uncertain."[18]

The risk of unemployment for LMIC is more serious than for developed countries. The industry of most LMIC is labor intensive. While labor may be cheap(er) in LMIC economies, the ripple effects of A/IS and automation will be felt much more than in the HIC economies. The 2016 World Bank Development Report stated that the share of occupations susceptible to automation and A/IS is higher in LMIC than in

HIC, where such jobs have already disappeared. In addition, the qualities which made certain jobs easy to outsource to LMIC where wages are lower are those that may make them easy to automate.[19] An offsetting factor is the reality that many LMIC lack the communication, energy, and IT infrastructure required to support highly automated industries.[20] Notwithstanding this reality, the World Bank estimated the automatable share of employment, unadjusted for adoption time lag, for LMIC ranges from 85% in Ethiopia to 62% in Argentina, compared to the OECD average of 57%.[21]

In the coming decades, the automation wave calls for higher investment and the transformation of labor market capacity development programs. Innovative and fair ways of funding such an investment are required; the solutions should be designed in cooperation with the companies benefiting from the increase of profitability, thanks to automation. This should be done in a responsible way so that the innovation cycle is not broken, and yet workforce capacity does not fall behind the needs of 21st century employment. At the same time, A/IS and other digital technologies offer real potential to innovate new approaches to job-search assistance, placement, and hiring processes in the age of personalized services. The efficiency of matching labor supply and demand can be tremendously enhanced by the rise of multisided platforms and predictive analytics, provided they do not entrench discrimination.[22] The case of platforms, such as LinkedIn, for instance, with its 470 million

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registered users, and online job consolidators such as indeed.com and Simply Hired, are interesting as an evolution in hiring practices, at least for those able to access the internet.

Tailored counseling and integrated retraining programs also represent promising grounds for innovation. In addition, much will have to be done to create fair and effective lifelong skill development/training, infrastructures, and mechanisms capable of empowering millions of people to viably transition jobs, sectors, and potentially locations, and to address differential geographic impacts that exacerbate income and wealth disparities. Effectively enabling the workforce to be more mobile—physically, legally, and virtually—will be crucial. This implies systemic policy approaches which encompass housing, transportation, licensing, tax incentives, and crucially in the age of A/IS, universal broadband access, especially in rural areas of both HIC and LMIC.

Recommendations

To thrive in the A/IS age, workers must be provided training in skills that improve their adaptability to rapid technological changes; programs should be available to any worker, with special attention to the low-skilled workforce. Those programs can be private, that is, sponsored by the employer, or publicly and freely offered through specific public channels and government policies, and should be available regardless of whether the worker is in between jobs or still employed. Specific measures include:

- Offering new technical programs, possibly earlier than high school, to increase the workforce capacity to close the skills gap and thrive in employment alongside A/IS.

- Creating opportunities for apprenticeships, pilot programs, and scaling up data-driven evidence-based solutions that increase employment and earnings.

- Supporting new forms of public-private partnerships involving civil society, as well as new outcome-oriented financial mechanisms, e.g., social impact bonds, that help scale up successful innovations.

- Supporting partnerships between universities, innovation labs in corporations, and governments to research and incubate startups for A/IS graduates.[23]

- Developing regulations to hold corporations responsible for employee retraining necessary due to increased automation and other technological applications having impact on the workforce.

- Facilitating private sector initiatives by public policy for co-investment in training and retraining programs through tax incentives.

- Establishing and resourcing public policies that assure the survival and well-being of workers, displaced by A/IS and automation, who cannot be retrained.

- Researching complementary areas, to lay solid foundations for the transformation outlined above.
  - Requiring more policy research on the dynamics of professional transitions in different labor market conditions.

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- Researching the fairest and most efficient public-private options for financing labor force transformation due to A/IS.

- Developing national and regional future of work strategies based on sound research and strategic foresight.

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Issue: Analysis of the A/IS impact on employment is too focused on the number and category of jobs affected, whereas more attention should be addressed to the complexities of changing the task content of jobs.

Background

Current attention on automation and employment tends to focus on the sheer number of jobs lost or gained. It is important to focus the analysis on how employment structures will be changed by A/IS, rather than solely dwelling on the number of jobs that might be impacted. For example, rather than carrying out a task themselves, workers will need to shift to supervision of robots performing that task. Other concerns include changes in traditional employment structures, with an increase in flexible, contract-based temporary jobs, without employee protection, and a shift in task composition away from routine/repetitive and toward complex decision-making. This is in addition to the enormous need for the aforementioned retraining. Given the extent of disruption, workforce trends will need to measure time spent unemployed or underemployed, labor force participation rates, and other factors beyond simple unemployment numbers.

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The *Future of Jobs 2018* report of the World Economic Forum highlights:

"...the potential of new technologies to create as well as disrupt jobs and to improve the quality and productivity of the existing work of human employees. Our findings indicate that, by 2022, *augmentation* of existing jobs through technology may free up workers from the majority of data processing and information search tasks—and may also increasingly support them in high-value tasks such as reasoning and decision-making as

augmentation becomes increasingly common over the coming years as a way to supplement and complement human labour."[24]

The report predicts the shift in skill demand between today and 2022 will be significant and that "proactive, strategic and targeted efforts will be needed to map and incentivize workforce redeployment… [and therefore]… investment decisions [on] whether to prioritize automation or augmentation and the question of whether or not to invest in workforce reskilling."[25]

Comparing Skills Demand, 2018 Versus 2022, Top Ten

TODAY, 2018	TRENDING, 2022	DECLINING, 2022
1. Analytical thinking and innovation	1. Analytical thinking and innovation	1. Manual dexterity, endurance, and precision
2. Complex problem-solving	2. Active learning and learning strategies	2. Memory, verbal, auditory, and spatial abilities
3. Critical thinking and analysis	3. Creativity, originality, and initiative	3. Management of financial and material resources
4. Active learning and learning strategies	4. Technology design and programming	4. Technology installation and maintenance
5. Creativity, originality, and initiative	5. Critical thinking and analysis	5. Reading, writing, math, and active listening
6. Attention to detail, trustworthiness	6. Complex problem-solving	6. Management of personnel
7. Emotional Intelligence	7. Leadership and social influence	7. Quality control and safety awareness
8. Reasoning, problem-solving, and ideation	8. Emotional intelligence	8. Coordination and time-management
9. Leadership and social influence	9. Reasoning, problem-solving, and ideation	9. Visual, auditory, and speech abilities
10. Coordination and time management	10. Systems analysis and evaluation	10. Technology use, monitoring, and control

Source: Future of Jobs Survey 2018, World Economic Forum, Table 4

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Recommendations

While there is evidence that robots and automation are taking jobs away in various sectors, a more balanced, granular, analytical, and objective treatment of A/IS impact on the workforce is needed to effectively inform policy making and essential workforce reskilling. Specifics to accomplish this include:

- Creating an international and independent agency able to properly disseminate objective statistics and inform the media, as well as the general public, about the impact of robotics and A/IS on jobs, tax revenue, growth,[26] and well-being.

- Analyzing and disseminating data on how current task content of jobs have changed, based on a clear assessment of the automatability of the occupational description of such jobs.

- Promoting automation with augmentation, as recommended in the *Future of Jobs Report 2018* (see chart on page 154), to maximize the benefit of A/IS to employment and meaningful work.

- Integrating more granulated dynamic mapping of the future jobs, tasks, activities, workplace-structures, associated work-habits, and skills base spurred by the A/IS revolution, in order to innovate, align, and synchronize skill development and training programs with future requirements. This workforce mapping is needed at the macro, but also crucially at the micro, levels where labor market programs are deployed.

- Considering both product and process innovation, and looking at them from a global perspective in order to understand properly the global impact of A/IS on employment.

- Proposing mechanisms for redistribution of productivity increases and developing an adaptation plan for the evolving labor market.

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Section 4—Education for the A/IS Age

Issue: Education to prepare the future workforce, in both HIC and LMIC, to design ethical A/IS applications or to have a comparative advantage in working alongside A/IS, is either lacking or unevenly available, risking inequality perpetuated across generations, within and between countries, constraining equitable growth, supporting a sustainable future, and achievement of the SDGs.

Background

Multiple international institutions, in particular educational engineering organizations,[27] have called on universities to play an active role, both locally and globally, in the resolution of the enormous problems that the world faces in securing peace, prosperity, planet protection, and universal human dignity: armed conflict, social injustice, rapid climate change, abuse of human rights, etc. Addressing global social problems is one of the central objectives of many universities, transversal to their other functions, including research in A/IS. UNESCO points out that universities' preparation of future scientists and engineers for social responsibility is presently very limited, in view of the enormous ethical and social problems associated with technology.[28] Enhancing the global dimension of engineering in undergraduate and postgraduate A/IS education is necessary, so that students can be prepared as technical professionals, aware of the opportunities and risks that A/IS present, and ready for work anywhere in the world in any sector.

Engineering studies at the university and postgraduate levels is just one dimension of the A/IS education challenge. For instance, business, law, public policy, and medical students will also need to be prepared for professions where A/IS are a partner, and to have internalized ethical principles to guide the deployment of such technologies. LMIC need financial and academic support to incorporate global A/IS professional curricula in their own universities, and all countries need to develop the pipeline by preparing elementary and secondary school students to access such professional programs. While the need for curriculum reform is recognized, the impact of A/IS on various professions and socioeconomic contexts is, at this time, both evolving and largely undocumented. Thus, the overhaul of education systems at all levels should be preceded by A/IS research.

Much of LMIC education is not globally competitive today, so there is a risk that the global advent of A/IS could negatively affect the chances of young people in LMIC finding

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productive employment, further fueling global inequality. Education systems worldwide have to be reformed and transformed to fit the new demands of the information age, in view of the changing mix of skills demanded from the workforce.[29] In 21st century education, it has been observed that children need less rote knowledge, given so much is instantly accessible on the web and more tools to network and innovate are available; less memory and more imagination should be developed; and fewer physical books and more internet access is required. Young people everywhere need to develop their capacities for creativity, human empathy, ethics, and systems thinking in order to work productively alongside robots and A/IS technologies. Science, Technology, Engineering, Art/design, and Math (STEAM) subjects need to be more extensive and more creatively taught.[30] In addition, research is needed to establish ways that a new subject, empathy, can be added to these crucial 21st century subjects in order to educate the future A/IS workforce in social skills. Instead, in rich and poor countries alike, children are continuing to be educated for an industrial age which has disappeared or never even arrived. LMIC education systems, being less entrenched in many countries, may have the potential to be more flexible than those in HIC. Perhaps A/IS can be harnessed to help educational systems to leapfrog into the 21st century, just as mobile phone technology enabled LMIC leapfrog over the phase of wired communication infrastructure.

Recommendations

Education with respect to A/IS must be targeted to three sets of students: the general public, present and future professionals in A/IS, and present and future policy makers. To prepare the future workforce to develop culturally appropriate A/IS, to work productively and ethically alongside such technologies, and to advance the UN SDGs, the curricula in HIC and LMIC universities and professional schools require innovation. Equally importantly, preuniversity education systems, starting with early childhood education, need to be reformed to prepare society for the risks and opportunities of the A/IS age, rather than the current system which prepares society for work in an industrial age that ended with the 20th century. Specific recommendations include:

- Preparing future managers, lawyers, engineers, civil servants, and entrepreneurs to work productively and ethically as global citizens alongside A/IS, through reform of undergraduate and graduate curricula as well as of preschool, primary, and secondary school curricula. This will require:

  - Fomenting interaction between universities and other actors such as companies, governments, NGOs, etc., with respect to A/IS research through definition of research priorities and joint projects, subcontracts to universities, participation in observatories, and co-creation of curricula, cooperative teaching, internships/service learning, and conferences/seminars/courses.

  - Establishing and supporting more multidisciplinary degrees that include

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A/IS, and adapting university curricula to provide a broad, integrated perspective which allows students to understand the impact of A/IS in the global, economic, environmental, and sociocultural domains and trains them as future policy makers in A/IS fields.

- Integrating the teaching of ethics and A/IS across the education spectrum, from preschool to postgraduate curricula, instead of relegating ethics to a standalone module with little direct practical application.

- Promoting service learning opportunities that allow A/IS undergraduate and graduate students to apply their knowledge to meet the needs of a community.

- Creating international exchange programs, through both private and public institutions, which expose students to different cultural contexts for A/IS applications in both HIC and LMIC.

- Creating experimental curricula to prepare people for information-based work in the 21st century, from preschool through postgraduate education.

- Taking into account transversal competencies students need to acquire to become ethical global citizens, i.e., critical thinking, empathy, sociocultural awareness, flexibility, and deontological reasoning in the planning and assessment of A/IS curricula.

- Training teachers in teaching methodologies suited to addressing challenges imposed in the age of A/IS.

- Stimulating STEAM courses in preuniversity education.

- Encouraging high-quality HIC-LMIC collaborative A/IS research in both private and public universities.

- Conducting research to support innovation in education and business for the A/IS world, which could include:

  - Researching the impact of A/IS on the governance and macro/micro strategies of companies and organizations, together with those companies, in an interdisciplinary manner which harnesses expertise of both social scientists and technology experts.

  - Researching the impact of A/IS on the business model for the development of new products and services through the collaborative efforts of management, operations, and the technical research and development function.

  - Researching how empathy can be taught and integrated into curricula, starting at the preschool level.

  - Researching how schools and education systems in low-income settings of both HIC and LMIC can leverage their less-entrenched interests to leapfrog into a 21st century-ready education system.

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- Establishing ethics observatories in universities with the purpose of fostering an informed public opinion capable of participating in policy decisions regarding the ethics and social impact of A/IS applications.

- Creating professional continuing education and employment opportunities in A/IS for current professionals, including through online and executive education courses.

- Creating educative mass media campaigns to elevate society's ongoing baseline level of understanding of A/IS systems, including what it is, if and how it can be trusted in various contexts, and what are its limitations.

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Section 5—A/IS and Humanitarian Action

Issue: A/IS are contributing to humanitarian action to save lives, alleviate suffering, and maintain human dignity both during and in the aftermath of man-made crises and natural disasters, as well as to prevent and strengthen preparedness for the occurrence of such situations. However, there are ethical concerns with both the collection and use of data during humanitarian emergencies.

Background

There have been a number of promising A/IS applications that relieve suffering in humanitarian crises, such as extending the reach of the health system by using drones to deliver blood to remote parts of Rwanda,[31] locating and removing landmines,[32] efforts to use A/IS to track movements and population survival needs following a natural disaster, and to meet the multiple management requirements of refugee camps.[33] There are also promising developments using A/IS and robotics to assist people with disabilities to recover mobility, and robots to rescue people trapped in collapsed buildings.[34] A/IS are also being used to monitor conflict zones and to enable early warning systems.[35] For example, Microsoft has partnered with the UN Human Rights Office of the High Commissioner (OHCHR) to use big data in order to track and analyze human rights violations in conflict zones.[36] Machine learning is being used for improved decision-making regarding asylum adjudication and refugee resettlement, with a view to increasing successful integration between refugees and host communities.[37] In addition, there is evidence that a recent growth in human empathy has increased well-being while diminishing psychological and physical violence,[38] inspiring some researchers to look for ways of harnessing the power of A/IS to introduce more empathy and less violence into society.

The design and ethical deployment of these technologies in crisis settings are both essential and challenging. Large volumes of both personally identifiable and demographically identifiable data are collected in fragile environments, where tracking of individuals or groups may compromise their security if data privacy cannot be assured. Consent to data use is also impractical in such environments, yet crucial for the respect of human rights.

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Recommendations

The potential for A/IS to contribute to humanitarian action to save and improve lives should be prioritized for research and development, including by organizing global research challenges, while also building in safeguards to protect the creation, collection, processing, sharing, use, and disposal of information, including data from and about individuals and populations. Specific recommendations include:

- Promoting awareness of the vulnerable condition of certain communities around the globe and the need to develop and use A/IS applications for humanitarian purposes.

- Elaborating competitions and challenges in high impact conferences and university hackathons to engage both technical and nontechnical communities in the development of A/IS for humanitarian purposes and to address social issues.

- Support civil society groups who organize themselves for the purpose of A/IS research and advocacy to develop applications to benefit humanitarian causes.[39]

- Developing and applying ethical standards for the collection, use, sharing, and disposal of data in fragile settings.

- Following privacy protection frameworks for pressing humanitarian situations that ensure the most vulnerable are protected.[40]

- Setting up clear ethical frameworks for exceptional use of A/IS technologies in life-saving humanitarian situations, compared to "normal" situations.[41]

- Stimulating the development of low-cost and open source solutions based on A/IS to address specific humanitarian problems.

- Training A/IS experts in humanitarian action and norms, and humanitarian practitioners to catalyze collaboration in designing, piloting, developing, and implementing A/IS technologies for humanitarian purposes. Forging public-private A/IS participant alliances that develop crisis scenarios in advance.

- Working on cultural and contextual acceptance of any A/IS introduced during emergencies.

- Documenting and developing quantifiable metrics for evaluating the outcomes of humanitarian digital projects, and educating the humanitarian ecosystem on the same.

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Endnotes

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4 A/IS has the potential to advance positive change toward all seventeen 2030 Sustainable Development Goals, which are:

Goal 1. End poverty in all its forms everywhere

Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture

Goal 3. Ensure healthy lives and promote well-being for all at all ages

Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

Goal 5. Achieve gender equality and empower all women and girls

Goal 6. Ensure availability and sustainable management of water and sanitation for all

Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all

Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Goal 10. Reduce inequality within and among countries

Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable

Goal 12. Ensure sustainable consumption and production patterns

Goal 13. Take urgent action to combat climate change and its impacts

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Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development

Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

Goal 17. Strengthen the means of implementation and revitalize the global partnership for sustainable development

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